Recent Strategies in High Risk Surgery

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Preface

> Rather than reacting to every risk we hear and see, we should make an effort to discern which ones we can do something about.
>
> —Ben Carson, 2007 [1]

The first surgical operation (or should it be designated as a spiritual one?) was conducted on Adam (Genesis, Chap. 2). One of his ribs was extracted during sleep and converted into a whole woman, Eve. Theoretically it might, if viable stem cells were collected from bone marrow, fat, and other sources. They could then be grown in laboratory conditions and differentiated into all possible tissues. Yet establishing these myriads of cultures, converting them into full organs, assembling and harmonizing them into a living and functioning organism overnight would be a formidable task, definitely demanding a miraculous context.

Given enough time, if a recipient oocyte were used along with assisted reproduction techniques, a less mind-boggling nuclear transfer from Adam could perhaps do the trick. However, the book of Genesis provides no clue about a surrogate mother or a pregnancy preceding Eve's appearance. One way or another, both donor and recipient had a tranquil night. They were awake and in excellent shape the next morning, so the intervention could hardly qualify as high-risk surgery.

More dangerous were amputations performed during civilian life and particularly in military conditions, a rather recent and well-documented example being the Crimean War (1854–1856), often conducted on casualties suffering from severe injuries and shock. Indeed, amputations are deemed the oldest and most practiced major operation since Ancient Times, being documented even in the Prehistoric Era. Certainly not the safest procedures, as hemorrhage and infection were the rule. Due to lack of anesthesia, they had to be performed in minutes. It was not uncommon that a finger or two of the medical assistants holding the targeted limb were amputated as well depending on the haste, technical skill, and manual dexterity of the surgeon.

Reportedly, the most accomplished and humane of the professionals in the alluded to Eastern European clash was Nikolay Pirogov, Professor of Surgery at the Imperial Academy of Military Medicine in Saint Petersburg, Russia. Did he fulfill

the requirements for a surgeon as defined in the Middle Ages by Guy de Chauliac (1300–1368): an eagle's eye, a lion's heart, a lady's hand? He is definitely credited with the invention of the first system of triage, classifying the injured Russian combatants into five modalities according to risk, as well as with the isolation of those bearing infected wounds in order to diminish cross contamination, insisting as well on thorough ventilation of the hospitals. Moreover, he established a group of volunteer nurses to take care of severely ill or disabled soldiers, one of the first such teams in the world.

By the way, the title of founder of modern nursing was conquered during the same Crimean War by a volunteer at the inimical British Army, namely Florence Nightingale, not only on account of her dauntless dedication to the wounded, but also because of her subsequent lucid and widespread publications, still cited today. Last but not least, it should be added to the merits of the previously mentioned Pirogov the pioneering introduction of anesthesia in the battlefield (with chloroform) [2].

What is currently the intraoperative complication surgeons abhorring most? All events that can be followed by sudden heart arrest, from anesthesia accidents to ventricular fibrillation to abrupt hypoxia are frightening; however, these are uncommon in general surgery. Less rarely, one encounters massive bleeding and hemorrhagic shock, particularly within the trauma context, which can run out of control. As a matter of fact, nowadays, the majority of the casualties die after the operation, not in the course of it, even though a few succumb on the spot. Epidemiological surveys confirm that uncontrolled bleeding is the most frequent cause of death in the surgical theater. Arrhythmias and heart arrest are also mentioned, whereas in the Intensive Care Unit infectious complications cannot be omitted.

Irreversible exsanguination has been particularly associated with certain subsets of trauma nominally liver bursting, crush injuries of the pelvis, rupture of the heart or major vessels, and post-transfusion coagulopathy. It represents an exorbitant challenge for the surgeon and should always be considered in high energy trauma requiring large volumes of blood, particularly in those with more ominous prognosis as indicated by the Injury Severity Score (ISS) or the regional Abbreviated Injury Scale (AIS).

Of course, the concept of high-risk surgical patients encompasses the whole perioperative period and all major organs and systems, not just the incision and the tissues temporarily under the scalpel blade. Book chapters are divided into preoperative and postoperative modalities for technical and didactic purposes only. Surgical risk is not a discrete measurement isolated from time, space, and context. On the contrary, its tools and resources such as clinical evaluation, validated indices and biomarkers, respiratory and circulatory dynamics, data collated from the operative field and other metrics need to be pieced together in a big and often changing meteorological map. Reflections and reinterpretations are mandatory until the patients is out of harm's way.

Are there surgical candidates of such a high risk that they are absolutely unfit for surgery? Even if they are not explicitly terminal or moribund? That's not an

infrequent dilemma, potentialized by narrow-mindedly assessing indexes, scales, and scores. Currently, any operation with a probability of fatal outcome above 10% (some authorities set the cut-off point at 5%) is classified as a high-risk intervention. It goes beyond saying that these patients should be scrupulously reevaluated and discussed before any surgical decision is adopted.

What about operative repair of a ruptured abdominal aortic aneurysm, which incurs risks of up to 40–50% mortality? [3]. A legitimate argument in favor of the procedure is that no survival at all is the rule when nothing is done. Yet not many will consider this business as usual, or a stage for conventional indications and algorithm presets. Besides potentially beneficial alternatives like endovascular repair, seasoned and responsible professionals will walk the extra mile, meticulously addressing objective findings such as life expectancy along with functional, social, and cognitive status. From the point of view of ethics and human values, listening to the patient and his/her family is even more critical, with emphasis on their expectations and priorities regarding survival versus independence and quality of life.

According to the Aphorisms of Hippocrates (400 BCE), "He who would become a surgeon should join an army and follow it." Yet in less ancient times, it was emphasized that war was "the worst training for an immature surgeon and probably bad for a mature one" [4]. Historically, it has acted both ways. For most young medical professionals, draft evasion was the preferred route as recruitment meant career interruption, harsh life conditions, and the daily danger of death. At the same time, it was a magnet for a couple of others, ready to pay a high price for the chance of conducting anatomical studies and notably acquiring surgical experience, no matter how austere and chilling the environment is.

In Renaissance Italy (sixteenth century) Andreas Vesalius, known as the Father of Anatomy, was able to publish his masterpiece *De humani corporis fabrica*, on the basis of relatively undisturbed dissections. It is true that eventually the Catholic Inquisition decreed his death on account of such "profanations"; however, he was able to commute the sentence. Analogously Dr. Nicolaes Tulp, a renowned Amsterdam surgeon in the seventeenth century, could quite freely use human bodies collected from beggars or hanged criminals, for his surgical refinement and notably for teaching anatomy. There was no inquisition in the predominantly protestant Netherlands at that time, and one of his anatomy classes famously depicted by Rembrandt, ranks among the most reproduced paintings by the Old Master.

In Britain and the USA, there was no Tribunal of the Holy Office either, nonetheless use of cadavers for teaching or training was illegal or sharply limited till the middle 1800s, fostering the practice of bodysnatching. Around two centuries ago, medical students themselves sometimes engaged in graverobbing in the USA, so that their anatomical studies would not be compromised. Fortunately, along the twenty-first century legislation in virtually all countries regularized skeleton use for medical teaching. Yet in Britain supply was scarce leading to regular importations from Southeast Asia from the 1930s till the 1980s. Although little information is available, it is likely that these restrictions stimulated a few surgeons to forge ahead for professional advancement abroad, including armed conflicts.

Many landmark achievements in the handling of the seriously injured were effectively spearheaded by military personnel, such as the first mobile field hospitals in tents, as well as the first organized ambulance corps during the American Civil War of 1861–1865 (horse drawn wagons). Yet there is evidence in favor of Baron Dominique-Jean Larrey, renowned as the chief surgeon of Napoleon's army, for the invention of the *ambulances volantes* ("flying" ambulances) during the French Revolutionary Wars (1792–1799), more specifically in 1793. If simple carts and hammocks are considered, these were actually employed by fighting armies much earlier since ancient times.

Orthopedic care including fracture and nerve injury along with rehabilitation is believed to have started during World War I, blood transfusion and intravenous saline are inextricably linked to World War II (even though not widely available and thus sparingly used) [5], and helicopter transfer of critical cases to the Vietnam War (mostly during the last part of it, in the late 1960s and the 1970s). The last-mentioned conflict marked the advent of early mechanical ventilation for severe adult respiratory distress syndrome/ARDS. As soldiers were not as often succumbing to renal failure as during WWII, due to more abundant intravenous fluids and a better understanding of hemorrhagic shock, ARDS converted into a relatively early and irreversible mechanism of death. Forrest Bird, the inventor of the handy and ubiquitous mechanical ventilator, adapted the helicopters for apparatus use so more seriously injured casualties could be evacuated alive till the hospital [6].

At this point, one should not construe that civilian surgical life stood still. As early as 1505, the Royal College of Surgeons of Edinburgh was established. The French created the Académie Nationale de Chirurgie in 1731, to some extent emulated by the *Medical Surgical Society of Bologna, Italy* (*Societas Medica Chirurgica Bononiensis*) in 1802. A Collegium Chirurgicum Amstelaedamense had been organized in 1736 in Amsterdam (The Netherlands); however, it was more a professional guild than a scientific society. The USA joined the crowd much later. In 1879, an Academy of Surgery was established in Philadelphia, followed by the American Surgical Association (1880) and the American College of Surgeons (1913).

Such worthy trailblazers notwithstanding, the Extracorporeal Life Support Organization (ELSO) did not start before 1989, the Surviving Sepsis Campaign/SSC just in 2002, the Transplantation Society was born in 2003, the Enhanced Recovery After Surgery for Perioperative Care/ERAS Society in 2010, and the Surgical Data Science Initiative in 2016. It is not surprising that after such a relatively short life span concepts espoused by some of these organizations, particularly by SSC and ERAS, are still deemed as controversial.

Given that technical advances were not rarely marred by troublesome and costly backtracks, their implementation has been typically slow. Many active professionals who finished residency around the 80s and early 90s probably trained without surgical intensive care units, or at best with very simple and insufficiently equipped ones. Treatment protocols and guidelines for surgical emergencies were lacking or irregularly enforced, and monitoring devices were underused. Current concepts of fluid and electrolyte balance, sepsis, shock, mechanical ventilation, blood coagulation and thrombosis, nutritional and metabolic care, solid organ transplantation,

therapeutic interventional radiology, endoscopic handling of complications, robotic surgery, not to speak of state-of-the-art antibiotics and anticoagulants, extracorporeal membrane oxygenation or mechanically assisted circulatory support, surfaced only in recent decades and are still evolving.

Within an environment so packed with challenges, uncertainties, and constraints, is it conceivable that personal attitudes of the surgeon enhance the problem ? In some circles, it is surmised that surgeons are intrinsically arrogant and narcissistic, carrying along a large ego. It is believed that they trust more their personal knowledge and accumulated experience than anything or anyone else [6]. Such frame of mind would not be conducive to careful patient evaluation, to consulting with or listening to colleagues and other healthcare professionals, and to a lifelong drive towards technically and scientifically updating oneself, which presuppose a hefty degree of humility and recognition of one's limitations.

From the point of view of patient care, excessive self-sufficiency could end up not only in ethical breaches but in sheer disaster, even in face of relatively common disease contexts [7]. However, there is an unquestionable exaggeration in these judgments. Ill prepared and overconfident surgeons definitely exist, as other healthcare and lay professionals, and their missteps lend themselves to deplorable situations such as the anecdote reproduced below, yet there is little ground for generalization.

One surgical resident after finishing his training program, settled in a faraway place. Years later, he revisited his *alma mater* and met his old mentors. He told them that he was quite happy in his city, where he had become a specialist in complicated cases. Who referred to him those complications? It is very simple, he answered. All patients that I operate on become complicated.

There is no question that high quality multidisciplinary teams handle even the most demanding redo operations cleanly and effectively, whereas for novices the tiniest deviation from the standard path could mean big trouble, whether the patient was previously classified as high risk or not. Major societies nominate centers of surgical excellence precisely for the guidance of residents and fellows, who search reputable places for training and professional update, in a range of clinical settings from the elective and straightforward till the most emergent and unpredictable ones. Of course, patients and health insurance companies are no less eager to engage with such centers, given their star performance, which enhances the stimulating atmosphere of such centers, and supports them so they can stay at the forefront of the specialty. However, even the most experienced and well-equipped units do not rest on their laurels and their phronesis. They prognostically investigate every single admission, very closely monitoring those in the higher echelons of risk.

If the fault does not squarely lie on the shoulders of the surgeons, at least not on the responsible and qualified ones, maybe surgical ambience and general atmosphere are flawed and biased, carrying part of the blame for inappropriate patient selection or matching intervention. Many generations of surgeons were trained to become lone heroes or commanding officers, something which translated into highly skilled and resolute technicians, not necessarily humanists and team workers. Some did consult whenever possible with clinical colleagues and with the

anesthesiologist in case of serious comorbidities. The patient's feelings were also taken into consideration. However, the final decision in favor or against operation, as well as the choice of timing and extent of the intervention was unwaveringly personal and non-transferable. For many of them, it would be an intolerable loss of face, a "capitis diminutio" if others intervened in the process and they were instigated and coaxed to comply with, as the concept of multidisciplinarity was vague, misunderstood and underrated.

Only in recent decades have academic and a few nonacademic institutions established surgical committees composed of a variety of medical specialties, in charge of assessing candidates for elective high-risk surgery or organ transplantation, and of recommending the aptest operative treatment, if any. The surgeon's voice is respected: first and foremost, it is his or her procedure and ultimate responsibility. Nevertheless, the trend is always for the collective judgment to prevail, and indeed such becomes registered in hospital files. Although reluctant in the beginning surgeons now fully endorse such dialogue, as it leads to better tailored interventions with a safer postoperative period, more successful long-term outcomes, and much less overall morbidity and mortality. Potentially futile or poorly dimensioned procedures are openly discussed and appraised in this environment.

Incidentally, such initiatives also incentivize surgeons to expand the boundaries of the comfortable yet confined universe of their specialty, delving into and becoming familiar with the procedures, techniques, and therapies of internists, endoscopists, interventional radiologists, anesthesiologists, intensivists, and surgeons in competing domains, thus becoming able to robustly participate in the committee's deliberations. Of course, the opposite is analogously true, as other specialists will miss the point and fail to effectively contribute to the surgical committee, if they are not cognizant of all the tools, risks, and recent trends of the trade.

Do the abundant technical and scientific options and advances mean that a surgeon must convert into an omniscient, Olympic expert in all fields? A Renaissance style polymath at ease with all possible troubles, and a moving encyclopedia up to date till the very last article? Of course, these are tall orders demanding an artificial intelligence managed database, not a book, and a range of servers and data centers, not a human brain. Electronic libraries, surgical video repositories and scientific digital hubs exist of course, and a helpful selection is cited at the internet site item of the book. Ordinary chapters logically address more basic needs for bedside and general use. The crux of the endeavor is to assist the surgeon in an effective way and in the real world, not for grandiose performances in remote settings such as video conferences or surgical grand rounds. The prize is not for simply navigating the bewildering maze, but for safely arriving at the destination.

By the way the European Society for Vascular Surgery (ESVS), following the steps of a handful of other organizations, has recently implemented "Virtual Vascular—A living textbook with chapters published every month." The rationale is that the traditional vascular textbook (and by extension, any surgical book) is dead because "parts of even the latest textbooks are obsolete, as soon as they are published." Digital publishing in turn never should get old because it can promptly be

amended, updated, or replaced. Moreover, it can be accessed with a variety of desk and portable devices from essentially anywhere.

One should not deride the praiseworthy approach. Nevertheless, what are review journals, electronic or in paper format, if not ongoing textbooks with new chapters all the time? Typical publications in other areas, however occasionally concerning surgery like CA-A Cancer Journal for Clinicians and Disease-A-Month, exist since respectively 1950 and 1954. More focused journals like *Surgery, Gynecology and Obstetrics* (now Journal of the American College of Surgeons/JACS) have been publishing reviews since the first half of last century, in early times of the narrative model and more recently as scoping, systematic, or umbrella modalities with or without meta-analysis.

It is unprecedented for standard books to be retracted or detracted as a consequence of such competition. There will always be room for virtual and printed material presented as journals, books, bulletins, internet sites, or electronic libraries. A galaxy of opportunities means that everyone can find his or her slot under the sun. The critical point is that all should be authoritative, pertinent, useful, well-referenced, and as up to date as feasible. Last minute electronic text and video guides, checklists, and technical sketches are not hard to come by, so missing or superseded information can and should be replaced and complemented.

According to renowned inventor Richard Buckminster Fuller (1895–1983), general human knowledge was estimated to duplicate every century until 1900. The interval dropped to a quarter of a century by 1945. Now doubling occurs after 12 h only [8]. Conflicting data is available for medical knowledge, yet still overpowering: it doubled every 50 years until 1950, then every 7 years in 1980, every 3–5 years by 2011, and the forecast for 2020 was 73 days [9]. Evidently, these figures are questionable and they oftentimes include pure trash. Regarding trustworthy and credible information, only a handful is directly or indirectly pertinent to surgery although still representing a data deluge.

Not even electronic chapters can be prepared every day or every few hours, like buns on the production line of a bakery, so as not to miss the very latest advances. If by chance they were, and this would require a Herculean commitment by both authors and readers, there would still exist fresher material waiting in the pipeline. It is not unlike the dog trying to catch its tail, or Aristotle's paradox of the hare chasing the slow tortoise. No matter how much success is accomplished or how punctiliously updated a text is, this will always be a job half done, a Sisyphean, never-ending task.

To the best of our knowledge, this is the first book addressing a continuum of management, care, and strategies for high-risk surgical candidates, not just for conventional populations or encompassing routine therapeutic approaches. One that bypasses artificial dilemmas generated by a mega-data search of the literature, or improvised solutions which lack the indispensable groundwork, targeting instead tested and proven even though often innovative options and pathways. And despite multi-authorship from major universities in several continents, one with a streamlined presentation of conditions, tools and strategies, parsed and curated for ready implementation.

References

1. Carson B, Lewis G. Take the risk: learning to identify, choose and live with acceptable risk. Grand Rapids: Zondervan; 2007.
2. Barton CR, Beeson M. Anesthesia for trauma during wartime. CRNA. 1997;8(1):2–12.
3. Hoornweg LL, Storm-Versloot MN, Ubbink DT, Koelemay MJW, Legemate DA, Balm R. Meta analysis on mortality of ruptured abdominal aortic aneurysms. Eur J Vasc Endovasc Surg. 2008;35:558–70.
4. Gerbode F. A definition of surgery. Ann Surg. 1963;158(5):775–7.
5. Pierre NL, Yeo CJ, Tholey RM. What we owe the world wars: challenges that fueled surgical innovation. Am Surg. 2021;87(9):1525–28.
6. Forrest Bird. percussionaire.com/about/our-legacy. Accessed 22 Nov 2022.
7. Stanbouly D, Chuang SK. Humility will get you further than ego or pride in your career as a surgeon. J Stomatol Oral Maxillofac Surg. 2022;123(3):269–70.
8. Ray A. Human knowledge is doubling every 12 h. www.linkedin.com. Accessed 3 Jan 2023.
9. Anonymous. The importance of critical thinking skills at a time of exponential growth of medical knowledge. https://ifdhe.aha.org/education-events/importance-critical-thinking-skills-time-exponential-growth-medical-knowledge. Accessed 18 Feb 2023.

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Contents

Part I
Preoperative Evaluation and Management

Chapter 1
Surgical Risk in Distressed or Underserved Populations

McKenzi Heide, Emma Johnson, and Christopher DuCoin

Introduction

Every surgical procedure comes with an associated risk of morbidity and mortality. However, there is large disparity in post-surgical outcomes between disadvantaged communities and their more privileged counterparts that is not explained simply by natural variability in inherent risk. For example, when a Black adult man is rolled in to an elective or emergent surgical procedure, he has as much as a 36% higher chance of death than his White counterpart [1]. In addition, ones' economic status can accurately predict their life expectancy [2, 9]. Although we persistently optimize surgical techniques, pre and postoperative management and standards of care, this gap in outcomes continues to elude us, likely signifying a systemic failure to address the true issue.

Medical care is estimated to account for roughly 20% of modifiable risk factors that contribute length and quality of life [3]. The remaining 80% are composed of modifiable risk factors that can be defined as social determinants of health (SDOH). The CDC describes these SDOH as "nonmedical factors that influence health outcomes … the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life" [4].

Five key concepts of social determinants of health [4, 5]:

- *Healthcare access and quality*:
- Including geographic proximity to care, monetary access to care, and perceived discrimination by providers preventing care
- *Education access and quality:*

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- Quality of free public schooling and access to higher education
- *Social and community context:*
- Social support from relationships and interactions with family, friends, co-workers, and community members as well as social stressors such as racism, marginalization, and bigotry
- *Economic stability:*
- Economic Stability refers to the stress of poverty, access to proper nutrition, and insurance etc. Economic stability is often used interchangeably with socioeconomic status (SES). In literature, SES is often assessed using the ADI index which is a composite measure of 17 census variables based on income, education, household characteristics, and housing [6]. Additionally, SES may also be described using geographic locations via the Social Vulnerability index (SVI) which also uses census data to rank locations on 16 social factors, including poverty, lack of vehicle access, and crowded housing, and minority status [7].
- *Neighborhood and built environment:*
- Neighborhood is the socioeconomic composition, crime, social cohesion, and support of the community as well as disorder such as trash, graffiti, abandoned or dilapidated buildings, and infrastructure [5].
- Built environment is the physical attributes of our surroundings that influence individual health behaviors. Examples include walkability and recreation; health amenities such as well stocked grocery stores and parks, and undesirable amenities such as fast-food restaurants and liquor stores [5].

It is well established that SDOH are associated with health outcomes in general and outcomes of surgical procedures. Despite this knowledge, the medical disparities seen along the lines of class, race, and location have not improved and continue to drastically affect the prognosis and outcomes of patients. One possible reason for this is that though these factors are often separated in literature for ease of organization and study, they will always be intertwined in reality. The systemic and confounding nature of SDOH makes them difficult to address as an individual practitioner. In the following chapter we will describe the outcomes of high-risk surgeries in economically and socially marginalized communities, with the ultimate goal being to identify specific variables seen in literature that may play a significant role in disparities and provide possible solutions for the individual surgeon in their practice.

Cardiothoracic and Vascular Surgeries

Cardiovascular disease (CVD) remains the leading cause of mortality in the United States. Thus, the effects of SDOH on CVD in particular have been more broadly studied than many other disease states. Regarding socioeconomic status, it is known that increasing social disadvantage is associated with more prevalent cardiovascular risk factors, inflammation, and incidental cardiovascular disease [8]. As for race, Black adults experience higher burden of cardiovascular risk factors such as hypertension

and obesity and are more than twice as likely to die of CVD, relative to White adults [9]. When concerning neighborhood and built environment, those residing in high-vulnerability areas are less likely to receive care from high-volume hospitals and less likely to have stable primary care [9, 10]. Cardiothoracic and vascular surgeries are not immune to the effects of SDOH. When studied independently from chronic CVD, post-surgical outcomes in these fields are shown to be significantly linked to SDOH.

There is a clear racial divide between Black and White patients in surgical outcomes of many common high-risk cardiac surgeries. Wu et al. found Black race to be an independent risk factor for 30-day mortality following a carotid endarterectomy (CEA), with Black patients also showing a greater proportion of in-hospital death following a CEA procedure [11]. While studying race and coronary artery bypass graft (CABG) outcomes, Rangrass et al. found that non-white patients had 33% higher risk-adjusted mortality rates after the procedure than White patients (odds ratio [OR], 1.33; 95%CI, 1.23-1.45) [12]. Some of these gaps may be due to the quality of hospital and, when assessed independently, differences in hospital quality explained 35% of the observed disparity in mortality rates between races (OR, 1.22; 95%CI, 1.12-1.34). Overall Black patients are more likely to be in a low SES, present with greater disease burden, and receive care from lower volume surgeons and hospitals [9–12], all of which heavily impact surgical outcomes.

Low socioeconomic status, independent of race, is strongly associated with increased postoperative mortality and readmission following high-risk surgeries such as AAA repair, CABG and CEA [11– 15]. Impoverished patients are significantly more likely to present with ruptured AAA or symptomatic disease at initial carotid revascularizations, as well as more likely to undergo emergency rather than elective repair compared to patients of higher income class [11, 13]. Such differences in low-income populations may be attributed to decreased compliance with health screening, decreased access to primary care coverage, and increased use of low-volume surgeons [13]. It is logical to assume that the racial disparity is rooted in lower SES, as many of the same contributing SDOH are often cited when studying race and economic status, however SES does not fully explain outcome disparities as Black patients have worse outcomes following cardiac procedures than White patients of similar SES [15]. This suggests racism plays a fundamental role in disease or access to care and these healthcare disparities cannot be solely attributed to economic status. It is clear that while prior disease state affects surgical outcomes, there is no one sole contributor to risk. Rather, outcomes are affected by the complex interplay between socioeconomic status, access to health care, and the adverse effects (both generational and current) of stress and racism on overall health and wellbeing.

Surgical Oncology

Not surprisingly, the trend of health disparities is also seen in surgical oncology and those affected by these inequalities are disproportionately Black and Latinx. Despite NIH-funded research requiring inclusion of minorities since 1993, Stewart et al. found that racial and ethnic minorities and elderly patients are less likely to be

involved in surgical oncology studies relative to the proportion of incident of cancer they bear when compared to the White and younger population [16]. They proposed several barriers to participation, including patient-physician interaction, and they found that Black patients not only refused surgical intervention more frequently, but also were offered surgical intervention less than their White counterparts. Additionally, SES plays a role in minority patients' ability to access oncological clinical trials further demonstrating the overarching relationship between low income and access to healthcare. Elderly patients are also less likely to be involved in surgical oncology trials although they disproportionately bear the burden of increased incidence of cancer diagnoses. Townsley C. et al. propose that geriatric patients' comorbidities contribute at least partially to their lesser enrollment [17].

When focusing on colorectal cancer surgical interventions, a study out of Scotland found that patients of a lower SES have worse overall and cancer-related survival after curative surgery [18]. "Deprived" in the context of this paper refers to the Scottish Index of Multiple Deprivation that measures relative differences in factors such as fewer resources, lower income, and less opportunity across area codes. These deprived patients had twice the risk of postop mortality (as an independent predictor) compared to the patients from the highest SES studied (odds ratio 2.26 95% CI 1.45-3.53). The 5-year survival rate was similarly disparate, with the lowest SES patients having a 25% increased risk of mortality from colorectal cancer (95% CI 1.03-1.51) when early mortality was included in the calculations. A study out of the UK found that similarly, "deprivation" was an independent predictor of curative resection as well as overall survival [19].

Race also plays a role in the disparities of surgical oncology. Tripathi et al. reported that Black patients had a significant diagnostic delay to definitive surgery for stages I-III melanoma when compared to their non-Hispanic White counterparts, which is associated with higher melanoma-specific deaths [20]. In breast cancer, patients with delays from diagnosis to surgery of only 6 weeks had decreased survival, with this effect on survival once again more prominent in Black patients, patients of lower SES, and patients without insurance/using public insurance [21]. Sheppard et al. found that the time to surgery for black patients was 47 days versus 33 days for white patients ($p < 0.01$), HR 0.58 (95% CI 0.44-0.78) [22]. When looking at survival in epithelial ovarian cancer, Chan J et al. found that race was an independent prognostic factor [23]. Their analysis showed that Black patients with stage I-II disease had fewer lymphadenectomies (23% vs. 27.1% in White patients, $P < 0.001$) and fewer nodes identified (5 vs. 7, $P < 0.001$). While prior findings had demonstrated lymphadenectomy's prognostic value in these patients, their analysis did not show a statistically significant survival difference in patients that had LN dissection.

High-risk surgery outcomes, such as those following pancreaticoduodenectomy, HCC, and esophagectomy also have disparities over race and ethnicity. Several studies have reported that there is a racial difference in patients who receive surgery for resectable pancreatic adenocarcinoma, which can only be partially accounted for as patient refusal [24]. When analyzing borderline-resectable pancreatic adenocarcinoma specifically, White patients had pancreaticoduodenectomies more than

non-white patients (19.5% vs. 12.8%, $P < 0.001$) and RR 0.75 (CI 0.68-0.83, $P < 0.001$), with major influencing factors being insurance (Medicaid or lack of insurance), advanced patient age, and larger tumor size [25]. They did not find a significant difference in major non-curative surgeries between these two groups, which they propose is largely due to less access to care among Black patients. In a study that defines success of pancreaticoduodenectomy as TOO (Textbook Oncologic Outcome being resection, LN evaluation, normal hospital course, no mortality within 30 days, subsequent chemotherapy), several factors contributed to lower odds of achieving this success [26]. The failure to achieve TOO resulted in increased long-term mortality. These factors included having Medicaid (OR 0.85), being operated on at a community hospital (odds ratio 0.47), being Black (OR 0.79), and presenting at an advanced age (OR 0.97).

Similarly, with hepatocellular carcinoma, Black, Hispanic, and Native American/Alaskan patients had surgical treatment rates of 25–45% less than their White counterparts did, and these disparities were present even when adjusting for SES, geographic location, and tumor characteristics [27]. Patients were found to be 23% more likely to have surgery (resection with intention of removing all known cancer, ablation, or transplant) if their household income was over $45,510 ($P = 0.002$). For esophagectomies, there was a racial disparity in recommendation for surgery (odds ratio 3.03, CI 2.67-3.43, $p < 0.0001$), while lower SES was associated with worse overall survival [27, 28]. SES was measured with income quartiles, and there was a protective effect associated with higher incomes (hazard ratio 0.803, CI 0.742-0.867).

Trauma and Emergency General Surgery

As seen in previous sections of this chapter, SES is a known independent predictor of mortality following many major surgical procedures [31]. It is important to consider the comparison of circumstances of emergent surgery in trauma cases, versus planned or elective procedures and their disproportionately worse outcomes [32]. These emergent procedures may be even more prone to exacerbating SDOH. Unfortunately, there is less published on trauma surgery and race, age, gender, and geography than there is with other surgical subspecialties, but with the above in mind, similar conclusions may be drawn.

In trauma cases involving pediatric patients, LaPlant et al. found that Native American patients were 81% less likely than White patients to have emergency surgery after MVA [33]. In addition, Black patients were 23% less likely while Hispanic patients were 22% less likely. Rural patients also experience less frequent care from a Level I or II trauma center than their urban counterparts, at 3.32% vs. 11.83% and 2.63% vs. 9.67% respectively, and rural patients had a 14% higher risk of death after controlling for injury severity and type, age, sex, comorbidities, and region [34]. Cain et al. further discovered an increased mortality and complication rate in these high-risk surgeries directly associated with lower SES, stating that when compared to the highest SES, low-SES patients have a risk-adjusted mortality

rate 29.9% higher [32]. They found that these risks were present with adjustment to other factors and were not mitigated despite the presence of hospital resources intended to help low SES patients.

Diaz, A et al. found that non-elective colon cancer and diverticulitis surgery was 20% more likely in counties with highest social vulnerability when compared to those with the lowest [31]. Similarly, these high-vulnerability counties are twice as likely to have emergent versus elective cholecystectomies. These poor outcomes have a myriad of attributing factors, such as lack of insurance, transportation and language barriers, and lack of a primary care providing them with their age-appropriate cancer screenings (specifically cervical, breast, and colorectal cancers) [3, 32]. In short, patients in these vulnerable communities have less access to healthcare thus making an emergency presentation more likely.

A 2023 study by McCrum et al. illustrated that patients with low access to hospitals and able to complete emergency surgical care had a higher in-hospital mortality than high-access patients [35]. In this case, "access" was defined by distance to the hospital, its capacity, and the population demand. Better geographic access was protective against in-hospital mortality (OR 0.95, CI 0.94-0.97), without a significant difference in morbidity. Notably, the patients who accounted for the "low-access" group were more likely to be White.

The Interplay Between Race, Neighborhood, and Socioeconomic Status

Low SES

As discussed in previous sections of this chapter, one's health is not just affected by individual circumstances, but by an intertwining root system of social determinants. Thus, to understand how our patients are affected by SDOH, we must understand how these determinants coexist.

Low socioeconomic status is the social determinant of health most broadly associated with poor post-surgical outcomes [15, 31]. It has been well described in literature that patients of lower SES experience higher operative mortality. This contrast may be due to higher comorbidities, more severe disease at time of presentation due to delayed care, unsafe discharge conditions, and decreased access to high-quality surgical care. An intuitive example of this is seen in those suffering from homelessness. Non-housed populations have an increased risk of postoperative readmission than housed patients, despite lower measured postoperative complication rates [36]. Additionally, non-housed patients' risk of readmission is more strongly correlated to their comorbidities than that of housed patients, suggesting that they are less able to mitigate potential complications due to these comorbidities [36]. While the non-housed population is an extreme example of low SES, any person's ability to afford healthy food, safe living conditions, medications, wound care

supplies, and appropriate time for healing affects their health before and after surgery [9, 37]. From a broader view, the strong association between SES and health outcomes is likely aided by the interplay of the different SDOH. Often, lower income patients have several other social determinants of health such as living in highly vulnerable neighborhoods, non-white race, and decreased access to preventative health care, all of which lend themselves to worse health outcomes.

Neighborhood/Environment

Living in a disadvantaged or socially vulnerable neighborhood is independently associated with poorer post-surgical outcomes. One study found that the risk-adjusted probability of 30-day mortality was higher among patients from highly vulnerable counties after colectomy (OR 1.1 95%CI 1.1-1.3), CABG (OR 1.4, 95%CI 1.2-1.5) and lung resection (OR 1.4 [95%CI 1.1-1.8] [15]). Additionally, with these surgeries, patients who resided in highly vulnerable counties were 20–40% more likely to die and 10–20% more likely to experience a serious complication within 30-days of surgery [31].

Once again, the explanation for this disparity is likely multifactorial, as those residing in a highly vulnerable neighborhood are more likely to be socioeconomically disadvantaged, part of a minority ethnic group, or have more comorbidities [37]. Notably, independent of other factors, neighborhood is an important agent in one's personal health maintenance behaviors, that is, regular exercise or healthy diet. Highly vulnerable neighborhoods are less likely to have access to grocery stores with healthy food or safe recreational areas for exercise. This leads to worse baseline health and increased rate of comorbidities [9, 37]. These so-called food deserts are linked to poor health among all residents, but there is an even stronger association among individuals experiencing additional adverse SDOH such as economic instability [9]. Additionally, different neighborhoods may be more significantly affected by different SDOH. For example, predominantly non-white neighborhoods are more likely to exist in "pharmacy deserts," which are associated with worse medication adherence likely leading to worse treatment and prognosis.

Access

Access to care and access to high-quality care is also associated heavily with neighborhood, race, and SES. Those from highly vulnerable counties are more likely to present with advanced disease stage, more symptomatic disease, and need emergent surgery [11, 13, 15, 38]. This is likely largely due to decreased screening and access to primary care seen in low SES areas [9, 13, 39]. Simultaneously, despite more disease burden, low SES has also been associated with a decreased probability of receiving surgical care [15]. The exact cause of this is not well elucidated in

literature, though access to insurance, geographic separation from quality care, and difference in referral patterns may play a role. Nonetheless, reduced access to timely, high-quality surgical care exacerbates already existing health disparities seen in these patients and affects surgical outcomes.

Independent of SES and geographic location, Black and minority patients are less likely to receive surgery [40]. What's more, minority and Black patients are more likely to refuse surgery when offered [41]. While the rate of patient refusal is not large enough to explain the racial gap in surgical care, it is an important addition to our understanding. Johnson et al. found that physicians were more verbally dominant and less patient-centered in their approach to Black patients [42]. In this study, physicians spoke twice as much during encounters with Black patients than White patients and showed a less positive effect. Both provider affect, described as tone of voice and body language, and patient-centered communication, such as greater patient input, have been associated with better treatment adherence, and health outcomes [42]. Thus, implicit biases and cultural exposure may guide a surgeon's approach to each patient and impact if a patient will undergo surgery at all. Altogether, this points to the relevance of cultural competence in determining appropriate access to care. This is especially important due to the synergistic nature of SDOH, as racial minorities are affected more strongly by determinants such as SES.

Hospital Quality and Volume

Hospital quality and Hospital or surgeon volume is a crucial factor in access to care. There is an established inverse relationship between hospital volume and surgical mortality. Within this, surgeon volume may account for a relatively large proportion of the apparent effect of hospital volume [43]. Patients in highly vulnerable communities, with low SES, or racial minorities are more likely to receive surgical care from both low-volume hospitals and low-volume surgeons [11, 15, 29, 41]. To solidify the importance of this relationship, it has been shown that surgery at a high-volume or high-quality hospital mitigates some of the risk associated between low economic status and postoperative morbidity and mortality [15]. One could assume that patients use low-quality hospitals out of the convenience or necessity of proximity, but hospital choice is not entirely due to geographic location. When examining several high-risk surgeries, Dimick J. et al. found that Black patients were almost twice as likely as White patients to live within five miles of a high-quality hospital [29]. Additionally, in a subset of patients living within five miles of a high-quality hospital, Black patients were 33%, 44%, 110% more likely than their White neighbors to go to a low-quality hospital for CABG, lung cancer resection, and AAA repair respectively. This disparity was stronger in highly segregated areas and completely disappeared when looking only at areas of low segregation. The mechanics of this are not well elucidated however, it may be explained by patient preference, as Black patients may feel unwelcome in hospitals with a low volume of Black patients, or by race-related differences in physician referral patterns [15].

Despite this, there is variable evidence of the volume-outcome relationship by specific surgery. An umbrella analysis by Hoshijima et al. showed that, when compared with several other oncologic, cardiac, and vascular high-risk surgeries, only pancreaticoduodenectomy fulfilled the criteria of class I and II evidence for both hospital and surgeon volume-mortality relationships, with a decrease in OR for hospital (0.42, 95% confidence interval [CI] [0.35–0.51]) and for surgeon (0.38, 95% CI [0.30–0.49]) [30]. Despite this, there is a clear association between SDOH and hospital choice and low-volume hospitals that largely serve marginalized and underfunded populations are consistently associated with worse outcomes. This may be linked to difficulty recruiting well-trained specialty surgeons or funding policies that have a disproportionally negative impact on low-volume/safety net hospitals. However, it is clear that the root cause of disparities in outcomes is complex and more research is needed before attempts at centralization can be made.

Race

Black race is a known risk marker for poor surgical outcomes. As seen throughout this chapter, Black patients are more likely to present later in the course of their disease, need emergent surgery, as well as seek treatment at lower-volume centers that often have worse quality of care [15, 29]. Again, research points largely to discrepancies in access to care being associated with factors such as SES or insurance status. But the clear gap in post-surgical mortality rates between Black and White patients cannot be attributed purely to this. Race continues to present as an independent risk factor even when adjusting for hospital quality and SES [12, 15, 44]. High SES does partially mitigate post-surgical risks of mortality and morbidity among Black patients. However, Black patients are more profoundly affected by SDOH than White patients are, and have worse surgical outcomes than White patients of the same SES [12, 15, 44]. Moreover, neighborhood-level racial/ethnic segregation is associated with increased risk of CVD in Black, compared with White patients [9]. This indicates that racism in the United States may play a fundamental part in underlying health and wellbeing.

Race as a Marker

It is important to consider the way in which we use race in the context of medical research. Race should not be framed as a "risk factor," as risk factor is defined as something with a causal role in disease development. Rather, it is racism that puts the burden of risk factors largely on certain groups of people. Assuming that race is a risk factor is a fallacy that ignores the generalization that not every Black, Latino, nonwhite patient has the same risk factors such as CAD, metabolic syndrome, SES, etc. [45]. It has been proposed that race should be thought of not as a risk factor but as a

"risk marker" instead; a factor that is noncausal in its association to disease [46]. Additionally, race is not a biological entity, but a socially constructed one. It is often used in place of ethnicity or conflated with a genetic or biological cause for disease. Structural racism and generational trauma, as well as the healthcare inequalities that we've demonstrated in this chapter still exist today, continue to perpetuate health disparities [46]. This idea exemplifies the inherent difficulty of addressing SDOH confounding variables that are highly individualized to each patient. We must be careful not to use the massively oversimplified and incorrect implication of "race" as a risk factor to ease the logistics of our research and patient care. Instead, we must look at our patients as people with multifaceted risk markers that contribute to their health.

Addressing SDOH

Solutions at the Level of the Individual Surgeon

SDOH are often predetermined outside of the healthcare setting. This makes them difficult to address from the standpoint of the individual provider. Traditionally, the onus has been on the primary care physician to address chronic health issues, social issues, and lifestyle changes. When faced with the continued health disparities seen in this country, it is time to address a core idea that routine surgical care may not be sufficient. Though the individual provider is not responsible for changing a patients' social circumstances, surgical visits may be an untapped resource for the socially responsible surgeon to initiate risk factor reduction.

Ogden et al established a framework of sustained life change following la life crisis [47]. The authors found that most successful lifestyle changes were precipitated by a significant life crisis, be it health related or not. However, many people go through crisis and do not initiate sustaining changes. For example, a patient may not stop smoking until after their fourth MI. This study established that life crisis was an important trigger for change but became sustained when associated with three factors:

- *Disruption of function*: The unhealthy behavior served a function in a patient's life. For example, smoking was stress relief while in a bad romantic relationship. If a life crisis removes the function of the behavior, such as breaking up with the aforementioned significant other, sustained cessation is more likely.
- *Reduction of choice*: The precipitating life crisis creates a sense of decreased ability to choose to do the unhealthy behavior. For example, a patient may move into a social group where smoking is socially unacceptable, or a patient may be unable to eat certain foods after bariatric surgery.
- *Behavioral model of causes and solutions*: This is an internalized understanding that lifestyle choices are directly related to health consequences.

A life crisis gives patients an opportunity to create a new identity for themselves. Then subsequently, social or medical intervention decreases a need for the habit, medical intervention and education creates perceived decrease in choice to continue

the habit, and education introduces a cause-and-effect behavioral model solidifying the foundation of healthy lifestyle choices as the core of ones' new self. Thus, a preoperative visit with a surgeon, particularly for a high-risk surgery as those discussed in this chapter, is the perfect opportunity to address lifestyle modification and other SDOH. It is in these moments that patients may be most willing to initiate change but it is unlikely that change will be sustained without proper support and education from their provider [48].

An example of this in practice is the program Strong for Surgery through the American College of Surgeons [49]. This campaign works to integrate preoperative checklists for elective operations to screen for potential risk factors that can lead to surgical complications, and to provide appropriate interventions to ensure better surgical outcomes. The checklists target eight areas known to be highly influential determinants of surgical outcomes: Nutrition, Glycemic Control, Medication Management, Smoking Cessation, Safe and Effective Pain Management after Surgery, Delirium, Prehabilitation, and Patient Directives. A purposeful initiative such as this enables change by providing clear health goals to both patients and surgeons. Additionally, a clear framework may aid in catching social determinants that actually can be addressed by individual providers.

Systemic Solutions

There is a need for improved data collection on SDOH. The current data collected on SDOH is often an indirect measure of true patient experience. Yet, to address determinants, researchers need to understand SDOH at a base level, such as through individual health behaviors, while also controlling for variables such as neighborhood and SES. Variables such as these have the ability to immensely modify the current data available on patient experience while simultaneously improving outcomes, making further investigation a necessity. Not only is SDOH data difficult to collect and time consuming for the individual provider, but there is also inconsistent use of standardized patient risk assessment protocols for screening, and a significant lack of diversity in research studies across all fields of medicine [50]. There needs to be a strong push from the surgical community for greater data collection. Emphasizing the importance of this increased data collection will inherently increase the *generalizability* of the work done and the applicability of this to the general population.

However, Individual surgeons are limited to the change they can make when addressing SDOH. The most enduring solution will come from systemic policy changes that would work to create a more equitable health care system and prioritize population health. Surgeons can and must play a role in championing change, which should begin through the advocacy of health equity in their own patients. It is indisputable that inequalities affect the health of both surgical and medical patients, thus health equity is everyone's responsibility. As a field, surgeons must accept the importance of SDOH, make a dedicated effort to identify disparities, and respond with advocacy.

References

1. Harris E. Older black men have higher mortality after elective surgery. JAMA. 2023;329(12):969. https://doi.org/10.1001/jama.2023.3197.
2. Fox M. Social determinants of health and surgery. An overview. The American College of Surgeons; 2021. https://bulletin.facs.org/2021/05/social-determinants-of-health-and-surgery-an-overview/. Accessed 6/30/23 2023.
3. Magnan S. Social determinants of health 101 for health care: five plus five. In: NAM perspectives. National Academy of medicine; 2017. https://nam.edu/social-determinants-of-health-101-for-health-care-five-plus-five/. Accessed 30 Jun 2023.
4. CDC. Social determinants of health at CDC. 2022. https://www.cdc.gov/(2022). Accessed 30 Jun 2023.
5. Gomez SL, Shariff-Marco S, DeRouen M, Keegan TH, Yen IH, Mujahid M, et al. The impact of neighborhood social and built environment factors across the cancer continuum: current research, methodological considerations, and future directions. Cancer. 2015;121(14):2314–30. https://doi.org/10.1002/cncr.29345.
6. Maroko ARDT, Arno PS, Hubel M, Yi S, Viola D. Integrating social determinants of health with treatment and prevention: a new tool to assess local area deprivation. Prev Chronic Dis. 2016;13:160221. https://doi.org/10.5888/pcd13.160221.
7. CDC. Agency for Toxic Substances and Disease Registry: CDC/ATSDR SVI Fact Sheet. 2022. https://www.atsdr.cdc.gov/placeandhealth/svi/fact_sheet/fact_sheet.html. Accessed 30 Jun 2023.
8. Acquah I, Hagan K, Javed Z, Taha MB, Valero-Elizondo J, Nwana N, et al. Social determinants of cardiovascular risk, subclinical cardiovascular disease, and cardiovascular events. J Am Heart Assoc. 2023;12(6):e025581. https://doi.org/10.1161/jaha.122.025581.
9. Javed Z, Haisum Maqsood M, Yahya T, Amin Z, Acquah I, Valero-Elizondo J, et al. Race, racism, and cardiovascular health: applying a social determinants of health framework to racial/ethnic disparities in cardiovascular disease. Circ Cardiovasc Qual Outcomes. 2022;15(1):e007917. https://doi.org/10.1161/circoutcomes.121.007917.
10. Khera R, Vaughan-Sarrazin M, Rosenthal GE, Girotra S. Racial disparities in outcomes after cardiac surgery: the role of hospital quality. Curr Cardiol Rep. 2015;17(5):29. https://doi.org/10.1007/s11886-015-0587-7.
11. Wu WW, Mota L, Marcaccio C, Liang P, Moreira CC, Hughes K, et al. Impact of neighborhood social disadvantage on carotid artery disease presentation, management, and discharge outcomes. J Vasc Surg. 2023;77(6):1700–9.e2. https://doi.org/10.1016/j.jvs.2023.01.204.
12. Rangrass G, Ghaferi AA, Dimick JB. Explaining racial disparities in outcomes after cardiac surgery: the role of hospital quality. JAMA Surg. 2014;149(3):223–7. https://doi.org/10.1001/jamasurg.2013.4041.
13. Perlstein MD, Gupta S, Ma X, Rong LQ, Askin G, White RS. Abdominal aortic aneurysm repair readmissions and disparities of socioeconomic status: a multistate analysis, 2007-2014. J Cardiothorac Vasc Anesth. 2019;33(10):2737–45. https://doi.org/10.1053/j.jvca.2019.03.020.
14. Al Adas Z, Nypaver TJ, Shepard AD, Weaver MR, Ryan JT, Huang J, et al. Survival after abdominal aortic aneurysm repair is affected by socioeconomic status. J Vasc Surg. 2019;69(5):1437–43. https://doi.org/10.1016/j.jvs.2018.07.084.
15. Diaz A, Pawlik TM. Social determinants of health and surgical care. Curr Probl Surg. 2023;60(4):101300. https://doi.org/10.1016/j.cpsurg.2023.101300.
16. Stewart JH, Bertoni AG, Staten JL, Levine EA, Gross CP. Participation in surgical oncology clinical trials: gender-, race/ethnicity-, and age-based disparities. Ann Surg Oncol. 2007;14(12):3328–34. https://doi.org/10.1245/s10434-007-9500-y.
17. Townsley C, Pond GR, Peloza B, Kok J, Naidoo K, Dale D, et al. Analysis of treatment practices for elderly cancer patients in Ontario. Canada J Clin Oncol. 2005;23(16):3802–10. https://doi.org/10.1200/jco.2005.06.742.

18. Oliphant R, Nicholson GA, Horgan PG, Molloy RG, McMillan DC, Morrison DS, et al. Deprivation and colorectal cancer Surgery: longer-term survival inequalities are due to differential postoperative mortality between socioeconomic groups. Ann Surg Oncol. 2013;20(7):2132–9. https://doi.org/10.1245/s10434-013-2959-9.
19. Bharathan B, Welfare M, Borowski DW, Mills SJ, Steen IN, Kelly SB, et al. Impact of deprivation on short- and long-term outcomes after colorectal cancer surgery. Br J Surg. 2011;98(6):854–65. https://doi.org/10.1002/bjs.7427.
20. Tripathi R, Archibald LK, Mazmudar RS, Conic RRZ, Rothermel LD, Scott JF, et al. Racial differences in time to treatment for melanoma. J Am Acad Dermatol. 2020;83(3):854–9. https://doi.org/10.1016/j.jaad.2020.03.094.
21. Smith EC, Ziogas A, Anton-Culver H. Delay in surgical treatment and survival after breast cancer diagnosis in young women by race/ethnicity. JAMA Surg. 2013;148(6):516–23. https://doi.org/10.1001/jamasurg.2013.1680.
22. Sheppard VB, Oppong BA, Hampton R, Snead F, Horton S, Hirpa F, et al. Disparities in breast cancer Surgery delay: the lingering effect of race. Ann Surg Oncol. 2015;22(9):2902–11. https://doi.org/10.1245/s10434-015-4397-3.
23. Chan JK, Zhang M, Hu JM, Shin JY, Osann K, Kapp DS. Racial disparities in surgical treatment and survival of epithelial ovarian cancer in United States. J Surg Oncol. 2008;97(2):103–7. https://doi.org/10.1002/jso.20932.
24. Tohme S, Kaltenmeier C, Bou-Samra P, Varley PR, Tsung A. Race and health disparities in patient refusal of Surgery for early-stage pancreatic cancer: an NCDB cohort study. Ann Surg Oncol. 2018;25(12):3427–35. https://doi.org/10.1245/s10434-018-6680-6.
25. Molina G, Clancy TE, Tsai TC, Lam M, Wang J. Racial disparity in Pancreatoduodenectomy for borderline Resectable pancreatic adenocarcinoma. Ann Surg Oncol. 2021;28(2):1088–96. https://doi.org/10.1245/s10434-020-08717-x.
26. Sweigert PJ, Eguia E, Baker MS, Paredes AZ, Tsilimigras DI, Dillhoff M, et al. Assessment of textbook oncologic outcomes following pancreaticoduodenectomy for pancreatic adenocarcinoma. J Surg Oncol. 2020;121(6):936–44. https://doi.org/10.1002/jso.25861.
27. Merritt RE, Abdel-Rasoul M, D'Souza DM, Kneuertz PJ. Racial disparities in provider recommendation for esophagectomy for esophageal carcinoma. J Surg Oncol. 2021;124(4):521–8. https://doi.org/10.1002/jso.26549.
28. Erhunmwunsee L, Gulack BC, Rushing C, Niedzwiecki D, Berry MF, Hartwig MG. Socioeconomic status, not race, is associated with reduced survival in Esophagectomy patients. Ann Thorac Surg. 2017;104(1):234–44. https://doi.org/10.1016/j.athoracsur.2017.01.049.
29. Dimick J, Ruhter J, Sarrazin MV, Birkmeyer JD. Black patients more likely than whites to undergo surgery at low-quality hospitals in segregated regions. Health Aff (Millwood). 2013;32(6):1046–53. https://doi.org/10.1377/hlthaff.2011.1365.
30. Hoshijima H, Wajima Z, Nagasaka H, Shiga T. Association of hospital and surgeon volume with mortality following major surgical procedures: meta-analysis of meta-analyses of observational studies. Medicine (Baltimore). 2019;98(44):e17712. https://doi.org/10.1097/md.0000000000017712.
31. Diaz A, Hyer JM, Barmash E, Azap R, Paredes AZ, Pawlik TM. County-level social vulnerability is associated with worse surgical outcomes especially among minority patients. Ann Surg. 2021;274(6):881–91. https://doi.org/10.1097/sla.0000000000004691.
32. Cain BT, Horns JJ, Huang LC, McCrum ML. Socioeconomic disadvantage is associated with greater mortality after high-risk emergency general surgery. J Trauma Acute Care Surg. 2022;92(4):691–700. https://doi.org/10.1097/ta.0000000000003517.
33. LaPlant MB, Hess DJ. A review of racial/ethnic disparities in pediatric trauma care, treatment, and outcomes. J Trauma Acute Care Surg. 2019;86(3):540–50. https://doi.org/10.1097/ta.0000000000002160.
34. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: geographic disparities in trauma mortality. Surgery. 2016;160(6):1551–9. https://doi.org/10.1016/j.surg.2016.06.020.