Integrating local health departments to reduce suicide-related emergency department visits among people with substance use disorders – Evidence from the state of Maryland

Deanna Barath (MPH)*, Jie Chen (PhD)

University of Maryland, 4200 Valley Drive, Suite 3310, College Park, MD 20742, United States of America

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ABSTRACT

Individuals with a substance use disorder (SUD) are six times as likely than those without a SUD to attempt suicide, however just 18% of the SUD population has received treatment. One of the barriers to treatment is appropriate and timely mental health services. This resulted in a substantial increase in emergency department (ED) visits related to SUD and suicide. This study sought to determine if the number of suicide-related ED visits for patients with SUD is associated with the types of mental health activities provided by their local health department (LHD). Specifically, we examined whether patients with a SUD aged 18–64 experienced reductions in suicide-related ED visits when their LHD directly engaged in mental health activities, such as (1) primary prevention for mental illness or (2) mental health services. Using linked datasets for 2012 from the National Profile of Local Health Departments, U.S. Census data, Area Health Resource File, and Maryland's State Emergency Department Databases (SEDD), we employed multivariable logistic regressions and instrumental variable models to examine this association. After adjusting for the endogeneity of LHDs' activity measures and controlling for individual-, hospital-, LHD-, and county-level characteristics, results demonstrated patients with a SUD experienced a 6% and 5% reduction in suicide-related ED visits when their LHD directly provided primary prevention for mental illness and mental health services, respectively. The results are small but significant, with robust standard errors. This study suggests LHDs may be key players in preventing suicide-related ED visits among the SUD population.

1. Introduction

There has been a dramatic increase in the number of drug, alcohol, and suicide deaths in nearly every age group over the last decade, which have more than doubled overall since 1999 (Farberman and Lang, 2019). While each independently damages lives, there is a substantial body of evidence linking substance use disorders (SUDs), a substance dependence and/or misuse (Coffey et al., 2010), with fatal and non-fatal suicide attempts. Notably, individuals with a SUD are six times more likely than those without a SUD to attempt suicide (Center for Substance Abuse Treatment, 2008), alcohol is present in about 30–40% of fatal and non-fatal suicide attempts, and prescription and over-the-counter medications accounted for 94% of the roughly 230,000 emergency department (ED) visits for a drug-related suicide attempt in 2011 (Substance Abuse and Mental Health Services Administration, 2013).

The strong association between SUDs and suicide attempts can be explained by the myriad of shared risk factors such as poor mental and physical health, social isolation, unemployment, lack of social supports, and stressful life events (Borges et al., 2000; Center for Substance Abuse Treatment, 2008; Substance Abuse and Mental Health Services Administration, 2017). While SUDs are treatable, a large treatment gap exists and if left untreated, individuals with a SUD are at a higher risk for suicidal ideation, self-inflicted injury, and mortality (Arias et al., 2016a; Center for Substance Abuse Prevention, 2015; Center for Substance Abuse Treatment, 2008). When these individuals present in the ED, they are often seeking treatment and referrals (Center for Substance Abuse Treatment, 2008; Perhats and Valdez, 2008). However nearly 30% of suicide-related ED visits with a co-occurring SUD are discharged from the ED without treatment (Bouchery et al., 2015; Weiss et al., 2017). This is a serious concern because a history of suicide ideation and self-inflicted injury are strong predictors of a future fatal

suicide attempt, followed by SUDs and other mental health disorders (Arias et al., 2016b; Ribeiro et al., 2016).

This is why the ED continues to be recognized as an important site for identifying patients experiencing suicide ideation and/or self-inflicted injuries with a SUD and linking them to care (Betz et al., 2016; Perhats and Valdez, 2008). While active contact (Denchev et al., 2017; Stanley et al., 2015), community-based education (Fountoulakis et al., 2011), psychotherapy (Agyemang et al., 2014; Brown and Jager-Hyman, 2014; Chen and Rizzo, 2010), and pharmacotherapy (Agyemang et al., 2014) have been shown to reduce suicide ideation, self-inflicted injury, and SUD, a reoccurring problem is connecting at-risk individuals with appropriate and timely mental health care services. This is partly due to patient help-seeking behavior (e.g. maladaptive coping strategies, lack of perceived need, preference for self-management, mistrust, and stigma) (Calear et al., 2014; Hom et al., 2015; Niederkrotenthaler et al., 2014; Thornicroft, 2008); structural factors (e.g. geography, availability of treatment services, insurance, and childcare) (Brook et al., 2006; Calear et al., 2014; Fountoulakis et al., 2011; Hom et al., 2015; Stanley et al., 2015); and systematic issues around ED intake, evaluation, and discharge (Ahmedani et al., 2015; Baraff et al., 2006; Betz et al., 2016; Perhats and Valdez, 2008).

The 2012 *National Strategy for Suicide Prevention* (Office of the Surgeon General and Prevention, 2012) outlined goals and objectives that largely focused on mental and physical care integration and overall care coordination as a guide to suicide prevention in the U.S. These strategies were supported by the Affordable Care Act (Croft and Parish, 2013) and since the ACA passed many hospitals transformed into accountable care organizations, adopted care coordination practices, and shifted to a population health perspective (Anderson and Chen, 2019; Costich et al., 2015; Ingram et al., 2015). Thus, creating an opportunity for local health departments (LHDs) to become established partners in the care continuum for patients with a history of suicide ideation, self-inflicted injuries, and/or SUD (DeSalvo et al., 2016; Scutchfield et al., 2015).

LHDs play a central role in their communities and by statute, work to protect and promote population health (Cornette et al., 2014). While the provision of various LHD activities have been linked to improved self-reported health (Ingram et al., 2012), lower preventable deaths (Mays et al., 2016), and lower health disparities (Luo et al., 2013; Shah and Sheahan, 2015), the wide array of activities LHDs are involved in make them unique partners and well suited to address the treatment barriers previously mentioned. LHDs can impact social norms around SUD and mental health treatment through community health promotion activities (Calear et al., 2014); track and monitor substance use behaviors (Hudson et al., 2017); engage in policy advocacy, law implementation, and regulation enforcement around drugs, alcohol and other substances (e.g. cigarette tax (Grucza et al., 2014) and the administration of overdose education and nasal naloxone distribution (Walley et al., 2013)) (Novak et al., 2019).

Additionally, many LHDs are already engaged in activities around injury/suicide, substance misuse, and mental health prevention and treatment (National Association of County and City Health Officials, 2016; Purtle et al., 2016; Shah et al., 2016). Recent research links mental health LHD activities to reductions in health care costs (Chen et al., 2018a; Chen et al., 2018) and readmission rates (Chen et al., 2018b) and LHD SUD activities to reductions in ED utilization (Novak et al., 2019). LHDs in Maryland actively provide population-based interventions and health care services to address mental health issues (National Association of County and City Health Officials, 2013), but to our knowledge there are no studies evaluating the provision of these services and subsequent ED visits.

This study seeks to determine if the probability of a suicide-related ED visit is associated with the types of mental health activities provided directly by the LHD for adult patients between the ages of 18 and 64 with a co-occurring SUD. Specifically, we examined two mental health activities directly provided by LHDs: (1) primary prevention for mental

illness and (2) mental health services. Maryland has 24 LHDs that serve county residents of varying socio-economic status, race/ethnicities, and geographies. These county characteristics impact the strength and scalability of primary prevention activities. We hypothesize that LHDs' direct provision of primary prevention for mental illness and mental health services is related to significant reductions in suicide-related ED visits (suicidal ideation and self-inflicted injury (Brennan et al., 2016; Kuramoto-Crawford et al., n.d.)) for individuals with a SUD.

2. Methods

2.1. Data

The National Profile of Local Health Departments is a national survey sent to all LHDs every three years by the National Association of County and City Health Officials (NACCHO) to collect information on organizational structures, populations served, finances, workforce, and activities conducted within the past year. In 2013, all LHDs in Maryland completed the survey between January and March (National Association of County and City Health Officials, 2013). LHD jurisdictions in Maryland are set at the county level, therefore county identifiers were used to link the NACCHO data to the 2012 U.S. Census data, Area Health Resource File (Health Resources and Services Administration), and Maryland's State Emergency Department Databases (SEDD) (HCUP State Emergency Department Databases (SEDD), 2012). The U.S. Census data and Area Health Resource File were linked to obtain county-level demographic and health care access variables (Health Resources and Services Administration). The SEDD captures all individual ED visits that are not admitted and includes hospital identifiers, patient demographics, all diagnoses, procedures, expected payment source, and total charges.

2.2. Sample

The sample population included individuals in Maryland aged 18–64 with an ED visit. Using the Agency for Healthcare Research and Quality's (AHRQ) definition of SUD, which used the DSM-IV, and corresponding International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes (Coffey et al., 2010), we focused our sample on patients with any diagnostic code for a SUD during an ED visit in 2012 (n = 34,734). This definition includes alcohol-related disorders, drug-related disorders, drug dependence in pregnancy, dental disorders in pregnancy, poisoning by opiates and related narcotics, miscellaneous history codes related to substance use, and miscellaneous history or injury codes related to mental illness (Coffey et al., 2010). The hospitals in our analysis were limited to acute care (short-term), nonprofit, voluntary hospitals and excluded psychiatric facilities. Hospital characteristics were verified using the American Hospital Directory.

2.3. Variables

The dependent variable indicates a suicide-related ED visit in 2012 (n = 2523), where suicide-related is defined as suicidal ideation and/or self-inflicted injury (Brennan et al., 2016; Kuramoto-Crawford et al., n.d.). ED visit were coded as 1 if there was at least one diagnostic code for suicide ideation (ICD-9-CM = V62.84) and/or external cause of injury code for suicide and self-inflicted injury (ICD-9-CM E-code = E950–E959) as defined by the AHRQ (Owens et al., 2017), and 0 if otherwise.

The independent variable indicates the specific mental health activity directly provided by the LHD. This study examined two mental health activities separately: (1) population-based primary prevention activities for mental illness, and (2) behavioral/mental health services. Our independent variables were conceptualized around the primary, secondary, and tertiary stages of prevention. For example, population-

based primary prevention activities for mental illness focus on activities that prevent a disease or illness from occurring or minimize the effect of a modifiable risk factor, and behavioral/mental health services align with both the secondary and tertiary prevention strategies (Center for Disease Control, 1992; Chen et al., 2018b; Cornette et al., 2014). NACCHO survey respondents were asked "how your LHD provided that activity or service in your jurisdiction during the past year" and response options included: LHD performed the activity directly; contracted it out; provided by others in the community independent of LHD funding; not available in community, or; don't know (National Association of County and City Health Officials, 2013). Dichotomous variables were constructed for each independent variable, where 1 equaled a response of directly providing the mental health activity in their jurisdiction during the past year, and 0 equaled otherwise.

2.4. Conceptual framework and covariates

Our conceptual framework was adapted from the Andersen Behavioral Model (Andersen, 1995) and literature on the LHD framework (Chen et al., 2018a; Chen et al., 2018b). Specifically, we selected *predisposing* factors (age, sex, and race/ethnicity), *need* factors (number of chronic conditions), and *enabling* factors (insurance type and household income in patients' residential zip code) of an ED visit to control in the model (Andersen, 1995). Other control variables included hospital characteristics (number of staffed hospital beds), county characteristics (total county population size, percentage of urban/rural geographies, percentage of the population that was Black, number of Federally Qualified Health Centers (FQHCs), and the number of primary care physicians per 1000 population), and LHD characteristics (governed by local board of health, the number of LHD full-time equivalent employees, LHD per capita expenditures) (Chen et al., 2018a; Chen et al., 2018b; Coffey et al., 2010).

2.5. Analysis

We first described the means of our sample by LHD mental health activity and characteristics of the individuals, hospitals, LHDs, and county. Results are presented for the entire patient population with a SUD (n = 34,734), then stratified by those with and without a suicide-related ED visit. We used the independent group *t*-test to determine if the differences observed between the subpopulations were significant.

Then, we employed multivariable logistic models to examine whether individuals with a SUD experienced a reduction in suicide-related ED visits if they lived in a county where the LHD directly provided mental health activities. In model 1 we controlled for individual patient characteristics to produce a baseline assessment, before adding the hospital, LHD, and county characteristics to our control variables of model 2. The analysis was done separately for the two LHD mental health activity measures and the Odds Ratios were reported.

It is likely that LHDs' investment in mental health activities in the county depends on the mental health needs of their residents (i.e. the higher the need the higher the investment from the local agency). To adjust for this endogeneity concern, we used an instrumental variables (IV) design for model 3 to reduce the risk of endogeneity of LHDs' activity measures (Chen et al., 2018b). We used two instrumental variables from the NACCHO profile of LHDs (1) "whether LHDs had the authority to set and impose fees", and (2) "whether LHDs had the authority to impose taxes for public health." These two variables can directly influence LHDs' decisions to invest in local health services but will not influence an individual's ED visit after controlling for covariates listed above. This IV approach was previously used in literature to address the endogeneity concern (Chen et al., 2018b). We tested the IVs and the model passed the tests for (a) the validity of instruments, (b) over-identifying restrictions and (c) the endogeneity of LHD factors. Stata 14 was used for this analysis.

3. Results

Among individuals aged 18–64 in Maryland with a SUD in 2012 (n = 34,734), 7.26% (n = 2523) also experienced a suicide-related ED visit. These individuals were more likely to be white, female, and younger compared to those with a SUD without a suicide-related ED visit (Table 1). They were also more likely located in rural areas and live in counties with low LHD expenditures per capita.

Overall, the results of the multivariable logistic regression models (Table 2) demonstrated a decrease in suicide-related ED visits among individuals with a SUD when residing in a county that directly provided mental health activities. The baseline results presented in model 1 showed a significant decrease in suicide-related ED visits of 11% (95% Confidence Interval [CI] = [0.80–0.98]) when LHDs directly provided primary prevention for mental illness and 22% (95% CI = [0.71–0.87]) when LHDs directly provided behavioral/mental health services. Results also showed that Black and Other racial groups had significantly lower rates of suicide-related ED visits compared to white individuals. Residents of rural areas had significantly higher rates of suicide-related ED visits compared to their urban counterparts. Aging, having multiple chronic conditions, and a greater median household income all increase the odds of having a suicide-related ED visit among those with a SUD.

In model 2, we added an extra set of covariates to capture the availability of health care resources in the hospital, LHD, and county. When individuals with a SUD lived in counties where the LHD directly provided primary prevention for mental illness, suicide-related ED visits decreased by 7% (95% CI = [0.79–1.10]), and by 13% (95% CI = [0.74–1.02]) when the LHD provided behavioral/mental health services. Results indicated individuals living in a county with more FQHCs, more primary care doctors, and a local health board had higher odds of a suicide-related ED visit. This finding could be reflective of more health care resources being recruited into counties with higher mental health care needs. Hence, we observed the higher suicide-related ED visits in counties with higher resources.

Therefore, the independent variable could be exposed to a self-selection issue. To address this endogeneity concern, we used the IV approach proposed in the method section in model 3 which includes variables (1) "whether LHDs had the authority to set and impose fees," and (2) "whether LHDs had the authority to impose taxes for public health." After adjusting for the endogeneity issue identified in model 2, the results of model 3 showed that a LHDs' direct provision of primary prevention for mental illness and mental health services were significantly associated with 6% (95% CI [0.08, 0.03]) and 5% (95% CI [0.07, 0.03]) reduction of suicide-related ED visits, respectively.

4. Discussion

Our results suggest county residents with a SUD were 5–6% less likely to experience a suicide-related ED visit when Maryland LHDs engage in the direct provision of mental health activities for primary prevention for mental illness and mental health services. The results are small yet significant, with robust standard errors. The results support previous findings linking the provision of mental health activities at LHDs with lower readmission rates (Chen et al., 2018b), inpatient admissions for preventable hospitalizations (Chen et al., 2018a), and healthcare costs (Chen et al., 2018). Additionally, we found the provision of mental health activities to be highly interrelated in Maryland, which is in-line with research on the national prevalence of activities in LHDs addressing mental health (Purtle et al., 2016).

The findings also highlight some of the known individual, community, and geographical characteristics commonly associated with suicide-related ED visits and SUDs such as having multiple chronic conditions, identifying as White, and living in a low-income and/or rural area (Arias et al., 2016a; Canner et al., 2018; Harp and Borders, 2019). However, our full model indicates LHDs may be able to address some of the disparities in suicide and SUDs such as gender, age, and insurance

Table 1

Summary statistics of SUD patients categorized by suicide-related ED visits in Maryland, 2012.

Data source: 2013 National Association of County and City Health Officials (NACCHO) National Profile of Local Health Departments; 2012 Area Health Resource File; and 2012 Maryland, State Emergency Department Databases (SEDD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

Variable	SUD and suicide-related ED visit?			
	SUD Mean (SD) (n = 34,734)	No Mean (SD) (n = 32,211)	Yes Mean (SD) (n = 2523)	p-Val Ha: diff ≠ 0
Direct provision of LHD activity				
Primary prevention of mental illness (%)	48 (50)	47 (50)	49 (50)	0.178
Behavioral/mental health services (%)	46 (50)	46 (50)	44 (50)	0.262
Individual characteristics				
Race/ethnicity (%)				
White	64 (48)	63 (48)	72 (45)	0.000
Black	31 (46)	31 (46)	23 (42)	0.000
Hispanic	2 (15)	2 (15)	2 (15)	0.571
Asian	1 (8)	1 (8)	< 1 (7)	0.490
Native	< 1 (4)	< 1 (4)	< 1 (3)	0.314
Other	2 (15)	2 (16)	2 (14)	0.101
Age	41 (14)	41 (14)	38 (13)	0.000
Female (%)	34 (48)	34 (47)	36 (48)	0.082
Chronic conditions (#)	3 (1.91)	3 (2)	3 (2)	0.000
Insurance type (%)				
Uninsured	24 (43)	24 (43)	24 (43)	0.731
Medicare	13 (33)	13 (33)	12 (32)	0.059
Medicaid	37 (48)	37 (48)	36 (48)	0.289
Private ins	23 (42)	22 (42)	25 (43)	0.001
Other ins	4 (19)	4 (19)	3 (17)	0.027
Median household income by zip code (%)				
Quartile 1 ($1–$38,999)	21 (40)	21 (41)	15 (36)	0.000
Quartile 2 ($39,000–$47,999)	15 (36)	15 (36)	16 (36)	0.247
Quartile 3 ($48,000–$62,999)	23 (42)	23 (42)	22 (41)	0.207
Quartile 4 ($63,000+)	41 (49)	41 (49)	47 (50)	0.000
Hospital characteristics				
Number of beds (%)				
< 50	2 (14)	2 (14)	2 (13)	0.151
50–100	6 (23)	6 (23)	6 (24)	0.858
101–200	28 (45)	29 (45)	24 (42)	0.000
201–425	55 (50)	55 (50)	59 (49)	0.001
426+	8 (28)	8 (27)	10 (29)	0.025
LHD characteristics				
LHD total population (unit = 1000 people)	45 (29)	45 (29)	46 (29)	0.155
Local health board	0.75 (43)	0.75 (0.43)	0.80 (0.4)	0.000
LHD FTE (#)	453 (269)	455 (269)	434 (261)	0.001
LHD per capita expenditures (%)				
Below median	32 (47)	32 (47)	39 (49)	0.000
Above median	66 (47)	66 (47)	60 (49)	0.000
Unknown	2 (15)	2 (15)	1 (11)	0.001
County characteristics				
Urban (%)	94 (24)	94 (23)	92 (26)	0.001
Black (%)	31 (46)	31 (46)	23 (42)	0.000
FQHC (#)	9 (12)	10 (12)	8 (11)	0.000
PCPs per 1000 population (#)	422 (351)	420 (351)	446 (355)	0.001

Abbreviations: SUD = substance use disorder; ED = emergency department; LHD = local health department; suicide-related ED visit = any diagnosis for suicide ideation and/or intentional self-inflicted injury; FQHC = Federally Qualified Health Centers; PCP = primary care providers; FTE = full-time equivalence.

Interpretation: The study population focuses on individuals aged 18–64, in Maryland with a SUD in 2012. This sample is then divided by those with and without a suicide-related ED visit. The mean of each variable should be interpreted by the indicator aside each variable where # = mean number and % = mean percent and the column it falls under. The column for p-Val represents p-value of the independent group t-test, which tests if the difference between two means is 0. The difference is calculated by subtracting the mean(yes) from mean(no). The test assumes the difference is zero. A p-value < 0.05 means the difference between means is greater than zero.

coverage which had no impact on the probability of a suicide-related ED visit (Cook et al., 2016).

Interestingly, the probability of having a suicide-related ED visit and co-occurring SUD significantly increased when the LHD was governed by a local health board. This was evident in model 2 and 3. Model 3 showed a 23% increase in suicide-related ED visits with co-occurring SUD when LHDs provided primary prevention for mental illness, and 14% increase with the provision of mental health services. Though having a local board is the most common LHD governance structure (Wallace et al., 2014), this association indicates variance in the degree

to which local health boards impact the provision of LHD activities. Recent studies have identified the need for more training of local board of health members (Nguyen et al., 2019), as 1-in-3 fail to utilize data to identify disparities and do not support community efforts to address the cause of disparities (Shah et al., 2019). Additional research is needed to fully understand this association.

Suicide and substance misuse are preventable public health issues requiring coordinated, interdisciplinary approaches that rely on culturally competent evidence-based best practices that are specific to local needs, and are systematically implemented to minimize unnecessary

Table 2

Side-by-side model comparison measuring the likelihood of a having a suicidal-related ED visit among SUD patients (aged 18–64) by the LHDs' direct provision of mental health preventive care and services, 2012 (n = 34,734).

Data source: 2013 National Association of County and City Health Officials (NACCHO) National Profile of Local Health Departments; 2012 Area Health Resource File; and 2012 Maryland, State Emergency Department Databases (SEDD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

Variables	Model 1: Limited Logistic regression		Model 2: Full Logistic regression		Model 3: Full IV (2SLS) regression	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	β (95% CI)	β (95% CI)
Direct provision of LHD activity						
Primary prevention of mental illness						
No	Reference		Reference		Reference	
Yes	0.89 (0.80–0.98)		0.93 (0.79–1.10)		−0.06 (−0.08 to −0.03)	
Behavioral/mental health services						
No		Reference		Reference		Reference
Yes		0.78 (0.71–0.87)		0.87 (0.74–1.02)		−0.05 (−0.07 to −0.03)
Individual characteristics						
Race/ethnicity						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	0.69 (0.62–0.78)	0.69 (0.62–0.77)	0.69 (0.62–0.77)	0.69 (0.62–0.77)	−0.02 (−0.03 to −0.01)	−0.02 (−0.03 to −0.02)
Hispanic	0.9 (0.68–1.18)	0.89 (0.68–1.17)	0.89 (0.67–1.17)	0.89 (0.68–1.17)	−0.01 (−0.03–0.01)	−0.01 (−0.03–0.01)
Asian	0.68 (0.38–1.23)	0.65 (0.36–1.17)	0.60 (0.33–1.08)	0.60 (0.33–1.08)	−0.03 (−0.06–0.00)	−0.03 (−0.07–0.00)
Native	0.49 (0.12–2.06)	0.48 (0.11–2.01)	0.47 (0.11–1.96)	0.47 (0.11–1.96)	−0.04 (−0.09–0.01)	−0.04 (−0.09–0.01)
Other	0.67 (0.49–0.9)	0.66 (0.49–0.89)	0.66 (0.49–0.89)	0.66 (0.49–0.90)	−0.02 (−0.04 to −0.01)	−0.02 (−0.04–0.00)
Age	1.05 (1.03–1.07)	1.05 (1.03–1.07)	1.06 (1.04–1.08)	1.06 (1.04–1.08)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
Age squared	0.99 (0.99–0.99)	0.99 (0.99–0.99)	1.00 (1.00–1.00)	1.00 (1.00–1.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
Female	0.97 (0.89–1.06)	0.97 (0.89–1.06)	0.98 (0.89–1.06)	0.97 (0.89–1.06)	0.00 (−0.01–0.00)	0.00 (−0.01–0.00)
Chronic conditions	1.17 (1.15–1.2)	1.17 (1.15–1.2)	1.18 (1.16–1.21)	1.18 (1.16–1.21)	0.01 (0.01–0.01)	0.01 (0.01–0.01)
Insurance type						
Uninsured	Reference	Reference	Reference	Reference	Reference	Reference
Medicare	1.07 (0.91–1.25)	1.06 (0.91–1.24)	1.05 (0.90–1.23)	1.05 (0.90–1.23)	0.00 (−0.01–0.01)	0.00 (−0.01–0.01)
Medicaid	0.97 (0.87–1.09)	0.97 (0.87–1.08)	0.98 (0.87–1.09)	0.97 (0.87–1.09)	0.00 (−0.01–0.01)	0.00 (−0.01–0.01)
Private ins	1.02 (0.9–1.15)	1.01 (0.9–1.14)	0.99 (0.88–1.12)	0.99 (0.88–1.12)	0.00 (−0.01–0.01)	0.00 (−0.01–0.01)
Other ins	0.78 (0.6–1)	0.78 (0.6–1.01)	0.76 (0.59–0.99)	0.76 (0.59–0.98)	−0.02 (−0.03–0.00)	−0.02 (−0.03–0.00)
Median household income of patient's ZIP code						
Quartile 1 ($1–$38,999)	Reference	Reference	Reference	Reference	Reference	Reference
Quartile 2 ($39,000–$47,999)	1.16 (0.98–1.36)	1.18 (1–1.39)	1.18 (0.99–1.4)	1.19 (1.00–1.41)	0.02 (0.01–0.03)	0.02 (0.01–0.03)
Quartile 3 ($48,000–$62,999)	1.18 (1.01–1.38)	1.19 (1.01–1.39)	1.19 (1.00–1.41)	1.19 (1.00–1.41)	0.02 (0.00–0.03)	0.01 (0.00–0.02)
Quartile 4 ($63,000+)	1.56 (1.34–1.83)	1.59 (1.36–1.86)	1.56 (1.31–1.87)	1.57 (1.32–1.87)	0.04 (0.03–0.06)	0.04 (0.03–0.05)
Hospital characteristics						
Number of beds						
< 50			Reference	Reference	Reference	Reference
50–100			0.99 (0.68–1.45)	0.98 (0.68–1.43)	−0.03 (−0.06 to −0.01)	−0.02 (−0.04–0.00)
101–200			1.00 (0.70–1.44)	1.01 (0.71–1.44)	−0.02 (−0.05–0.00)	−0.01 (−0.03–0.01)
201–425			1.34 (0.94–1.92)	1.34 (0.94–1.91)	0.00 (−0.02–0.02)	0.01 (−0.01–0.03)
426+			1.45 (0.98–2.12)	1.43 (0.98–2.09)	0.00 (−0.03–0.02)	0.01 (−0.02–0.03)
LHD characteristics						
LHD total population			0.98 (0.96–0.99)	0.98 (0.97–0.99)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
Local health board (n = 24)			4.89 (1.24–19.24)	4.41 (1.19–16.36)	0.23 (0.13–0.34)	0.14 (0.05–0.23)
LHD FTE			1.00 (1.00–1.00)	1.00 (1.00–1.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
LHD per capita expenditures						
Below median			Reference	Reference	Reference	Reference
Above median			0.47 (0.36–0.62)	0.47 (0.37–0.6)	−0.10 (−0.13 to −0.07)	−0.08 (−0.1 to −0.06)
Unknown			0.39 (0.26–0.58)	0.40 (0.27–0.59)	−0.08 (−0.10 to −0.06)	-0.06 (−0.08 to −0.04)
County characteristics						
Urban			0.45 (0.36–0.57)	0.44 (0.35–0.55)	−0.04 (−0.06 to −0.02)	−0.06 (−0.08 to −0.05)
Black			1.00 (1.00–1.01)	1 (0.99–1.01)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
FQHC			1.06 (1.01–1.11)	1.05 (1–1.11)	0.01 (0.00–0.01)	0.00 (0.00–0.01)
PCPs per 1000 population			1.00 (1.00–1.00)	1.00 (1.00–1.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)

Abbreviations: SUD = substance use disorder; ED = emergency department; LHD = local health department; suicide-related ED visit = any diagnosis for suicide ideation and/or intentional self-inflicted injury; FQHC = Federally Qualified Health Centers; PCP = primary care providers; FTE = full-time equivalence.

Model specifications: Independent variable: LHD activity. Dependent variable: suicide-related ED visits. Model 1 is a baseline model controlling only for individual patient characteristics. Model 2 is the full model controlling for hospital, LHD, and county characteristics. Model 3 used an instrumental variable (IV) approach to adjust for endogeneity. The two IV variables used were (1) "whether LHDs had the authority to set and impose fees", and (2) "whether LHDs had the authority to impose taxes for public health". Each model was done separately for the two LHD activity measures. The resulting Odds Ratios are reported, and comparative reference groups are labeled for each variable.

duplication (Lubell et al., 2017; National Association of State Mental Health Program Directors, 2017; Office of the Surgeon General and National Action Alliance for Suicide Prevention, 2012; Stone et al., 2017; Substance Abuse and Mental Health Services Administration (SAMHSA), 2012) Maryland has been working to implement these strategies to reduce ED visits for mental and substance use disorders and reduce suicide and drug-related deaths. The establishment of health enterprise zones aimed to integrate mental and physical health care by screening for depression at all encounters and immediately linking those in need to mental health services, often with the services at LHDs (Creekmur and Carter, 2015). Maryland's all-payer approach to health care reform rewards providers that improve health outcomes, quality, and control costs (Rajkumar et al., 2014), therefore, many hospitals have adopted a care coordination strategy to reduce readmissions. Additionally, Maryland State Care Coordinators are stationed at county health departments to help residents transition out of SUD treatment centers into the recovery community, linking them to community/faith based services and other health and human services (Maryland Department of Health and Behavioral Health Administration).

Findings from this study support the research promoting a public health approach (Center for Substance Abuse Prevention, 2015), the Public Health 3.0 infrastructure (DeSalvo et al., 2016), and the 21st Century Cures Act (H.R. 34 and 114th Congress, 2016) to address suicide ideation, self-inflicted injuries, and SUD through partnerships, care integration, and care coordination (Brownson et al., 2012).With LHDs having a central role in public health assessment, policy development, the assurance of service delivery, and community-engaged health programs, they may be able to address barriers to timely services and reach vulnerable at-risk populations (Center for Substance Abuse Prevention, 2015; Ingram et al., 2012). An investment in LHDs may be cost-effective in states such as Maryland that use a capitated budget for hospitals and are seeking to produce cost savings through prevention and care coordination activities (Chen et al., 2018; Costich et al., 2015; McCullough et al., 2018).

This study is not without limitations and interpretations of this study must consider the following. First, the results from NACCHOs' National Profile of Local Health Departments contain self-reported information which was not independently verified. The survey was completed by LHD staff of varying ranks and knowledge about LHD activities, which may have resulted in some response bias. This could be exacerbated by the broad range of LHD activities included in the survey without clear definitions. Additionally, the level of effort, time, and reach of mental health activities for (1) primary prevention for mental illness and (2) mental health services could not be ascertained through the response options. Though NACCHO's 2016 National Profile of LHDs dataset were available, the file was insufficient for a statewide analysis, thus the complete 2013 file was used. Another limitation of our data is the inability to ascertain what types of interventions were implemented at the LHD or hospital during 2012, though we tried to account for this in model 3. Our study also depended on administrative data, like ICD-9-CM codes and E-codes that are used primarily for billing purposes. Furthermore, we used Diagnostic and Statistical Manual of Mental Disorders, 4th. Edition (DSM-IV) definition of SUD, as DSM-V was released mid-2013. This could lead to us underreporting suicide-related ED visits. Lastly, additional research is needed to evaluate LHD activities in other states to determine if these results are generalizable to other states.

Though these results demonstrate a benefit of LHDs engaging in mental health activities, specifically directly providing primary prevention for mental illness and mental health services, there is a need to further examine the impact of LHD mental health activities on the health system. This includes understanding the patient population utilizing LHD services, including a granular analysis of the different SUDs patients have and the exact services provided at the LHD; differences between community provided services, contracted services, and direct services; and how hospitals partner with LHDs. A future study should

examine if these results vary by county for residents that were admitted into hospitals. Future studies should also examine external forces of change that impact the provision of primary prevention for mental illness and mental health services, such as the political environments (e.g. policies, leadership, and local boards of health), public health accreditation status, budget cuts, and infrastructure.

5. Conclusion

LHDs are expected to design and implement activities that reflect their community's health needs, target specific populations, and alleviate barriers to services. LHDs are the major source of health care for vulnerable populations and often coordinate community-engaged health programs. However, preventing suicide ideation and self-inflicted injuries, especially among those with a SUD, requires a coordinated and interdisciplinary approach. This study suggests that LHDs may be key players in preventing suicide-related ED visits among individuals with a SUD. Additional research is needed to evaluate LHD activities in other states to determine if these results are generalizable. Findings from this study can help to inform future studies that can explore how funding and policies influence LHDs' provision of primary prevention for mental illness and mental health services, how LHDs are indirectly involved with the provision of these activities, and how LHD activities are leveraged by the health care system.

Declaration of competing interest

The authors declare there is no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2019.105825.

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