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## Disparities in Surgical Access: A Systematic Literature Review, Conceptual Model, and Evidence Map

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### Introduction

Healthcare disparities in quality represent one of the greatest challenges in achieving uniformly high-quality care (1). Research reporting disparities in surgical outcomes are abundant (2–6). The cornerstone of delivering high quality healthcare is ensuring optimal access for all patients. A relative lack of access to surgical services may be a contributing factor to disparities in surgical outcomes.

Access is “the timely use of personal health services to achieve the best possible outcomes” (7). Utilization of services, the process of entering and staying in the system, and the actual quality of care received are all involved. Disparities in access arise when the system disproportionately under-performs for a specific group of patients relative to the historically

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advantaged population (8, 9). Surgery, because of its time sensitive, often high acuity nature, is greatly dependent on access.

In complex surgical systems, there is no established, methodical way of conceptualizing or measuring disparities in surgical access. Efforts to reduce disparities in surgical access require metrics (standardized measurable indicators), which provide the foundation for focused and tailored interventions, which can be applied broadly. The aims of this systematic review were to identify measures of disparities in surgical access in the US (US), produce a conceptual model for operationalizing them, and build an evidence map of this literature.

This study was a part of the American College of Surgeons' collaborative effort towards reducing disparities in surgical care - MEASUR (Metrics for Equitable Access and care in SURgery). The overarching mission is to ensure optimal access and equitable healthcare for all surgical patients in every setting across the entire surgical continuum of care. Through research and expert consensus, the MEASUR project, will identify and develop measures that capture disparities in surgical care.

## Methods

### Protocol and registration

This review was prospectively registered in the Prospero International Prospective Register of Systematic Reviews (2018 ID: CRD42018091926). The objective was to identify quantitative measures of surgical access disparities in the US and structure these measures into a novel conceptual model.

We defined a measure as a quantitative primary or secondary study outcome that was assessed across disparity domains (race/ethnicity, socioeconomic status, insurance status, education, geographic location, and other).

### Search criteria

Surgical access disparity measures are ill-defined, therefore a broad search strategy was utilized. An existing literature search strategy was employed using the following terms: *healthcare disparities*, *health status disparities* and *surgery* (3). A PubMed search of publications published between January 2008 and March 2018 was conducted. The date last searched was March 16<sup>th</sup>, 2018. Reference mining was utilized to identify additional publications.

### Eligibility criteria

Included studies incorporated quantitative measures of disparities in surgical access. The definition for surgical access was extrapolated from the NASEM healthcare access definition (7); the timely use of surgical services to achieve the best possible outcomes including the utilization of surgical services, the process of entering and staying in the surgical system, and the quality of care received. The specific measurements of surgical access utilized and the disparity domain (race/ethnicity, socioeconomic status, insurance status, education, geographic location and other) for which the measures were utilized were extracted. We

extracted measures of surgical access disparities, as such, only studies which showed a statistically significant disparity in the specific surgical access measurement were included. This was done as the aim of this literature review was to extract measurable indicators in areas where significant disparities in surgical access were identified, these measurable indicators have the potential to be converted into disparity sensitive surgical access metrics. Studies were excluded if they were not written in English or not conducted in the US.

### Data extraction and analysis

The individual measures of surgical access disparities were extracted from each study. Two investigators screened the articles and extracted the measures (EdJ and MG). For each measure, the reported disparity group was identified (racial/ethnic, education, insurance, income, geography and other). The measures were classified into surgical specialties by the 14 subspecialties defined by the American College of Surgeons; general, thoracic, colon and rectal, obstetrics and gynecology, gynecology oncology, neurology, ophthalmic, oral maxillofacial, orthopedic, otolaryngology, pediatric, plastic maxillofacial, urology and vascular.

Measures were categorized per a conceptual model derived from the Alkire et al, 2016 Global Access to Surgical Care model (10). The conceptual model was reviewed and refined in biweekly MEASUR project meetings with input from members of the American College of Surgeons, National Quality Forum, Eastern Virginia Medical School and the University of California—Los Angeles.

Measures were graphed on an evidence map; a systematic approach to evidence synthesis to represent gaps in knowledge and interpret individual studies within the context of a global knowledge on disparities to highlight future research needs (11). The evidence map illustrates the number of measures by surgical access domain (y-axis), surgical specialty (x-axis), disparity domain (color) and number of studies reporting disparities for each measure (diameter of the markers). This map depicts the landscape of evidence describing measures of surgical access disparities. Insights and findings from this map was derived through observation and discussion among co-authors and MEASUR project co-investigators.

## Results

### Search results

The search returned 1,375 original articles. Based on the inclusion and exclusion criteria, 225 studies were included. From these studies, 223 measures of surgical access were extracted (Fig 1).

### Conceptual Model of Surgical Access Disparities

Measures were classified based on the following categories: Provider Access, Surgical Indication Detection, Progression to Surgery and Receipt of Optimal Care (Fig 2). The unidirectional arrows in the diagram suggest how each of the categories sequentially influences other categories.

## Provider Access

Provider access measures reflect disparities in access to the highest quality of surgical care and discharge provider facilities. A total of 30 provider access measures were identified (Table 1). Measures showed disparities in the use of low-volume hospitals, low-volume surgical practitioners, the use of safety net hospitals, and the use of hospitals with a higher risk-adjusted surgical mortality. Key examples are described. One measure reported access disparities to a Level I or II trauma center within 60 minutes via an ambulance or helicopter (12). Three measures examined disparities in optimal discharge disposition to indicated rehabilitation facilities for trauma (13), cardiac surgery (14) and traumatic brain injury patients (15–17).

## Surgical Indication Detection

Surgical indication detection measures represent disparities in the time of diagnosis, presentation or referral (detection) of a potential surgical condition (indication). There were 39 measures identified (Table 2). Twenty-one measures described a more advanced stage of cancer at the time of diagnosis including breast (18–22), lung (23), rectal (24), hepatocellular carcinoma (25) and pancreatic neuroendocrine tumors (26). Fourteen measures examined more advanced clinical presentations of conditions (meaning non-cancer). Examples of advanced clinical presentations include the severity (patency) of peripheral arterial disease at presentation (27–31), the time from onset of pediatric abdominal pain to presentation for appendicitis (32) and pain intensity or wellbeing scores for patients undergoing knee replacements for osteoarthritis (33).

## Progression to Surgery

Progression to surgery measures reflect disparities in the process of attaining a surgical opinion or procedure once a surgical indication has been detected. One hundred measures describing progression to surgery were identified (Table 3). Four measures examined disparities in persons for whom surgery was indicated being offered a surgical option for conditions like pelvic organ prolapse (34), loco-regional pancreatic cancer (35), or pediatric sensorineural hearing loss (36). Thirty-six measures examined disparities in persons with a potential surgical indication receiving the indicated surgical procedure (decision to treat) for cancer, vascular, orthopedic, cardiac, neurosurgery, otolaryngology, and bariatric surgery. Twelve measures examined disparities in the total surgical rates per population for surgeries like joint replacements (37–39), elective abdominal aortic aneurysm repair (40), or carotid endarterectomies (41). Five measures examined disparities in the emergency-to-elective procedure ratios for conditions in which an elective procedure may have prevented a later emergency procedure, like abdominal aortic aneurysm repair (40) or brain tumor craniotomies (42). Disparities in the time between surgical indication detection and the surgical evaluation or procedure were examined by eight measures. Examples of this include the time between a breast cancer biopsy to surgery (43–45), the time between presentation of pediatric abdominal pain to undergoing appendectomy (46) and the interval between sonographic detection of carotid stenosis warranting carotid endarterectomy and the procedure (47).

## Receipt of Optimal Care

Receipt of optimal care measures reflect disparities in a patient's ability to receive the highest quality surgical care. A total of 54 measures examined optimal care disparities, 37 examined surgical care and 14 examined postoperative follow up care (Table 4). These measures included disparities in post-mastectomy breast reconstruction (48–57), the recommended number of lymph nodes removed for conditions like gastric cancer (58) or lung cancer (59), immediate versus delayed cholecystectomy rates (60), and amputation rates for lower extremity open fractures (61). Fifteen measures examined disparities in the utilization of minimally invasive procedures such as laparoscopic appendectomies (62), hysterectomies (63, 64) or cholecystectomies (65), as well as breast-conserving surgery versus mastectomies (18, 19, 21, 66–68). Optimal postoperative follow-up measures examined disparities in emergency stoma reversal rates (69), rates of breast-conserving surgery without receipt of full radiotherapy (43), or failure to complete internal fixation removal for cases of pediatric femoral shaft fractures (70).

## Disparity groups

The measures of surgical access were categorized into six disparity domains; racial/ethnic, education, insurance, income, geography, and other (e.g. marital status, sex, immigration status). Figure 3 shows that the proportion of measures in each group remained similar throughout the phases of the conceptual surgical access model.

## Evidence map

An evidence map illustrating the 223 measures of surgical access disparities in the US, stratified by surgical access domain, surgical specialty and disparity domain is shown in Figure 4. Two surgical specialties (ophthalmic and oral maxillofacial) did not have any measures of disparities identified and were thus not included in the evidence map.

## Discussion

Measures of surgical access disparities in the US have been broadly applied; our novel conceptual model, illustrates the multiple interrelated strata of disparities. By further compartmentalizing surgical access disparities, more targeted interventions can be developed to accurately measure and address them.

For breast cancer surgical care, as an example, there are various measures in each surgical access domain. Racial/ethnic minority patients are more likely to access care at lower quality providers (71, 72), the indication for surgery is detected later (present at a later stage of diagnosis (18, 19)), progression to surgery takes longer (increased biopsy diagnosis to surgery time (43–45)), and indicated surgical treatment is less likely to occur (43, 73–75). If a surgical procedure is performed, it may not be the optimal procedure for the patient and the patient may not receive the adequate follow-up (less breast-conserving surgery vs. mastectomy (19, 66, 67), less likely to receive the full indicated postoperative radiotherapy course (43), less likely to have recommended sentinel lymph node biopsies (76), lower post-mastectomy breast reconstruction rates (48–56, 77, 78)). This can be simplified to say that

racial/ethnic minority populations have less access to breast cancer surgical care, but by addressing each domain, a more thorough understanding is developed.

Each disparity measure in each facet of the surgical access model may have a multitude of causal factors. Etiologies contributing to disparities in surgical access include; healthcare literacy, ability to navigate the healthcare system, mistrust of healthcare providers and hospitals, healthcare affordability, misunderstanding of disease severity and treatment options, and a lack of access to adequate health care facilities and qualified personnel (8, 79–83).

Another factor to consider is implicit bias in the healthcare system towards minority groups (84, 85). Implicit bias is defined as a ubiquitous societal preference for a social group that is both unconscious and automatic informed by an individual's experiences and perceptions of others (86). Physician implicit bias may negatively impact patient communication, clinical assessments, and decision-making for vulnerable patients (87–89).

The disparity domains examined are co-linear. Race/ethnicity and the various social determinants of health are intricately linked. Some studies adjust for the confounding effects of each determinant. While this allows a category such as race/ethnicity to be examined individually, it may not reflect the true extent of the 'real-life' disparity for these groups.

Most of the studies examining surgical access disparities utilized large existing retrospective databases. The disparity domains examined are thus limited to the availability of these variables in the databases themselves. The disparity domain for measures of surgical access disparities were predominately race/ethnicity followed by insurance status and income. Few studies examined other disparity domains such as HIV status (90), immigration status (14), linguistic isolation (91) and residing in a high health risk community (92).

Limitations of this review include that all measures were stratified into one surgical specialty and surgical access domain. Some cumulative disparity measures may include more than one surgical specialty. These were largely classified as general – this may skew the evidence map displaying access disparities towards general surgery. We included only studies quantitatively comparing surgical access measures which found a significant disparity. As such, if the evidence map does not show a measure in each area, it is not known whether this is because there is no research in this area or if there is literature that did not find a significant disparity.

The evidence map illustrates areas for future targeted quality improvement intervention and areas where more research is needed. Cells populated with many measures are areas where disparity improvement initiatives may be targeted. An example of a populated cell is the surgical indication detection domain in vascular surgery. Measures in this cell are largely delays in presentation of peripheral arterial disease or abdominal aortic aneurysms, presentation delays may result in emergent and/or more invasive surgical procedures. Quality improvement efforts to reduce disparities in this area may be warranted. The evidence map also illustrates cells with few or no measures, some of these cells are in surgical fields where there are known disparities in surgical outcomes. These are areas where further health outcomes research examining disparities are warranted.

## Conclusion

Two hundred and twenty-three measures of surgical access disparities in the US are available. These measures were categorized using a four-faceted conceptual model for surgical access; Provider Access, Surgical Indication Detection, Progression to Surgery and Receipt of Optimal Care. This model establishes a novel paradigm for conceptualizing surgical access disparities. These measures were illustrated in an evidence map which displays many critical gaps in the literature. It is essential to incorporate measures of surgical access disparities into future surgical improvement initiatives.

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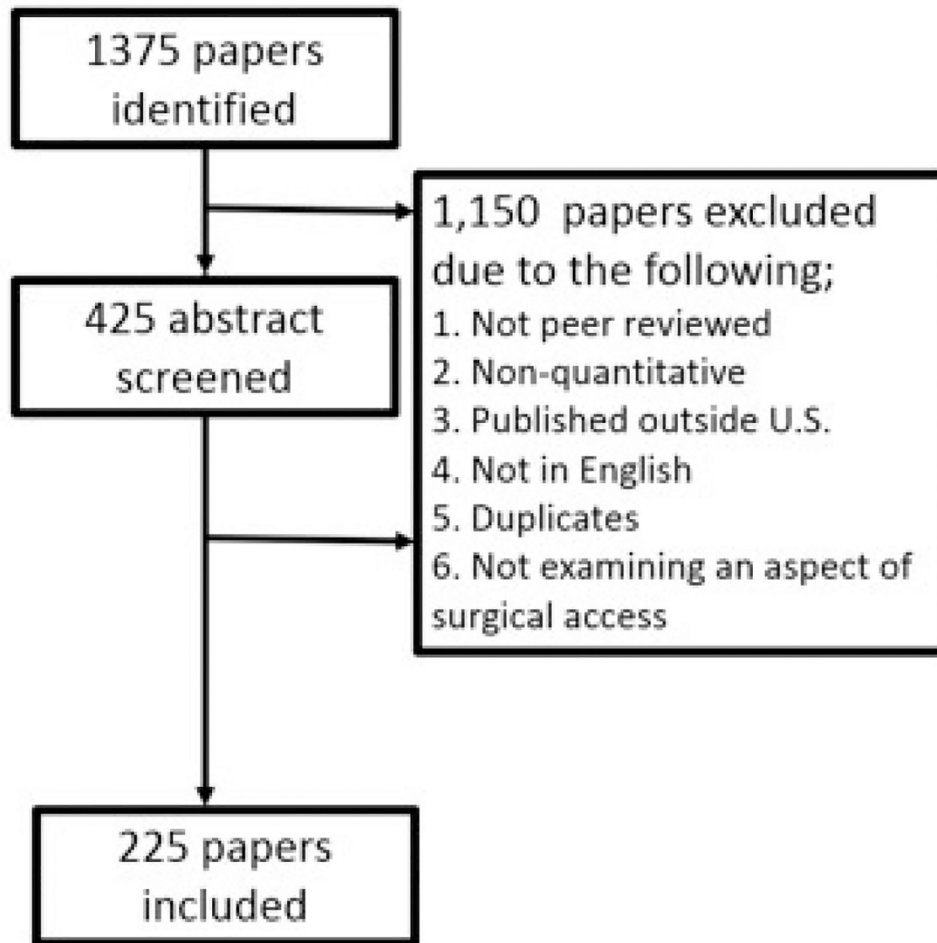
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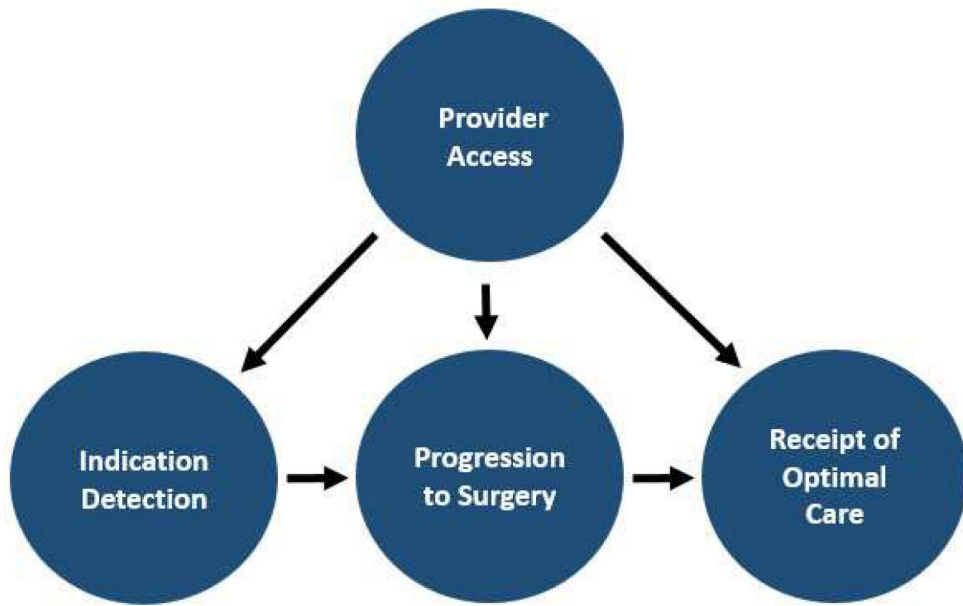
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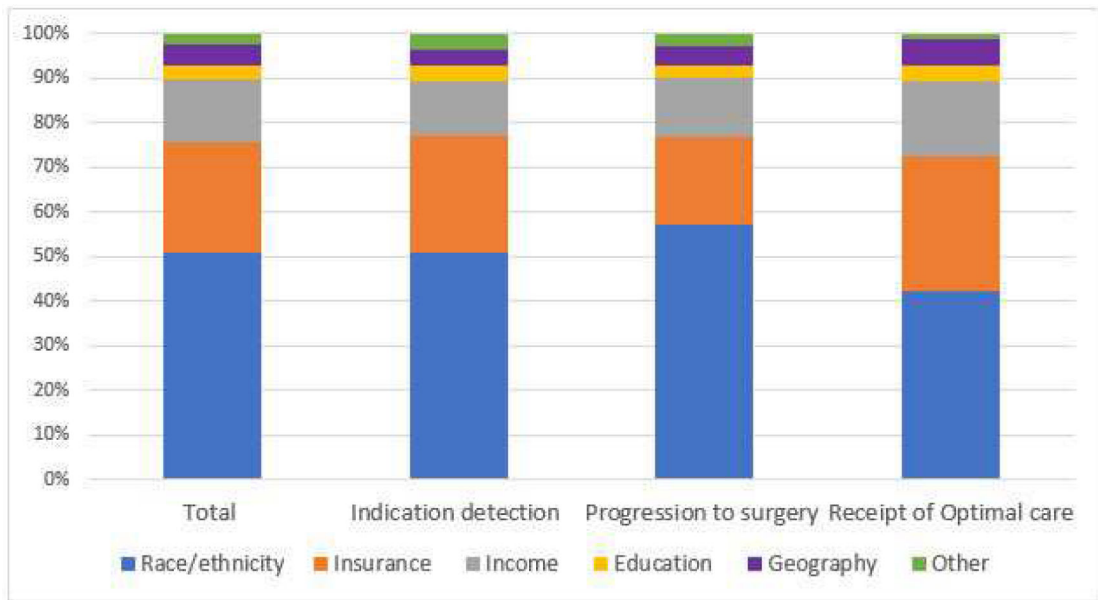
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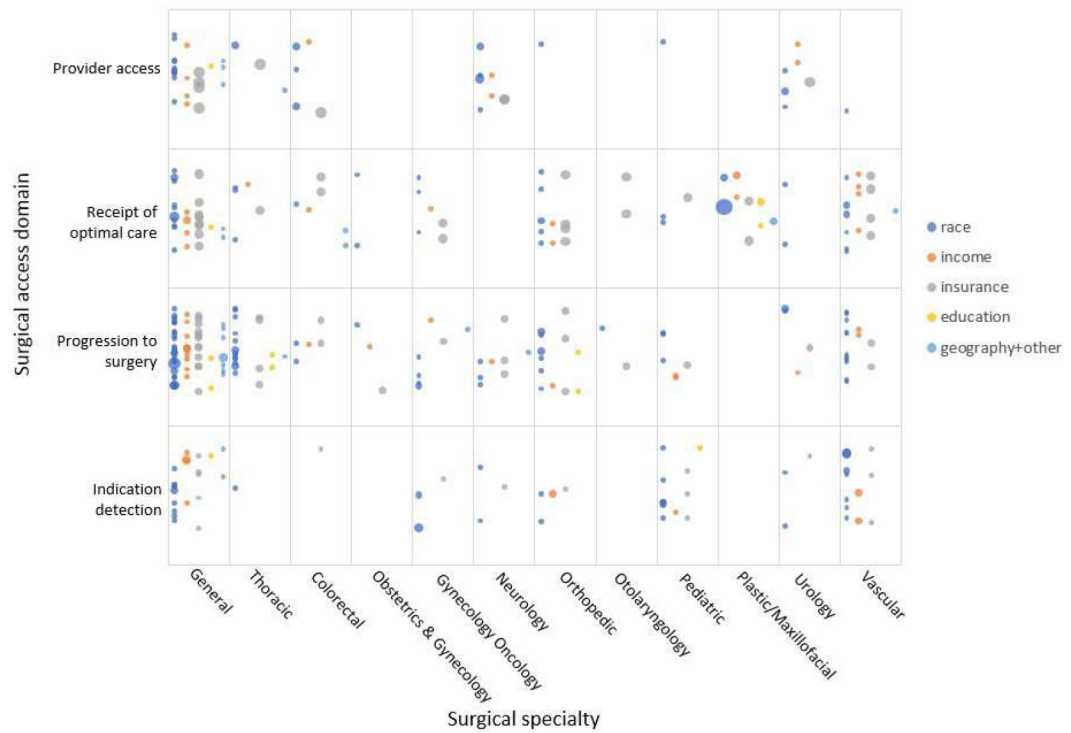
**Fig 1.** Flow diagram of studies for inclusion in a systematic literature review of measures of surgical access in the US.



**Fig 2.**  
A conceptual model for classifying surgical access disparity measures in the US.



**Fig 3.** Measures of surgical access disparities in each surgical access segment categorized by disparity domain (race/ethnicity, insurance, income, education, geography, and other).



**Fig 4.**

Evidence map of measures of surgical access disparities in the US. \*Bubble size indicates number of studies supporting each measure. Plotting of the bubbles in each cell is systematic to increase readability of the figure. Horizontally, the bubbles are in five rows based on the disparity domain (color). A random placement generator was used to distribute bubbles vertically inside each cell.

**Table 1:**

## Provider Access Measures of Surgical Access Disparities

Measure	Disparity group examined	Surgical specialty
Surgical access disparity		
Proportion of patients with traumatic brain injury discharged to rehabilitation, long term acute care or nursing facilities	Racial/ethnic (15–17); insurance (15, 17)	Neurological
Proportion of patients receiving trauma care who are discharged to an inpatient rehab facility	Other- undocumented immigrants(13)	General
Proportion of patients who are referred to cardiac rehabilitation post percutaneous intervention or cardiac surgery	Other- hospital specific (14)	Thoracic
Proportion of patients with access to a level 1 or 2 trauma center within 60 minutes via ambulance or helicopter	Income (12); geography (12); insurance (12)	General
Disparity in the use of low volume hospitals/ low volume surgeon/safety net hospital use/hospital use with higher risk adjusted mortality		
Hepatocellular carcinoma liver surgeries	Racial/ethnic (93); income (93); education (93)	General
Pancreatic cancer resection	Racial/ethnic (94)	General
Knee arthroplasty	Racial/ethnic (95)	Orthopedic
Total hip replacement	Racial/ethnic (96)	Orthopedic
Thyroidectomy	Racial/ethnic (97, 98); Insurance (98); income (98)	General
Coronary artery bypass grafting	Racial/ethnic (99) (100)	Thoracic
Adrenal operation	Racial/ethnic (101)	General
Endocrine surgery	Racial/ethnic (92); other - high health risk communities (92)	General
Receiving radical prostatectomy at center offering robot-assisted radical prostatectomy	Racial/ethnic (102); income (102); insurance (102)	Urology
Localized prostate cancer treatment by high volume urologist	Racial/ethnic (103)	Urology
Diagnosis by low volume and change to high volume for prostate cancer treatment	Racial/ethnic (103)	Urology
Colorectal cancer care	Racial/ethnic(104); insurance (104)	Colon & rectal
Trauma surgery	Racial/ethnic(105)	General
Carotid endarterectomy	Racial/ethnic(41)	Vascular
Critical limb ischemia amputation or revascularization	Racial/ethnic (106); income (106); insurance (106)	Vascular
Breast cancer resection for patients aged >65years	Racial/ethnic (75)	General
Pediatric neurooncological surgery	Racial/ethnic(107, 108); income (107)	General
Brain tumor craniotomy	Racial/ethnic (42); insurance (42)	Neurological
Breast cancer, colorectal cancer, gastric cancer, lung cancer, pancreatic cancer, coronary artery bypass grafting, angioplasty, abdominal aortic aneurysm repair, carotid endarterectomy, total hip replacement	Racial/ethnic (72)	General



Measure	Disparity group examined	Surgical specialty
Esophageal, pancreatic and colorectal cancer procedure	Racial/ethnic (109); insurance (109)	General
Ovarian cancer surgical care	Racial/ethnic (110, 111)	Gynecologic oncology
Endometrial/uterine cancer	Racial/ethnic (112, 113)	Gynecologic oncology
Benign prostatic hypertrophy treatment access to hospitals offering laser prostatectomy	Income (114)	Urology
Scoliosis surgical procedure	Racial/ethnic (115)	Orthopedic
Grouped oncology- colectomy, cystectomy, esophagectomy, gastrectomy, hysterectomy, lung resection, pancreatectomy, prostatectomy	Racial/ethnic (116); income (116); insurance (116)	General
Acute ischemic stroke admission to hospitals performing mechanical thrombectomy at high volume	Racial/ethnic (117); income (117); insurance (117)	Neurological

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**Table 2:****Surgical Indication Detection Measures of Surgical Access Disparities**

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Stage of diagnosis for pediatric patients aged <math>\leq 21</math> diagnosed with primary sarcomas	Racial/ethnic (118)	Pediatric
Stage of diagnosis for pediatric patients diagnosed with well differentiated thyroid cancer	Income (119); education (119); insurance (119)	Pediatric
Stage at diagnosis of pediatric patients aged <math>\leq 10</math> years diagnosed with melanoma	Racial/ethnic (120)	Pediatric
Stage at presentation of pediatric patients aged <math>\leq 18</math> years diagnosed with primary central nervous system tumors	Racial/ethnic (121)	Pediatric
Stage of diagnosis for patients diagnosed with a pancreatic neuroendocrine tumor	Racial/ethnic (26)	Pediatric
Stage of diagnosis at presentation of patients diagnosed with adenocarcinomas	Racial/ethnic (122); geography (122)	General
Stage of diagnosis for patients diagnosed with rectal cancer	Insurance (24)	Colon & rectal
Stage at diagnosis of patients with endometrial cancer	Racial/ethnic (112, 123, 124)	Gynecologic oncology
Stage at diagnosis of patients with cervical cancer	Insurance (125); racial/ethnic (126, 127)	Gynecologic oncology
Stage at diagnosis of patients with breast, prostate or colorectal cancer	Income (128) education (128)	General
Stage at diagnosis of patients with breast cancer (female)	Racial/ethnic (18, 19); income (18–20); geography (20); insurance (21)	General
Stage at diagnosis of patients with breast cancer (male)	Income (22)	General
Proportion of patients with metastatic disease at the time of diagnosis of small bowel carcinoid tumor	Racial/ethnic (129)	General
Stage at diagnosis of patients with soft tissue sarcoma (in the extremity)	Racial/ethnic (130)	Orthopedic
Proportion of patients with well differentiated thyroid cancer detected incidentally on unrelated imaging	Insurance (131)	General
Stage of tumor disease severity at presentation for patients with brain tumors	Racial/ethnic (42); insurance (42)	Neurological
Stage at diagnosis of patients with hepatocellular carcinoma	Racial/ethnic (25); insurance (25)	General
Stage at diagnosis of patients with lung cancer	Racial/ethnic (23)	Thoracic
Stage at diagnosis of patients with vestibular schwannoma	Racial/ethnic (132)	Neurological
Later stage of diagnosis for patients diagnosed with prostate cancer measured by prostate specific antigen (psa) level or gleason scores	Racial/ethnic (133)	Urology
Proportion of patients with chronic venous insufficiency presenting with advanced disease requiring ulcer debridement	Racial/ethnic (134)	Vascular
Clinical severity score in venous insufficiency patients presenting for radiofrequency ablation	Racial/ethnic (135)	Vascular
Proportion of patients with peripheral artery disease presenting with critical limb ischemia	Racial/ethnic (136)	Vascular
Proportion of peripheral artery disease presenting with critical limb ischemia who undergo a revascularization attempt (limb salvage) vs amputation	Racial/ethnic (27, 137)	Vascular
Severity of patients with peripheral artery disease at presentation (patency)	Racial/ethnic (27–29); insurance (28, 29, 31); income (29, 30)	Vascular
Rate of limb salvage in patients presenting with advanced peripheral arterial disease	Racial/ethnic (27, 29, 138); insurance (29, 31);	Vascular

Measure of surgical access disparity	Disparity group examined	Surgical specialty
	income (29, 30)	
Proportion of patients undergoing carotid endarterectomy for asymptomatic carotid artery stenosis	Insurance (139) ; racial/ethnic (139)	Vascular
Age at first presentation of patients presenting with pediatric nonsyndromic craniosynostosis	Racial/ethnic (140)	Pediatric
Age at first surgical intervention for patients presenting with pediatric nonsyndromic craniosynostosis	Insurance (141); racial/ethnic (141)	Pediatric
Proportion of pediatric patients with perforated appendicitis	Racial/ethnic (32, 46); income (32, 46); Insurance (32)	Pediatric
Proportion of pediatric appendicitis patients experiencing symptoms > 48 hours before surgical presentation	Racial/ethnic (32)	General
Proportion of patients with perforated appendicitis	Insurance (142)	General
Pre-operative knee replacement wellbeing scale	Racial/ethnic (33)	Orthopedic
Pre-operative knee replacement pain intensity scale	Racial/ethnic (33)	Orthopedic
Complexity score of presenting problems at a tertiary care hand surgery facility (higher)	Insurance (143)	Orthopedic

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**Table 3:**

Progression to surgery measures of surgical access disparities.

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of women with pelvic organ prolapse offered a surgical option	Income (34); insurance (34)	Obstetrics & gynecology
Proportion of patients with advanced knee/hip replacement being recommended for a total joint replacement	Racial/ethnic (144)	Orthopedic
Proportion of patients with sensorineural hearing loss meeting the audiology criteria for cochlear implantation receiving pediatric cochlear implant referral	Insurance (36); other -married parents (36)	Otolaryngology
Proportion of patients with hepatocellular carcinoma receiving a surgical referral	Geography (145); insurance (145)	General
Proportion of patients with locoregional pancreatic cancer receiving a surgical consult or evaluation	Racial/ethnic (35)	General
Cumulative proportion of patients with breast, prostate, lung or colorectal cancer, who undergo indicated surgical treatment	Income (128); education (128)	General
Cumulative proportion of patients who receive indicated first course directed surgery for breast, prostate, lung, uterine, cervix, ovarian, melanoma, urinary bladder and colorectal cancer	Racial/ethnic (146)	General
Proportion of patients who receive all indicated treatment for breast, prostate, lung, uterine, cervix, upper gi, head & neck cancer, hodgkin lymphoma and diffuse b cell lymphoma	Other -hiv patients (147)	General
Proportion of patients who undergo indicated pancreatic cancer surgical resection	Insurance (90, 122); racial/ethnic (35, 122); Geography (122)	General
Proportion of patients who undergo indicated pancreatic neuroendocrine tumor surgical resection	Racial/ethnic (26)	General
Proportion of patients who undergo indicated pancreatic adenocarcinoma surgical resection	Racial/ethnic (148) ; income(149)	General
Proportion of patients who undergo indicated surgery for uterine grade iii endometrial adenocarcinoma, carcinosarcoma, clear cell carcinoma & papillary serous carcinoma	Racial/ethnic (123)	Gynecologic oncology
Proportion of patients who undergo definitive surgery for high grade endometrial cancer	Racial/ethnic (150)	Gynecologic oncology
Proportion of patients who undergo definitive surgery for cervical cancer	Insurance (125)	Gynecologic oncology
Proportion of patients who undergo stage adjusted surgery for cervical cancer	Racial/ethnic (127)	Gynecologic oncology
Proportion of patients who undergo indicated prostate cancer resection	Racial/ethnic (133, 151); insurance (151); income (151)	Urology
Proportion of patients undergoing surgical resection for lung cancer	Racial/ethnic (59, 152)	Thoracic
Proportion of stage adjusted patients undergoing surgical resection for lung cancer	Racial/ethnic (59)	Thoracic
Proportion of patients undergoing surgery for localized non-small cell lung cancer	Racial/ethnic (153, 154)	Thoracic
Proportion of patients undergoing surgical resection for stage i and ii non small cell lung cancer within 6 weeks of diagnosis	Racial/ethnic (155)	Thoracic
Proportion of patients undergoing surgical resection, chemotherapy or radiation for stage iii non small cell lung cancer within 6 weeks of diagnosis	Racial/ethnic (155)	Thoracic
Proportion of patients undergoing surgical resection for stage i and ii non small cell lung cancer	Racial/ethnic (156)	Thoracic

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of patients with lung cancer receiving the 'standard' therapy	Insurance (157)	Thoracic
Proportion of patients undergoing surgical resection for breast cancer	Income (20, 73); geography (20) ; racial/ethnic (43, 73)	General
Proportion of patients undergoing surgical resection for non-metastatic breast cancer	Racial/ethnic (74)	General
Proportion of patients aged over 65 years who receive primary surgical treatment (mastectomy or breast conserving surgery) for stage i and ii breast cancer	Racial/ethnic (75)	General
Proportion of patients who receive stage specific treatment for breast cancer	Insurance (71)	General
Proportion of patients undergoing surgery for colorectal cancer	Racial/ethnic (73); income (73); Insurance (158)	Colon & rectal
Proportion of patients undergoing definitive surgery for rectal cancer	Insurance (24)	Colon & rectal
Proportion of patients older than 80 years undergoing surgery for colorectal cancer	Racial/ethnic (159)	Colon & rectal
Proportion of hiv patients who receive indicated cancer treatment for cumulative solid tumor and lymphoma	Racial/ethnic (147); insurance (147)	General
Proportion of patients undergoing debulking surgery for ovarian cancer	Income (160)	Obstetrics & gynecology
Proportion surgery for ovarian cancer	Racial/ethnic (160, 161)	Obstetrics & gynecology
Proportion of patients undergoing surgery for soft tissue sarcoma of the extremities	Racial/ethnic (130)	Orthopedic
Proportion of patients undergoing hepatectomy or ablation for hepatocellular carcinoma	Racial/ethnic (162)	General
Proportion of patients undergoing esophagectomy for esophageal cancer	Racial/ethnic (163)	General
Proportion of patients undergoing surgery for vestibular schwannomas	Racial/ethnic (132)	Neurological
Proportion of patients with peripheral arterial disease meeting vascular lab criteria for procedural intervention receiving the intervention (angioplasty, stenting, endarterectomy or bypass grafting)	Racial/ethnic (79)	Vascular
Proportion of patients with carotid artery disease meeting vascular lab criteria for intervention undergoing a procedure [carotid end arterectomy or stenting]	Racial/ethnic (79) insurance (164)	Vascular
Proportion of patients undergoing procedure when admitted for a traumatic brain injury	Insurance (15)	Neurological
Proportion of patients undergoing mechanical revascularization procedures after acute ischemic stroke	Racial/ethnic (117); income (117); insurance (117)	Neurological
Proportion of elderly patients with arteriovenous fistulas among hemodialysis patients	Racial/ethnic (165)	Vascular
Proportion of patients undergoing total joint replacement for advanced knee/hip osteoarthritis	Racial/ethnic (144, 166); income (166)	Orthopedic
Proportion of patients undergoing knee replacement for knee osteoarthritis	Education (167); insurance (167)	Orthopedic
Proportion of patients undergoing hip replacement for hip osteoarthritis	Education (167); insurance (167)	Orthopedic
Proportion of patients with scoliosis undergoing surgical intervention	Insurance (115); racial/ethnic (115)	Orthopedic
Proportion of patients undergoing catheter ablation for atrial fibrillation	Racial/ethnic (168); insurance (168)	Thoracic

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of patients undergoing a procedure (angiogram, per cutaneous intervention, coronary artery bypass grafting) during/after acute myocardial infarction admission	Racial/ethnic (169); sex (169)	Thoracic
Proportion of patients undergoing coronary revascularization (coronary artery bypass grafting or percutaneous coronary intervention) after myocardial infarction	Racial/ethnic (170); education (170); insurance (170)	Thoracic
Proportion of patients undergoing aortic valve replacement for severe aortic stenosis	Racial/ethnic (171)	Thoracic
Proportion of patients declining indicated aortic valve replacement recommendation for severe aortic stenosis	Racial/ethnic (171)	Thoracic
Proportion of patients receiving indicated bariatric surgery	Racial/ethnic (172, 173); geography (172); income (173, 174); insurance (173)	General
Proportion of patients receiving bariatric surgery, laparoscopic gastric bypass, when indicated	Racial/ethnic (175)	General
Proportion of patients undergoing tympanostomy tube placement for otitis media	Racial/ethnic (176)	Otolaryngology
Proportion of medicare patients undergoing deep brain stimulation surgery for parkinson's disease	Racial/ethnic (177); income (177)	Neurological
Time between diagnosis of pediatric well-differentiated thyroid cancer to intervention	Income (119); insurance (119)	General
Time between diagnosis of gynecological malignancy to surgery	Other - public vs. Private hospital (178)	Gynecologic oncology
Time between presentation of pediatric abdominal pain to appendectomy	Racial/ethnic (46); income (46)	Pediatric
Time between diagnosis via sonogram of carotid stenosis warranting carotid endarterectomy and carotid endarterectomy receipt	Racial/ethnic (47)	Vascular
Time between clinical presentation of ureteropelvic junction obstruction to urology evaluation/pyeloplasty	Racial/ethnic (179)	Urology
Time between abnormal imaging or core biopsy to surgery for breast cancer patients	Racial/ethnic (43-45); insurance (44)	General
Time from polysomnography test recommending adenotonsilectomy for children with sleep disordered breathing to receipt of adenotonsilectomy among pediatric patients	Insurance (180)	Otolaryngology
Proportion of adults undergoing knee arthroplasty	Racial/ethnic (37, 38)	Orthopedic
Proportion of adults over 65 undergoing knee/hip arthroplasty	Racial/ethnic (39)	Orthopedic
Proportion of patients with peripheral vascular disease receiving lower extremity amputation	Racial/ethnic (181)	Vascular
Proportion of patients undergoing an elective abdominal aortic aneurysm repair per population	Racial/ethnic (40)	Vascular
Proportion of patients receiving a thoracic endovascular aneurysm repair per population	Racial/ethnic (182)	Vascular
Proportion of people receiving stress urinary incontinence surgery per population	Racial/ethnic (183)	Vascular
Proportion of people receiving carotid endarterectomy per population	Racial/ethnic (41)	Vascular
Outpatient surgery volume per population	Racial/ethnic (184)	General
Number of general surgeons per population	Racial/ethnic (184)	General
Number of carotid endarterectomy, lumbar spine fusion, knee replacement, aa repair, prostatectomy, hip replacement, aortic valve repair, open & internal fixation of the femur and appendectomy procedures per population	Geography (185)	General

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Number of laparoscopic appendectomy procedures per population	Racial/ethnic (186); income (186)	General
Proportion of patients with diabetes hospitalized for diabetes-related cardiovascular disease who receive a cardiac procedure (percutaneous transluminal coronary angioplasty, coronary artery bypass grafting)	Racial/ethnic (187)	Thoracic
Proportion of patients undergoing angiography and revascularization procedures after myocardial infarction	Racial/ethnic (188); income (188)	Thoracic
Proportion of patients with lumbar spine stenosis who undergo surgery	Racial/ethnic (189)	Orthopedic
Ratio of emergency to elective gastrointestinal procedures among pediatric patients	Racial/ethnic (190)	Pediatric
Ratio of emergency to elective abdominal aortic aneurysm procedures	Racial/ethnic (40)	Vascular
Ratio of emergency to elective thoracoabdominal aortic aneurysm procedures	Racial/ethnic (191)	Vascular
Ratio of emergency to elective craniectomy procedures for brain tumors	Racial/ethnic (42); insurance (42)	Neurological
Ratio of cumulative emergency to elective biliary, hernia and colorectal operations	Racial/ethnic (192)	General
Proportion of patients with early hepatocellular carcinoma who receive a liver transplant	Racial/ethnic (25, 162, 193–195); Insurance (25, 193, 194)	General
Proportion of patients with hepatocellular carcinoma receiving surgery (local ablation or a liver transplant)	Income (162); insurance (162)	General
Proportion of patients not listed on hepatocellular carcinoma liver transplant list for non-medical reasons	Insurance (194); racial/ethnic (194)	General
Proportion of patients placed on the liver transplant list for end stage liver disease	Education (196); insurance (196); racial/ethnic (196)	General
Proportion of patients with end stage liver disease referred to a transplant center	Racial/ethnic (196)	General
Proportion of patients who attend a transplant center if referred for end stage liver disease	Racial/ethnic (196)	General
Higher model for end-stage liver disease (meld) score on liver transplant waitlist	Racial/ethnic (197)	General
Proportion of patients receiving a liver transplant within 3 years of being listed	Racial/ethnic (197)	General
Higher model for end-stage liver disease (meld) score at presentation to a liver transplant center	Racial/ethnic (198)	General
Proportion of patients referred early for liver transplant evaluation	Racial/ethnic (198)	General
Proportion of patients on the active renal transplant waitlist	Other- linguistic isolation (199)	General
Proportion of patients who are referred for a renal transplant	Income (91)	General
Proportion of patients who die whilst on renal transplant waitlist	Income (200)	General
Proportion of patients on the renal transplant waitlist who received a renal transplant	Income (200) ; racial/ethnic (201)	General
Proportion of patients who attend/present to their first renal transplant evaluation appointment	Racial/ethnic (201)	General
Proportion of patients on the renal transplant waitlist who are inactive due to loss of follow up	Racial/ethnic (201)	General
Median time from transplant referral to deceased donor transplant	Racial/ethnic (201)	General
Time from a patient starting renal dialysis to being placed on the renal transplant waitlist	Insurance (202); income (202); racial/ethnic (202)	General

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of patients who receive a preemptive (pre-dialysis initiation) decreased donor renal transplant	Insurance (203); racial/ethnic (203)	General
Proportion of patients who receive assessment for renal transplantation	Insurance (204); racial/ethnic (204)	General
Proportion of pediatrics patients who receive a preemptive renal live donor transplant	Racial/ethnic (205)	General
Proportion of patients with cystic fibrosis who are accepted onto the lung transplant waitlist after their first lung transplant evaluation	Insurance (206); education (206); income (206)	General

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**Table 4:**

## Receipt of Optimal Care Measures of Surgical Access Disparities

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of early-stage, unilateral breast cancer patients receiving breast reconstruction after mastectomy	Racial/ethnic (48–56); insurance (48, 50, 52, 54–56); geography (48, 57); income (50, 54); education (50, 51)	General
Proportion of patients receiving breast reconstruction during the same hospitalization (i.e. immediately) after mastectomy	Insurance (152, 207); racial/ethnic (77, 78); income (77); education (77)	General
Proportion of stage 0 to ii unilateral breast cancer patients receiving contralateral prophylactic mastectomy	Racial/ethnic (208)	General
Ratio of mastectomies performed in outpatient vs. Inpatient settings	Racial/ethnic (209)	General
Proportion of patients with hepatocellular carcinoma who undergo bridging locoregional therapy among all patients who receive an orthotopic liver transplant	Racial/ethnic (210); education (210); insurance (210)	General
Proportion of patients with soft tissue sarcoma who receive limb sparing surgery	Racial/ethnic (211, 212)	Orthopedic
Proportion of patients with ovarian cancer undergoing bowel resection, peritoneal biopsy/omentectomy	Racial/ethnic (111)	Gynecologic oncology
Proportion of gastric cancer patients with surgically treated gi malignancy receiving “adequate lymphadenectomy” (more than 15 esophagus, 15 stomach, 12 small bowel, 12 colon, 12 rectum, and 15 pancreas)	Income (58)	General
Proportion of lung cancer patients receiving appropriate lymph node resection	Racial/ethnic (59)	Thoracic
Stage-adjusted proportion of lung cancer patients receiving appropriate lymph node resection	Racial/ethnic (59)	Thoracic
Proportion of ovarian cancer patients who have the recommended number of lymph nodes removed	Racial/ethnic (111)	Gynecologic oncology
Proportion of breast cancer patients who have the recommended number of lymph nodes removed	Racial/ethnic (76)	General
Proportion of patients with gastric cancer who have the recommended number of lymph nodes removed	Insurance (213)	General
Proportion of patients localized/regional prostate cancer who have the recommended number of lymph nodes removed	Racial/ethnic (214)	Urology
Proportion of pediatric patients presenting to the emergency department with abdominal pain who received abdominal ct imaging to confirm appendicitis	Racial/ethnic (46); insurance (46)	General
Proportion of patients with end-stage renal disease who have an arteriovenous fistula at initial hemodialysis	Racial/ethnic (215)	Vascular
Proportion of patients with acute cholecystitis who receive immediate cholecystectomy	Insurance (60); racial/ethnic (60)	General
Proportion of all patients admitted for acute ischemic stroke who receive reperfusion on the first admission day, invasive angiography, and operative procedures including carotid endarterectomy	Income (216)	Neurological
Proportion of all carotid endarterectomy surgeries with inappropriate clinical indicators (high comorbidity in asymptomatic patient, operating in a setting of a recent or severe disabling stroke, minimal stenosis, operating contralateral to symptoms, occluded artery)	Racial/ethnic (41)	Vascular
Proportion of patients with lower extremity fractures (open tibial/fibular and femoral fractures) who undergo amputations	Racial/ethnic (61)	Orthopedic
Proportion of patients with graves' disease who receive a thyroidectomy	Income (217)	General
Proportion of patients presenting with blunt injuries with pelvic fractures who receive diagnostic procedures (vascular ultrasound, ct of the abdomen),	Insurance (218)	General

Measure of surgical access disparity	Disparity group examined	Surgical specialty
transfusions, venous pressure monitoring, and arterial catheterization for embolization		
Proportion of patients with symptomatic heart failure who receive biventricular pacing	Racial/ethnic (219); income (219); insurance (219)	Thoracic
Proportion of patients undergoing major elective orthopedic surgery who receive autologous blood transfusion	Insurance (220); income (220); racial/ethnic (220)	Orthopedic
Proportion of patients receiving laparoscopic vs. Open hysterectomies	Racial/ethnic (63)	Obstetrics & gynecology
Proportion of patients receiving laparoscopic vs. Open hysterectomies for the indication of fibroids	Racial/ethnic (64)	Obstetrics & gynecology
Proportion of patients receiving laparoscopic vs. Open hysterectomy for uterine cancer	Racial/ethnic (113)	Gynecologic oncology
Proportion of breast cancer patients who receive breast conservation surgery vs. Mastectomy	Insurance (18, 21); racial/ethnic (19, 66, 67); income (66, 68)	General
Proportion of cumulative open vs. Laparoscopic rates of cumulative colorectal surgery for colorectal cancer, diverticular disease, inflammatory bowel disease and benign colorectal tumors	Racial/ethnic (221)	Colon & rectal
Proportion of patients undergoing surgery for colorectal cancer who have laparoscopic vs. Open surgery	Income (222) ; insurance (222, 223); geography (223)	Colon & rectal
Proportion of patients undergoing surgery for ulcerative colitis open vs. Laparoscopic surgery	Insurance (224)	General
Proportion of patients undergoing a laparoscopic vs. Open surgery appendectomy, gastric fundoplication or gastric bypass	Racial/ethnic (62)	General
Proportion of patients undergoing acute surgery, minimally invasive vs. Open for appendectomy or cholecystectomy	Racial/ethnic (65); insurance (65)	General
Rates of laparoscopic vs. Open appendectomies for patients ages between 11 and 18.	Racial/ethnic (225)	Pediatric
Proportion of patients undergoing an abdominal aortic aneurysm repair via endovascular vs. Open surgery	Racial/ethnic (226, 227); insurance (226)	Vascular
Proportion of patients undergoing a thoracic aortic repair via thoracic endovascular aortic repair vs. Open surgery	Racial/ethnic (228);	Vascular
Proportion of patients presenting with critical limb ischemia from peripheral arterial disease undergoing endovascular or open revascularization vs. Amputation	Racial/ethnic (106, 229); income (106); insurance (106)	Vascular
Proportion of patients receiving a non-traumatic amputation as the transfemoral compared to transtibial position	Income (230); insurance (230); Other- sex (230)	Orthopedic
Proportion of patients with choledocholithiasis receiving ercp vs. Common bile duct exploration	Geography (231)	General
Proportion of patients undergoing a radical prostatectomy vs. A minimally invasive radical prostatectomy	Racial/ethnic (232)	Urology
Proportion of patients who underwent a breast conserving surgery for breast cancer completing the recommended length of radiation	Insurance (18) ; racial/ethnic (43)	General
Proportion of patients post mastectomy for local-regionally advanced breast cancer receiving local radiotherapy	Geography (233)	General
Proportion of patients post endometrial cancer surgery completing the recommended adjuvant radiotherapy/chemotherapy course	Insurance (124)	Gynecologic oncology
Proportion of women receiving surgery for ovarian cancer who receive the recommended adjuvant chemotherapy post operatively	Income (160)	Gynecologic oncology

Measure of surgical access disparity	Disparity group examined	Surgical specialty
Proportion of patients discharged post lower limb trauma admission who receive follow up inpatient care	Insurance (234)	Orthopedic
Proportion of patients with cervical cancer who undergo surgery and do not receive the recommended postoperative radiotherapy	Insurance (125)	Gynecologic oncology
Proportion of patients who receive a stoma reversal	Racial/ethnic (69) ; insurance (69) ; income (69)	General
Proportion of patients receiving post hospital trauma care	Insurance (235)	General
Proportion of people with a colon cancer colectomy who receive the recommended adjuvant chemotherapy	Geography (236)	Colon & rectal
Proportion of patients with primary extremity soft tissue sarcoma who receive adjuvant radiation	Racial/ethnic (211)	Orthopedic
Proportion of patient who have femoral shaft internal fixation materials removed	Racial/ethnic (70); Income (70)	Orthopedic
Proportion of prelingual patients who receive a cochlear implant undergoing a sequential cochlear implantation on the other side	Insurance (237)	Otolaryngology
Proportion of patients who miss a follow up appointment post cochlear implantation	Insurance (237)	Otolaryngology
Proportion of patients who fail to arrive at an appointment at a tertiary hand surgery referral center	Insurance (143)	Orthopedic

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