Spatial Patterns of Sleep Disorders in Cleveland : Residential Segregation as Fundamental Cause?

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Why Sleep matters

• Public Health Crisis

- According to the National Center on Sleep Disorders Research, about 50 to 70 million Americans experience sleep disorders, which means that 1 in 3 adults do not regularly get the recommended amount of uninterrupted sleep they need to protect their health, which impact on physical and mental health outcomes

• Economic productivity

- According to RAND Corporation, if individuals who sleep under six hours started sleeping six to seven hours, they could add \$226.4 billion to the U.S. economy.

Sociology significance of sleep health

• The social patterning of Sleep

- sleep is *patterned* by societal factors (such as technology, racism, economics and natural environment), as well as social factors (such as relationships, networks and socio-economic factors) and individual factors (like genetics, beliefs and attitudes (Grandner, 2017).

• The medicalization and pharmaceutization of Sleep

- Medicalization when non-medical issues become defined and treated as medical problems (Conrad, 2007).

- Pharmaceutization when healthy people use drugs for non-medical reasons to enhance their performance and/or appearance; may occur in the absence of medicalization (Gabe & Martin, 2023).

- Both medicalization and pharmaceutization are shaped by Neoliberalism through 3 processes: creating a culture of enhancement regarding health & body, commodifying health and health services, emphasis on productive imperative that ensures maximizing workers productivity.(Barbee, Moloney, & Konrad, 2018)

- In 2020, 8.4% of adults used sleep medication every day or most days in the past 30 days (CDC)

- The social inequalities in sleep health
 - Spatial disparities, Gender disparities, Racial disparities, Age disparities, and Class disparities

FUNDAMENTAL CAUSE THEORY

- Fundamental Cause Theory (FCT) is a sociological framework that describes and explains the effects of social inequalities and their impact on health outcomes.
- Residential Segregation as a Fundamental Cause. (Williams & Collins, 2001)
 - Racial residential segregation is a fundamental cause of racial disparities in health
- Segregation creates conditions inimical to health in the social and physical environment

Data



Data - MetroHealth Electronic Health Record (EHR)

165,699 Individuals, resident in Cleveland, seen at MetroHealth between January 2016 - February 2021

Dependent Variable: Sleep disorders diagnosis

ICD 10 codes ("F51", "F51.0", "F51.1", "F51.11", "F51.13", "F51.19", "F51.2", "F51.3", "F51.4", "F51.5", "F51.8", "F51.9", "G25.8", "G47.", "G47.0", "G47.1", "G47.10", "G47.11", "G47.12", "G47.13", "G47.14", "G47.14", "G47.2", "G47.3", "G47.30", "G47.31", "G47.310", "G47.33", "G47.34", "G47.37", "G47.38", "G47.39", "G47.411", "G47.411", "G47.419", "G47.421", "G47.429", "G47.8", "G47.9", "R06.81")

- Independent & Control Variables : Demographic Characteristics and Elixhauser Comorbidity

- Elixhauser Comorbidity Score

(Congestive heart failure, Cardiac arrhythmias, Valvular disease, Pulmonary circulation disorders, Peripheral vascular disorders, Hypertension, uncomplicated, Hypertension, complicated, Paralysis, Other neurological disorders, Chronic pulmonary disease, Diabetes, uncomplicated, Diabetes, complicated, Hypothyroidism, Renal failure, Liver disease, Peptic ulcer disease, excluding bleeding, AIDS/HIV, Lymphoma, Metastatic cancer, Solid tumor without metastasis, Rheumatoid arthritis/collagen vascular diseases, Coagulopathy, Obesity, Weight loss, Fluid and electrolyte disorders, Blood loss anemia, Deficiency anemia, Alcohol abuse, Drug abuse, Psychoses, Depression)

- Demographic characteristics

(Gender, Age, Race and Ethnicity, Marital status, Health insurance type, Encounter visits)

- Geocoded residential addresses

Neighborhood Data (265 census tracts in the city of Cleveland)

- American Community Survey(ACS_5years estimates) - Census tracts level data, ACS_5yrs estimates 2016-2020 for demographics, and socioeconomic factors.

- Bergs-3 Area Deprivation Index (ADI) -Economic Hardship, Financial Strength, Educational Attainment
- Measures of Index of Concentration at the Extremes (ICE)- Racial segregation (ICE-Race), Income segregation (ICE-Income), Racialized Economic segregation (ICE-Race + Income)

- US Environmental Protection Agency (EPA) - Built environment data(Road density & National Walk Score) for Cuyahoga county 2020

- City of Cleveland Shapefile for mapping

Methods

- Logistic regression analysis for the odds of sleep disorders at the individual level
- Ordinary least squares regression (OLS) at the neighborhood level
- Spatial cluster analysis at the neighborhood level (Moran's' I statistics)
- Geographically Weighted Regression (GWR) at the neighborhood level

- Analysis and mapping performed with R software using Rstudio

Table 2.1: Descriptive Statistics

	Overall sample
	N / Freq (%)
SLEEP DISORDER	
Yes	22,058 (13.3)
No	143,611 (86.7)
RACE	13.552 (3 kits
White	80,047 (48.3)
African American	65,059 (49.3)
Other Races	20,563 (12.4)
AGE	
0-24yrs	22,288 (13.4)
25-49yrs	75,532 (44.3)
50-64yrs	45,688 (27.6)
65+yrs	24,161 (14.6)
Female	97,218 (58.7)
Obesity (%)	53,688 (32)
Depression (%)	56,182 (34)
Hospital Encounters (Median)	13
Elixhauser Comorbidities (Median)	2
Marital Status (Married)	67,864 (41)
INSURANCE TYPE	
Self-pay	26,319 (15.9)
Medicare	13,992 (8.4)
Medicaid	32,393 (19.5)
Commercial	78,311 (47.2)
Uninsured	14,655 (8.8)

165,669

Ν



In the context of intersectionality and the weathering hypothesis;

• Are Black Women more likely to be diagnosed with sleep disorders relative to others?

	Model 1	Model 2	Model 3
	β(se)	β(se)	β(se)
Age (ref:o-24yrs)	1		
25-49утз	o.67***	0.67***	0.67***
10	(0.03)	(0.03)	(0.03)
50-64yrs	0.79***	0.79***	0.79***
	(0.04)	(0.04)	(0.04)
65+yrs	o.66***	0.66***	0.66***
0 0 000000	(0.04)	(0.04)	(0.04)
Race (ref: Black)			
White	0.02	0.10***	0.10***
	(0.02)	(0.03)	(0.03)
Other Races	0.06*	0.14***	0.14***
10 000 00000 0000 40	(0.03)	(0.03)	(0.03)
Insurance Type (ref: self-pay)			
Medicare	-0.02	-0.02	-0.02
	(0.04)	(0.04)	(0.04)
Medicaid	0.15***	0.15***	0.15***
17 17 14 17 17 17 17 17 17 17 17 17 17 17 17 17	(0.03)	(0.03)	(0.03)
Uninsured	-0.00	-0.00	-0.00
	(0.03)	(0.03)	(0.03)
Commercial	0.12***	0.11***	0.11***
	(0.02)	(0.02)	(0.02)
Married	-0.21***	-0.20***	-0.20***
	(0.02)	(0.02)	(0.02)
Female	-0.46***	-0.52***	-0.52***
	(0.02)	(0.02)	(0.02)
Hospital Encounters (mean (SD))	0.26***	0.26***	0.26***
	(0.01)	(0.01)	(0.01)
Comorbidity count (mean (SD))	0.40***	0.40***	0.40***
	(0.01)	(0.01)	(0.01)
Obese	1.46***	1.46***	1.45***
	(0.02)	(0.02)	(0.02)
Depressed	0.42***	0.42***	0.42***
(174) 	(0.02)	(0.02)	(0.02)
Black Female	(0.02)	0.14***	0.11*
		(0.03)	(0.05)
Obese Black Female		(2.20)	0.03
			(0.04)
Intercept	-3.33***	-3.38***	-3.37***
	(0.04)	(0.04)	(0.04)
AIC	103230	103216	103217

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D<0.00 ators in parentiteses are reported. p<0.05, p<0.01,

	Apnea	Insomnia	Others
	16,361	4,363	1,334
	β(se)	β(se)	β(se)
Age (ref:o-24yrs)	0	6	122
25-49yrs	0.78***	-0.07***	-0.34**
	(0.09)	(0.07)	(0.11)
50-04yrs	1.17***	-0.99***	-0.70***
6	(0.07)	(0.07)	(0.12)
05+yrs	1.31***	-1.23***	-0.53***
Dags (ref. Plank)	(0.09)	(0.09)	(0.14)
Kace (rei: black)		**	
winte	0.14*	-0.1/**	-0.01
Other Pages	(0.00)	(0.00)	(0.10)
Oller Races	-0.12	0.15	-0.04
Incurrence Time (noti calt new)	(0.07)	(0.07)	(0.12)
Madianna			*
Medicare	0.12	-0.02	-0.29* (0.13) -0.19*
Nr.3:	(0.08) -0.04 (0.05)	(0.09)	
Medicaid		0.12*	
t Taria ana a	(0.05)	(0.00)	(0.10)
onnsured	0.02	(0.07) -0.11**	-0.03 (0.11) -0.25** (0.02) -0.11 (0.06)
Common annial	(0.00)		
Commercial	0.20***		
· · · · · ·	(0.05)	(0.05)	
Married	0.18***	-0.18***	
Demole	(0.04)	(0.04)	
remaie	-0.49***	0.43***	0.39***
II	(0.04)	(0.05)	(0.08)
Hospital Encounters (mean (SD))	0.07***	-0.05***	-0.10***
	(0.01)	(0.02)	(0.03)
Comorbidity count (mean (SD))	0.23***	-0.28***	-0.02
	(0.02)	(0.02)	(0.03)
Obese	0.81***	-0.76***	-0.49***
	(0.04)	(0.04)	(0.06)
Depressed	-0.43***	0.42***	0.24***
	(0.04)	(0.04)	(0.06)
Black Female	0.18*	-0.09	-0.28*
	(0.07)	(0.07)	(0.12)
Intercept	-0.36***	-0.18***	-1.95***
	(0.09)	(0.09)	(0.14)
AIC	23015	20141	9857

p<0.00



Residential segregation and compositional effects of neighborhoods

- Is the diagnosis of sleep disorders higher for Individuals who live in predominantly Black neighborhoods (Q1) than individuals who live in predominantly White neighborhoods (Q5)
- Is the diagnosis of sleep disorders higher for Individuals who live in Lowest Income (Q1) than individuals who live in Highest Income neighborhoods (Q5)
- Is the diagnosis of sleep disorders higher for Individuals who live in predominantly Black and Lowest Income (Q1) than individuals who live in predominantly White and Highest Income neighborhoods (Q5)

Index of Concentration at the Extremes (ICE)

The three measures come from Census ACS 2020, and each of these measures were divided into 5 Quintiles.

ICE-RACE (Racial Segregation) - Q1 (Most Black) - Q5 (Most White)

ICE-INCOME (Income segregation) - Q1 (Lowest Income) - Q5(Highest Income)

ICE- RACE+INCOME (Racialized-Economic segregation)- Q1(Most Black and Lowest Income) - Q5(Most White and Highest Income)

Emphasis will be on Q1 vs Q5. This is a better reflection of Inequality (socio-spatial polarization)

	Q1 (most Black)	Q2	Q3	Q4	Q5 (most White)	P-value
Insurance Type. n (%)						<0.001
Self-pay	8,832(17.5)	3,521(16.4)	4,265(16.5)	2,250(15.0)	7,451(14.1)	
Medicare	3,482(6.9)	1,566(7.3)	1,703(6.6)	1,101(7.4)	6,140(11.6)	
Medicaid	12,579(24.9)	4,677(21.8)	5,969(23.1)	3,160(21.1)	6,007(11.4)	
Uninsured	5,393(10.7)	2,089(9.7)	2,607(10.1)	1,441(9.6)	3,125(5.9)	
Commercial	20,210(40.0)	9,630(44.8)	11,341(43.8)	7,024(46.9)	30,106(57.0)	
Age(yrs), n (%)						<0.001
0-24	6,845(13.6)	3,253(15.1)	3,980(15.4)	2,186(14.6)	6,024(11.4)	
25-49	22,619(44.8)	9,726(45.3)	12,331(47.6)	6,877(45.9)	21,979(41.6)	
50-64	14,574(28.9)	5,820(27.1)	6,580(25.4)	3,889(26.0)	14,825(28.1)	
65+	6,458(12.8)	2,684(12.5)	2,994(11.6)	2,024(13.5)	10,001(18.9)	
Married, n (%)	15,760(31.2)	8,438(39.3)	10,597(40.9)	6,239(41.7)	26,830(50.8)	<0.001
Race	<i></i>					<0.001
White	2,743(5.4)	9,842(45.8)	15,362(59.3)	9,314(62.2)	42,786(81.0)	
Black	46,019(91.1)	8,445(39.3)	4,333(16.7)	2,300(15.4)	3,962(7.5)	
Other Races	1,734(3.4)	3,196(14.9)	6,190(23.9)	3,362(22.4)	6,081(11.5)	
Female, n (%)	30,602(60.6)	12,517(58.3)	14,973(57.8)	8,671(57.9)	30,455(57.6)	<0.001
Comorbidity score (mean, SD)	0.07(1.00)	-0.01(1.00)	0.06(1.05)	0.08(1.07)	-0.11(0.95)	<0.001
Hospital Encounter (mean, SD)	0.07(1.06)	-0.03(0.96)	0.04(1.05)	0.07(1.07)	-0.09(0.90)	<0.00
Obese, n (%)	20,093(39.8)	6,963(32.4)	8,606(33.2)	4,926(32.9)	13,080(24.8)	<0.001
Depressed, n (%)	15,715(31.1)	7,506(34.9)	10,189(39.4)	5,791(38.7)	16,981(32.1)	<0.001
Sleep Disorder, n (%)	7,374(14.6)	2,845(13.2)	3,753(14.5)	2,081(13.9)	6,005(11.4)	<0.001
Insomnia, n (%)	1,521(3.0)	666(3.1)	840(3.2)	458(3.1)	1,208(2.3)	<0.001
Apnea, n (%)	5,532(11.0)	2,066(9.6)	2,718(10.5)	1,526(10.2)	4,519(8.6)	<0.001
Other Sleep problems, n (%)	410(0.8)	164(0.8)	245(0.9)	138(0.9)	377(0.7)	0.005

Note: Frequencies with percentages for categorical variables and means with standard deviations for continuous variables are reported. χ_2 test (for categorical variables) and F -test (for continuous variables). The mean values for sleep disorder, sleep disorder types, hospital encounters, and Elixhauser comorbidity index are standardized means. n/s: not significant, * p<0.05, ** p<0.01, *** p<0.00

	Q1 (Lowest Income)	Q2	Q3	Q4	Q5 (Highest Income)	P-value
Insurance Type. n (%)	incomey				incomey	<0.001
Self-pay	7,589(16.7)	6,677(16.7)	4,542(16.5)	938(15.4)	6,573(14.1)	
Medicare	2,885(6.3)	2,554(6.4)	2,310(8.4)	526(8.6)	5,717(12.3)	
Medicaid	11,564(25.4)	9,694(24.3)	5,117(18.6)	874(14.3)	5,143(11.0)	
Uninsured	5,034(11.1)	4,221(10.6)	2,384(8.7)	417(6.8)	2,599(5.6)	
Commercial	18,435(40.5)	16,775(42.0)	13,157(47.8)	3,348(54.9)	26,596(57.0)	
Age(yrs), n (%)						<0.001
0-24	6,543(14.4)	6,049(15.2)	3,726(13.5)	697(11.4)	5,273(11.3)	
25-49	20,928(46.0)	18,537(46.4)	12,189(44.3)	2,664(43.7)	19,214(41.2)	
50-64	12,593(27.7)	10,751(26.9)	7,588(27.6)	1,813(29.7)	12,943(27.8)	
65+	5,443(12.0)	4,584(11.5)	4,007(14.6)	929(15.2)	9,198(19.7)	
Married, n (%)	15,093(33.2)	14,727(36.9)	11,615(42.2)	2,697(44.2)	23,732(50.9)	<0.001
Race		COL 1977 - 1999	0 0 0 00 00			<0.001
White	10,531(23.1)	16,037(40.2)	15,611(56.7)	3,840(62.9)	34,021(73.0)	
Black	31,010(68.1)	17,211(43.1)	7,762(28.2)	1,351(22.1)	7,725(16.6)	
Other Races	3,966(8.7)	6,673(16.7)	4,137(15.0)	912(14.9)	4,875(10.5)	
Female, n (%)	27,146(59.7)	23,464(58.8)	16,100(58.5)	3,355(55.0)	27,153(58.2)	<0.001
Comorbidity score (mean, SD)	0.08(1.03)	0.07(1.02)	0.01(1.01)	-0.03(1.01)	-0.14(0.92)	<0.001
Hospital Encounter (mean, SD)	0.08(1.07)	0.05(1.04)	0.02(1.03)	-0.04(0.95)	-0.13(0.86)	<0.001
Obese, n (%)	17,209(37.8)	14,255(35.7)	8,774(31.9)	1,787(29.3)	11,643(25.0)	<0.001
Depressed, n (%)	15,701(34.5)	14,594(36.6)	9,640(39.4)	2,115(34.7)	14,132(30.3)	<0.001
Sleep Disorder, n (%)	6,608(14.5)	5,729(14.4)	3,680(13.4)	786(12.9)	5,255(11.3)	<0.001
Insomnia, n (%)	1,409(3.1)	1,298(3.1)	802(2.9)	144(2.4)	1,040(2.2)	<0.001
Apnea, n (%)	4,905(10.8)	4,200(10.5)	2,671(9.7)	592(9.7)	3,993(8.6)	<0.001
Other Sleep problems, n (%)	381(0.8)	323(0.8)	257(0.9)	58(1.0)	315(0.7)	0.001

Table 3.2: Descriptive Statistics of Sample Stratified by ICE INCOME (Income Segregation)

Note: Frequencies with percentages for categorical variables and means with standard deviations for continuous variables are reported. χ_2 test (for categorical variables) and F -test (for continuous variables). The mean values for sleep disorder, sleep disorder types, hospital encounters, and Elixhauser comorbidity index are standardized means. n/s: not significant, * p<0.05, ** p<0.01, *** p<0.00

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	Q1 (most Black & low Income)	Q2	Q3	Q4	Q5 (most White & high Income)	P-value
Insurance Type. n (%)						<0.001
Self-pay	5,740(17.2)	5,516(16.8)	5,464(16.2)	4,940(15.1)	4,659(14.2)	
Medicare	2,101(6.3)	2,253(6.9)	2,542(7.5)	3,200(9.8)	3,896(11.8)	
Medicaid	8,767(26.2)	7,807(23.8)	7,051(20.9)	4,810(14.7)	3,957(12.0)	
Uninsured	3,689(11.0)	3,493(10.6)	3,201(9.5)	2,237(6.8)	2,035(6.2)	
Commercial	13,171(39.4)	13,731(41.9)	15,478(45.9)	17,599(53.7)	18,332(55.8)	
Age(yrs), n (%)						<0.001
0-24	4,628(13.8)	4,826(14.7)	4,977(14.8)	4,114(12.5)	3,743(11.4)	
25-49	15,334(45.8)	14,929(45.5)	15,452(45.8)	14,057(42.9)	13,760(41.9)	
50-64	9,555(28.5)	8,905(27.1)	8,942(26.5)	9,323(28.4)	8,963(27.3)	
65+	3,951(11.8)	4,140(12.6)	4,365(12.9)	5,292(16.1)	6,413(19.5)	
Married, n (%)	10,321(30.8)	11,540(35.2)	13,682(40.6)	15,768(48.1)	16,553(50.3)	<0.001
Race						<0.001
White	3,128(9.3)	9,639(29.4)	18,460(54.7)	24,501(74.7)	24,319(74.0)	
Black	28,484(85.1)	20,039(61.1)	9,144(27.1)	3,460(10.6)	3,932(12.0)	
Other Races	1,856(5.5)	3,122(9.5)	6,132(18.2)	4,825(14.7)	4,628(14.1)	
Female, n (%)	20,134(60.2)	19,351(59.0)	19,871(58.9)	18,977(57.9)	18,885(57.4)	<0.001
Comorbidity score (mean, SD)	0.07(1.00)	0.07(1.04)	0.04(1.03)	-0.06(0.97)	-0.12(0.94)	<0.001
Hospital Encounter (mean, SD)	0.07(1.06)	0.06(1.07)	0.02(1.01)	-0.05(0.96)	-0.10(0.88)	<0.001
Obese, n (%)	13,035(38.9)	11,993(36.6)	11,386(33.8)	9,063(27.6)	8,191(24.9)	<0.001
Depressed, n (%)	10,719(32.0)	11,319(34.5)	12,627(37.4)	11,177(34.1)	10,340(31.4)	<0.001
Sleep Disorder, n (%)	4,893(14.6)	4,650(14.2)	4,782(14.2)	3,935(12.0)	3,798(11.6)	<0.001
Insomnia, n (%)	1,062(3.2)	988(3.0)	1,022(3.0)	834(2.5)	787(2.4)	<0.001
Apnea, n (%)	3,640(10.9)	3,452(10.5)	3,499(10.4)	2,935(9.0)	2,835(8.6)	<0.001
Other Sleep problems, n (%)	252(0.8)	270(0.8)	329(1.0)	241(0.7)	242(0.7)	0.001

Table 3.3: Descriptive Statistics of Sample Stratified by ICE RACE & INCOME (Racialized Economic | Segregation)

Note: Frequencies with percentages for categorical variables and means with standard deviations for continuous variables are reported. χ_2 test (for categorical variables) and F -test (for continuous variables). The mean values for sleep disorder, sleep disorder types, hospital encounters, and Elixhauser comorbidity index are standardized means. n/s: not significant, * p<0.05, ** p<0.01, *** p<0.00

Odds Ratio	Estimate	CI Lower (2.5%)	CI Upper (97.5%)	P-value
Insurance Type. Ref: Self-	pay			
Medicare	0.98	0.91	1.05	NS
Medicaid	1.16	1.10	1.22	***
Uninsured	1.00	0.94	1.06	NS
Commercial	1.12	1.07	1.17	***
Age (Ref:o-24)				
25-49	1.96	1.83	2.10	***
50-64	2.21	2.06	2.37	***
65+	1.94	1.78	2.11	***
Married	0.81	0.79	0.84	***
Race (Ref; Black)				
White	1.06	1.00	1.13	NS
Other Races	1.12	1.04	1.20	**
Female	0.60	0.57	0.62	***
Black_Female	1.15	1.07	1.23	***
Comorbidity score	1.50	1.47	1.53	***
Hospital Encounter	1.30	1.28	1.32	***
Obese	4.29	4.14	4.44	***
Depressed	1.52	1.47	1.57	***
ICE RACE (Ref: Q1)				
Q2	1.04	0.98	1.10	NS
Q3	1.08	1.02	1.15	**
Q4	1.00	0.93	1.07	NS
Q5	1.06	1.00	1.12	*
Intercept	0.03	0.03	0.04	***
DF	165668			
AIC	103213			

Note: n=165,669. Odds Ratio with confidence interval at 95% are reported. * p < 0.05, ** p < 0.01, ** p < 0.00. NS: not significant

Odds Ratio		CI	CI	P-value	
	Estimate	Lower (2.5%)	Upper (97.5%)		
Insurance Type. Ref: Self-					
pay					
Medicare	0.97	0.90	1.05	NS	
Medicaid	1.16	1.10	1.23	***	
Uninsured	1.00	0.94	1.07	NS	
Commercial	1.12	1.07	1.1 7	***	
Age (Ref:0-24)					
25-49	1.95	1.82	2.09	***	
50-64	2.20	2.05	2.36	***	
65+	1.92	1.77	2.09	***	
Married	0.81	0.79	0.84	***	
Race (Ref; Black)					
White	1.08	1.02	1.13	**	
Other Races	1.34	1.06	1.22	***	
Female	0.60	0.57	0.62	***	
Black_Female	1.15	1.07	1.22	***	
Comorbidity score	1.50	1.47	1.53	***	
Hospital Encounter	1.30	1.28	1.32	***	
Dbese	4.29	4.14	4.44	***	
Depressed	1.52	1.47	1.58	***	
CE INCOME (Ref: Q1)					
Q2	1.04	0.99	1.08	NS	
Q3	1.04	0.99	1.09	NS	
Q4	1.05	0.96	1.15	NS	
Q5	1.10	1.05	1.15	***	
Intercept	0.03	0.03	0.04	***	
DF	165668				

Note: n=165,669. Odds Ratio with confidence interval at 95% are reported. * p<0.05, ** p<0.01, *** p<0.00. NS: not significant

Odds Ratio	Estimate	CI Lower (2.5%)	CI Upper (97.5%)	P-value
Insurance Type. Ref: Self-	pay			
Medicare	0.97	0.91	1.05	NS
Medicaid	1.16	1.10	1.23	***
Uninsured	1.00	0.94	1.06	NS
Commercial	1.12	1.07	1.17	***
Age (Ref:o-24)				
25-49	1.96	1.83	2.09	***
50-64	2.20	2.05	2.37	***
65+	1.93	1.78	2.11	***
Married	0.81	0.79	0.84	***
Race (Ref; Black)				
White	1.07	1.01	1.13	*
Other Races	1.12	1.04	1.20	**
Female	0.60	0.57	0.62	***
Black_Female	1.15	1.07	1.22	***
Comorbidity score	1.50	1.47	1.53	***
Hospital Encounter	1.30	1.28	1.32	***
Obese	4.29	4.14	4.44	***
Depressed	1.52	1.47	1.57	***
ICE RACE + INCOME (Re 01)	ef:			
Q2	0.99	0.94	1.04	NS
Q3	1.07	1.02	1.13	*
Q4	1.03	0.97	1.09	NS
Q5	1.09	1.02	1.15	**
Intercept	0.03	0.03	0.04	***
DF	165668			
AIC	103207			

Note: n=165,669. Odds Ratio with confidence interval at 95% are reported. * $p{<}0.05,$ ** $p{<}0.01,$ *** $p{<}0.00.$ NS: not significant

Odds Ratio	Estimate	CI Lower (2.5%)	CI Upper (97.5%)	P-value
Medicare	0.97	0.90	1.05	NS
Medicaid	1.16	1.10	1.23	***
Uninsured	1.00	0.94	1.07	NS
Commercial	1.12	1.07	1.17	***
25-49	1.96	1.83	2.09	***
50-64	2.20	2.05	2.37	***
65+	1.93	1.77	2.10	***
Married	0.81	0.78	o.84	***
Race (Ref; Black)				
White	1.07	1.00	1.14	÷
Other Races	1.12	1.04	1.21	**
Female	0.60	0.57	0.62	***
Black_Female	1.15	1.07	1.23	***
Comorbidity score	1.50	1.47	1.53	***
Hospital Encounter	1.30	1.28	1.32	***
Obese	4.29	4.15	4.44	***
Depressed	1.52	1.47	1.58	***
ICE RACE (Ref: Q1)				
Q2	1.02	0.96	1.09	NS
Q3	1.06	0.99	1.14	NS
Q4	0.95	o.88	1.03	NS
Q5 ICE INCOME (Ref: Q1)	0.98	0.91	1.07	NS
Q2	1.03	0.99	1.08	NS
Q3	1.06	0.99	1.12	NS
Q4	1.04	0.94	1.15	NS
Q5 ICE RACE + INCOME (Ref: Q1)	1.11	1.04	1.20	**
Q2	0.97	0.92	1.03	NS
Q3	1.02	0.95	1.10	NS
Q4	0.96	0.88	1.04	NS
Q5	1.03	0.94	1.13	NS
Intercept DF AIC	0.03 165668 103204	0.03	0.04	***

Table 3.7: Logistic Regression of Sleep Disorder Diagnosis (model 4)

Note: n=165,669. Odds Ratio with confidence interval at 95% are reported. * p<0.05, ** p<0.01, *** p<0.00. NS: not significant

Question 3 Spatial patterns and processes

 Is the distribution of Sleep disorders in Cleveland clustered or random? Any spatial dependence, i. e spatially autocorrelated?

2. What are the neighborhood level factors predicting neighborhood level sleep disorders?

3. Are neighborhood patterns of sleep disorders shaped by socio-spatial polarization of the city through the mechanism of racial residential segregation ?

265 census tracts in the City of Cleveland

$$SDXj = (A j / Bj) \times Cj$$

SDXj: Sleep disorder diagnoses from census tract j.

Aj: The number of people with sleep disorder diagnoses from census tract j.

Bj: The total number of people from census tract j seen at MetroHealth.

Cj: The total population of census tract j.



ADI-3: Neighborhood risk index of the social determinants of health over time and place (Berg et al, 2021)

	Sleep Disorder	Economic Hardship	Financial Strength	Educational Attainment	ICE- Race	Comorbidity	Hospital Encounters	Road Density	Walkability Index
Sleep Disorder	1.00	04	03	.04	.14	.22	.36	.04	.07
Economic Hardship	04	1.00	70	54	71	-55	.52	-49	.36
Financial Strength	03	70	1.00	-55	•57	43	37	39	26
Educational Attainment	.04	53	•55	1.00	.20	38	35	43	24
ICE-Race	.14	71	•57	.20	1.00	44	37	34	18
Comorbidity	.22	-55	43	38	44	1.00	.82	.30	.14
Hospital Encounter	.36	.52	37	35	37	.82	1.00	.29	.16
Road Density	.04	-49	39	43	34	.30	.29	1.00	-59
Walkability Score	.07	.36	26	24	18	.14	.16	-59	1.00
N=265									

OLS Model	Model 1	Model 2	Model 3	Model 4
	β(se)	β(se)	β(se)	β(se)
Economic Hardship	-23.18	-74.13***	-82.91***	-37.52
Financial Strength	-22.04	-24.49	-24.32	(22.33) -37.27**
Educational Attainment	(14.94) 13.38	(13.42) 26.50	(13.38) 28.87	(13.49) 56.00**
Comorbidity score	(19.36)	(17.43) -115.41	(17.79) -99.98	(18.78) -44.73
Hospital Encounters		(115.73) 734.75***	(115.68) 728.99***	(113.74) 694.60***
Road Density		(119.97)	(119.62) 0.37	(117.00) 8.70
Walkability score			(17.14) 24.42	(16.86)
ICE- Raco			(14.81)	(14.58)
ICL- Race				(19.39)
Intercept	343.30***	353.95***	355.61***	365.108***
	(15.79)	(14.21)	(14.24)	(14.11)
F(df)	0.91(261)	13.98(259)	10.59(257)	11.53(256)
Adjusted R-squared	-0.00	0.20	0.20	0.24

N=265. Standardized coefficients with standard errors are reported. * $p{<}0.05,$ ** $p{<}0.01,$ *** $p{<}0.00.$ NS: not significant

Moran's I test of spatial autocorrelation



OLS Assumption of Spatial Interdependence

- However, in Spatial statistics and analysis OLS is not reliable, as it is based on the assumption of spatial interdependence and ignores the effect of spatial autocorrelation, according to the first law of Geography, the Tobler's law, which says nearby things are similar, farther things are dissimilar.

- Detection of spatial autocorrelation, if Moran's I statistic is significant, it suggests the presence of spatial autocorrelation or spatial dependence, i. e a Clustering Effect

GWR Model	#10				
	Min	ıst Qu.	Median	3rd Qu.	Max
Economic Hardship	-150.26	-35.14	-5.19	13.65	172.55
Financial Strength	-95.74	-45.01	-24.95	12.70	163.78
Educational Attainment	-36.87	11.15	24.22	37.14	72.41
Comorbidity score	-1292.03	-670.04	-71.47	273.06	1361.79
Hospital Encounters	-1228.73	35.52	285.15	1163.13	2286.91
Road Density	-50.13	-8.86	6.49	23.40	90.60
Walkability score	-80.00	-21.74	-12.92	7.76	76.34
ICE- Race	-41.56	14.64	50.52	93.85	175.18
Intercept	198.97	315.41	366.28	402.04	528.63
Adjusted R-squared	0.65				

Diagnostic information	OLS Model 4	GWR Model	
Number of data points	265	265	
R-squared	0.26	0.75	
Adjusted R-squared	0.24	0.65	
Residual sum of squares	11146219	3833415	
AIC	3593.461	3346.564	
AICc	3594.327	3436.393	
BIC	3420.056	3337-799	



Clustering Patterns of Sleep Disorders



Spatial Clustering of Racial Segregation



Spatial Clustering of MetroHealth Encounters



Spatial Clustering of Comorbidities



Spatial Clustering OF Educational Attainment



Spatial Clustering OF Financial Strength



Spatial Clustering Of Economic Hardship



GWR R Squared



Thanks for listening!

QUESTIONS

Geographic Weighted Regression and Moran's I libraries

- (GWmodel), (sf), (spdep), (magrittr), (tibble), (tigris)

(References: http://www.geo.hunter.cuny.edu/~ssun/R-Spatial/spregression.html)