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Research Paper

Differences in preoperative frailty assessment of surgical candidates by sex, age, and race

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ABSTRACT

Introduction: Surgical decision-making often relies on a surgeon's subjective assessment of a patient's frailty status to undergo surgery. Certain patient demographics can influence subjective judgment when compared to validated objective assessments. In this study, we explore the relationship between subjective and objective frailty assessments according to patient age, sex, and race.

Methods: Patients were prospectively enrolled in urology, general surgery, and surgical oncology clinics. Using a visual analog scale (0−100), operating surgeons independently rated the patient's frailty status. Objective frailty was classified using the Fried Frailty Criteria ranging from 0 to 5. Multivariable proportional odds models were conducted to examine the potential association of factors with objective frailty, according to surgeon frailty rating. Subgroup analysis according to patient sex, race, and age was also performed.

Results: Seven male surgeons assessed 203 patients preoperatively with a median age of 65. A majority of patients were male (61 %), white (67 %), and 60 % and 40 % underwent urologic and general surgery/surgical oncology procedures respectively. Increased subjective surgeon rating (OR 1.69; $p < 0.001$) was significantly associated with the presence of objective frailty. On subgroup analysis, a higher magnitude of such association was observed more in females (OR 1.86; $p = 0.0007$), non-white (OR 1.84; $p = 0.0019$), and older (>60, OR 1.75; $p = 0.0001$) patients, compared to male (OR 1.45; $p = 0.0243$), non-white (OR 1.48; $p = 0.0109$) and patients under 60 (OR 1.47; $p = 0.0823$).

Conclusion: The surgeon's subjective assessment of frailty demonstrated tendencies to rate older, female, and non-white patients as frail; however, differences in patient sex, age, and race were not statistically significant.

Introduction

Frailty is exceedingly common among surgical patients, with reported prevalence as high as 37 %, and up to 46 % meeting pre-frail classification [1,2]. Readily identifying frail patients during the surgical planning process is critical given it has been well established that frailty is associated with increased postoperative complications; prolonged length of stay; required discharge to skilled or assisted-living facilities; and higher rates of in-hospital mortality [3–8]. Preoperative frailty assessments have demonstrated an ability to improve 1-year mortality via early identification and referral to pre-surgical care clinics for surgical preparation, also termed “prehabilitation” [9]. Prehabilitation programs with interventions such as physical exercise, nutritional support, and psychological counseling may improve mobility

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in frail patients, lower 30-day mortality rates, and decrease post-acute care facility discharges postoperatively [10,11].

Surgeons most often rely on subjective frailty assessments based on personal accounts and understanding despite the longstanding development and acceptance of frailty definitions and assessments [12–14]. Although most surgeons view frailty screening favorably, only one-third of practices include formal assessments due to concerns regarding clinical feasibility, doubt regarding its impact on decision-making, and belief that frailty is identified without questionnaires or physical testing [14–16]. Notably, subjective frailty assessments have demonstrated poor-to-fair agreement with objective frailty measures and often underestimate the prevalence of pre- to intermediately frail patients [17–21].

The agreement between subjective and objective frailty assessment is of considerable interest given the significant influence a patient's frailty status has on surgical decision-making and expected surgical pathway. When using objective measures, a disparity based on race and sex has been demonstrated, as patients who are female, Black, or Hispanic present with significantly higher rates of frailty, even after adjusting for sociodemographic and health characteristics [1,2,22,23]. Surgeon frailty assessment is strongly biased by the patient's age as well, with increased difficulty in discriminating between frail and non-frail patients in younger groups [17].

These disparities are apparent in subjective assessments where women are estimated to be higher-risk surgical candidates and perceived frail women receive significantly fewer interventions than their male counterparts [24–26]. There is also a significant disparity in decisions to surgically treat peripheral arterial disease and lung cancer among black patients, although the influence of perceived frailty is unclear [27,28]. Age may play an exaggerated role in decision-making as well, with surgeons potentially using it as a surrogate measure for the patient's physiologic status [17].

Here, we explore the relationship between subjective and objective frailty assessments based on patient age, sex, and race. In a cohort of patients undergoing preoperative consultation, a subjective surgeon assessment regarding frailty status was obtained followed by blinded objective frailty measurements. We hypothesized that sex-, race-, and age-based disparities among surgical candidates would influence surgeon assessment, with certain groups demonstrating greater agreement between subjective and objective frailty ratings.

Methods

Study design and participants

This study was approved by the Emory University Institutional Review Board. Patients aged 18 years or older undergoing major surgical intervention for a urologic, general surgery, or surgical oncology illness requiring hospital admission were prospectively enrolled in the study. Patients unable to ambulate, with poor manual dexterity or inability to grip, or unable to read or verbally understand the questionnaires were excluded. A total of 203 patients were enrolled consecutively after surgical consultation and consent to proceed with surgery from 2014 to 2018.

Frailty assessments

Objective and subjective frailty assessments were performed during the preoperative clinic. Seven surgeons quantified subjective frailty and were blinded to the results of the objective measurements. All surgeons were male, and either White or Asian race. The average years in practice were 10, with a minimum of 5 years and a maximum of 20 years. Objective frailty status was evaluated using the Fried Frailty Criteria assessment tool by a study coordinator. It is a well-studied test and an accepted objective measure of the physiologic reserve, with good prognostic ability for surgical patients [3,6,12,29]. The assessment tool measures five components: weight loss, exhaustion, physical activity, walk time, and grip strength. Supplemental Table 1 provides the stratifications and thresholds used to determine whether a patient met the criteria for frailty per component. Patients were assigned 1 point for each component that met these criteria with a potential range of 0–5 points. Based on the Fried Frailty Criteria, a score of 0–1 is defined as not frail, 2–3 as intermediately frail, and 4–5 as frail. For our study, objectively frail patients were defined as those with two or more positive components.

Quantification of subjective frailty was performed using a visual analog scale from 0 to 100 (Fig. 1). Surgeons were asked to indicate their judgment of the patient's ability to handle the stress of surgery by placing a mark on a separate piece of paper between "not frail" (score = 0) and "frail" (score = 100). This method has been well-studied and validated to accurately measure patient and physician attitudes or opinions [30]. The distance in millimeters from the "fully able" or "not frail" end was used as the subjective rating given by the surgeons. Higher numerical ratings indicated increased subjective frailty.

Statistical analysis

Descriptive statistics were recorded, including age, race, sex, surgical department, open versus minimally-invasive approach, cancer-related procedure, American Society of Anesthesiologists (ASA) score, Charlson Comorbidity Index (CCI), ECOG (Eastern Cooperative Oncology Group) Performance Status, objective frailty rating, and surgeon subjective rating. The univariate association of each predictor with objective frailty was examined with ANOVA for numerical covariates and a chi-squared test for categorical covariates. This was repeated on subpopulation analysis by age (<60 vs ≥ 60), race (white vs non-white), and sex (male vs female). The proportional odds model was used to assess the association between the ordinal objective frailty score (0–5) and subjective surgeon rating (rescaled on a range of 0 to 5 units, with 1 unit the equivalent of 20 mm on the visual analog scale). The estimated odds ratio can be interpreted as the change of odds in higher objective frailty score for every unit increase in rescaled subjective surgeon rating. The univariate association (UVA) of each factor was carried out along with multivariable analysis (MVA) controlling for covariates either through a main effect model or an interaction model for the association in subgroups (e.g., race, sex, and age). The MVA implemented a backward variable selection procedure, with removal criteria as $p > 0.05$. The ECOG score was included in all models since although it may overlap with frailty, it remains a subjective measurement and does not include actual questionnaires assessing patient-reported outcomes nor account for objective physical measurements. In addition, open versus minimally invasive surgical technique was included in the models to account for potential disease severity since one method may more often be utilized in advanced scenarios and the provider's thought process may influence frailty assessment. The proportional odds assumption was checked as appropriate. All analyses were done using SAS Version 9.4 (Cary, NC, USA), and SAS macros developed by the Biostatistics and Bioinformatics Shared Resource at Winship Cancer Institute with a p-value <0.05 representing statistical significance [31].

Fig. 1. Visual analog scale completed by surgeons.

Results

Baseline characteristics

Two hundred and three patients underwent preoperative assessment. Table 1 summarizes the baseline demographics and characteristics for the overall cohort and for patients meeting frailty criteria (≥2 components) versus those who did not. Most subjects were male (60.6 %) and white (67.0 %). Half of frail patients were female (50.8 %) compared to 34.5 % of non-frail patients ($p = 0.029$). Frail patients were older, with a median age of 67 (59–74) compared to 61 (53–69) for non-frail patients ($p = 0.005$). No difference in prevalence was observed between white (67.6 % vs 65.6 %) and non-white (32.4 % vs 34.4 %) patients ($p = 0.778$). The frail group was found to have greater proportions of ECOG Performance Status 1 (31.1 % vs. 9.2 %) and 2+ (11.5 % vs. 2.1 %) patients ($p < 0.001$). There was also a higher percentage of ASA class 3–4 (86.9 % vs. 71.1 %, $p = 0.016$). The median CCI for the cohort was 4 (3–5) and no difference was observed between the two groups. The percentage of patients who underwent operations by urology, surgical oncology, and general surgery services were 59.6 %, 28.6 %, and 11.8 % respectively. The median surgeon subjective frailty rating was higher for frail patients (26, IQR 11–58) than non-frail patients (9, IQR 3–22) ($p < 0.001$). Most surgeries were oncological (81.8 %) and were performed in an open fashion (67.0 %). Frail patients underwent a significantly higher proportion of open surgeries (82 % vs. 60.6 %, $p = 0.003$).

Factors associated with objective frailty

On univariate analysis (Table 2), factors associated with higher objective frailty scores included age (p = 0.003), female sex ($p = 0.002$), ECOG performance status ($p < 0.001$), ASA ($p = 0.005$), CCI ($p = 0.004$), surgical technique ($p = 0.008$), and surgeon subjective rating ($p < 0.001$). Race was not associated with higher objective frailty scores ($p = 0.78$). Table 3 reports the subjective frailty ratings performed by surgeons according to sex, race, and age. There is a significant increase in surgeon scoring for frail versus non-frail patients across all demographics. According to age among non-frail patients, those younger (<60) had significantly lower surgeon scores than older patients (7 vs. 10.5; $p = 0.013$). Objectively frail female (30, IQR 7–65), non-white (33, IQR 13–65), and older (31, IQR 12–67.5) patients were assigned higher subjective ratings by surgeons when compared to frail male (23.5, IQR 11–49), white (25.5, IQR 9–53.5), and younger (20, IQR 7–35) patients, however, these differences were non-significant.

Table 4 demonstrates the multivariable proportional odds models of factors associated with objective frailty. A greater surgeon rating was associated with an increased probability of identifying frailty among patients (OR 1.69; $p < 0.001$). Male patients (OR 0.52; $p = 0.019$) were half as likely to be objectively frail, as were patients that underwent minimally invasive surgeries (OR 0.44; $p = 0.006$). Patients undergoing non-cancer-related surgeries were twice as likely to be categorized with higher frailty scores (OR 2.08; $p = 0.037$). An ECOG performance status

Table 1
Baseline demographics and characteristics for the overall cohort, and for frail versus non-frail patients.

	Overall (*n* = 203)	Not Frail (*n* = 142; 70.0 %)	Frail (*n* = 61; 30.0 %)	
	n (%)			p-value
Age, years*	65 (52–72)	61 (53–69)	67 (59–74)	**0.005**
Gender				
Male	123 (60.6)	93 (65.5)	30 (49.2)	**0.029**
Female	80 (39.4)	49 (34.5)	31 (50.8)	
Race				
White	136 (67.0)	96 (67.6)	40 (65.6)	0.778
Non-White	67 (33.0)	46 (32.4)	21 (34.4)	
ECOG Performance Status				
0	161 (79.3)	126 (88.7)	35 (57.4)	**<0.001**
1	32 (15.8)	13 (9.2)	19 (31.1)	
2+	10 (4.9)	3 (2.1)	7 (11.5)	
ASA Physical Status				
1–2	49 (24.1)	41 (28.9)	8 (13.1)	**0.016**
3–4	154 (75.9)	101 (71.1)	53 (86.9)	
Charlson Comorbidity Index*	4 (3–5)	4 (3–5)	5 (4–6)	0.059
Surgical Department				
Urology	121 (59.6)	83 (58.5)	38 (62.3)	0.196
Surgical Oncology	58 (28.6)	45 (31.7)	13 (21.3)	
General Surgery	24 (11.8)	14 (9.8)	10 (16.4)	
Open Surgery	136 (67.0)	86 (60.6)	50 (82.0)	**0.003**
Cancer Surgery	166 (81.8)	118 (83.1)	48 (78.7)	0.456
Surgeon Subjective Rating*	11 (4–30)	9 (3–22)	26 (11–58)	**<0.001**

* Median (IQR). Abbreviations: Eastern Cooperative Oncology Group (ECOG); American Society of Anesthesiologists (ASA).

Table 2
Univariable association with objective frailty (0–5) by proportional odds model.

	Odds ratio (95 % CI)	OR p-value
Age	1.04 (1.01–1.06)	**0.003**
Gender		
Male	0.44 (0.26–0.73)	**0.002**
Female	Ref.	
Race		
White	1.08 (0.63–1.84)	0.78
Non-White	Ref.	
ECOG performance status		
0	0.12 (0.04–0.38)	**<0.001**
1	0.62 (0.17–2.22)	0.465
2+	Ref.	
ASA physical status		
1–2	0.42 (0.22–0.77)	**0.005**
3–4	Ref.	
Charlson Comorbidity Index	1.21 (1.06–1.37)	**0.004**
Surgical Department		
Urology	0.72 (0.33–1.59)	0.415
Surgical Oncology	0.57 (0.24–1.35)	0.203
General Surgery	Ref.	
Open Surgery		
No	0.48 (0.27–0.83)	**0.008**
Yes	Ref.	
Cancer Surgery		
No	1.43 (0.75–2.72)	0.279
Yes	Ref.	
Rescaled Surgeon Subjective Rating*	1.92 (1.54–2.41)	**<0.001**

* Unit = 20. Abbreviations: odds ratio (OR); confidence interval (CI); Eastern Cooperative Oncology Group (ECOG); American Society of Anesthesiologists (ASA) Physical Status.

Table 3
Summary of surgeon subjective frailty rating by objective frailty, stratified by sex, race, and age.

	Not frail	Frail	p-value
Male patients	9 (2–20)	23.5 (11–49)	**<0.001**
Female patients	11 (4–25)	30 (7–65)	**0.003**
p-value	0.282	0.806	
White patients	9 (3–21)	25.5 (9–53.5)	**<0.001**
Non-White patients	9 (2–23)	33 (13–65)	**<0.001**
p-value	0.869	0.504	
Age < 60	7 (0–14)	20 (7–35)	**0.009**
Age ≥ 60	10.5 (4–26.5)	31 (12–67.5)	**<0.001**
p-value	**0.013**	0.224	

Ratings = Median (IQR) for surgeon subjective frailty rating (0–100).

Table 4
Multivariable analysis of the association with objective frailty (0–5) by proportional odds model.**

	Odds Ratio (95 % CI)	OR p-value
Rescaled Surgeon Rating*	1.69 (1.32–2.15)	**<0.001**
Gender		
Male	0.52 (0.30–0.90)	**0.019**
Female	Ref.	
Open		
No	0.44 (0.25–0.79)	**0.006**
Yes	Ref.	
Cancer		
No	2.08 (1.05–4.14)	**0.037**
Yes	Ref.	
ECOG Performance Status		
0	0.30 (0.08–1.08)	0.065
1	1.08 (0.29–4.05)	0.904
2+	Ref.	

** Backward selection with an alpha level of removal of 0.05 was used. The following variables were removed from the model: ASA, Age, Charlson Comorbidity Index, Division, and Race.

of 0 was also shown to be negatively associated with objective frailty (OR 0.30, $p = 0.002$). It should be stated that age was no longer a factor associated with frailty on multivariable analysis.

Subjective correlation with objective frailty according to sex, race, and age

*On subgroup analysis, a higher surgeon rating increased the probability of identifying objective frailty across sex, race, and old age (*Table 5*).* Surgeon rating was not associated with an increased probability of identifying objective frailty in patients under 60 (Table 5). Across subgroups, there was a stronger association between rising surgeon subjective rating and objective frailty among female (OR 1.85; $p = 0.0007$), non-white (OR 1.84; $p = 0.0019$), and older (OR 1.75; $p = 0.0001$) patients, compared with male (OR 1.45; $p = 0.0243$), white (OR 1.48; $p = 0.0109$), and younger (OR 1.47; $p = 0.0823$) patients. However, interaction p-values between male and female ($p = 0.281$), white and non-white ($p = 0.3556$), and young and old ($p = 0.5025$) subgroups suggested non-significant differences.

Discussion

This study examined the influence of age, race, and sex on subjective frailty assessment by surgeons. Using validated objective frailty criteria, frail patients tended to be older, female, and with worse performance status. Overall, the surgeon rating was independently associated with identifying objectively frail patients across demographics, except for patients <60 years old. However, frailty was more prevalent among older and female patients, which may explain the stronger association between surgeon rating and frailty in these groups. Although there were stronger associations between higher surgeon-assigned frailty scores with female, Black, and older patients, the statistical interaction was non-significant suggesting these variables may not significantly influence a surgeon's perception of frailty among patients scheduled for surgery. Even though sex and race may not impact subjective perception, misidentifying younger patients as frail or not frail is a notable finding. This is the first study to assess surgeons' subjective assessment of a patient's frailty status according to sex and race among surgical patients and further examine the role of age; this proves important given the influence provider judgment can have on clinical decision-making [25,26,32].

Table 5
Adjusted association with objective frailty score by surgeon's rating as in the subgroups by sex, age, and race.

	Odds Ratio (95 % CI)	OR p-value	Interaction p-value
Male patients	1.45 (1.05–1.99)	0.0243	0.281
Female patients	1.85 (1.29–2.64)	0.0007	
White patients	1.48 (1.10–2.01)	0.0109	0.3556
Non-White patients	1.84 (1.25–2.70)	0.0019	
Age < 60	1.47 (0.95–2.29)	0.0823	0.5025
Age ≥60	1.75 (1.32–2.32)	0.0001	

Abbreviations: confidence interval (CI); odds ratio (OR)
Variables included in adjusted analysis: Sex, Open Surgery Status, Cancer Status, and ECOG Performance.

Surgical approach and oncologic status in frailty

In both univariable and multivariable models, patients undergoing open surgery were significantly more likely to be objectively frail. One potential explanation for this may be that frail patients tend to harbor more advanced disease requiring a more extensive surgical approach. However, several studies assessing frailty have not shown similar associations. In a retrospective study comparing open and minimally invasive pancreatectomy, the modified Frailty Index score among patients was equally distributed between the open and minimally invasive groups [33]. There are few studies comparing frailty in open and minimally invasive surgical approaches across multiple surgical disciplines, such as in our study. Thus, the heterogeneity of the pathologies and surgeries in our study may introduce a level of selection bias that can explain this association. In the multivariable proportional odds model, frail patients were less likely to undergo cancer operations. This association, however, was not seen in univariable analysis, which could suggest surgeons have decreased accuracy when assessing frailty in this subgroup. Although surgical approach and oncologic status are not patient characteristics, they can still indirectly provide information to guide treatment discussions, particularly in those who may fall into the intermediately frail category.

Trends in surgeon assessment according to patient sex and race

There was a minimal division between subgroups in the non-frail cohort, however, these gaps widened among objectively frail patients by subjective assessment. Surgeons scored female, non-white, and older patients higher on their subjective frailty rating. These were the same set of patients in which increasing surgeon ratings indicated a greater probability of identifying objective frailty. In a study from Lee et al. [24] examining general population perceptions of fitness for surgery, biases related to patient gender were observed with white female standardized patients, who were provided instructions to portray themselves as frail, receiving fewer recommendations to undergo surgery when compared with white male standardized patients receiving the same instructions. However, this trend was reversed where "frail" female Black standardized patients received stronger support for surgery versus the "frail" male standardized Black patients [24]. In contrast, McDonagh et al. [19] found no sex-based difference in clinician-estimated frailty among a cohort of adults with heart failure. Although reports vary in the role sex or gender influences the perception of frailty, consistent disparities are observed in treatment decision-making between male and female patients. Female patients are less likely to receive recommendations for knee replacements, intervention for peripheral arterial disease, and surgery for lung cancer [27,28,34]. In the context of frailty, women are less likely to receive liver transplants or undergo vascular surgery compared with male patients, despite sex not impacting mortality outcomes among frail patients [25,26].

Racial differences in frailty

Notably, our results did not demonstrate a difference in the prevalence of objective frailty between white and non-white patients. This is in contrast to the observed patterns shown in other cohorts, even when adjusting for socioeconomic status [22,23]. However, surgeons tended to rate frail non-white patients higher compared with frail white patients, and were more successful in identifying objective frailty, illustrating a potential disparity in frail non-white patients seeking surgery. This is one of the first studies to examine the subjective assessment of frailty in non-white patients, however, the role this plays in decision-making has yet to be explored. Disparities in access to surgical care have been reported among Black and Hispanic patients. These patients are up to 10 % less likely to receive intervention for arterial disease and lung cancer [27,28]. It is important to further confirm if racial biases are indeed found among subjective assessments of frailty, and whether this may exacerbate the reported under-treatment of non-white patients.

Impact of age and subjectivity on surgeon assessment of frailty

Higher surgeon rating was indeed associated with an increased probability of identifying objective frailty, however, surgeons were unable to categorize patients under the age of 60 as frail consistently. This is consistent with our prior study, which showed that surgeons often use age as a surrogate measurement for frailty upon subjective assessment, with a tendency to underestimate younger patients [17]. In a cohort aged 40–64 admitted for emergency surgical services, Smart et al. [35] demonstrated there was a significant proportion of younger adults (16 %) who were identified as frail and experienced longer stays. In general, there is wide variation in provider-reported rates of frailty across specialties and patient populations, with both significant over- and under-estimation. In a cohort of patients undergoing abdominal aortic aneurysm repair, vascular surgeon assessment considered 18.1 % of patients "unfit" for surgery, while the objective frailty risk analysis index identified 34.6 % of patients to be frail with only 9.1 % overlap with the subjective assessment [36]. In a study of advanced chronic kidney disease patients, Fried criteria identified 34 % to be frail, whereas 44 % of patients were qualified as frail by physician impression, with a weak agreement between assessments [32]. Among patients with heart failure, two separate studies reported fair agreement between formal and subjective provider assessment of frailty, yet overall, physicians tended to significantly overestimate non-frail patients and underestimate the true prevalence of frailty [19,20]. These results have encouraged the inclusion of self-rated indices in frailty measurements to improve detection rates, particularly in younger patients in which fitness status may not be visibly apparent [37].

Limitations and future directions

There are limitations to this study. Notably, each patient was only seen and evaluated by their primary surgeon, and therefore we cannot assess for agreement in rating between surgeons. There is also no standardization in the demographics and baseline characteristics of patients that present to each surgeon's preoperative clinic for assessment, so variation in characteristics may exist between patients seen by each surgeon. Patients who did not undergo surgery were not included in the study and thus may limit generalizability of results. Interestingly, frail patients were more likely to undergo open surgery. The reasons for this are not completely clear. Patients undergoing an open approach may have more advanced or chronic pathologies affecting systemic physiologic reserve which could have contributed to frailty. Regardless, it may represent some level of selection bias within the cohort. All the surgeons that participated in the study were male and non-Black, which may contribute to the observed disparities among female and black patients. Therefore, it would be of interest to standardize the patients seen by each surgeon, establish an agreement between ratings, and include female surgeon assessments. In addition, there appeared to be a difference in the association with objective frailty between non-oncologic and oncologic surgery. This should be considered in future analyses to verify the validity of each group separately given the potential heterogeneity in patient populations and surgeries.

Conclusions

We found surgeon subjective rating to more strongly indicate frailty among female, non-white, and older patients, however, the difference within subgroups was not significant. These results support the use of objective measurements of frailty in assessing fitness for surgery to improve outcomes. Future work should include the development of models that include patient feedback given the weaker association of subjective ratings in male, non-white, and younger patients.

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Ethics approval

This study was approved by the Emory Institutional Review Board for patients aged 18 or older with planned surgical procedure.

CRediT authorship contribution statement

Edouard H. Nicaise: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Gregory Palmateer:** Writing – review & editing, Writing – original draft. **Benjamin N. Schmeusser:** Writing – review & editing, Writing – original draft, Visualization, Investigation. **Cameron Futral:** Writing – original draft, Investigation. **Yuan Liu:** Software, Resources, Methodology, Funding acquisition, Formal analysis, Data curation. **Subir Goyal:** Software, Resources, Methodology, Formal analysis, Data curation. **Reza Nabavizadeh:** Writing – review & editing, Writing – original draft. **David A. Kooby:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Shishir K. Maithel:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **John F. Sweeney:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Juan M. Sarmiento:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Kenneth Ogan:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Viraj A. Master:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors have no relevant conflicts of interest to disclose.

Data availability

Individual participant data that underlie the results reported in this article, after deidentification can be made available upon reasonable request by investigators who provide a methodological sound proposal following publication. Proposals should be directed to the corresponding author. To gain access, data requestors will need to sign a data access agreement.

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