Utilization of Antiemetic Medication as a Marker of Healthcare Disparities in Anesthesia

Michael H. Andreae

Columbia University

Author Note

Michael H. Andreae, Graduate School of Arts, Columbia University

Michael H. Andreae is currently Assistant Professor of Anesthesiology at the Montefiore Medical Center, Albert Einstein College of Medicine of Yeshiva University, Bronx, New York

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Correspondence regarding this article should be addressed to Michael H. Andreae, Department of Anesthesiology, Montefiore Medical Center, 111 East 210th Street, New York, NY 10467. Contact: mhandreae@gmail.com

Abstract

Background: US Health care disparities are well described, but have not been much studied in anesthesia. Race, ethnicity, gender, immigration and socio-economic status (e.g. medical insurance coverage) could lead to discrimination also by anesthesia providers. We hypothesize that insurance status predicts anesthesia quality. We assume that antiemetic prophylaxis is good surrogate marker of anesthesia quality, because it is universally available, indicated independent of patient co-morbidities and not impacted by regulatory or financial constraints. **Methods**: We will fit classical logistic regression, propensity matching and Bayesian statistical models to investigate if medical insurance predicts antiemetic prophylaxis in the subset of the National Anesthesia Clinical Outcomes Registry (NACOR) with complete electronic anesthesia records. Participating anesthesia providers in the US upload anesthesia cases to NACOR to serve for research and quality improvement. Our unit of analysis is the anesthesia case; patients may be counted repeatedly. We will control for patient and provider characteristics and procedure type. **Discussion:** Our conclusions may be limited by selection bias as not all anesthesiologists participate in NACOR and not all participating providers upload full electronic medical records. **Conclusion**: If we documented healthcare disparities in anesthesia at the provider level, this would be a novel and worrisome finding deserving further investigation and appropriate countermeasures.

Keywords: Healthcare disparities, anesthesia, National Anesthesia Clinical Outcomes Registry, antiemetic, health insurance, Bayesian statistics

Introduction

Healthcare Disparities in the United States

The healthcare disparities in the United States of America described decades ago by Gornick (Gornick et al., 1996), unabatedly persist to the present (Schoen, Osborn, Squires, & Doty, 2013) and are linked to social determinants of health and equality (Cooper, Cooper, McGinley, Fan, & Rosenthal, 2012; Marmot, 2013) health inequality is worse in the US than abroad (Schoen, et al., 2013). Strikingly, life expectancy for African Americans is almost 4 years shorter compared to the Caucasian American population (Kochanek, Arias, & Anderson, 2013). The medical profession cannot and will not accept this grave inequality which contradicts basic principles of medical ethics (IOM, 2003). Poverty, poor education, differences in medical insurance coverage, geographic location, legal or social status, race & gender, patient and community attitudes & perceptions and, last but not least, provider bias might lead to healthcare disparities also in anesthesia (Silber et al., 2013). This paper investigates if antiemetic utilization as a marker of high quality anesthesia care is predicted by medical insurance status in the large National Anesthesia Clinical Outcomes Registry (NACOR) (Dutton & Dukatz, 2011).

Known predictors of healthcare disparities

Race and ethnicity impact survival. African-Americans have been shown in innumerable studies to have inferior health outcomes compared to their White contemporaries (IOM, 2003; Nelson, 2002; Santry & Wren, 2012). Race is associated with lower socioeconomic status, income and education. However, the observed associations persist after controlling for these material factors. Hispanic minorities likewise experience a systematic gap in health outcomes (Juckett, 2013).

Gender and sexual orientation determine treatment and access. Gender and sexual orientation can also lead to systematic bias and consequently to inferior treatment and outcomes (Schoen, et al., 2013). Homo- and bisexual men showed poorer health than heterosexual controls; lesbian and bisexual women likewise were at increased risk for heart disease (Fredriksen-Goldsen, Kim, Barkan, Muraco, & Hoy-Ellis, 2013). Leresche discusses the exemplary observation that women experience higher pain scores, cautioning that this may be confounded by lower pain thresholds (Leresche, 2011). As another example, gender differences exist in orthopedics with regards to osteoporosis, fracture risk and utilization of services (Cawthon, 2011; Novicoff & Saleh, 2011). Women experience in general more difficult access to care, the more so the poorer and less educated they are (Schoen, Simantov, Gross, Brammli, & Leiman, 2003).

Socioeconomic status determines health. Low socioeconomic status is associated with higher mortality in many populations. Education, income, legal status, geographic location, social networks may have different causal pathways leading to inferior health outcomes.

Income predicts mortality. Sabanayagam tried to compare income and education as predictors of mortality and found the poverty income ratio a better predictor of mortality in a national multi-ethnic sample of US adults (Sabanayagam & Shankar, 2012).

Education affects health outcomes. Berkman recently reviewed the literature and concluded that low health literacy is associated with inferior utilization of health care services and worse clinical outcomes (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011).

Treatment and outcomes vary according to geographic location. Geographic differences in health outcomes occur at the state level, but can go down to the county and zip code:

Differences in healthcare delivery systems across states can lead to variance in health outcomes beyond the influence of poverty (McCarthy, 2013). Lower average income in constituents sharing the same zip code was associated with higher disability and greater hospital utilization (Cooper, et al., 2012). Rates of certain surgical procedures varied within the same Los Angeles County; much of this variability may be due to different ethnic mixes in the varied neighborhoods rather than differences in health status alone. This geographic variability is important when investigating large datasets drawing data from across the nation, like the NACOR dataset we propose to study.

Immigration and legal status determine health status. Page-Reeves demonstrated this eloquently for diabetes care in immigrants living in New Mexico (Page-Reeves et al., 2013). Hispanics are at greater risk to develop diabetes. Structural barriers limit access to care. Fear among the undocumented, cultural and language barriers contribute to worse clinical outcomes (Page-Reeves, et al., 2013).

Medical insurance status influences health outcomes. Medical insurance coverage, which varies by state in the US, predicts access to healthcare delivery and mortality for an individual (McCarthy, 2013). As Hoffman reports from a national insurance status survey patients perceive that the lack or loss of medical insurance covers leads to a plethora of adverse consequences, among them difficulties in paying medical bills, limited access to health services, postponed treatment, failure to obtain medications, especially among low wage workers (Hoffman, Schoen, Rowland, & Davis, 2001). Hoffman's finding echoed similar results by Schoen in an earlier survey (Schoen & DesRoches, 2000). McWilliams validated these and other claims in a systematic review of the literature on the effects of insurance status for acute and chronic conditions in adults for which there is effective therapy available (McWilliams, 2009).

Medical insurance in not enough, but it can make a big difference in health outcomes (Marmot, 2013).

Healthcare Disparities in Surgery, Anesthesia, and Pain Medicine

Health disparities are recognized in surgery.

Trauma outcomes vary according to SES, race and insurance. A systematic review by Haider synthesizes the evidence of studies on the influence of insurance status, race and ethnicity, and socioeconomic status on trauma outcomes (Haider, Weygandt, et al., 2013). The authors found strong evidence suggesting that insurance status is associated with mortality independent of injury type. Median income predicted higher mortality rates; minority patients have worse outcomes after trauma than their Caucasian counterparts. The effects of race were independent of insurance status.

Disparities in non-trauma surgical care and outcomes have long been recognized. Already in 1977, Egbert described how black patients were several times more likely to receive treatment from a resident surgeon as opposed to a fully trained attending surgeon (Egbert & Rothman, 1977). Generations later it is clear that health disparities based on race persist after controlling for insurance status (Haider, Scott, et al., 2013). Haider led a systematic review of racial outcome disparities in surgery; the authors acknowledged the contribution of provider and systematic factors (Haider, Scott, et al., 2013). Being a procedure based specialty, racial disparities in the level of training of providers seem important (Egbert & Rothman, 1977). This also applies to anesthesia. Resident surgeons involvement can lead to longer case duration at the very least (Silber, et al., 2013), which in turn can increase infection rates (Campbell et al., 2008). Black patients are at higher risk for poor outcomes after diverticulitis surgery, especially in emergency cases (Alavi, Cervera-Servin, Sturrock, Sweeney, & Maykel, 2012). Minorities are

more likely to be treated by surgeons with lower surgical volumes, with the latter being linked to poorer outcomes (Haider, Scott, et al., 2013). The surgical approach may differ with whites more likely to receive less invasive minimal surgery (Ricciardi et al., 2008).

Health care disparities are widely acknowledged in pain medicine. A systematic review and meta-analysis by Meghani raises alarm about the persistent racial and ethnic disparities in the treatment of pain, clearly a domain of anesthesiologists (Meghani, Byun, & Gallagher, 2012). Jimenez found racial and ethnic disparities also in perioperative treatment of pain in children, too (Jimenez, Seidel, Martin, Rivara, & Lynn, 2010).

Health care disparities likely also exist in anesthesia. Healthcare disparities have rarely been investigated in anesthesia to date, however (Silber, et al., 2013). Several reports seem to dismiss anesthesia's contribution to healthcare disparities altogether. Silber reported on the influence of race on operating room time, controlling for obesity and socioeconomic factors. Silber found statistically significant and clinically meaningful longer procedure times in black patients (Silber, et al., 2013). The authors predicated that the excess in duration was mostly due to longer surgeries as opposed to the anesthesia induction time and emergence; the contribution to the observed disparity by the anesthesia team would hence be limited. After controlling for potential confounders, Toledo no longer found differences in actual use of labor epidural analgesia in a large academic labor anesthesia department (Toledo et al., 2012). Earlier, analyzing the New York State Perinatal Database, Glance in contrast did find lower labor epidural analgesia rates in minorities (Glance et al., 2007). Likewise, Rust described an association between race and ethnicity and epidural rate for labor pain in Georgia Medicaid beneficiaries (Rust et al., 2004). Student nurse anesthetists complained about racial discrimination in a survey conducted by Elisha (Elisha & Rutledge, 2011). In general, the

literature on anesthesia related health disparities seems sparse, apart from labor analgesia and pain medicine. Is there no contribution to healthcare disparity by anesthesiologists or has their contribution just not been established yet?

Anesthesia is important for improving perioperative outcomes. To dismiss the potentially central contribution of anesthesia in observed healthcare disparities is to belittle the impact of anesthesia on perioperative outcomes in general. Anesthesia as a specialty had a significant role in improving surgical mortality over the last generations. Anesthesiologists focused on patient safety starting in the 1970 and as a specialty have been credited with a major reduction in perioperative mortality (Gaba, 2000; Leape, 1994). Silber documented that direction of anesthesia care by highly qualified (board certified) anesthesia providers reduces mortality (Silber et al., 2000). Besides providing anesthesia care in the operating room, anesthesiologists often act as gatekeepers and wardens for the surgical patients before and after surgery and promote an institutional culture of safety (Gaba, 2000). As described for surgeons above, this impact may depend on the status and training of the provider. Anesthesiologists with less experience, inferior training or lower status in the hospital hierarchy are likely to have less of a beneficial influence on mortality and morbidity for their patients (Silber, et al., 2000).

Theoretical Framework: Effectors of health care disparities

Our attempts to counteract healthcare disparities will be most effective if they interrupt the causal chain linking patient characteristics to poor outcomes. It is insufficient to enumerate predictors associated with inferior healthcare outcome. We need to understand the underlying mediators and mechanisms. The models ascribing causality can be classified into three groups:

Patient and community risk behavior leads to higher mortality and morbidity. According to this libertarian perspective, individuals are independent agents endowed with a free

will, make poor choices and are therefore responsible for the consequent health risks they incur. Following this logic, patients with lung cancer "chose to smoke," obese people are responsible for how much they ate (Knowles, 1977). This model is false. Addiction may serve as an obvious counterexample. Addiction is a disease (McLellan, Lewis, O'Brien, & Kleber, 2000). It does not make sense to argue that patients choose to be addicted. Page-Reeves deconstruct the "free will" model using the example of diabetes care in New Mexico (Page-Reeves, et al., 2013). Page-Reeves instead argues for a model considering social determinants of health and health relevant behavior (Page-Reeves, et al., 2013). The concept of health behavior choices being expressions of deliberate free will has repeatedly been challenged; for example Lynch showed that health behavior patterns may be imprinted in earlier life stages. Indeed, childhood parental socioeconomic status explaining much of adult risk behavior (Lynch, Kaplan, & Salonen, 1997). The Institute of Medicine report also unequivocally showed that the health disparities associated with race are not explained by inability to pay, lack of insurance or even attitudes or treatment decisions by African American patients; rather, these disparities are the result of systematic racial discrimination by their physicians and providers (IOM, 2003).

Discrimination at the provider level may explain inferior outcomes. Subconscious or intentional bias may lead physicians and other providers to administer differential care according to race or ethnicity contributing to inferior health outcomes (Santry & Wren, 2012). The US Congress tasked the Institute of Medicine with a report on racial and ethnic healthcare disparities. Nelson summarized how stereotyping, bias and outright discrimination by providers leads to inferior health outcomes in the US (IOM, 2003; Nelson, 2002). These differences in the quality of medical care delivered to ethnic and racial minorities were not explained by barrier to access care, patients' attitudes & decisions or their inability to pay.

Systematic bias in the healthcare delivery system results in lower health status. Health care system bias could also be impersonal, expressed in the rules and regulations or unequal geographic allocation of resources(McCarthy, 2013); they can unfairly lead to inferior treatment options for minorities or stigmatized populations, also detailed for example by Nelson (Nelson, 2002). A good example of the impersonal systematic bias is the inferior care afforded to immigrant and undocumented populations (Page-Reeves, et al., 2013). Page-Reeves illustrates how regulatory forces can significantly hamper access to care and cause insecurity among immigrant populations with resultant poorer health outcomes (Page-Reeves, et al., 2013). Page-Reeves goes so far as to calls this "structural violence" (Page-Reeves, et al., 2013).

Finding the Culprit: Who is Responsible for Healthcare Disparities?

This paper seeks to investigate if disparities exist also in anesthesia. More precisely, we seek to establish if the quality of anesthesia care differs depending on the medical insurance status. We seek to investigate healthcare disparities at the provider level. On a personal note, the author enjoys working in anesthesia not least because anesthesiologists typically need not care about the insurance status of their patients. If a patient makes it to the operating room, insurance questions have either been resolved or are suspended for emergency surgery. Anesthesiologists operate under the pretense that we treat all-comers equal. Yet anesthesiologists are not free of racial bias or other prejudice. We simply ignore if these may lead to disparate anesthesia care unbeknownst to us and/or against our best intentions.

Identifying causal factors of healthcare disparities is difficult. Differentiating which actors or factors in the health care delivery process are responsible for observed healthcare disparities can be perplexing, especially when it comes to anesthesia and perioperative care (Silber, et al., 2013). We are facing several challenges. (1) We seek to single out the effect of the

anesthesia provider from among the contribution of all actors in the perioperative process. (2) We need to control for the many potential confounders of the relationship between medical insurance status and healthcare disparities. (3) We would like to ensure that the observed detrimental effect or possibly the inferior care delivered is unlikely to be due to or influenced by monetary considerations. Either incentives to the providers or restrictions on the part of the payer are examples of systemic impersonal mechanisms causing healthcare disparities.

(1) Many actors are involved in the perioperative process. Refereeing physicians, admitting personal, surgeons, anesthesiologists, nurses in the postoperative care unit and on the floor and after hospital care facilities all have their role in providing comprehensive surgical care. Silber, in his investigation of racial disparities in operative procedure time, observed longer durations in surgeries of black people. Most of the difference was accounted for by the time between surgical incision and wound closure, i.e. the operation proper. This suggested that the surgical team operating was responsible for any difference in duration (Silber, et al., 2013). The contrary is difficult to prove. Anesthesiologists could however have contributes to the excess duration of the procedure time observed in Blacks. We will list just a few examples from cardiovascular /general surgery and orthopedics. (a) An insufficiently fluid pre-loaded patient may need several attempts during unclamping of the aorta to stabilize before surgery can carry on. This can be the fault of poor choices by the anesthesia provider. (b) If the airway is insufficiently secured, the surgeon may be forced to halt a procedure until it is safe to proceed. If the stomach is not deflated (by the oro-gastric tube inserted by anesthesia) poor visualization or access can hinder surgical progress. (c) An insufficient regional anesthetic block, inadequate neuromuscular relaxation or inadequate sedation light anesthesia may slow surgery if the patient continues to move about under the scalpel. We conclude that Silber's study is inconclusive as to

how much the surgical versus the anesthesia team contributed to the observed difference in length of procedure time and hence to healthcare disparities (Silber, et al., 2013).

(2) Many patient factors predict healthcare disparities. Some of these are highly co-linear. For example race and socioeconomic status are statistically so closely associated that including one in a regression model often removes any apparent contribution of the other. It is often very difficult to separate their effects even with advanced statistical methods(Cook, McGuire, & Zaslavsky, 2012). We need to control for geographic variations in care on the state and down to the county level (Cooper, et al., 2012), if we examine national registries like the NACOR we propose to study.

*(3) Difference in insurance may dictate differential treatment***.** The hands of a provider are tied if the insurance limits the therapeutic options or if they are restricted by hospital administrators ordering certain clinical pathways. An example might be the choice of neuromuscular blocker used, which can affect postoperative complications like aspiration pneumonia or prolonged ventilation increasing the risk of ventilator associated pneumonia. Administrators may restrict choices neuromuscular blocking agents as some (e.g. rocuronium) account for a large share of the hospitals pharmaceutical budget. Hospital administrators on the other hand seek to maximize payments by providers by ensuring documentation of certain aspects of care considered markers of quality. Examples include administration of beta-blockers and application or warming blankets. The actual treatment administered may differ from the documentation (a) the more high compliance is enforced by the billing department and (b) the less providers accept the evidence supporting such therapy. If we seek to identify health care disparities at the individual provider level, we should hence try to observe documented aspects of care not influenced my monetary constraints or regulatory reporting requirements.

Antiemetic utilization as a surrogate marker of quality of anesthesia care

A suitable surrogate marker for the quality of anesthesia care delivered at the provider level would hence have three attributes: (1) the marker is independent of patient characteristics (comorbidity, genetic disease, health status, ability to pay, patient attitudes and choices) and confounders (income, education level, geographic location). (2) Administration of the marker is the sole responsibility of the anesthesia provider without input by any other actors in the perioperative process (surgeon, nurses, admission, pathology). (3) The utilization of the marker is unlikely to be influenced by regulatory, monetary or insurance constraints or considerations (reporting requirements, cost, and financial bonus or billing aspects). We propose to investigate antiemetic prophylaxis as a surrogate marker of anesthesia quality, because we feel this marker has all three above postulated attributes.

Postoperative nausea and vomiting is an important outcome. Besides the individual unpleasant experience by the nauseated patient, PONY is one of the main reasons of prolonged stay in the recovery unit and hence prophylactic antiemetic interventions have widespread impact in perioperative care of the patient (Apfel et al., 2004). Every diligent anesthesia provider should consider antiemetic prophylaxis without consideration of insurance status. Antiemetic administration is especially indicated in patients at high risk for PONY (females, young patients, non-smokers, and history of PONY or motion sickness) (Apfel, et al., 2004). There are two principle choices of antiemetic prophylaxis, ondansetron and dexamethason. On one hand, ondansetron is still under patent protection and therefore costly; its administration may hence be constraint by monetary considerations. Also ondansetron is contraindicated in rare certain cardiac conditions (QT prolongation). On the other hand, dexamethason is off patent, widely available, extremely cheap and without any contraindications. Either of the two antiemetic agents

should be available and suitable for prophylaxis of postoperative nausea and vomiting (PONY) in any given patient.

We assume that utilization of antiemetic prophylaxis is a suitable surrogate marker of quality of anesthesia care. We consider medical insurance as a surrogate marker for socioeconomic status. We want to investigate the effect of socioeconomic status on quality of anesthesia provided by the individual anesthetists in the subset of the National Anesthesia Outcome Registry (NACOR) with full electronic anesthesia records (Dutton & Dukatz, 2011).

Hypothesis

Medical insurance status predicts antiemetic prophylaxis during surgery as a surrogate marker of quality anesthesia care. Contingent on our assumption, if our hypothesis is true, American anesthesia providers on average may provide different quality of anesthesia depending on the insurance status of their patients. Inferior anesthesia quality may lead to inferior perioperative outcomes (Santry & Wren, 2012; Silber, et al., 2013). American anesthesiologists as a specialty would hopefully accept the responsibility for the described health care disparities in anesthesia and take corrective action to ensure equitable high quality care to all their patients.

Methods

Description of the sample studied: The National Anesthesia Clinical Outcomes Registry

The National Anesthesia Clinical Outcomes Registry (NACOR) receives information on anesthesia cases from participating institutions and anesthesia providers (Dutton & Dukatz, 2011). The subset of NACOR containing complete electronic anesthesia records (including dose and time of antiemetic prophylaxis administered) comprises about one million anesthesia cases. We propose to study this subset. Datasets contain about 65 variables for each case. Variables span information on the provider of the anesthesia (ID, location, class (university hospital,

private anesthesia group)), on the patient (Age, gender, anesthesia risk classification, insurance status, disease) and on the procedure (Billing code, modifiers, indication ICD code). The data is heterogeneous with many missing data, as not all participating participants upload the same information. Some participating providers may only upload billing data, other the full electronic anesthesia record containing even individual physiological parameters recorded minute by minute.

We will describe the characteristic of the subset of NACOR datasets forming the bases of our analysis, anesthesia records with complete information on the administration of antiemetic prophylaxis. We will explore the bivariate associations between the dichotomous outcome variable antiemetic prophylaxis and the independent variables describing patients, procedures & providers; patient characteristics include medical insurance status (our primary predictor of interest), patient age, gender, American Association of Anesthesiology risk classification, co-morbidities, (but not race, which is not recorded in NACOR). We will report procedure types and indications (Billing code, modifiers, indication ICD code). Provider characteristics include information on the anesthetist [nurse anesthetist versus resident versus attending alone] and institutional data [geographic location, academic versus private versus government institution].

We shall use parametric tests where the assumptions of normality do not seem violated and non-parametric test, where graphical or statistical tests suggested possible violations of the underlying assumptions. We will report proportions, mean and standard deviation or the median and the interquartile range (as appropriate for the distribution of values observed for each parameter) and indicated the statistical test used in the table of characteristic of patients. We will describe any datasets excluded for missing information, in particular, we will report the

characteristics of our NACOR subset sample (with complete electronic anesthesia records) comparing it against the full NACOR dataset to investigate possible selection bias.

Statistical analysis

We will consider three statistical models. Administration of antiemetic prophylaxis is the primary outcome and medical insurance status is the ordinal predictor, controlling for patient & provider characteristics. We will consider (1) a logistic regression model, (2) a multivariate matching with propensity score matching and (3) a hierarchical Bayesian model. We will focus our analysis on the ten most frequent procedure performed. We will consider findings statistically significant if the p-value is less than the alpha of 0.05. We used the statistical software package R for all statistical tests(R, 2012). R is available under the General Public License of the Free Software Foundation at no cost. We will investigate the effect of medical insurance as predictor on the administration of antiemetic medication as primary outcome, controlling for potential confounders like patient characteristics, provider characteristics and procedure type and indication. The predictor insurance status is an ordinal variable; possible values are ordered from highest insurance coverage, i.e. private insurance, Health Maintenance Organization, Medicare, Medicaid, to the lowest no medical insurance reported. Our outcome is dichotomous, antiemetic prophylaxis administered or not. Our unit of analysis is the anesthesia case, not the patient. Patients may have several operations, each generating one anesthesia record; patients may hence be counted several times. We will only consider antiemetic prophylaxis administered during anesthesia care, either in the operating room or while dropping off the patient in the recovery unit, but before sign-out to the recovery staff.

(1) We will fit a classical logistic regression model. Besides insurance status as our primary outcome, we have decided a priori to include gender and age in model, because both

have been previously shown to be risk factors for PONY and are hence considered indications for antiemetic prophylaxis; as such they may act as confounders of associations. In addition, we will choose those independent variables for the initial model that show a statistically significant association in the bivariate analysis. We used stepwise backward elimination starting from our initial model based on the likelihood ratio test with a cutoff at 0.05 to eliminate independent variables from the model. For each model eliminated we will confirm that the given variable was not a confounder for the present model. We will use a change in the beta coefficient of larger than 20% as our cutoff to determine if a variable is considered a confounder. We will determination the correct functional form and explore potential violations of the assumptions of linearity. We will run locally weighted regression of yvar on xvar (and examined the graph for all independent variables in our final model), for a graphical assessment of potential violations of the assumption of linearity. We will test for the correct functional form, fitting fractional polynomials as part of our final logistic regression model. We will examine if the addition of a polynomial improves the model significantly. We will explore the potential interaction between the independent variables age and gender in a simple logistic regression model; a cut of for our likelihood ratios test shall be at an alpha level of 0.05. We will examine the goodness of fit with the Hosmer-Lemeshow goodness of fit test. We will consider constructing a classification tables and a ROC curve. We will perform a sensitivity analysis of our model assumptions and choices.

(2) We will match insured versus non-insured/Medicaid cases. We employ propensity scores to match exactly on procedure and institution type, age ±5 years and gender (Silber, et al., 2013). We will use optimal matching (Rosenbaum, 2010). This minimizes the distance within matched pairs by seeking a near fine balance for co-morbidities and geographic location. We will test the Null-Hypothesis of no difference between pairs (Hollander & Wolfe, 1999).

(3) We will build a hierarchical Bayesian model. Cases will be nested in providers and these will be nested in institutions. (There are no patient identifiers to track repeated operations to the same patient.) We will use flat priors for the main effect of insurance status on antiemetic prophylaxis but mildly informative priors to limit the variability within each hierarchical level and to inform the effect of age and gender on the likelihood of antiemetic prophylaxis. We will perform a sensitivity analysis investigating the appropriateness of these prior assumptions. We will compare the results of our three models to explore the robustness of our findings to the choice of model.

Conclusions

If we find that medical insurance status predicts antiemetic prophylaxis, controlling for patient, procedure and provider covariate confounders. We would consider this as an indication that quality of anesthesia provided varies by socioeconomic status. We would conclude that healthcare disparities exist in anesthesia at the provider level.

Strength

The size of the subset of NACOR we propose to study likely makes this the largest study of healthcare disparities in anesthesia undertaken to date. This will increase our power to detect an association between insurance status and antiemetic prophylaxis if it exists. Controlling for likely confounders including patient characteristic, provider characteristic and procedure type, decreases the chance that the association is spurious. Focusing on the ten most frequent procedure types will increase the homogeneity of the sample and the robustness of the findings. If we come to similar conclusions with all three statistical models (classical logistic, matching and hierarchical Bayesian) we propose to fit, this would further corroborate the robustness of the

healthcare disparities detected and argue against a spurious association. We would conclude that the effect is robust to the statistical approach chosen, giving our findings more credence.

Limitations

Selection bias may limit our conclusions. Not all providers and institution use electronic anesthesia records and if they do they may not upload the data to NACOR, e.g. for regulatory or privacy reasons. Will certain providers with greater likelihood to discriminate on insurance status be less likely to have electronic medical records or to upload their datasets? This possibility may limit the generalizability of our findings as this may result in selection bias. Comparing the characteristics of anesthesia cases in our subset with the full NACOR dataset may give us some indication of this occurring.

Information bias may result in under- or overestimation of the observed effect. Providers may have forgotten to record the administration of antiemetic medication, but still have administered the prophylaxis. They may have recorded the dose, but might still have failed to administer the prophylaxis. Both instances of misclassification of outcome (antiemetic prophylaxis administration) could lead to an over- or underestimation of healthcare disparities as we defined them. This distortion of the effect would be larger if the misclassification were not completely at random but differential depending on our predictor of interest (health insurance status). Because antiemetic prophylaxis is generally not considered critical or relevant for billing and malpractice, malicious intent to falsify the record is unlikely to lead to numerous differential misclassifications. Sloppy failure to record the medication, while actually giving it, seems a more likely occurrence. However, poor record keeping is likely associated with poor anesthesia quality and hence this misclassification would not invalidate the conclusions we draw from our analysis.

Our conclusions hinge on our assumption. If antiemetic prophylaxis is not a good indicator of anesthesia quality, then we cannot conclude that healthcare disparities exist in anesthesia, even if we find that insurance status predicts antiemetic administration. Likewise, if or as soon as antiemetic prophylaxis is used widely as such a marker, bias will be introduced in the documentation and administration of these agents and they may no longer genuinely reflect quality. Analogously, insurance status while closely linked to race and socioeconomic status is only one predictor of healthcare disparities and we do not know what might cause providers to differentiate based on the former versus the latter and/or if the same causal pathways are involved.

Impact

Demonstrating health care disparities in such a large dataset in anesthesia would be novel. The fact that the surrogate marker of anesthesia quality is exclusively in the domain of the anesthesia will likely make a greater impression on the anesthesia community than an intervention or marker for which anesthesiologists are only partially involved or responsible for, like procedure time(Silber, et al., 2013) Our work clearly puts the onus on the individual provider as opposed to system bias due to regulations or geographic variations. Our findings may hopefully lead to a somber assessment of healthcare disparities in anesthesia by all stakeholders, and appropriate counter measures. The anesthesia community has risen to the opportunity in the past and provided leadership in provision of equitable and safe care to all our patients (Gaba, 2000).

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