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Social vulnerability and time to surgeon evaluation for primary hyperparathyroidism in a Massachusetts cohort

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ABSTRACT

Background: Identifying patients at risk for under-evaluation of primary hyperparathyroidism is essential to minimizing long-term sequelae, including osteoporosis, nephrolithiasis, and cardiovascular disease. This study assessed the impact of social vulnerability on time-to-surgery evaluation among patients with primary hyperparathyroidism in a Massachusetts cohort.

Methods: This is a retrospective review of patients from an institutional database with the first incident of hypercalcemia between 2010 and 2018 and subsequent biochemical diagnosis of primary hyperparathyroidism. The overall social vulnerability index and social vulnerability index subthemes were merged with the institutional data via patient ZIP code. Patients were stratified into social vulnerability index quartiles, where quartile 4 represented the highest vulnerability. Baseline sociodemographic and clinical characteristics were compared, and Cox regression was used to assess the association between social vulnerability index and time to surgeon evaluation.

Results: Of 1,082 patients included, those with a higher social vulnerability index were less likely to be evaluated by a surgeon (quartile 1 social vulnerability index: 31.1% vs. quartile 2 social vulnerability index: 31.41% vs. quartile 3 social vulnerability index: 25.93% vs. quartile 4 social vulnerability index: 21.92%, $P = .03$). On adjusted analysis, patients with the highest vulnerability had a 33% lower estimated rate of surgeon evaluation and were seen 67 days later compared with patients with the lowest vulnerability (hazard ratio: 0.67, confidence interval 0.47–0.97, $P = .032$). Differential rates of surgical evaluation by vulnerability persisted for the social vulnerability index subthemes for socioeconomic status, minority status and language, and housing type and transportation.

Conclusion: Among a Massachusetts cohort, highly vulnerable populations with primary hyperparathyroidism are at greater risk for under-evaluation by a surgeon, which may contribute to the development of long-term sequelae of their disease.

Introduction

Primary hyperparathyroidism (PHPT) is diagnosed in an estimated 100,000 people in the United States annually.[1] Untreated PHPT increases the risk of bone fractures, osteoporosis, nephrolithiasis, and cardiovascular disease.[2–5] The only effective treatment is surgery; however, prior studies have shown that up to 80% of patients with a biochemical diagnosis of PHPT never receive a referral for surgery.[6] Identifying patients at risk for under-evaluation by a surgeon is essential to minimizing long-term sequelae of the disease.

Concerningly, disparities in surgical evaluation exist when assessing patients based on their socioeconomic status, race/ethnicity, insurance status, and language. For example, African-American, Asian, and Hispanic patients are significantly less likely to undergo parathyroidectomy than their White counterparts.[1,7–11] Moreover, lower socioeconomic status, non-English primary

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language, and lack of private insurance are also associated with a lower likelihood of undergoing surgery for PHPT.[8,11,12] Social determinants of health (SDOH), defined by the World Health Organization as the "non-medical factors that influence health outcomes," have also been proposed as possible factors contributing to disparities in care.[13] However, no prior studies have evaluated the cumulative impact of several SDOHs on surgical evaluation for PHPT.

The Centers for Disease Control and Prevention Social Vulnerability Index (SVI) has emerged as a surrogate for quantifying SDOH by assigning social vulnerability to US census tracts.[14] The SVI assigns an overall score to a geographic area based on 15 social factors obtained from US Census data. These factors can be grouped into 4 subthemes (socioeconomic status, household characteristics, minority status and language, and housing type and transportation) to elucidate which SDOHs are most prominent in particular communities. Each geographic region receives an overall SVI and a separate SVI for each subtheme, providing a measure of vulnerability at the census tract level.

Identifying the relationship between SVI and surgical evaluation of PHPT is integral to identifying at-risk patients who may face barriers to receiving timely care. This study aimed to evaluate the impact of social vulnerability on time to surgeon evaluation among patients with PHPT and to identify which SVI subthemes contribute most to disparities in care in a Massachusetts cohort.

Material and Methods

Study population

A prospectively collected institutional electronic health record data registry was queried for patients with first incident hypercalcemia (serum calcium $\geq$ 10.4 mg/dL) between 2010 and 2018. Patients with a subsequent biochemical diagnosis of PHPT based on a parathyroid hormone (PTH) >65 pg/mL after the initial documented hypercalcemia were included in the study. Patients with normo-hormonal hyperparathyroidism were included based on the *International Classification of Diseases* (ICD) code. Patients were excluded if they had a ZIP code outside of Massachusetts or if they were missing data for the ZIP code. Patients with an ICD code for end-stage renal disease, secondary hyperparathyroidism, or tertiary hyperparathyroidism were excluded. Furthermore, patients with a Current Procedural Terminology code indicating a history of a kidney transplant or a prior parathyroidectomy were also excluded. Finally, patients who died within a year of the incident of hypercalcemia were also excluded. The final cohort included all patients meeting the inclusion and exclusion criteria, regardless of whether they ultimately underwent a parathyroidectomy. This study was approved by the Beth Israel Deaconess Medical Center Institutional Review Board.

Variables and definitions

Patient demographics, lab values (initial calcium level, PTH, a glomerular filtration rate [GFR] <60), time to surgical evaluation from initial calcium value, and history of nephrolithiasis, fracture, or osteoporosis were collected. Patient demographics included age, sex, race and ethnicity, insurance status, ZIP code, marital status, and the number of Elixhauser comorbidities. The number of Elixhauser comorbidities was categorized as 0, 1 to 2, 3 to 4, 5 to 6, or >7. The ZIP code of each patient at the time of the first incident of hypercalcemia was collected via chart review. Normal laboratory values were defined as 15 to 65pg/mL for PTH and 8.4 to 10.2mg/dL for serum calcium based on the institutional normal range. Time to surgeon evaluation was defined as the time (days) from the date of initial elevated calcium to the date each patient was evaluated by a surgeon. Time to surgeon evaluation was measured starting at the time of incident hypercalcemia because PTH lab values were biased toward those evaluated by an endocrinologist, as these labs were often collected on the date of specialist evaluation by an endocrinologist.

The SVI data and documentation are publicly available and reported by the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry.[14] Social Vulnerability Index data from 2018 was accessed for this analysis.[14] Because the SVI is reported at the census tract level instead of the ZIP code level, census–tract-weighted SVI was matched to study population ZIP codes using a similar methodology to previously published work.[15] A weighted value for overall SVI and each subtheme's SVI was assigned to each patient. Percentile rankings for SVI scores vary from 0 to 1, where communities with a higher SVI rating are considered more vulnerable. Data for each of the 4 SVI subthemes (socioeconomic status, household characteristics, minority status and language, and housing type and transportation) are also reported using the same scale. Using a similar methodology to prior studies, patients were then stratified into SVI quartiles where the first quartile (Q1) represented the lowest vulnerability and the fourth quartile (Q4) represented the highest vulnerability.[16–18]

Statistical analysis

Data analysis was performed using Stata version 16.1, and geospatial visualization was performed using R, version 4.2.2 (R Foundation for Statistical Computing). Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean and SD, or median and IQR, as appropriate. Baseline sociodemographic and clinical characteristics were compared across SVI quartiles using ANOVA, Kruskal–Wallis test, or χ^2 analysis, as appropriate. The Kaplan–Meier method was used for time-to-surgeon evaluation analysis. The log-rank test was then used to determine significant differences in time to surgical evaluation among the 4 SVI quartiles. Multivariable Cox regression was used to assess the association of overall SVI and SVI subthemes on time to surgeon evaluation adjusting for age, sex, comorbidities, renal dysfunction (GFR <60 mL/min), PTH and calcium values, and history of osteoporosis or nephrolithiasis. Restricted mean survival times were utilized to estimate adjusted differences in time to surgeon evaluation.[19] Geospatial distribution of SVI subthemes by ZIP code tabulation area was conducted using study population–weighted SVI for each ZIP code.

Results

Study population

A total of 1,082 patients were included. The majority of patients were female (74%) and White (67%), with a mean age of 62.9 (SD ± 13.5) years (Table I). Most patients were unmarried (54%), had >7 comorbidities (29%), and had either private insurance (46%) or Medicare (38%). Patients had a median calcium of 10.7 mg/dL (interquartile range: 10.6–11.1) and a median PTH of 89 pg/mL (72–122). When assessing complications related to PHPT, 33% of patients had osteoporosis, 56% had a GFR <60 mL/min, 12% had a history of nephrolithiasis, and 3% had a history of a vertebral

Table I
Patient demographics and comorbidities stratified by SVI Quartile

Characteristic	Total cohort n = 1,082	Quartile 1 (low vulnerability) n = 275	Quartile 2 n = 272	Quartile 3 n= 244	Quartile 4 (high vulnerability) n = 291	*P* value*
Age, mean (SD)	62.9 (13.5)	62.9 (12.2)	62.6 (13.1)	62.1 (14.7)	61.3 (13.9)	.49
Female sex, *n* (%)	800 (74)	198 (72)	206 (76)	186 (76)	210 (72)	.55
Race and ethnicity, *n* (%)						< .001
AIAN	1 (<1)	0 (0)	1 (<1)	0 (0)	0 (0)	
Asian	44 (4)	6 (2)	16 (6)	13 (5)	9 (3)	
Black	179 (17)	13 (5)	14 (5)	29 (12)	123 (42)	
Hispanic or Latino	59 (5)	3 (1)	2 (1)	25 (10)	29 (10)	
White	724 (67)	237 (86)	222 (82)	158 (65)	107 (37)	
Other	75 (7)	16 (6)	17 (6)	19 (8)	23 (8)	
Insurance status, *n* (%)						< .001
Medicaid	166 (15)	22 (8)	29 (11)	44 (18)	71 (24)	
Medicare	409 (38)	96 (35)	95 (35)	103 (42)	115 (40)	
Private	495 (46)	154 (56)	143 (53)	93 (38)	105 (36)	
Uninsured	12 (1)	3 (1)	5 (2)	4 (2)	0 (0)	
Marital status, married or life partner, *n* (%)	501 (46)	162 (59)	140 (51)	99 (41)	99 (34)	< .001
Elixhauser comorbidities						< .001
0	89 (8)	22 (8)	25 (9)	32 (13)	10 (3)	
1–2	286 (26)	87 (32)	84 (31)	51 (21)	64 (22)	
3–4	213 (20)	52 (19)	58 (21)	50 (20)	53 (18)	
5–6	180 (17)	50 (18)	35 (13)	43 (18)	52 (18)	
7+	314 (29)	64 (23)	70 (26)	68 (28)	112 (38)	
Calcium, mg/dL, median (IQR)	10.7 (10.6–11.1)	10.7 (10.5–11.1)	10.7 (10.6–11.0)	10.8 (10.6–11.1)	10.7 (10.6–11.1)	.27
PTH, pg/mL, median (IQR)	89 (72–122)	93 (76–123)	91 (72–121)	85 (70–123)	87 (72–123)	.20
Osteoporosis, *n* (%)	353 (33)	97 (35)	105 (39)	78 (32)	73 (25)	.005
GFR <60 mL/min, *n* (%)	601 (56)	142 (52)	148 (54)	131 (54)	180 (62)	.076
Nephrolithiasis, *n* (%)	128 (12)	31 (11)	36 (13)	31 (13)	30 (10)	.701
Vertebral fracture, *n* (%)	29 (3)	7 (3)	6 (2)	9 (4)	7 (2)	.732

Data are presented as median (IQR) or mean (SD) for continuous and frequencies (percentages) for categorical measures.
GFR, glomerular filtration rate; *PTH*, parathyroid hormone.
* *P* value based on analysis of variance, Kruskal–Wallis test, or χ^2 analysis as appropriate.

fracture. Among all patients, only 27.5% ($n = 298$) were evaluated by a surgeon, and 23.1% ($n = 250$) underwent parathyroidectomy.

SVI quartiles

There was no difference in age, sex, calcium, or PTH by SVI quartile (Table I). Patients with a higher SVI were more likely to be Black (Q1 SVI: 5% vs Q2 SVI: 5% vs Q3 SVI: 12% vs Q4 SVI: 42%, $P <$ .001) and to have more comorbidities (>7 Elixhauser comorbidities; Q1 SVI: 23% vs Q2 SVI: 26% vs Q3 SVI: 28% vs Q4 SVI: 38%, $P <$ .001). Patients with a higher SVI were less likely to be evaluated by a surgeon (Q1 SVI: 31.1% vs Q2 SVI: 31.41% vs Q3 SVI: 25.93% vs Q4 SVI: 21.92%, $P = .03$). They were also less likely to be married (Q1 SVI: 59% vs Q2 SVI: 51% vs Q3 SVI: 41% vs Q4 SVI: 34%, $P <$ .001), have private insurance (Q1 SVI: 56% vs Q2 SVI: 53% vs Q3 SVI: 38% vs Q4 SVI: 36%, $P <$ .001), and a history of osteoporosis (Q1 SVI: 35% vs Q2 SVI: 39% vs. Q3 SVI: 32% vs Q4 SVI: 25%, $P = .005$).

Overall SVI and time to surgeon evaluation

Patients with the highest vulnerability (Q4) had a 33% lower estimated rate of surgeon evaluation and were seen an estimated 67 days later compared with patients with the lowest vulnerability (Q1) (adjusted hazard ratio [aHR]: 0.67, CI 0.47–0.97, $P = .032$). Time to surgeon evaluation increased with increasing vulnerability (Figure 1). The log-rank test for differences between SVI quartiles was significant ($P <$ .001). On the adjusted Cox regression analysis (Table II), increasing age was associated with a decreasing estimated rate of being evaluated by a surgeon (HR: 0.97 [95% CI: 0.96–0.98]). Comparatively, higher calcium, higher PTH, and a history of osteoporosis or nephrolithiasis were associated with an increased estimated rate of being evaluated by a surgeon.

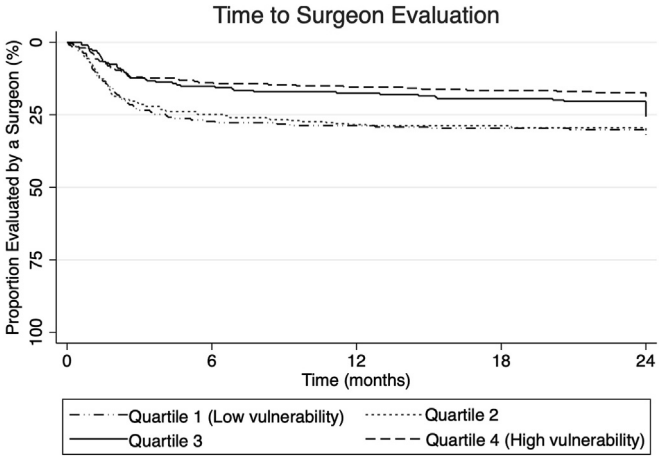

Figure 1. Kaplan–Meier curves for time to surgeon evaluation stratified by Social Vulnerability Index quartile.

SVI subthemes and time to surgeon evaluation

Certain subthemes had a higher impact on the odds of surgical evaluation (Table III). For the socioeconomic status SVI subtheme, patients with the highest vulnerability (Q4) had a 35% lower estimated rate of surgeon evaluation than those with the lowest vulnerability (Q1) (Q4, aHR: 0.65, CI 0.45–0.94, $P = .024$). Similarly, for the minority status and language SVI subtheme, patients with the highest vulnerability had a 36% lower estimated rate of surgeon evaluation than those with the lowest vulnerability (Q1) (Q4, aHR: 0.64, CI 0.43–0.96, $P = .031$). Finally, when assessing the housing

Table II
Multivariable cox proportional hazards model for time to surgeon evaluation

Characteristic	aHR	CI	*P* value
SVI quartile			
1 (low vulnerability)	*Ref.*	-	-
2	1.18	0.85–1.62	.324
3	0.73	0.51–1.05	.090
4 (high vulnerability)	0.67	0.47–0.97	.032
Age, continuous	0.97	0.96–0.98	< .001
Male sex	0.96	0.71–1.28	.763
Any Elixhauser comorbidity	1.00	0.67–1.50	.981
Calcium value (mg/dL), continuous	1.19	1.07–1.32	.001
PTH value (pg/mL), continuous	1.00	1.00–1.01	< .001
Osteoporosis	1.81	1.38–2.38	< .001
GFR <60 mL/min	0.55	0.17–1.69	.288
Nephrolithiasis	1.48	1.06–2.08	.021

aHR, adjusted hazard ratio; *GFR*, glomerular filtration rate; *PTH*, parathyroid hormone; *SVI*, Social Vulnerability Index.

Table III
Multivariable Cox proportional hazards model for time to surgeon evaluation by SVI theme

SVI subtheme	AHR	95% CI	*P* value
Socioeconomic status			
1 (low vulnerability)	*Ref.*	-	-
2	1.20	0.86–1.66	.281
3	0.93	0.66–1.31	.670
4 (high vulnerability)	0.65	0.45–0.94	.024
Household characteristics			
1 (low vulnerability)	*Ref.*	-	-
2	1.25	0.91–1.72	.164
3	0.84	0.60–1.19	.332
4 (high vulnerability)	0.77	0.53–1.12	.176
Minority status & language			
1 (low vulnerability)	*Ref.*	-	-
2	1.09	0.76–1.56	.650
3	0.78	0.54–1.12	.174
4 (high vulnerability)	0.64	0.43–0.96	.031
Housing type & transportation			
1 (low vulnerability)	*Ref.*	-	-
2	0.65	0.46–0.93	.019
3	0.63	0.44–0.89	.010
4 (high vulnerability)	0.66	0.47–0.93	.017

Models adjusted for covariates as specified in Table II.
aHR, adjusted hazard ratio; *SVI*, Social Vulnerability Index.

type and transportation subtheme, patients in the second, third, and fourth SVI quartiles all had a lower estimated rate of surgical evaluation than those with the lowest vulnerability (Q1) (Q2, aHR: 0.65, CI 0.46–0.93, $P = .019$; Q3, aHR: 0.63, CI 0.44–0.89, $P = .010$; Q4, aHR: 0.66, CI 0.47–0.93, $P = .017$). There were no differences in the estimated rate of surgical evaluation by vulnerability quartile when assessing the household characteristics SVI subtheme.

Geospatial analysis

Maps of Massachusetts were created to depict the geographic distribution of vulnerability. Geospatial analysis showed differences in the concentration of vulnerable populations observed for each SVI subtheme (Figure 2). For socioeconomic status, household characteristics, and housing type and transportation, clusters of ZIP code tabulation areas with higher levels of vulnerability were visualized in Eastern Massachusetts farther from major metropolitan areas. Comparatively, for the minority status and language subtheme, clusters of vulnerable populations were concentrated near cities with the highest population density.

Discussion

In this study, a Massachusetts hospital institutional database was used to assess disparities in surgical evaluation for patients with PHPT based on SVI. Among this cohort, patients with a higher SVI were more likely to be Black, to be Medicaid or Medicare insured, and to have a higher number of comorbidities. There was an overall low rate of surgical evaluation of all patients with PHPT that disproportionately impacted patients from the most vulnerable SVI quartile. When evaluating SVI subthemes, housing type and transportation, socioeconomic status, minority status, and language contributed most to differences in time to surgeon evaluation. Understanding the impact of these subthemes is integral to developing targeted interventions to mitigate disparities in surgical evaluation for PHPT and prevent long-term sequelae of untreated disease.

Undertreatment of PHPT and disparities in surgical evaluation of the disease are well established in the literature.[9] Although parathyroidectomy is considered the only curative option for PHPT, only 25% of the study population underwent surgical evaluation. This is similar to previously reported literature suggesting that 66% to 80% of patients with a biochemical diagnosis of PHPT never undergo surgical evaluation.[6,8,20] Concerningly, certain populations have disparate access to surgical evaluation and thus are less likely to receive appropriate care. For example, Black, Hispanic, and Asian patients are less likely to be evaluated by a surgeon and have significantly lower odds of undergoing parathyroidectomy.[9–11] For those who undergo surgery, Black and Hispanic patients incur higher costs, more complications, and are less likely to receive care from a high-volume surgeon.[21–23] Consistent with prior literature, the results of this study demonstrated that patients with higher vulnerability were more likely to be Black, placing them at higher risk for under-evaluation by a surgeon. Racial differences may not reflect trends across the country, however, given the race and ethnic distribution in Massachusetts compared with other states.

Disparities are not limited to racial differences but extend to SDOH-related barriers to care, including socioeconomic status, insurance status, language, and geographic location. For example, patients with limited English proficiency, non-private insurance, lower income quartile, and higher area deprivation have a lower likelihood of undergoing parathyroidectomy.[11,12,24] Whereas prior work has focused on individual SDOH, this study is the first to use the SVI, a surrogate for quantifying several SDOH, to assess disparities in surgical evaluation for patients with PHPT. Factors that have not previously been evaluated, including housing type and transportation, household composition, and disability, were able to be assessed in this study by utilizing the SVI. The results of this study indicate that more vulnerable patients in a single Massachusetts health system, as indicated by a higher SVI, were less likely to undergo surgical evaluation. These findings then pose the challenge of identifying targeted interventions that may attenuate these disparities in hopes of providing equitable and timely care to all patients.

Several point-of-care strategies have been suggested to improve disparities in surgical evaluation for patients with PHPT. At the provider level, many electronic health records have started to incorporate a measure of social vulnerability or social determinants of health.[25–27] This can provide physicians with the necessary information to identify vulnerable patients at the highest risk for under-evaluation of their disease. Furthermore, developing an automated system that flags patients for referral based on abnormal lab values can ensure appropriate evaluation of potential disease.[6] This may minimize the misdiagnosis of PHPT and limit the number of patients lost to follow-up in their continuum of care. Finally, engaging and educating primary care providers and

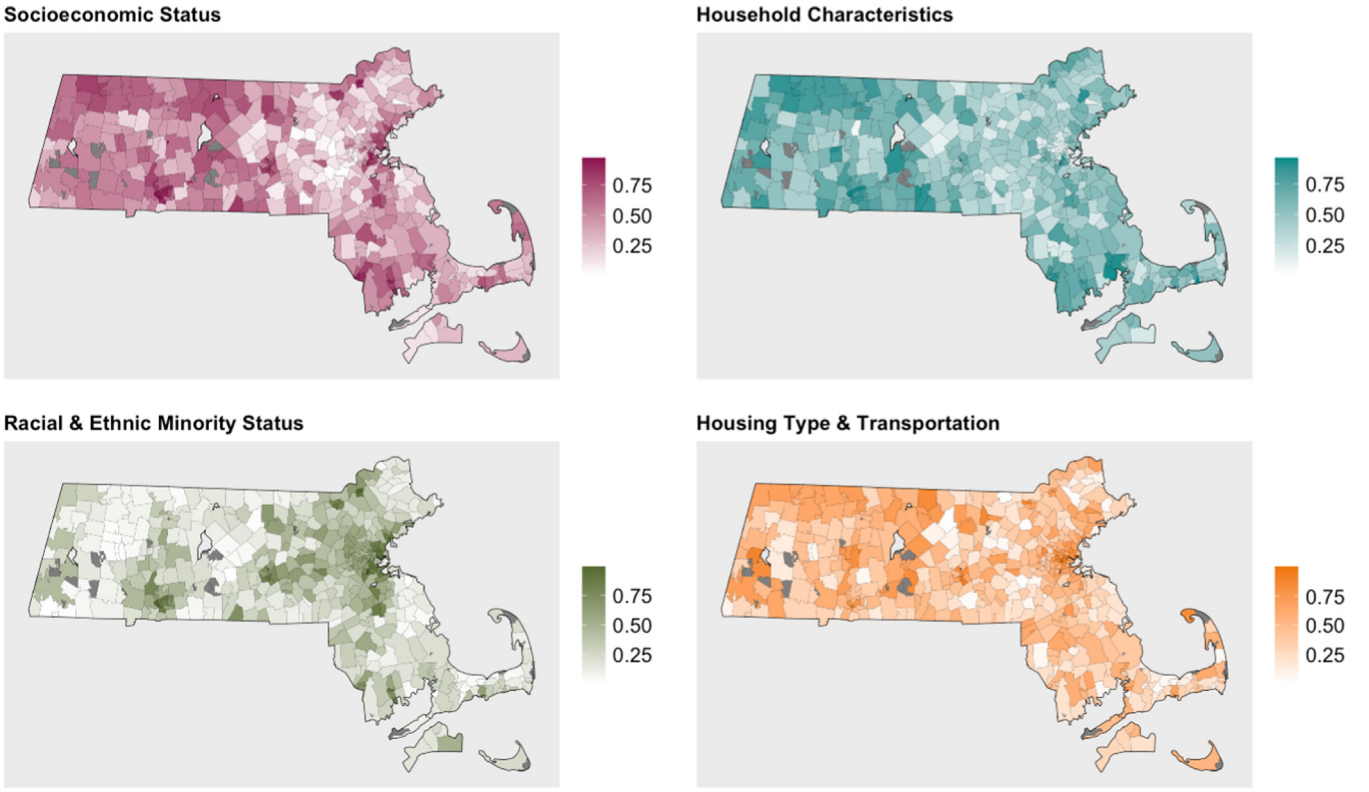

Figure 2. Geospatial representation of each Social Vulnerability Index subtheme (socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation) in Massachusetts by ZIP code tabulation area. Darker colors correspond to higher levels of vulnerability.

endocrinologists about the importance of surgical evaluation for potential PHPT is an essential component given the multidisciplinary approach to the disease.[6]

More specific targets for interventions can be identified through subtheme analysis of the SVI. The 4 SVI subthemes (socioeconomic status, household composition, disability, minority status and language, and housing type and transportation) provide a more granular context for which SDOH may have a differential effect on time to surgical evaluation for PHPT. Among the study cohort, the most prominent subthemes were housing type and transportation, socioeconomic status, and minority status and language. The impact of housing type, transportation, and socioeconomic status point to potentially modifiable barriers to care. Providing access to transportation or offering the option of a virtual visit may reduce missed clinic appointments or lack of follow-up after initial evaluation by a primary care provider or endocrinologist. Moreover, prior work has suggested that economic disadvantage, lack of education, and poor health literacy—factors included in the socioeconomic status subtheme—may serve as barriers for patients to obtain care.[28] Educating primary care providers and endocrinologists on the importance of clear communication and prompt surgical referral is key to providing patients with appropriate care. Geospatial visualization of the various subthemes can pinpoint ZIP code tabulation areas in Massachusetts at greatest risk for a longer time to surgical evaluation for PHPT. Finally, the effect observed with minority status and language, a non-modifiable risk factor, warrants further investigation into possible physician implicit bias when referring patients for surgical evaluation.

Although documentation of racial disparities is important, this study further clarifies that these disparities may not only be based on interpersonal racism but also issues of structural racism, including housing, transportation, etc. At the local, state, and federal levels, these findings present an opportunity for policy intervention targeted at these structural issues. Examples of this include transportation infrastructure aimed at improving transportation in areas largely populated by individuals of low socioeconomic status and of minority race and ethnicity. Surgeons have a role in this policy development by active participation in societies, policy development at the institutional level, and participation in local, state, and federal government and non-government organizations.

Study Limitations

This study has several limitations that should be acknowledged. This was a retrospective cohort study located in Massachusetts. Although this health system serves a diverse population of patients, the results may not be broadly generalizable to all other health systems. Further, Massachusetts is unique in that this state has the lowest uninsured rate, and data may not reflect trends across the country. Thus, the results of this study may be limited in their applicability across all states in the country. Given the low uninsured rate in Massachusetts, it is also possible that rates of evaluation may be even lower in other states that have insurance as a more substantial barrier to care. Although a vast majority of patients are referred in-system for management of PHPT, it is possible that some patients received care outside of the system and thus were not captured in the present study. However, approximately 96% of the cohort has a primary care provider within the institutional system, so it would be more costly for patients to seek care outside the system. The study is also limited by the inclusion criteria for PHPT.

Given that inclusion was made through a combination of a biochemical diagnosis of PHPT and ICD codes for normo-hormonal PHPT, there is potential for misclassification of patients with other causes of hyperparathyroidism (eg, vitamin D deficiency), despite

excluding those patients with ICD codes for secondary and tertiary hyperparathyroidism. However, we suspect this misclassification would be non-differential with respect to SVI and thus not contribute to bias of the primary outcome. A strength of this study is that by starting the query at the time of incident hypercalcemia, both patients who underwent surgery and those who never received a parathyroidectomy could be included. The SVI is reported at the census tract level; thus, there are inherent limitations to generalizing it to the individual patient level. Finally, although the data presented in this study indicated significant SVI subthemes that have a larger impact on time-to-surgery evaluation, future work could explore the specific factors within subthemes to provide more granularity to the findings.

In conclusion, among a Massachusetts cohort, highly vulnerable populations with PHPT are at greater risk for under-evaluation by a surgeon, which may contribute to the development of long-term sequelae of their disease. This emphasizes the importance of social vulnerability in the management of patients with PHPT and the need for targeted interventions to address barriers to care.

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Conflict of interest/Disclosure

The authors have no related conflicts of interest to declare.

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Discussion

Victoria Lai (Washington, DC): Because social vulnerability index (SVI) is a geographic construct, do you have data on the percentage of most vulnerable patients in your geographic area that your institution takes care of? How does this compare with other institutions in the same catchment area?

Jorge Gomez-Mayorga: We only studied patients from our institution, so we do not have data on differences between patients seen between institutions in the same geographic area.

Andrea Gillis (Birmingham, AL): Since you merged the SVI with institutional data, you may be selecting a subset of patients with hypercalcemia that may not have been adequately represented in the initial data set that was used to develop the SVI. So, I'm wondering why you used SVI when you have access to actual patient data. Also, can you comment on why there was no difference between your first and second, and first and third quartiles and the time to referral? That suggests this may not be a stepwise measure and perhaps should not be used in this fashion.

Jorge Gomez-Mayorga: We agree that the Social Vulnerability Index has not been validated at the individual level. However, the advantage of the SVI is we are able to evaluate the impact of many determinants of health and the outcomes. That is why we chose to use it. As far as the relationships of the different quartiles, we need to look at the specific differences among the groups. They were only compared as groups, and perhaps individual differences within the groups will help explain the results.

Rhea Udyavar (Seattle, WA): I was wondering why you did not use the area deprivation index instead of the social vulnerability index. Also, how did you account for gentrification that happens in communities that were historically marginalized but now have a higher proportion of affluent people living there?

Jorge Gomez-Mayorga: We felt that SVI provided the information we were looking for, but I agree that the area deprivation index would also be interesting to look at and compare. We were not able to account for gentrification, and this is certainly a limitation of our approach.

Bradford Mitchell (Dover, DE): The average patient I see often has hypercalcemia for many years before they get referred to me. Your study shows a 67-day delay; is that clinically significant?

Jorge Gomez-Mayorga: Patients with the highest vulnerability were seen an estimated 67 days later compared with patients with the lowest vulnerability. But more importantly, they had an overall 33% lower estimated rate of surgeon evaluation.