



Social determinants of health and outcomes of ventral hernia repair in a safety-net hospital setting

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Abstract

Purpose Lower socioeconomic status has been shown to be predictive of poorer surgical outcomes in ventral hernia repair. Recently, safety-net hospitals have been attempting to address these disparities to improve the care of patients of lower socioeconomic status.

Methods A query of all patients undergoing ventral hernia repair at our institution between 2010 and 2019 was completed ($n = 580$). Patients not from identifiable New Jersey ZIP-codes were excluded ($n = 572$). ZIP codes were assigned quartiles based off socioeconomic variables including median household income, percent below poverty line, and high school graduation rate. Patients were then assigned to socioeconomic status quartiles based off their residential ZIP-code. Outcomes of ventral hernia surgery were compared across ZIP-code quartiles. Logistic regression was used to analyze predictors of poor outcomes.

Results Patients from lower socioeconomic brackets were more likely to be younger ($p < 0.001$), female ($p = 0.014$), black ($p < 0.001$), and/or Hispanic ($p = 0.003$). Most notably, outcomes of ventral hernia were not significantly different between patients of different socioeconomic status ZIP-code quartiles. The risk of any post-operative morbidity was higher for longer procedures ($p < 0.001$) and for hernia repairs being done with other procedures ($p < 0.001$). Risk of prolonged length of stay and related 30-day readmission was higher with longer procedures ($p < 0.001$ and $p = 0.003$, respectively).

Conclusion We found that outcomes of ventral hernia repair at a safety-net hospital were unaffected by socioeconomic status. This supports the important role that safety-net institutions play in providing quality care to their vulnerable populations. Future studies at other safety-net hospitals should be done to further assess the updated impact of socioeconomic status on ventral hernia outcomes.

Keywords Ventral hernia · Social determinants of health · Socioeconomic status · ZIP-code quartiles · Safety-net hospital

Introduction

Despite steady advancements in surgical care and surgical technology, social determinants of health and socioeconomic status (SES) continue to have a determinative effect on access to care, health outcomes, and mortality associated with surgery [1, 2]. Social determinants of health have been correlated to various unfavorable health-related outcomes and explain the basis of many healthcare disparities [3–5]. A healthcare disparity is generally defined as lower quality

of care given to an individual as a result of their race, ethnicity, or SES [5]. Adverse results of healthcare administration are due in part to a lack of equitable access to care. Some examples of this inequity are the significantly greater rate of clinically vital surgeries offered to white patients relative to black patients [6], and the increased likelihood of women of lower SES diagnosed with early-stage breast cancer to experience significantly poorer physician–patient communication and lower satisfaction with surgery and clinical decision-making [7].

To this end, the field of surgical health disparities, in which we examine the effect of social determinants on elective and emergent surgical outcomes, is continuing to develop, but more work still needs to be done. Most of the current research into surgical disparities involves the effects of socioeconomic variables such as insurance status, gender,

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race, and safety-net hospital status. However, there is significant sociologic and medical evidence that social determinants including level of education, community poverty, and household income play possibly even more important fundamental roles in determining health outcomes [8, 9].

Safety-net hospitals continue to play a pivotal role in addressing social determinants of health, reducing health disparities, and helping socioeconomically disadvantaged patient populations receive access to quality evidence-based healthcare [10–12]. In 2000, the Institute of Medicine defined safety-net hospitals as hospitals that, by mission or mandate, provide care to a substantial share of vulnerable patients regardless of their ability to pay [13]. These institutions disproportionately serve large populations of vulnerable patients. Although there is data about overall safety-net hospital performance in surgical care [14–16], there is very little about the quality of care that safety-net hospitals deliver to local populations with substantial social determinant pressures. These data are invaluable towards improving care, as safety-net hospitals play an increasingly important role in our healthcare environment.

Among a variety of surgical procedures in the safety-net setting, ventral herniorrhaphy has among the highest odds ratios for mortality and readmission compared to other operations [11]. Ventral hernia repair is one of the most common surgical procedures in the country, with more than 350,000 procedures annually [17], for an approximated total cost of \$3.2 billion [18]. The term “ventral hernia” describes a large group of hernia disease that includes primary hernias (epigastric, umbilical, lumbar, Spigelian) and incisional hernias which occur after an abdominal incision for an operation. Ventral hernias can occur up to 20% of the time after laparotomies and 41% of surgical cancer patients developed a ventral hernia within two years after an open operation [19]. With an aging population likely to undergo an increasing amount of abdominal surgery, ventral hernia will continue to be a central focus of research. Low-income patients have significantly increased 30-day readmission rates following ventral hernia repair relative to medium- and high-income patients [20]. The purpose of this study is to further examine how the social determinants of health affect outcomes of ventral hernia repair in a safety net hospital setting.

Methods

Setting and population

A single-center, retrospective chart review of all patients aged 18 and over undergoing ventral hernia repair at University Hospital, a large academic safety-net hospital, in Newark, NJ, between 2010 and 2019 was conducted. Patient demographics, comorbidities and preoperative factors,

surgical data, and postoperative outcomes were extracted from the electronic medical record.

Social determinant data

Social determinants data based on relevant New Jersey ZIP-codes were obtained from a primary US Census Bureau website [21]. Patients who came from ZIP-codes outside of New Jersey or ZIP-codes that did not have available data on the Census Website (07101; 07602) were excluded. There were 115 different ZIP-codes represented in our data. Socioeconomic status variables included: Median household income (MHI), percentage of high school graduates (HSG), and percentage of individuals below the poverty line (BPL). SES data from each ZIP-code was ordered, and each ZIP-code was placed into quartiles. Quartile 1 is the highest SES bracket and quartile 4 is the lowest. Quartiles 1, 2, and 4 represent 29 ZIP-codes each, and quartile 3 represents 28 ZIP-codes. Patients were then assigned to ZIP-code quartiles. Similar ZIP-code-based quartiles rankings were employed by Agarwal et al. [22]. BPL was used for most analyses of SES because it correlated the highest amongst other SES indicators.

Outcomes

Poor outcomes of ventral hernia repair were assessed using any postoperative morbidity, related 30-day readmission, and prolonged length of stay (LOS). The term “any postoperative morbidity” used in the analysis included postoperative wound infections (superficial and deep), sepsis, wound disruption, pneumonia, pulmonary embolism, unplanned intubation, ventilator use, acute renal failure, and urinary tract infections. These outcomes were combined to increase the power of the analysis. Prolonged LOS was defined as ≥ 75 th percentile of all patients (≥ 3 days). This study received approval by the Rutgers New Jersey Medical School Institutional Review Board.

Statistical analysis

Comparison of demographics and outcomes between BPL quartiles were analyzed using chi-square tests for categorical variables and analysis of variance for continuous variables. Spearman’s rho was used to calculate correlations between socioeconomic status variables. Logistic regression was used to analyze variables predictive of poor outcomes (any morbidity, prolonged LOS, and related readmission within 30 days). All analyses were completed with a two-sided significance level of 0.05. Analyses were completed using SPSS version 25.

Results

Demographics

We identified 580 patients that underwent ventral hernia at our institution during this time frame. Of these, 8 patients were not from New Jersey ZIP-codes and were excluded ($N=572$). Out of the 572 patients, there were 115 unique New Jersey ZIP-codes. There were 29 ZIP-codes in quartiles 1, 2, and 4, and 28 ZIP-codes in quartile 3. Representing these ZIP-code quartiles, 383 (67%) patients were in the bottom quartile and 40 (7%) were in the top quartile for MHI. With respect to HSG, 310 (54%) were in the lowest quartile and 41 (7%) were in the highest quartile. Lastly, 356 (62%) patients were in the fourth quartile and 42 (7%) in the first quartile for BPL (Fig. 1). Almost all of the hernia repairs were primary (553 out of 572). As expected with our safety-net population, there were differences at baseline between the socioeconomic status ZIP-code quartiles (Table 1). Patients from ZIP-codes with more residents below the poverty line were significantly younger ($p < 0.001$) and were more likely to be female ($p = 0.014$), black ($p < 0.001$), and/or Hispanic ($p = 0.003$).

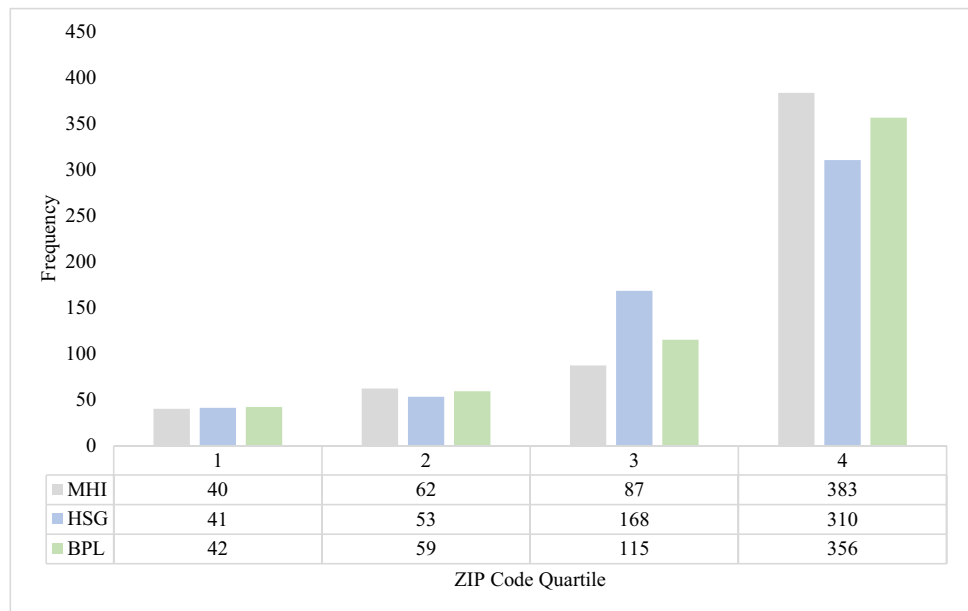
Socioeconomic status indicators

There were highly significant correlations between all three of the SES ZIP-code quartile indices (Table 2). Between BPL and MHI ZIP-code quartiles there was a $r_s = 0.876$ ($p < 0.001$), and between BPL and HSG ZIP-code quartiles there was a $r_s = 0.698$ ($p < 0.001$). This shows that these variables are highly related and are likely measuring the same metric. To avoid multicollinearity from impacting our results, it was decided to only use one SES variable moving forward. Analyses on outcomes were done using BPL because it correlated the highest with the other two variables (Table 2).

Predictors of poor surgical outcomes in ventral hernia

The incidence of poor surgical outcomes including any perioperative morbidity, prolonged LOS, and related 30-day readmission did not vary between BPL ZIP-code quartiles (Table 3). The risk of any post-operative morbidity was higher for longer procedures ($p < 0.001$) and for ventral hernias being done with other procedures ($p < 0.001$). The risk of prolonged LOS and related 30-day readmission was higher with longer procedures ($p < 0.001$ and $p = 0.003$, respectively). The risk of prolonged LOS was higher for patients who were not Hispanic ($p = 0.027$). BPL ZIP-code quartile did not significantly affect the risk of post-operative

Fig. 1 Frequency of patients across socioeconomic status ZIP-code quartiles



MHI, Median Household Income
 HSG, High-School Graduation Rate
 BPL, Percent Below Poverty Level
 SES, Socioeconomic Status

Table 1 Demographics for ventral hernia repair across BPL ZIP-code quartiles

| | Total | Quartile 1 | Quartile 2 | Quartile 3 | Quartile 4 | P value |
|--------------------|-------------|-------------|-------------|--------------|-------------|---------|
| <i>N</i> | 572 | 42 | 59 | 115 | 356 | |
| Total ZIP-codes | 115 | 29 | 29 | 28 | 29 | |
| BPL range | | 0 to 5.4% | 5.5 to 9.0% | 9.1 to 17.4% | > 17.4% | |
| Age, Mean (SD) | 49.7 (13.3) | 55.2 (11.3) | 54.2 (13.9) | 50.2 (11.3) | 48.1 (13.7) | <.001 |
| Male, count (%) | 252 (44.1%) | 25 (59.5%) | 32 (54.2%) | 40 (34.8%) | 155 (43.5%) | 0.014 |
| <i>Race</i> | | | | | | |
| Black, count (%) | 207 (36.2%) | 4 (9.5%) | 9 (15.3%) | 23 (20.0%) | 171 (48.0%) | <0.001 |
| White, count (%) | 82 (14.3%) | 25 (59.5%) | 24 (40.7%) | 20 (17.4%) | 13 (3.7%) | <0.001 |
| Unknown, count (%) | 258 (45.1%) | 13 (31.0%) | 23 (39.0%) | 63 (54.8%) | 159 (44.7%) | 0.034 |
| Other, count (%) | 25 (4.4%) | 0 (0%) | 3 (5.1%) | 9 (7.8%) | 13 (3.7%) | 0.126 |
| <i>Hispanic</i> | | | | | | |
| No, count (%) | 323 (56.5%) | 26 (61.9%) | 44 (74.6%) | 52 (45.2%) | 201 (56.5%) | 0.006 |
| Yes, count (%) | 150 (26.2%) | 5 (11.9%) | 8 (13.6%) | 38 (33.0%) | 99 (27.8%) | 0.003 |
| Unknown, count (%) | 99 (17.3%) | 11 (26.2%) | 7 (11.9%) | 25 (21.7%) | 56 (15.7%) | 0.125 |

BPL percent below poverty level

Table 2 Correlation between socioeconomic status indicator quartiles

| | MHI | HSG | BPL |
|-----|--------|--------|------|
| MHI | 1.00 | | |
| HSG | 0.696* | 1.00 | |
| BPL | 0.876* | 0.698* | 1.00 |

MHI median household income, HSG high-school graduation rate, BPL percent below poverty level, SES socioeconomic status
**p* < 0.001

morbidity, prolonged LOS, or related readmission within 30-days (Table 4).

Discussion

The majority of our institution’s patients are from lower socioeconomic brackets, generally falling within the lowest ZIP-code quartiles for the state. In our population, young age, female gender, and Black or Hispanic race patients were more likely to come from lower SES ZIP-code quartile areas. Despite these varying socioeconomic

factors which previous work has shown increases the risk of poor outcomes, the lack of correlation between BPL ZIP-code quartiles and poor surgical outcomes, post-operative morbidity, prolonged LOS, and related readmission within 30-days demonstrates that patients undergoing ventral herniorrhaphy achieved similar outcomes despite socioeconomic disparity at our institution. These effects were controlled for variables known to affect outcomes of ventral hernia repair, including surgical length and complexity. This is a novel finding in this field as SES is typically tied to surgical outcome.

Throughout the literature, social determinants of health have been correlated to various unfavorable health-related outcomes [3] and explains the basis of many healthcare disparities [4, 5]. Chatterjee et al. reported that patients of lower SES stand to benefit the most from high-quality patient-centered care [23]. Further, they indicated that safety-net hospitals are failing to provide the required level of care and are generally performing poorly on quality metrics based on processes of care. Our study differed from previous works on safety-net hospitals in that ventral herniorrhaphy outcomes were independent of SES. This suggests that SES are perhaps becoming less important

Table 3 Ventral hernia repair outcomes across BPL ZIP-code quartiles

| | Total | Quartile 1 | Quartile 2 | Quartile 3 | Quartile 4 | P value |
|--|-------------|------------|------------|------------|------------|---------|
| <i>N</i> | 572 | 42 | 59 | 115 | 356 | |
| Total ZIP-codes | 115 | 29 | 29 | 28 | 29 | |
| Any morbidity rate, count (%) | 47 (8.2%) | 3 (7.1%) | 6 (10.2%) | 8 (7.0%) | 30 (8.4%) | 0.891 |
| Prolonged LOS (≥ 3 days), count (%) | 143 (25.0%) | 11 (26.2%) | 13 (22.0%) | 29 (25.2%) | 90 (25.2%) | 0.955 |
| Related 30-day readmission rate, count (%) | 21 (3.7%) | 3 (7.1%) | 2 (3.4%) | 5 (4.3%) | 11 (3.1%) | 0.586 |

BPL percent below poverty level, LOS length of stay

Table 4 Predictors of poor outcomes in ventral hernia repair

| Variable | Any morbidity | | Prolonged LOS | | Related readmission < 30 days | |
|-----------------------------|------------------|----------------|---------------|----------------|-------------------------------|----------------|
| | OR | <i>p</i> value | OR | <i>p</i> value | OR | <i>p</i> value |
| Age | 1.00 | 0.779 | 1.02 | 0.051 | 1.02 | 0.254 |
| Sex | | | | | | |
| Male | 1.67 | 0.12 | 1.01 | 0.957 | 0.94 | 0.894 |
| Race | | | | | | |
| White | <i>Reference</i> | | | | | |
| Black | 0.72 | 0.583 | 1.63 | 0.225 | 1.52 | 0.588 |
| Other | 1.44 | 0.702 | 1.77 | 0.371 | 0.00 | 0.998 |
| Unknown | 2.03 | 0.259 | 1.63 | 0.273 | 1.61 | 0.581 |
| Hispanic | | | | | | |
| Yes | <i>Reference</i> | | | | | |
| No | 1.92 | 0.212 | 2.371* | 0.027 | 2.81 | 0.24 |
| Unknown | 0.64 | 0.438 | 1.11 | 0.793 | 1.53 | 0.63 |
| BPL ZIP-Code Quartile | | | | | | |
| 1 | <i>Reference</i> | | | | | |
| 2 | 1.41 | 0.655 | 0.85 | 0.766 | 0.47 | 0.435 |
| 3 | 0.99 | 0.99 | 1.02 | 0.969 | 0.61 | 0.552 |
| 4 | 1.54 | 0.551 | 1.15 | 0.776 | 0.45 | 0.324 |
| Procedure duration (per hr) | 1.376** | <.001 | 2.384** | <.001 | 1.354** | 0.003 |
| Other procedure(s) | 3.33** | <.001 | 1.57 | 0.066 | 1.29 | 0.605 |

BPL percent below poverty level, LOS length of stay

p* < 0.05, *p* < 0.01

as a predictor of poor short-term outcomes over time. However, definitive conclusions are hard to make using a single-center study.

Numerous studies determined that lower quality medical care in minorities and patients of low SES can be attributed to financial barriers and patient health beliefs [6, 24–29]. Given its status as a safety-net hospital, our institution substantiates the value of reducing economic barriers and emphasizing providing impartial care amongst staff. At our safety-net institution, ventral hernia repair outcomes are independent of SES. Risk of poor outcome of ventral hernia surgery (post-operative readmission, any morbidity, and prolonged LOS) are affected mainly by surgical factors alone.

Limitations

There were a few limitations to our study. The use of electronic medical record patient data comes with the limitation of presumed thorough record keeping. Chart reviews rely on accurate records for valid conclusions, so any instances of poor data reporting could have affected the results of this study. Additionally, since this is a single institution study with a vulnerable patient population, the results lack generalizability, particularly when compared to non-safety net hospitals.

Due to its status as a safety-net hospital in a city with high rates of poverty, the reduced volume of patients in higher ZIP-code quartiles could have masked a correlation. However, the extremely high *p*-value amongst BPL ZIP-code quartiles suggests that increasing sample size of higher SES patients would not have changed our results.

There are additional demographic variables which were not included in our analyses, including rates of obesity, smoking, and diabetes. These rates are known to be higher in patients of lower SES and were thus likely accounted for in our SES groups and, for this reason, likely had some effect on the outcomes. These variables were not included because we wanted to analyze the whole picture of the effect of SES and on the outcome. However, even without these variables being included in the analysis, the SES groups were not shown to be anywhere near significance for increased odds of poor outcomes in ventral hernia repair. This suggests that these factors were mitigated for in a safety-net hospital setting.

Future studies on SES and ventral herniorrhaphy outcomes at other safety-net hospitals will be beneficial as they will help to determine if our results are generalizable, or if our institution is an outlier amongst safety-net institutions. These future studies should be done at other safety-net hospitals with similarly diverse patient populations. If the results agree with our work, this could signify a significant shift in the effect of SES

on ventral hernia outcomes in this setting. In addition, these larger studies should attempt to stratify by type of ventral hernia repair.

Our results reinforced that the most predictive variables for poor outcome were intraoperative measures. This is not a surprise as intraoperative measures can be used to demonstrate surgical complexity. This relationship between longer lengths of ventral hernia procedures and the presence of concomitant procedures with post-operative outcomes should be further explored specifically in a tertiary safety-net hospital setting. This is important to study because poor outcomes lead to worse patient health and greater costs for healthcare systems and patients. Despite projected US healthcare expenditures rising to \$3.8 trillion [30], there continues to be a strain on hospitals attempting to minimize health disparities. With this fact in mind, hospitals serving higher-risk patients (typical safety-net hospitals) may be subject to an increased penalty burden because of the patients they treat, rather than their quality of care. Therefore, it is necessary for safety-net hospitals to lead research in these areas to advocate for more just healthcare systems.

Conclusion

In this retrospective review of surgical outcomes at a safety-net hospital, it was found that poor outcomes amongst patients undergoing ventral hernia repair were unaffected by SES variables. These results contradict work displaying poorer outcomes for ventral herniorrhaphy amongst patients of lower SES. Future studies should be done at other safety-net hospitals on ventral hernia to analyze if SES variables are becoming less predictive of poor clinical outcome in this setting.

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Compliance with ethical standards

Conflict of interest Amit Gupta, Joshua B. Cadwell, and Aziz M. Merchant MD declare that they have no conflict of interest.

Ethical approval All procedures performed were in accordance with the ethical standards of the institute and regional research committee and with the 1964 Helsinki declaration and its later amendments of comparable ethical standards.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this study formal consent is not required.

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