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Creation of a Surgical Outcomes Dashboard Incorporating Social Determinants of Health: A Novel QI Tool to Promote Health Equity

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Abstract

Background: Social determinants of health (SDOH), described by the World Health Organization as "non-medical factors that influence health outcomes," are becoming widely acknowledged for their impact on surgical outcomes. Incorporating SDOH into interactive clinical dashboards is an emerging trend, though no SDOH dashboard specific to surgical outcomes has been described. We present the development of a novel clinical dashboard focused on SDOH and surgical outcomes, highlighting its utility in identifying disparities at a quaternary-care academic hospital.

Methods: The dashboard was created by integrating data from the electronic health record (EHR) via Caboodle into a Tableau-based dashboard. The dashboard was deployed in February 2024 and is updated bimonthly. Data collected includes demographics, SDOH variables, and surgical outcomes. Statistical analysis was used to query relationships between these variables. SDOH was measured using the California Healthy Places Index (HPI), a tool that creates a composite score from population-based data within a region.

Results: The SDOH dashboard displays outcome measures over time and features interactive tabs. Patients in lower HPI quartiles were more likely to be non-white, have a primary language other than English, and have non-commercial insurance. There was no significant difference in LOS or PSI across HPI quartiles, but readmission rates were found to be significantly higher in the 2nd quartile.

Conclusion: While the SDOH Dashboard cannot determine the reasons for disparities, it is a unique interactive tool that can act as a starting point for exploring underlying causes and as a tool for assessing hypothesis-driven surgical outcomes research.

Keywords: Clinical dashboard, Social determinants, Surgical outcomes

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Abbreviations

SDOH: Social Determinants of Health; SVI: Social Vulnerability Index; HER: Electronic Health Record; LOS: Length of Stay; PSI: Patient Safety Indicators; AHRQ: Agency for Healthcare Research and Quality; HPI: Healthy Places Index

Introduction

Social determinants of health (SDOH), defined by the World Health Organization as "non-medical factors that influence health outcomes" [1], are increasingly recognized to impact surgical outcomes [2]. They are classified in one of five domains: economic stability, education quality and access, healthcare quality and access, social and community context and living environment [3]. Addressing health disparities experienced by people with different social determinants of health has become a top priority of the U.S. Office of Health and Human Services, and improving health equity is at the core of the Healthy People 2030 initiative [4].

While the impact of social factors on health outcomes has long been observed [5], the development of composite scores to measure social determinants of health is relatively new. In 2011 the U.S. Center for Disease Control published the Social Vulnerability Index (SVI) [6]. Initially developed to identify at-risk populations vulnerable to natural disasters and public health hazards, the SVI is now

a commonly used metric to study SDOH as they relate to inequitable health outcomes. Other frequently used composite metrics include the Area Deprivation Index, Social Deprivation Index, Distressed Communities Index, the RTI Rarity Local Social Inequality Score, among others [7,8]. Regardless of the metric used, recent literature across a variety of surgical subspecialties have revealed that lower SDOH scores are associated with worse postoperative outcomes in spine surgery, [9-11] orthopedic surgery, [12-14] neurosurgery, [15,16] colorectal surgery, [17,18] bariatric surgery, [19,20] pediatric surgery, [21] cardiothoracic and vascular surgery, [22] and emergency general surgery [23]. These retrospective studies highlight the need to identify effective interventions to address SDOH disparities, which are currently lacking, and may be enhanced by tools that facilitate tracking surgical outcomes in real time.

Interactive clinical dashboards are tools that simplify visualization of data trends and inform operational decision-making. Dashboards are used by clinicians and researchers to track process and outcomes measures and quantify the impacts of quality improvement initiatives. The incorporation of SDOH into clinical dashboards is an emerging trend. Examples of SDOH dashboards in published literature focus on maternal mortality, pediatric healthcare, emergency care, and COVID-19 [23]. However, no SDOH dashboard specific to surgical outcomes has been described in current literature. Therefore, we describe the development of a novel clinical dashboard incorporating SDOH focused on surgical outcomes and its utility in identifying SDOH disparities in surgical patients at an academic, quaternary-care hospital system.

Methods

Development of the surgical SDOH dashboard

The impetus for the Surgical SDOH dashboard was to efficiently visualize data trends pertaining to SDOH and surgical outcomes at an academic, quaternary-care hospital system. The dashboard was developed by incorporating data from the electronic health record (EHR) through Caboodle, the EHR's enterprise data warehouse, to a Tableau-based dashboard. Tableau is the data visualization software that was used for the dashboard's development.

Demographic data collected include patient age, gender, race/ethnicity, primary language, home county, and insurance type. SDOHs were measured using the California Healthy Places Index (HPI) quartile, details of which are elaborated below. Surgical outcomes collected include hospital length of stay (LOS), readmission rates, Patient Safety Indicators (PSI), discharge location, and mortality. Patient Safety Indicators are measures of potentially avoidable adverse events as described by the Agency for Healthcare Research and Quality (AHRQ) [24]. Quality benchmarks including risk-adjusted indexes were incorporated from the Vizient database and AHRQ data model. Data for the last three fiscal years is displayed for comparison. The dashboard was deployed in February 2024 and data is updated every other week.

Measuring social determinants of health

The California Healthy Places Index (HPI) is a tool that uses population-based data to create a composite score of SDOH within a geographic region. The score is devised from 23 indicators across all five domains of SDOH and has been linked to life-expectancy [25]. The tool incorporates data from the annual U.S. Census American Community Survey years 2015-2019, the Comprehensive Housing Affordability Strategy, and the CalEnviroScreen 4.0 Report from The Office of Environmental Health Hazard Assessment within the California Environmental Protection Agency [26]. Economic stability indicators include; percentage of people earning >200% poverty level income, employment, and per-capita income. Education quality indicators include percentage of people with college degree, high school degree, and preschool enrollment. Healthcare quality and access is measured by the percentage of people with healthcare insurance. Social and community context indicators include voter registration, automobile ownership, active commuting, park access, and retail accessibility. Living environment indicators include homeownership, household crowding, high burden of housing costs (defined as >50% income), and environmental pollution levels (including diesel particulates, water contaminants and ozone). Raw scores are then stratified by quartile, with the 1st quartile having the least healthy community conditions and the 4th quartile the healthiest.

Data analysis

Data was extracted from the Surgical SDOH Dashboard and analyzed using Excel. Demographic and surgical outcomes data was stratified by HPI quartile. A Chi squared test for independence with $\alpha = .05$ was used to examine the relationship between HPI quartile and demographic variables as follows: gender, race/ethnicity, primary language, and insurance type. The "Other" category for race/ethnicity includes patients who were identified as Other, American Indian and Alaskan Native, and Native Hawaiian and Other Pacific Islander. Ten patients were identified as Unknown or Declined to State for race/ethnicity, and they were not included in the statistical analysis. For insurance type, the five patients with "other" or no insurance were not included in the statistical analysis.

We conducted a one-way ANOVA to compare mean LOS of the four HPI quartiles. Tukey HSD post-hoc tests were also conducted to evaluate for a significant difference between the means of any pair. Chi squared analysis for independence with $\alpha = .05$ was also used to examine the relationship between HPI quartile and readmission rates and between HPI quartile and collective PSI rate.

Results

Characteristics of the surgical SDOH dashboard

In addition to containing tabs that display outcome measures over time, the SDOH dashboard displays data in an Equity Snapshot tab (Figure 1) and an Equity Drill Down tab (Figure 2). At the time of inquiry, the Surgical SDOH Dashboard contains data from 1,186 patients with any inpatient encounters with surgical staff, and 2,401 operations spanning from July 2020 to August 2024 with the equity tabs updated until June 2024. The Equity Snapshot tab displays patient demographic and SDOH data separated into respective patient groups, providing visualization of their respective proportions. As seen in the supplemental video, the dashboard is interactive, such that when an individual group is selected, the graphics change to reflect the data of the selected group for the rest of the categories (Video S1). For example, when the user clicks on the first HPI quartile, the remainder of the boxes will now reflect the demographics and SDH of just the patients in the first HPI quartile.

The Equity Drill Down Dashboard allows the user to query surgical outcomes data in detail for any demographic or SDOH variable. After the variable is selected, the dashboard displays the LOS Index Heat Map, All Cause Readmit Rates, PSI, Discharge Disposition, Case Mix Index, and Mortality Index for each patient category (Figure 2). Differences in this data can be viewed by selecting each of the patient

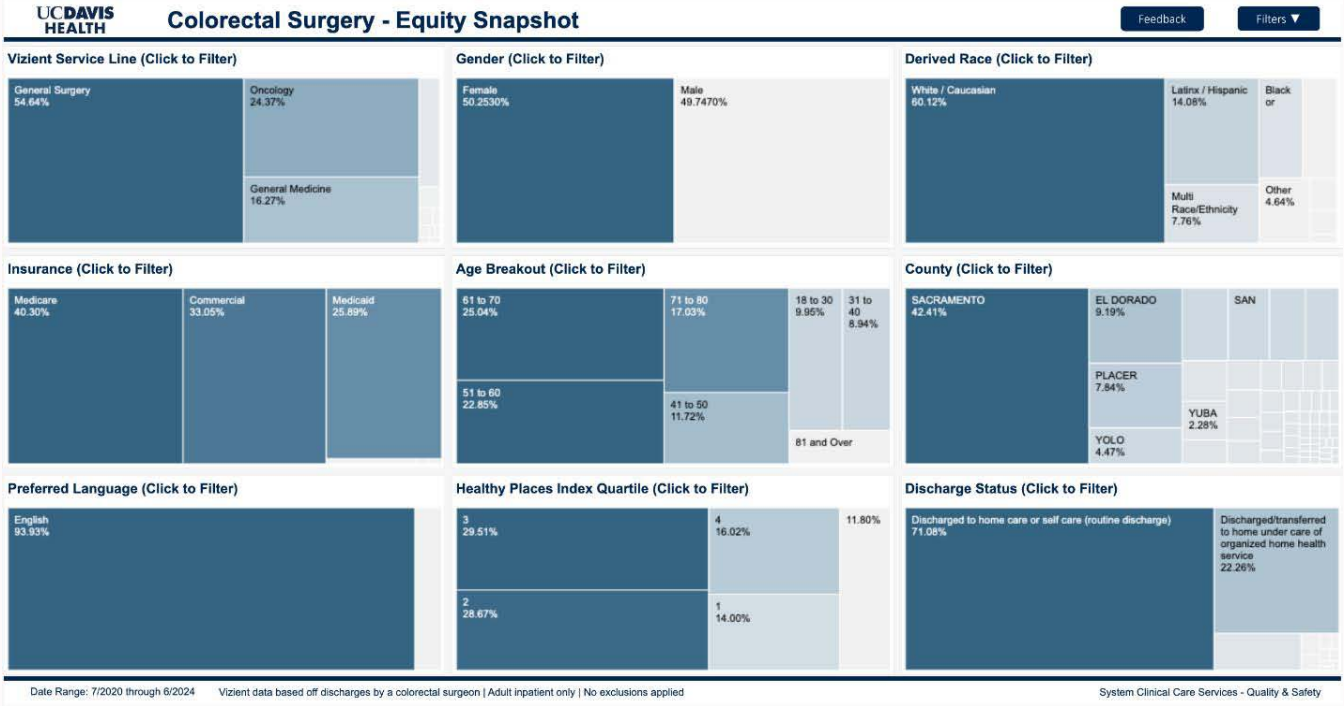

Figure 1: Equity Snapshot.

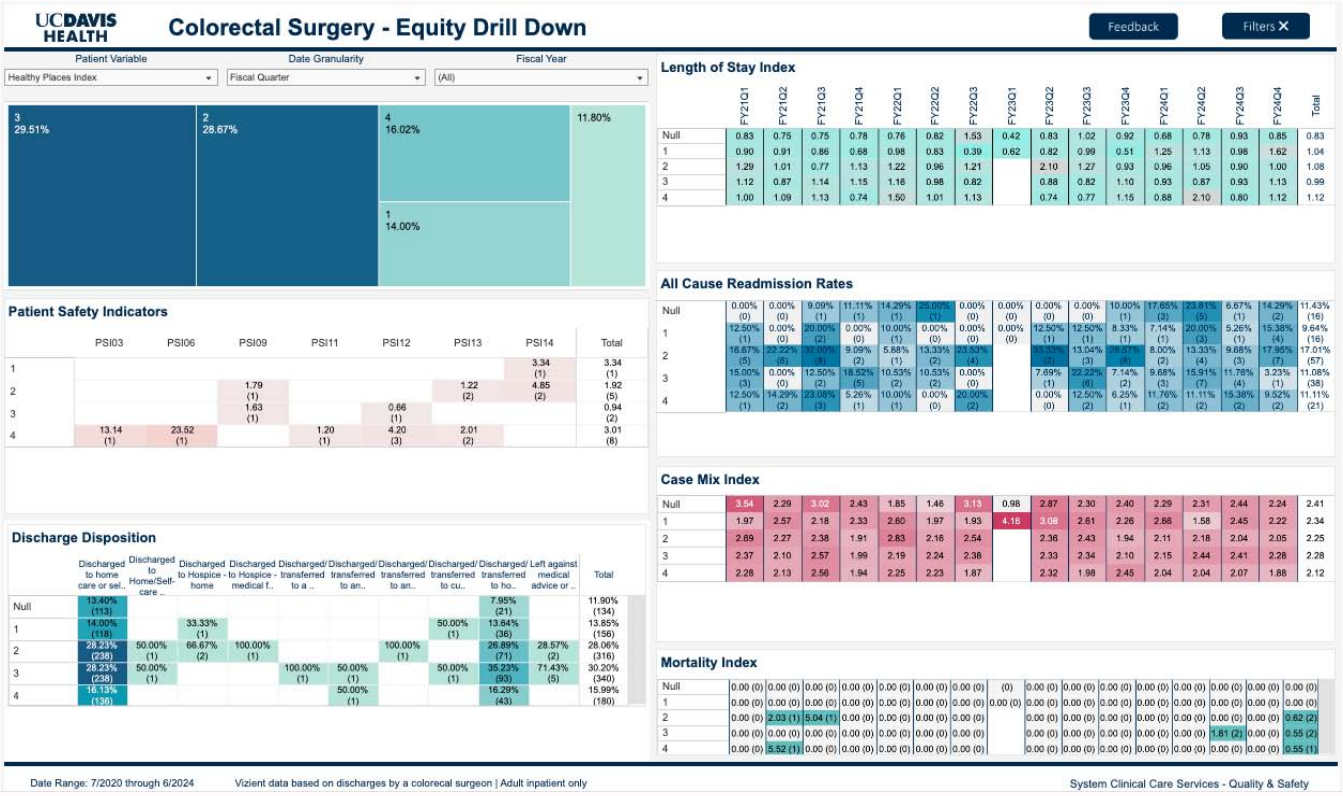

Figure 2: Equity Drill Down tab.

groups within a category (Figure 3A,B). Hovering over any data point provides additional details, including the number of patients or events, the observed outcome, and the expected outcome rate based on case mix index.

SDOH disparities in surgical outcomes

There is a statistically significant difference in the distribution of gender between the HPI quartiles, with male patients more likely to belong to a lower HPI quartile. X^2 (3, N=1046) = 20.38, p<.001.

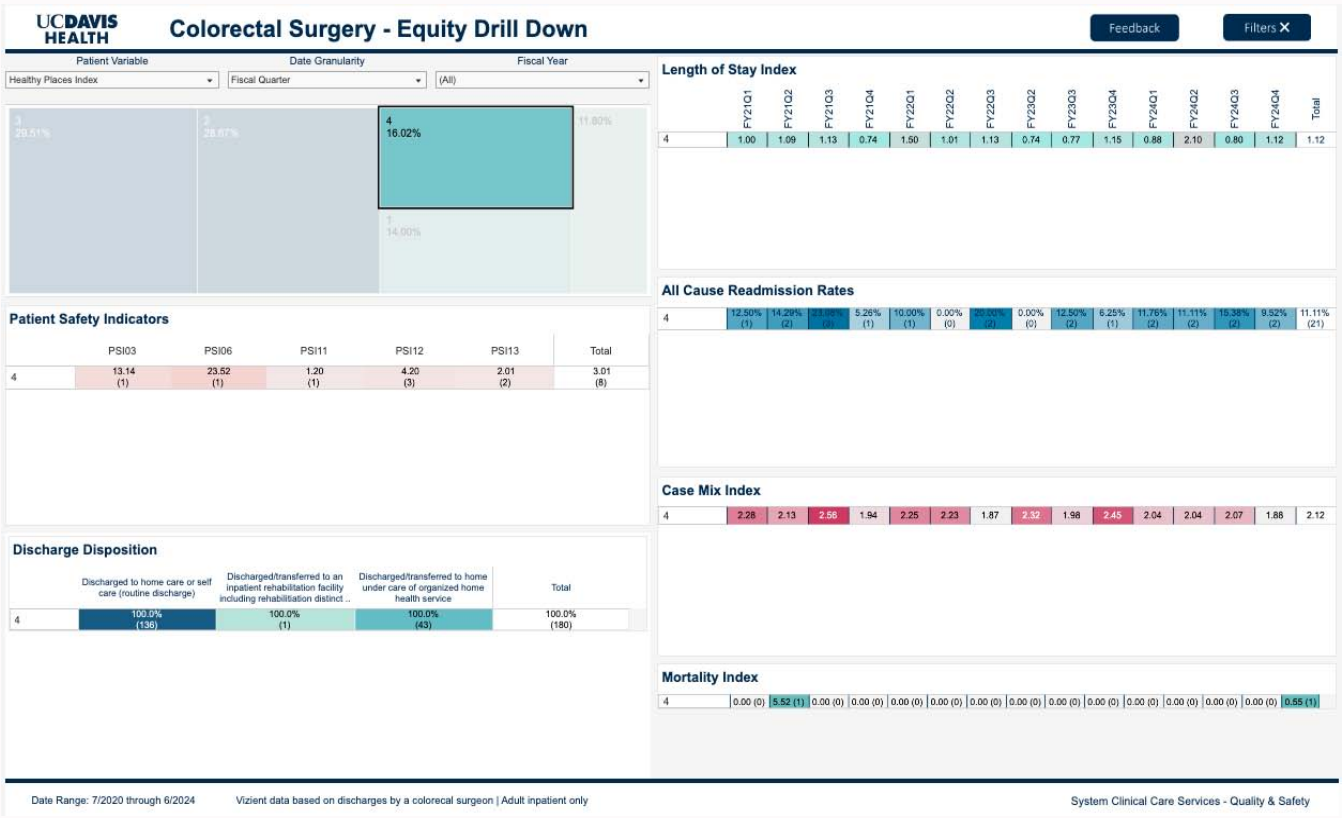

Figure 3A: Equity Drill Down tab displaying outcomes for the 4th HPI quartile.

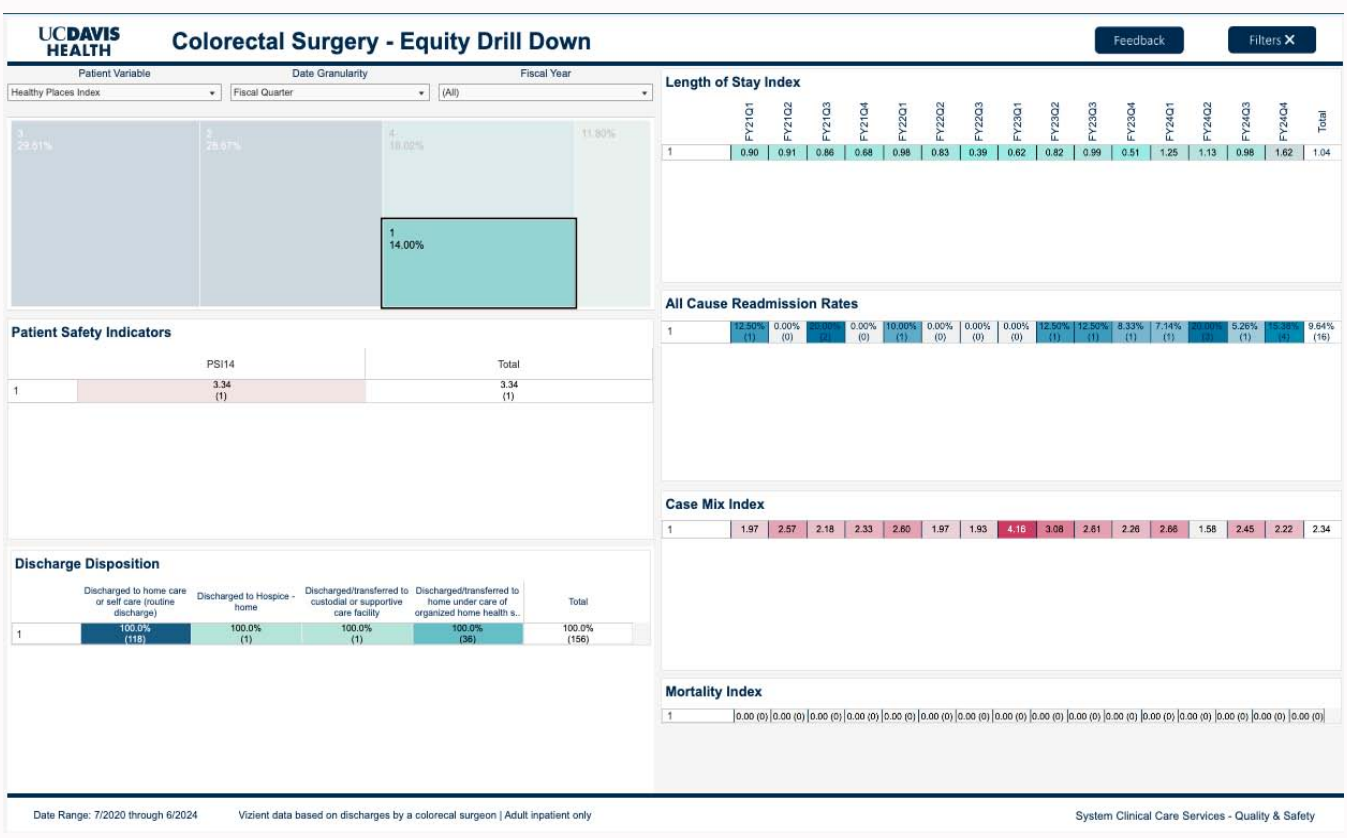

Figure 3B: Equity Drill Down tab displaying outcomes for the 1st HPI quartile.

Table 1: Demographic data by HPI quartile.

	1st HPI Quartile	2nd HPI Quartile	3rd HPI Quartile	4th HPI Quartile	Total	X^2	p-value
Gender						20.38	0.00014
Female	69 (12.9%)	204 (38.1%)	162 (30.2%)	101 (18.8%)	536		
Male	97 (19%)	136 (26.7%)	188 (36.9%)	89 (17.5%)	510		
Race/Ethnicity^						99.5	1.63×10^{-14}
White/Caucasian	61 (9.7%)	196 (31.3%)	235 (37.5%)	134 (21.4%)	626		
Latinx/Hispanic	44 (28.9%)	52 (34.2%)	44 (28.9%)	12 (7.9%)	152		
Black or African American	24 (34.3%)	21 (30%)	23 (32.9%)	2 (2.9%)	70		
Asian	16 (32%)	10 (20%)	13 (26%)	11 (22%)	50		
Multi Race/Ethnicity	9 (11.1%)	41 (50.6%)	17 (21%)	14 (17.3%)	81		
Other*	9 (15.8%)	18 (31.6%)	16 (28.1%)	14 (24.6%)	57		
Language						10.29	0.016
English	149 (15.2%)	315 (32.2%)	328 (33.5%)	186 (19%)	978		
Non-English	17 (25%)	25 (36.8%)	22 (32.4%)	4 (5.9%)	68		
Insurance						65.88	2.86×10^{-12}
Commercial	30 (8.8%)	93 (27.4%)	140 (41.3%)	76 (22.4%)	339		
Medicare	63 (14.7%)	144 (33.6%)	132 (30.8%)	89 (20.8%)	428		
Medicaid	73 (26.8%)	101 (37.1%)	76 (27.9%)	22 (8.1%)	272		

^Race/ethnicity category does not include Unknown/Declined to State (n=10).
*Other includes Other, American Indian/Alaskan Native, and Native Hawaiian/Other Pacific Islander.

Table 2: Surgical outcomes data by HPI Quartile.

	HPI Quartile			
	1st	2nd	3rd	4th
LOS				
Average LOS Index	1.04	1.08	0.99	1.12
Mean LOS	6.57	6.62	5.8	5.9
Standard Deviation	8.38	7.9	6.62	9.22
F statistic	0.85			
p-value	0.46			
All Cause Readmissions				
# of Readmits	16	57	38	21
Average Readmit Rate (%)	9.6	17	11.1	11.1
X^2	8.05			
p-value	0.045			
PSI				
# of Collective PSI Events	3	10	3	8
Average Collective PSI Rate (%)	1.8	2.9	0.8	4.2
X^2	7.15			
p-value	0.07			

There was also a significant difference between HPI quartile and the distribution of race/ethnicity, with white/Caucasian patients being more likely to belong to a higher HPI quartile compared to racial/ethnic minorities. X^2 (3, N=1036) = 99.5, p<.001. The relationship between HPI quartile and the distribution of insurance type also demonstrated statistical significance, X^2 (3, N= 1039) = 65.88, p<.001, with individuals in higher HPI quartiles more likely to have commercial insurance rather than Medicare or Medicaid. The HPI quartiles were also significantly different in their distribution of patients who spoke English as their primary language, X^2 (3, N=1046) =10.29, p=.016 (Table 1). Looking at just the 4th quartile HPI itself, 98% of those patients are primarily English speakers and only 2% are those with a primary language other than English. Comparatively, in the 1st quartile, 10% of those patients are primarily non-English speakers and 90% are primarily English speakers.

A one-way ANOVA revealed no significant effect of HPI quartile on LOS, F (3, N=1042) = 0.85, p=.46 (Table 2). The effect size, eta squared (η^2), was 0.0025, indicating a small effect. This finding suggests that there is no difference in mean LOS between HPI quartiles. A Chi square test of independence showed statistical significance between HPI quartile and readmission rate, X^2 (3, N=1046) = 8.04, p=.045, with the 2nd HPI quartile having the highest readmission rate (Table 2). However, the HPI quartiles were not significantly different in their collective PSI rate, X^2 (3, N=1046) = 7.15, p=.067 (Table 2).

Discussion

To our knowledge, our Surgical SDOH Dashboard is the first published example of a clinical dashboard focused on surgical outcomes that incorporates a composite SDOH score, allowing for rapid identification of potential disparities in surgical outcomes. On initial analysis, there was a significant difference in the distribution of gender, race/ethnicity, and insurance type between the HPI quartiles, which reflect known socioeconomic disparities in the broader population [27]. Among patients at our institution, there was a statistically significant difference in readmission rate between HPI quartiles. Interestingly, the second HPI quartile had the highest readmission rate, which was contrary to our expectations that the first quartile, which represents the least healthy community conditions, would be the highest based on the ordered structure of the quartiles. This may stem from a lack of safety net resources combined with an inadequate increase in income for individuals in the second quartile resulting in communities that lack essential socioeconomic support, even if they are considered to have healthier community conditions compared to those in the first quartile.

However, there were no observed statistically significant differences in the other measured surgical outcomes, LOS and PSI events, between HPI quartiles. This finding may be due to an insufficiently large sample size to detect differences. Additionally, we compared the four quartiles to each other, and there may have been small differences between two groups that were not captured. Another interpretation of this finding is that we are achieving equitable outcomes amongst the HPI quartiles. However, this is less likely given what is known about surgical disparities based on population wide data [27]. Importantly, this does not invalidate the existence of the HPI as a tool to capture SDOH, and as the dashboard captures more data, its findings should mature. The HPI provides a composite score of SDOH and provides insight into potentially vulnerable communities. The SDOH Dashboard is also equipped to track various interventions aimed at addressing disparities and improving health equity among surgical patients. The prospective nature of the dashboard allows for adaptability and continued improvements in functionality.

In its current iteration, the Surgical SDOH Dashboard has some notable limitations. Its data quality reflects that of its inputs, and HPI quartile data is missing for 140 patients, which represents 11.8% of the total inpatient encounters. As the HPI is reliant upon having a patient's residential addresses, patients experiencing housing instability may be disproportionately likely to have data missing and not be represented in the dashboard. The dashboard does not automatically flag disparities, these must be proactively inquired by the user. Data is not risk-adjusted in real-time; dashboard data must be extracted to perform multivariate regression analyses.

The California HPI as a metric to capture SDOH also has limitations. First, the HPI is a discrete variable rather than a continuous one, so it may miss nuance in communities that are at the border between adjacent quartiles. As its geocoding uses mailing address zip codes rather than discrete coordinates, it may not accurately capture those who live in mobile parks and rural communities that use P.O. boxes. As a population-based composite of SDOH measures, the HPI lacks granularity in identifying which SDOH may be most salient for a given patient. Although the HPI contains California-specific data and cannot be generalized to the broader U.S. population, it contains 6 of the 15 SDOH indicators within the SVI and is considered generally comparable [28]. The indices are unique in their methodology of weighing each of the 5 domains of SDOH with the HPI weighing the "neighborhood and built environment" more heavily and the SVI emphasizing "social and community context" in comparison [28].

While the dashboard cannot explain why disparities exist, it can serve as a starting point for investigating root causes, and a tool to measure hypothesis-driven surgical outcomes research. In addition to indices to assess SDOH on a population level, numerous tools have been developed to screen for SDOH on the individual patient level in various settings [29]. Optimal preoperative evaluation of SDOH in surgical patients remains an area of investigation [30], but a SDOH dashboard may be a way to identify patients that could benefit from more in-depth evaluation and provision of various resources to optimize perioperative care.

Conclusion

The Surgical SDOH dashboard is a novel interactive tool that allows clinicians and researchers to identify, intervene on and subsequently track surgical outcome disparities in a real-time, prospective manner, enhancing equitable patient experiences and quality of care. Social responsibility in surgery calls for understanding how factors like social determinants of health impact equitable surgical outcomes [31], which highlights the importance of addressing inequities in surgical care.

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