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When Does Postoperative Pain Resolve? Differences in Time to Onset of Sustained Postoperative Pain Relief(SuPPR)

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Abstract

Objectives—Prior work on postoperative pain trajectories have examined pain score changes over time using daily averages of pain scores. However, little is known about the time required until patients consistently report minimal postoperative pain.

Materials and Methods—We conducted a retrospective cohort study of surgical case data from 7,293 adult patients to examine the impact of age, gender, and the type of surgery on the time to sustained postoperative pain relief (SuPPR). We defined SuPPR as the time required until a patient reports the first of multiple (2, 3, 4, or 5 sequential measurements; e.g., SuPPR-2, SuPPR-3, etc.), uninterrupted, mild pain scores (4/10).

Results—Overall, SuPPR times ranged from 3 min for SuPPR-2 and 9 min for SuPPR-5 to 160.1 h for SuPPR-2 and 183.1 h for SuPPR-5. For the SuPPR-2 outcome, the median time to event was 10.9 h (interquartile range [IQR], 3–26.1 h) after surgery. For the SuPPR-5 outcomes, the median time to event was 31.5 h (IQR, 17.8–54.2 h) after surgery. The peak median difference between two sequential SuPPR definitions was between SuPPR-3 and SuPPR-2 at 9 h, with subsequent decreases to 6.5 h between SuPPR-4 and SuPPR-3, and 5.2 h between SuPPR-5 and SuPPR-4. There were statistically different differences across SuPPR 2 through 5 definitions by age, gender, and type of surgery.

Discussion—Although additional analyses are necessary, SuPPR may represent a novel method for evaluating acute pain service performance.

Keywords

postoperative pain; acute pain; pain scores

In a majority of patients, postoperative pain will diminish over the first few days following surgery.^{1–5} The most common assessment of pain resolution following surgery has focused

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on static pain scores at fixed postoperative intervals, which provide limited information regarding individual differences in temporal pain profiles, a parameter that could substantively impact the management of pain. Recent studies by Chapman and colleagues have highlighted disparities in acute postoperative pain trajectories following elective surgery¹ and surgery in cardiac³ and chronic pain² patients over several days. Using advanced modeling techniques (i.e., mixed effects model of linear growth), the studies reported individual differences in the trajectories with about one-third of patients having an increase in pain, a decrease in pain, or constant pain over the first 6 days after surgery. However, trajectories calculated by Chapman were linear trajectories of once-daily pain. Although an excellent experimental approach in highlighting the disparities in postoperative pain trajectories, this approach was unable to offer insights about the time until patients reported pain relief particularly over sequential assessments.

To address these knowledge gaps, the goal of the current study was to conceptually characterize durable effective acute postoperative pain relief (SuPPR) in a group of adults undergoing elective surgery. SuPPR is conceptually defined as the time required until a patient reports multiple sequential mild pain scores ($\leq 4/10$). Any interruption in this sequence is suggestive of a temporary improvement in pain management rather than a durably effective pain management plan. SuPPR is based on the supposition that while prediction and absolute prevention of postoperative pain may not be feasible in all patients, effective postoperative pain management is both desirable and achievable for a large proportion of surgical patients.

Overall, our primary aim was to examine times required for patients to achieve multiple consecutive mild pain scores after surgery. For this aim, we hypothesized that SuPPR could be defined by longer times for a patient to report the first of 2, 3, 4, or 5 consecutive mild pain scores ($\leq 4/10$). Our secondary aim was to compare differences in the time to SuPPR according to age, gender, and type of surgery, which are common patient-related factors associated with differences in postoperative pain experience.^{6,7} For the second aim, we hypothesized that a younger age and female gender would be associated with longer times until achieving SuPPR, whereas no differences would be observed with the different types of surgery.

MATERIALS AND METHODS

This study was a retrospective cohort study of surgical case data using a large electronic medical records system that was designed to examine the impact of age, gender, and the type of surgical procedure on postoperative pain trajectory in an adult population undergoing a variety of surgical procedures. The Institutional Review Board (IRB-01) at the University of Florida approved this study and results are reported in accordance with the STROBE criteria for cohort studies. (http://www.strobe-statement.org/fileadmin/Strobe/uploads/checklists/STROBE_checklist_v4_cohort.pdf)

Description of Data

Surgical case data were obtained from the University of Florida's Integrated Data Repository (IDR). The IDR is a large database of validated fields obtained from electronic medical

record systems used for patient tracking, billing, surgery, and hospital administration purposes.⁸ Subjects were adult patients aged 21 and over undergoing non-ambulatory surgery at UF Health at the University of Florida over a 1-year period starting in May of 2011. Case exclusion criteria included obstetric surgery, as well as those patients who received multiple separate surgeries within the study period to avoid contamination of pain scores from the effects of surgeries preceding or following the case of interest.

The numeric rating scale (NRS), which is based on an 11-point system ranging from 0 (no pain) to 10 (most intense pain imaginable), was used to document pain by clinical staff. A cut-point of 4 on the numerical rating scale was used based upon prior considerations of established cut-points defining mild and moderate pain intensity.^{9–12}

Pain scores were generally recorded every 4 h per nursing protocol, with a repeat query within 1 h following administration of analgesic medications for breakthrough pain. When the clinical staff documented a pain score as “patient asleep,” the pain score was converted to a missing value rather than 0/10 to account for the fact that some patients had received additional sedatives that may have facilitated sleep despite an otherwise large nociceptive load. All pain scores were recorded with a corresponding date/time stamp, as were the start and end times of the related surgical procedure. For each pain score, the time in minutes following the end of surgery was calculated to enable a stable reference point from which to calculate pain trajectories. End of surgery times generally reflected the closure of skin and emergence from anesthesia. Pain scores were filtered to include only those obtained after the listed end-surgery time through the end of postoperative day 7. If a patient was discharged from the hospital prior to achieving SuPPR, this patient was considered right-censored from the dataset.

Types of surgery were identified using current procedural terminology (CPT) codes published by the American Medical Association. Given the large number of CPT codes, surgeries were grouped into separate categories based upon their anatomic location according to the first digits of the CPT code. Anatomic types of surgery with less than 300 subjects within the cohort were removed from the analysis set. For patients with multiple CPT codes, only the primary CPT code was used for definition of the type of surgery. The total number of CPT codes used to describe each surgery was included as an index of the complexity of the surgical procedure. Patient comorbidity was scored by first extracting up to 50 comorbid diagnoses as coded by the international classification of disease 9, clinical modification (ICD-9-CM) for each patient. The ICD-9-CM codes were converted into a Charlson Comorbidity Index.^{13,14} Sex was defined as male or female. Age was defined in separate models as a continuous variable as well as a nominal variable consisting of the following empirically selected age groups: 21–39 years, 40–64 years, and 65 years or greater. Patients aged 85 years or greater were not grouped separately given the relatively small number of surgical patients in our cohort who met these criteria. Observations with missing pain scores or missing measurement time points for pain scores were removed from the analysis set.

Statistical Analysis

SuPPR was characterized as a series of time to the event for achieving 2, 3, 4, or 5 consecutive NRS pain intensity scores less than 5 of 10. Specifically, SuPPR was defined as the time to reach the FIRST desired pain intensity score of a series of consecutive NRS as aforementioned. If there were no such serial of consecutive NRS ratings for that subject, then the maximum measurement time for that subject was used as the time to event and denoted as censored.

The distribution of each of the time to event data for SuPPR was fitted by the non-parametric survival model via SAS *proc lifetest* procedure. Statistics for each fitted model including point estimates and 95% confidence intervals (CIs) for the 25th, 50th, and 75th percentiles using log-log transformation, as well as Kaplan-Meier curves, were reported. To investigate the risk factors associated with the time to SuPPR, we fit the semi-parametric Cox regression model via SAS *proc PHReg* procedure including main effects of age, gender, type of surgery, total number of diagnoses, total number of CPT codes used to describe the surgery, and their interactions with the time for testing the proportionality assumption for each main effect.

RESULTS

Demographics

Demographics of the patient cohort used for the SuPPR analysis can be found in Table 1. The analyses were conducted based on 7293 subjects between the ages of 21 to 97 years. The average age of the patient cohort was 56.4 ± 16.4 years. A higher percentage of patients was in the middle-aged group (i.e., 40–64 years). The patient cohort had roughly equal proportions of females and males. Finally, the majority of cases were musculoskeletal followed by digestive, nervous, and cardiovascular types of surgery.

Description of SuPPR Definitions

For the SuPPR definition of two consecutive mild pain scores (SuPPR-2), 10.6% of cases were censored (i.e., no consecutive NRS), and this percentage of censored cases increased for each subsequent definition, with a maximum of 40% of cases censored for the SuPPR-5 definition (Table 2). Overall, SuPPR times ranged from 3 min for SuPPR-2 and 9 min for SuPPR-5 to 160.1 h for SuPPR-2 and 183.1 h for SuPPR-5. The distribution of times to event for each SuPPR definition is shown in Fig. 1.

Kaplan-Meier curves for each SuPPR definition demonstrate a steady decrement in time to SuPPR definitions, with an inflection point increasing from approximately 27.7 h to approximately 55.6 h with progression from SuPPR-2 to SuPPR-5 (Fig. 2). Across the SuPPR definitions for the aggregate cohort, the Kaplan-Meier curves demonstrated a general divergent-convergent pattern, suggesting that differences within the SuPPR outcome array lead to temporary differences in the time to event. For the SuPPR-2 outcome, the median time to event was 10.9 h (interquartile range [IQR], 3–26.1 h) after surgery (Table 3). For the SuPPR-5 outcomes, the median time to event was 31.5 h (IQR, 17.8–54.2 h) after surgery.

By plotting the median differences between sequential SuPPR definitions, we could determine whether there were significant step-offs within the SuPPR outcome array to evaluate for natural break-points among the SuPPR scores. The median difference between the time to the first minimal pain score and the time to SuPPR-2 was 7.6 hours. This peak median difference between two sequential SuPPR definitions was between SuPPR-3 and SuPPR-2 at 9 h, with subsequent decreases to 6.5 h between SuPPR-4 and SuPPR-3, and 5.2 h between SuPPR-5 and SuPPR-4.

Group Differences in Postoperative Pain Trajectories Based on SuPPR Definitions

For most of the SuPPR definitions, the effects of age (Table 4), gender (Table 5), and type of surgery (Table 5) were each independently associated with differences in the times to multiple consecutive mild pain scores, which was measured with hazard ratio. For the following analyses, higher hazard ratios indicate the odds that a group will reach the specific SuPPR-related definition more quickly when compared with the control group. Therefore, higher hazard ratios loosely reflect an earlier time to achieving SuPPR. For the following section, differences for first mild pain scores are summarized, which is followed by a separate analysis of differences for consecutive mild pain scores as a function of different groups.

Reporting of the First and Consecutive Mild NRS Pain Intensity Scores for Age, Gender, and Surgery Type—The time to the first and consecutive (i.e., second, third, fourth, and fifth) mild pain ratings following surgery differed as functioning of age, gender, and surgery. Specifically, compared with the older aged group (i.e., 64 years old and over), the time to the first mild pain rating and consecutive mild pain ratings were significantly longer in the younger (i.e., 21–39 years old) and middle (i.e., 40–64 years old) age groups, which is summarized in Table 4. Similarly, the time to report mild pain ratings was longer in female patients compared to male patients across all outcome measures. The gender differences in the first and consecutive mild pain ratings are summarized in Table 5. Compared with urinary surgery, only musculoskeletal surgery lead to decreased times to event; all other types of surgery had no difference (i.e., pulmonary, nervous, integumentary, cardiovascular) or increased times to (i.e., digestive surgery) to SuPPR-1 (Table 6). Patients with increased numbers of comorbidities had longer times to event, as did those with more complex types of surgical procedures as indicated by a higher number of CPT codes (HR 0.914, $p < 0.001$, not reported). The effects of age, gender, comorbidity, and surgical complexity were relatively unchanged from the time required to achieve a single pain score.

Age—Figure 3A demonstrates the differences in times to multiple consecutive mild pain scores across the young (21–39 years), middle aged (40–64 years), and older (≥ 65 years) age groups based on the four SuPPR definitions. Using the log-rank test, univariate analysis showed a significant difference between the three age groups for each of the SuPPR definitions (all $P < 0.001$). In all cases, the time to event was greatest in the younger group, followed by middle group and then the older age group.

Hazard ratios for SuPPR outcomes differed as a function of age (Table 4). Similar to differences in the time to SuPPR-1, younger subjects had a longer time to reaching

consecutive mild pain scores compared to older cohorts. For SuPPR-2 through SuPPR-5, the independent effects of age trended more strongly in the same direction with hazard ratios, which were increasingly less than one.

Gender—Figure 3B demonstrates the differences in times to multiple consecutive mild pain scores for male and female patients based on the four SuPPR definitions. While differences in the time to report the first mild pain were marginally significant ($P = 0.04$), females required significantly longer times to reach two (SuPPR-2, $P < 0.001$), three (SuPPR-3, $P = 0.004$), four (SuPPR-4, $P < 0.001$), and five (SuPPR-5, $P < 0.001$) consecutive mild pain ratings compared to male patients.

Hazard ratios for SuPPR outcomes differed as a function of gender (Table 5). Similar to age differences in SuPPR (Section 3.3.1), the pattern in the time to mild pain scores was also observed for gender.

Compared to SuPPR-1, female subjects had longer time to reaching consecutive mild pain scores compared to male subjects. For SuPPR-2 through SuPPR-5, the independent effects of gender trended more strongly in the same direction with hazard ratios.

Anatomic Type of Surgery—Figure 3C demonstrates the differences in times to multiple consecutive mild pain scores based on the four different SuPPR definitions for different types of surgery based upon anatomic categorization. Based on log-rank test, univariate analysis showed a significant difference between the seven anatomic types of surgery for each of the SuPPR definitions (all $P < 0.001$). In all cases, the time to event was greatest in the integumentary, digestive, and urinary types of surgery.

Hazard ratios for SuPPR outcomes differed as a function of the type of surgery. Musculoskeletal and nervous surgeries had earlier time to reaching two consecutive mild pain scores (SuPPR-2) when compared with urinary surgery. Pulmonary surgery and cardiovascular surgery joined musculoskeletal and nervous surgeries for SuPPR-3. Each of these procedures had higher hazard ratios, which peaked at SuPPR-4 (cardiovascular, musculoskeletal, nervous, pulmonary) before declining slightly, but still remaining significant at SuPPR-5.

DISCUSSION

The current study reports a retrospective assessment of postoperative pain scores in a large sample of patients undergoing elective surgery at a large academic medical center. Overall, we characterized the time to reach multiple consecutive mild pain scores (4/10) following surgery based on four definitions of SuPPR in which a patient was required to meet the criteria if they reported two, three, four, or five consecutive uninterrupted mild pain scores. The time to reach a multiple consecutive mild pain scores differed as a function of the definition. The greatest incremental increase in time to multiple consecutive mild pain scores was observed between SuPPR-2 and SuPPR-3. Differences were also observed in several factors related to surgery and the patient (i.e., age and gender). Overall, younger and female patients had longer times to multiple consecutive mild pain scores across all SuPPR

definitions. Finally, differences in the time to SuPPR were also observed depending on the type of surgery.

Using a large electronic medical records system, the current study provides insight into the trajectory of pain over multiple time points over the course several days, which has the potential to inform clinical and research questions about variability in pain and its relief. Use of this type of system has been reported previously,^{15–18} but no current studies have addressed the usefulness of this system in tracking the trajectory of pain following surgery. In addition, the study complements the linear trajectory of postoperative pain reported by Chapman and colleagues following elective surgery¹ and surgery in cardiac³ and chronic pain² patients over several days. In the future, these results could be expanded upon to offer probabilistic expectations to patients on their time to SuPPR following surgery.

In terms of clinical utility, this information may at some point assist in the development and implementation of hospital-level metrics for postoperative pain management. This study identifies an important period where patients require more aggressive post-operative pain control, and this period may differ significantly based upon a host of clinical and sociodemographic factors. This time period may warrant increased attention due to the transition from intermittent to sustained analgesic responses, which may carry important implications for patient safety during analgesic titration as this time period has been associated with a greater likelihood of postoperative opioid-induced respiratory depression.¹⁹ Postoperative patients reporting low pain scores may do so because of low nociception or highly efficacious analgesia, both of which may be temporary occurrences that do not accurately portend a robust pain management program. Indeed, we commonly observe in clinical practice that the first several pain assessment-treatment-evaluation cycles often require a co-adaptation between the patient and the healthcare delivery system to identify which analgesic strategies optimally provide sustained, successful pain management.^{20,21} Rather than rewarding healthcare delivery systems for offering a non-selective “kitchen sink” approach to postoperative pain management principally predicated on high-dose opioid analgesia, which can lead to substantial increases in patient safety events with insignificant decreases in pain intensity across the hospital population, it may be advantageous to encourage expedited assessment-treatment-evaluation cycles to hasten the co-adaptation and personalization of analgesic strategies to individual patients. The time to SuPPR thus partially considers the adaptability of the healthcare system to an individual patient’s needs in requiring a sustained improvement, rather than a linear trend that may feature a decreasing overall trend in pain intensity yet still permit repeated episodes of severe pain. Note that such exceptions are even feasible with hierarchical mixed modeling techniques because the episodic exceptions of high pain scores would occur within not just groups of patients, but within individual pain trajectories.

Because SuPPR is based on the idea that prediction and/or prevention of postoperative pain may not be feasible in all patients, it may provide an opportunity to manage pain more effectively by providing “rescue” medications. Given that primary prevention of postoperative pain is unlikely in most cases, highly effective secondary prevention represents the most achievable outcome, and this could be enhanced through systems-level analgesic applications, including patient-controlled analgesia devices, active acute pain services, and

aggressive use of multimodal analgesics and regional anesthesia. Additionally, the use of various definitions of SuPPR may be an attractive target since it can partially account for differences in postoperative pain trajectories based on sociodemographics (i.e., age, gender) and the type of surgery in patients.

The current study reported variations in pain trajectories as a function of surgery and patient demographics. Specifically, integumentary, digestive, and urologic types of surgery were associated with longer times to durable effective analgesia. This may be due in part to greater tissue damage or increased nociceptive drive due to innervation of the affected structures associated with these types of surgery. However, other factors associated with the procedure, including the types of patients undergoing a specific surgery and the anesthetic and analgesic options available for different types of procedures, also contribute to postoperative pain. Regardless of the mechanisms, if these findings are replicated in future studies, this may help identify patients and procedures that would benefit from enhanced postoperative pain management. As for patient demographics, longer times to achieve SuPPR were observed in younger patients. Similar outcomes have been reported following total knee surgery.²² However, the current study is in contrast to Chapman's 2011 study¹ in which younger patients reported higher pain immediately following surgery but experienced a quicker rate of resolution. This discrepancy could reflect differences in surgical procedure and duration between older and younger adults, although age-related differences in opioid responses may also contribute.²³ Specifically, our findings could be explained by earlier reduction in nociceptive loading after surgery in addition to an increased potency and decreased clearance of analgesics in older populations. The discrepancies between our results and Chapman's could also be due to methodological differences. It is possible that by using a linear mixed modeling approach as opposed, or in comparison to, a generalized mixed model, Chapman's analysis may have failed to detect nonlinear time trends that could affect this comparison of results. Considering the increased interest in the field of pain and aging,²⁴ future studies should attempt to model these outcomes. In addition, the use of pain scales may also complicate prospective assessment, but recent studies suggest that the NRS is an ideal scale for elderly patients.²⁵

Finally, gender was associated with different times to pain relief, which was slower in female patients. The current study extends previous clinical and experimental studies related to differences in pain between males and females. A review by Fillingim et al.²⁶ summarized a number of clinical and experimental studies over the past decade and supported the idea that females experience more severe postoperative pain and greater pain sensitivity to laboratory assessments of pain (i.e., lower pain thresholds and tolerances, greater self-reported pain to suprathreshold stimuli) in addition to being at a greater risk for clinical pain conditions like fibromyalgia and temporomandibular disorder compared to males. Additional clinical studies also support the notion of greater postoperative pain and functional recovery in females following arthroscopic anterior cruciate ligament reconstruction.²⁷ This study reported that although no differences were observed in analgesic medication usage, females had greater pain and a reduced ability to perform a functional leg test following the surgery. Another study reported difference in pain and analgesic requirements following surgery in the same direction.⁶ While these earlier findings predominantly reflect outcomes based upon pain intensity ratings at static time points, our

results suggest these differences are maintained with respect to the time required to achieve SuPPR.

The current study has several limitations. First, the findings reported were based on a large retrospective study. Second, the current electronic medical records system did not permit further detail regarding the types of surgical procedures, information about analgesics (i.e., types and doses), nor patient functioning, which are universal challenges in collecting postoperative pain data. Data on pharmacokinetic considerations such as preemptive and preventative analgesics, as well as the patient state (static vs. dynamic) at the time of pain assessment, would have provided important context for consideration, but would have also barred the scale at which our data were considered. Third, the current study did not provide any mechanistic explanation regarding differences based on demographics or surgery, which has been a focus of research over the past several years. For example, the resolution of pain following surgery can be influenced by a number of patient-related factors, including psychological status,^{28,29} genetic variation,^{30,31} and neurophysiological systems underlying dysfunctional central pain processing.^{32–34} Many of these factors have been associated with risk factors for poor postoperative pain control. It would be informative if some of these quantitative and qualitative variables were included in future studies using these types of systems. Finally, the current design did not include long-term follow-up of patient outcomes (i.e., readmission or development of chronic pain).

These limitations notwithstanding, our results from very large post-operative cohort demonstrate significant differences among individuals in sustained recovery from acute pain after surgery. Although additional analyses are necessary, sustained effective acute postoperative pain relief may represent a novel method for evaluating performances of acute pain services.

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FIGURE 1.

Distribution of times to SuPPR-1 through SuPPR-5. Histogram demonstrating the count of each time requirement in hours until patients report a single or multiple sequential and uninterrupted minimal pain scores.

FIGURE 2.

Kaplan-Meier curves for SuPPR-1 through SuPPR-5. Here, the survival probability, denoted on the y-axis, reflects the probability that a subject will continue to suffer from acute postoperative pain, without receiving sustained, effective analgesia, at each time point listed on the x-axis. Progression from the time to first mild pain score (A) to SuPPR-2 (B), SuPPR-3 (C), SuPPR-4 (D), and SuPPR-5 (E) shows a general divergent-convergent pattern, suggesting that differences within the SuPPR outcome array lead to temporary differences in the time to event.

FIGURE 3.

Time to the first mild pain score (4/10) and two (SuPPR-2), three (SuPPR-3), four (SuPPR-4), and five (SuPPR-5) consecutive mild pain scores across different groups following surgery. Group differences were observed among age (A), gender (B), and surgery (C). First pain and SuPPR scores are expressed in the average ($\pm$ SE) number of minutes.

TABLE 1

Frequency (Number of Subjects and Percentages) of Age, Gender, and Surgical Groups following Postoperative Monitoring of Pain

	Subjects	Percentage (%)
Age		
21–39	1266	17.4
40–64	3469	47.6
65	2558	35.1
Gender		
Female	3553	48.7
Male	3740	51.3
Surgery		
Cardiovascular	993	13.6
Digestive	1727	23.7
Integumentary	582	8.0
Musculoskeletal	1949	26.7
Nervous	1150	15.8
Pulmonary	281	3.9
Urinary	611	8.4

TABLE 2
Time to Report First and Consecutive and Uninterrupted Mild Pain Scores (4 NRS) following Elective Surgery (n = 7293)

	Outcome Measures	Hours			Number of Events	Number of Censored Cases (%)
		Mean	Min	Max		
Post-Surgical Pain Scores (NRS)						
First Mild Pain Score	SuPPR-1	8.37 ± 13.88	0.02	160.07	7152	141 (2%)
Two (2) Consecutive and Uninterrupted Mild Pain Scores	SuPPR-2	16.58 ± 22.45	0.05	177.02	6158	775 (11%)
Three (3) Consecutive and Uninterrupted Mild Pain Scores	SuPPR-3	22.51 ± 26.37	0.08	175.33	5710	1583 (22%)
Four (4) Consecutive and Uninterrupted Mild Pain Scores	SuPPR-4	27.52 ± 28.74	0.10	188.92	5001	2292 (31%)
Five (5) Consecutive and Uninterrupted Mild Pain Scores	SuPPR-5	32.13 ± 31.20	0.15	183.07	4403	2890 (40%)

TABLE 3

Point Estimates (Hours) and 95% Confidence Intervals (Lower and Upper) for SuPPR Definitions Based on Aggregate Quartiles

SuPPR Outcome Measure	Quartiles		
	25 TH	50 TH	75 TH
SuPPR-1	0.6 (0.5–0.7)	3.3 (3.1–3.5)	11.3 (10.8–11.9)
SuPPR-2	3.0 2 (0.9–3.2)	10.9 (10.2–11.4)	26.1 (25.2–26.8)
SuPPR-3	6.6 (6.3–7.0)	19.8 (19.1–20.5)	40.1 (38.5–41.7)
SuPPR-4	11.9 (11.3–2.6)	26.3 (25.5–27.0)	47.1 (46.0–48.8)
SuPPR-5	17.8 (17.2–18.5)	31.5 (30.4–32.8)	54.2 (52.1–57.0)

TABLE 4

Parameter Estimates (SE) and Hazard Ratios for Age across Measures of SuPPR

Age Group	21–39		40–64	
	PE (SE)	P-value	HR	HR
SuPPR-1	–1.21(.17)	<0.001	0.30	–0.64(0.12)
SuPPR-2	–1.54(.29)	<0.001	0.22	–0.63(0.20)
SuPPR-3	–2.58(.38)	<0.001	0.08	–1.29(0.24)
SuPPR-4	–3.58(.47)	<0.001	0.03	–1.91(0.29)
SuPPR-5	–4.54(.57)	<0.001	0.01	–2.29(0.34)

Patients 65 were used as the reference point.
PE, Parameter estimate; SE, standard error; HR, hazard ratio.

TABLE 5

Parameter Estimates (SE) and Hazard Ratios between Males and Females across Measures of SuPPR

Gender	Female		
	PE (SE)	P-value	HR
SuPPR-1	−0.07(0.02)	0.004	0.93
SuPPR-2	−0.11(0.03)	<0.001	0.89
SuPPR-3	−0.71(0.23)	0.002	0.49
SuPPR-4	−1.14(0.28)	<0.001	0.32
SuPPR-5	−1.05(0.32)	0.001	0.35

Males were used as the reference point.

PE, Parameter estimate; SE, standard error; HR, hazard ratio.

TABLE 6
Parameter Estimates ($\pm$ SE) and Hazard Ratios of Different Surgical Procedures across Measures of SuPPR

Surgical Group	Cardiovascular			Digestive			Integumentary			Musculoskeletal			Nervous			Pulmonary		
	PE (SE)	HR		PE (SE)	HR		PE (SE)	HR		PE (SE)	HR		PE (SE)	HR		PE (SE)	HR	
SuPPR-1	-0.11 [*] (0.05)	0.90		-0.16 ^{***} (0.05)	0.85		-0.13 [*] (0.06)	0.87		0.15 ^{**} (0.05)	1.16		0.03 ^{ns} (0.05)	1.03		-0.06 ^{NS} (0.07)	0.94	
SuPPR-2	0.12 ^{***} (0.21)	1.13		-0.12 [*] (0.05)	0.89		-0.12 ^{NS} (0.06)	0.89		0.17 ^{**} (0.05)	1.19		0.16 [*] (0.05)	1.17		0.15 [*] (0.07)	1.16	
SuPPR-3	0.23 ^{***} (0.05)	1.26		-0.05 ^{ns} (0.05)	0.95		-0.13 ^{ns} (0.07)	0.88		0.24 ^{***} (0.05)	1.27		0.22 ^{***} (0.06)	1.24		0.31 ^{***} (0.08)	1.37	
SuPPR-4	0.32 ^{***} (0.06)	1.39		-0.03 ^{ns} (0.05)	0.98		-0.11 ^{ns} (0.08)	0.89		0.30 ^{***} (0.06)	1.35		0.29 ^{***} (0.06)	1.34		0.40 ^{***} (0.08)	1.49	
SuPPR-5	0.29 ^{***} (0.06)	1.35		-0.07 ^{ns} (0.06)	0.93		-0.15 ^{ns} (0.08)	0.87		0.29 ^{***} (0.06)	1.33		0.29 ^{***} (0.07)	1.35		0.36 ^{***} (0.09)	1.44	

Patients undergoing urinary surgery were used as the reference point.

PE, Parameter estimate; HR, hazard ratio

^{*} $P < 0.05$

^{**} $P < 0.01$

^{***} $P < 0.001$

^{NS}, Not significant.