

Wrong-Site Surgery:

A Study of 664 Events From 237 Facilities Across a 10-Year Period

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Abstract

Background: Wrong-site surgery (WSS) remains a significant and avoidable medical error, persisting despite decades of national and international efforts to prevent it. Pennsylvania is one of the few large governments or entities that mandates reporting of patient safety events ranging from near misses to serious events.

Methods: We used the Pennsylvania Patient Safety Reporting System database to study a 10-year period (2015–2024) of wrong-site surgery events at hospitals and ambulatory surgical facilities. We reviewed and analyzed event reports for the following clinically related variables: facility type, hospital procedure location, hospital bed size, error type, clinician specialty, body region, specific body part, procedure group, and specific procedure.

Results: We identified 664 WSS events that occurred in Pennsylvania during the 10-year period of 2015–2024. The events were reported by 237 hospitals and ambulatory surgical facilities. The 16 visuals presented in this study allow for a thorough analysis that will help readers understand the extent to which WSS has a multifactorial relationship with the variables targeted in this study.

Conclusions: The present study expands upon many of the previous WSS studies by exploring novel combinations of variables across one of the largest samples of WSS events. We anticipate that stakeholders will leverage the findings to identify WSS-related factors to target and inform interventions to enhance patient safety.

Introduction

Wrong-site surgery (WSS) remains a significant and avoidable medical error, persisting despite decades of national and international efforts to prevent it. While the development and implementation of safety protocols—such as the Universal Protocol¹ and World Health Organization Surgical Safety Checklist²—likely have helped to prevent WSS events, these “never events” still occur across a range of settings, including hospitals and ambulatory surgical facilities.^{3–15}

Pennsylvania is one of the few large governments or entities that mandates reporting of patient safety events ranging from near misses to serious events.³ Therefore, all licensed healthcare facilities, including acute care hospitals and ambulatory surgical facilities (ASFs) in Pennsylvania are required by law¹⁶ to report

WSS events to the Pennsylvania Patient Safety Reporting System (PA-PSRS)^a database. The combination of mandated reporting and a long-standing database have allowed the Patient Safety Authority (PSA) to develop a notable history of exploring, studying, and publishing on WSS,^{3,17-31} and we continue that practice by providing an updated and in-depth analysis of WSS event reports.

In this study, we utilized the PA-PSRS database and expanded upon our prior WSS research³ by examining events over a recent 10-year period. This expanded time frame allows for the analysis of a substantially larger sample of WSS events across the following clinically related variables: facility type, hospital procedure location, hospital bed size, clinician specialty, body region, specific body part, procedure group, and specific procedure. The present study will include novel cross-tabulations with the purpose of providing a deeper understanding of how WSS varies across different contexts. The findings are intended to inform stakeholders and support the development of targeted strategies to prevent WSS events.

Methods

Data Source and Sample

Data were obtained from patient safety event reports submitted by hospitals and ASFs to the PA-PSRS acute care database, which operates under Pennsylvania's mandatory event reporting laws. These reports contain both structured fields (e.g., event date, patient age, and care area) and unstructured fields (i.e., free-text entries), which allow reporters to describe the event and any actions taken. The de-identified reports do not contain medical records.

The identification and review of events for inclusion in this study were conducted in two distinct phases. During the first phase, the PA-PSRS database was queried for events that occurred over a 10-year period (January 1, 2015, to December 31, 2024) and satisfied one or more of the following inclusion criteria:

- Event was classified within the PA-PSRS taxonomy as an *Error Related to Procedure/Treatment/Test - Surgery/Invasive Procedure Problem* and one of the following event subtypes was selected: *wrong site*, *wrong side (L vs R)*, *wrong procedure*, *wrong patient*, or *preparation inadequate/wrong*.
- Event was classified within the PA-PSRS taxonomy as *Error Related to Procedure/Treatment/Test - Surgery/Invasive Procedure Problem* and at least one of the unstructured fields contained the words “left” and “right” or “incis” and “excis”^b.
- Event was classified under the Surgical Services care area group^c, and at least one of the unstructured fields included variations of one or more of the following phrases: *wrong site*, *wrong side*, *wrong level*, *wrong procedure*, *wrong patient*, *time out*, *incorrect side*, *incorrect site*, *incorrect procedure*, *incorrect patient*, *block*, or *mark*.

In the second phase, a researcher conducted a review of each report to determine whether it met the inclusion criteria by describing an invasive operative procedure and a WSS. (See **Table 1** for definitions along with examples of WSS organized by error type.) A total of 664 event reports were selected for inclusion in the study and 367^d of those event reports were included in our previous article about WSS during 2015–2019.³

Design, Analysis, and Variables Coded

We conducted a retrospective mixed-methods study using an exploratory sequential approach,³² beginning with an analysis of qualitative data, which were subsequently quantified for further examination. The qualitative data from PA-PSRS event reports were examined using directed content analysis,^{33,34} applying the framework method^{32,35,36} with variable categories guided by our previous research.^{3,17} The variables were quantified by frequency and evaluated through descriptive analysis. Descriptive analysis is a quantitative approach used to explore phenomena and identify patterns, aiming to improve understanding and explanation of their occurrence.^{3,37} This is often achieved through visual analysis of displays of data that illustrate multiple variable combinations and enable the triangulation of insights.

For each event report, the patient's age, patient's gender, event date, facility type, and facility bed size were extracted from the structured fields. From the unstructured fields in the event reports, a researcher manually reviewed and coded the following variables: hospital procedure location (three categories), error type (four categories), clinician specialty (23 categories; the spinal surgery category consists of orthopedic surgeons and neurosurgeons who performed spinal procedures), body region (12 categories), body part (41 categories), procedure group (11 categories), and specific procedure (34 categories). Consistent with our previous study of WSS,³ the variables were coded for what occurred during the event, not what was intended. For example, the researcher coded each event based on the procedure performed and the body region affected, which could have differed from the intended procedure or body region. For a description of the hierarchy in selection of codes per variable, see the methods section in our previous study.³ All coding assigned to events from 2015–2019 remained unchanged from our previous study, unless an opportunity to improve accuracy and reliability of codes was identified.

^aPA-PSRS is a secure, web-based system through which Pennsylvania hospitals, ambulatory surgical facilities, abortion facilities, and birthing centers submit reports of patient safety-related incidents and serious events in accordance with mandatory reporting laws outlined in the Medical Care Availability and Reduction of Error (MCARE) Act (Act 13 of 2002). All reports submitted through PA-PSRS are confidential and no information about individual facilities or providers is made public.

^bThe criteria were designed to identify reports involving wrong-side or wrong-procedure errors. Reports describing wrong-side errors often reference both the left and right sides, while those involving wrong-procedure errors—particularly those related to incisions or excisions—typically mention both procedures.

^cWithin PA-PSRS, the event reporter chooses among 168 care areas to indicate the location where an event occurred. In order to simplify our analysis, we sorted each of the care areas into higher-level care area groups.

^dOur previous article³ reported 368 WSS events during 2015–2019, but in rereview of the data we determined that one of the events should be excluded from our sample of WSS events, thereby reducing our sample to 367.

Table 1. Definition of Invasive Operative Procedure, Wrong-Site Surgery, and Examples by Error Type

Invasive operative procedure: Defined as “...skin or mucous membranes and connective tissue is incised or an instrument is introduced through a natural body orifice.”^{3,17,18,38} We further defined the invasive operative procedure as beginning “regardless of setting, at the point of surgical incision; tissue puncture; or the insertion of an instrument into tissues, cavities, or organs” and ending “after counts have concluded, the surgical incision has been closed, and/or operative device(s) such as probes have been removed, regardless of setting.”^{3,17,18,38}

Wrong-site surgery: Defined as a “surgical or other invasive procedure performed on the wrong side, site, or patient, or an incorrect procedure performed on the patient.”^{3,19,39-42}

Error Type	Examples From Event Reports
Wrong Side	• Chest tube placed on patient's right side, but was indicated for left side. • Patient was consented and marked for right eye cyclophotocoagulation (CPC) laser. Time-out completed and indicated the same. Prior to start of procedure, patient began to cough and required suctioning by anesthesia. Once surgery resumed, surgeon mistakenly completed the procedure on the left eye. • Patient scheduled for left shoulder arthroscopy with preoperative nerve block by anesthesia. Nerve block performed on right shoulder. Surgery was performed on left shoulder. Patient woke up from procedure complaining of pain in left shoulder and heaviness in right arm.
Wrong Site	• Patient scheduled for T12 and L1 kyphoplasty. Procedure performed and patient discharged to home. Several days later, patient called provider complaining of back pain. After review of postoperative imaging, it was noted that the procedure was performed at T11 and T12. • Patient scheduled for repair and pinning of digit four of right hand, but digit three of right hand was pinned. • Curettage of basal cell skin lesion on mid back was scheduled. Curettage of basal cell skin lesion on upper back was performed.
Wrong Procedure	• Left De Quervain's release performed as opposed to intended left carpal tunnel release. • Patient scheduled for hysterectomy with salpingectomy. Hysterectomy with bilateral salpingo-oophorectomy was performed. • Patient scheduled for tunneled dialysis catheter placement. Right-arm peripherally inserted central catheter line was instead inserted.
Wrong Patient	• Esophagogastroduodenoscopy and sigmoidoscopy performed on patient A rather than patient B. • Heart catheterization ordered and performed on patient A instead of patient B. • Patient A and patient B with the same last name. Patient A underwent a cystoscopy with stent intended for patient B.

Note: Information in each example was modified to ensure confidentiality.

Results

In addition to the figures and tables presented throughout the body of this manuscript, we also provide results in **Online Supplement Appendices S1–S9**. These appendices present WSS findings through various cross-tabulations of the following variables: year of event occurrence, facility type, error type, clinician specialty, body region, specific body part, procedure group, and specific procedure. Presenting the findings through multiple visualizations and variable combinations is intended to offer stakeholders a more comprehensive understanding of the patterns and characteristics of WSS events.

Patient Gender and Age

Patient gender was identified in 95% (633 of 664) of the reports and among those, 55% (347 of 633) were female and 45% were male (286 of 633). Across the sample, patient age was a mean of 57 years and

a median of 60 years (minimum was 0 years, 25th percentile was 48 years, 75th percentile was 72 years, and maximum was 99 years).

Wrong-Site Surgery by Facility Type, Hospital Procedure Location, and Hospital Bed Size

Figure 1 shows the occurrence of WSS events, across a 10-year period, at both individually licensed acute care hospitals and ASFs^e. The total annual frequency of WSS varied over time, peaking at 83 events in 2015 and reaching a low of 49 events in 2020. The majority of WSS events were associated with hospitals rather than ASFs and were distributed across operating rooms (ORs)^f, interventional radiology (IR), and other^g procedural locations. Within hospitals, the frequency of WSS was consistently higher in the OR compared to IR; however, IR reported between five and 16 WSS events annually throughout the study period. ASFs reported WSS events every year, with a maximum of 20 events in 2017 and a minimum of 11 events in 2020.

^eThe Health Care Facilities Act of Jul. 19, 1979, P.L. 130, No. 48 defines ambulatory surgical facility (ASF) as “a facility or portion thereof not located upon the premises of a hospital which provides specialty or multispecialty outpatient surgical treatment. Ambulatory surgical facility does not include individual or group practice offices of private physicians or dentists, unless such offices have a distinct part used solely for outpatient surgical treatment on a regular and organized basis. For the purposes of this provision, outpatient surgical treatment means surgical treatment to patients who do not require hospitalization, but who require constant medical supervision following the surgical procedure performed.”

^fThe hospital procedure location category labeled “operating room (OR)” included events occurring in the OR itself and also in the preoperative area, postoperative care unit, and procedure rooms (e.g., endoscopy/gastrointestinal laboratory, laser room, or dedicated anesthesia block room)

^gThe hospital procedure location category labeled “other” included events that occurred in a variety of settings, such as radiation oncology, rehabilitation unit, short stay unit, invasive cardiology, emergency department, electrophysiology laboratory, intensive care unit, newborn nursery, and nursing care unit (including medical/surgical, neurology, and medical oncology units).

In Pennsylvania, each week an average of 1.28 wrong-site surgery (WSS) events were reported during the period of 2015–2024 (664 WSS events during 520 weeks).

Table 2 presents the distribution of WSS events by year, facility type, and hospital bed size. Hospitals were the setting for the majority of WSS events, accounting for 79% (524 of 664), and hospitals having more than 300 beds were 41% (275 of 664) of the total. In comparison, ASFs reported 21% (140 of 664) of WSS events.

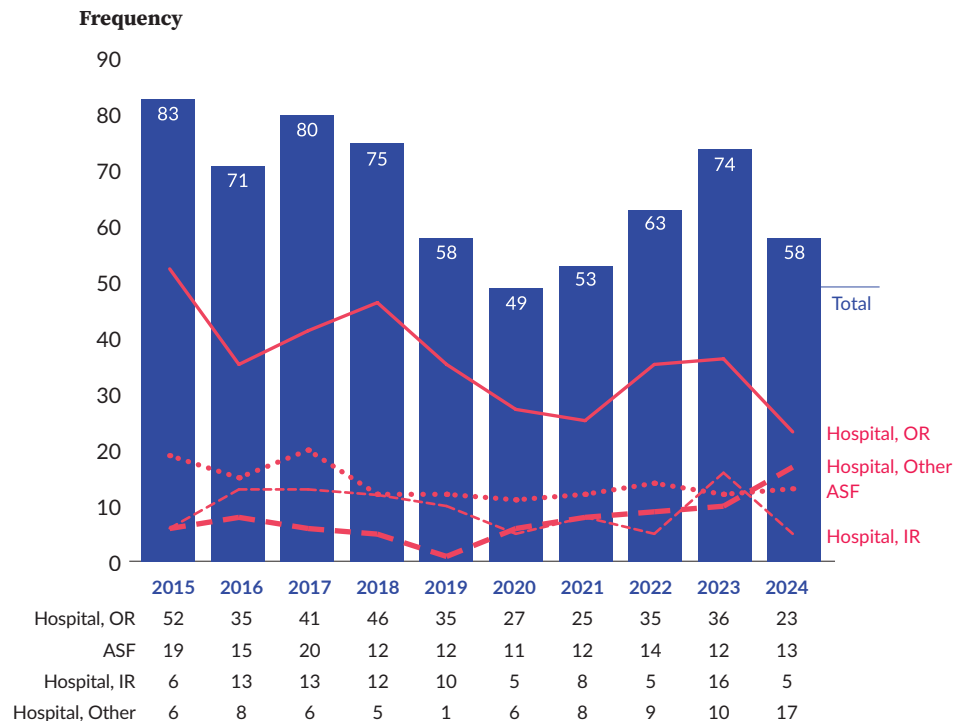
Table 2 also reveals the number of unique facilities that reported at least one WSS event during the 10-year period. During 2015–2024, 91 ASFs had at least one WSS, a range of 1 to 5 (mean=1.5; median=1), with 34 ASFs reporting two or more. We also found that the 146 acute care hospitals reported a range of 1 to 28 WSS events, a mean of 3.6, and a median of 2 (64 hospitals reported three or more WSS events).

Wrong-Site Surgery by Error Type and Other Clinically Related Variables

Figure 2 shows that wrong-side errors were the most common error type during eight of the 10 years, while wrong-site errors were the most frequent in the remaining two years. Across the 10-year period, the error types had the following distribution: 51% (340 of 664) were wrong side, 34% (227 of 664) were wrong site, 11% (75 of 664) were wrong procedure, and 3% (22 of 664) were wrong patient. The figure reveals, based on visual analysis of the data, that the frequency of each of the error types was variable and without a clear trend.

Figure 3 illustrates observable differences in the distribution of WSS error type dependent on facility type and hospital procedure location. For instance, wrong-side errors accounted for 62% (87 of 140) of WSS events at ASFs and 48% (253 of 524) at hospitals. In contrast, wrong-patient errors comprised 4% (21 of 524) of hospital events and less than 1% (1 of 140) at ASFs. As another example, within the hospital facility type, ORs reported 68% (132 of 195) of the wrong-site errors, but only 45% (25 of 55) of the wrong-procedure errors. Collectively, these findings suggest that the likelihood of specific error types may vary depending on both the facility type and the procedural location within hospitals.

Figure 1. Frequency of WSS Events Across Year of Occurrence, Facility Type, and Hospital Procedure Location



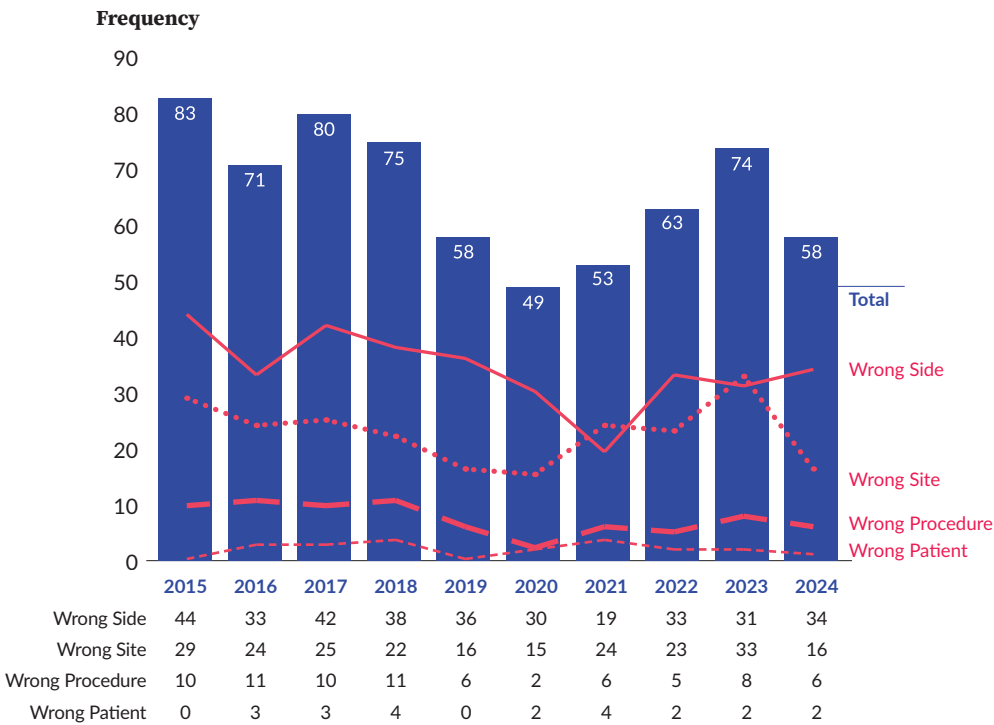
Note: The bars show the total annual frequency, aggregated across facility types and hospital procedure locations. Each line corresponds with a facility type and procedure location. The acute care hospital category encompasses children's hospitals, critical access hospitals, and long-term acute care hospitals. OR=operating room, ASF=individually licensed ambulatory surgical facilities, IR=interventional radiology, Other=variety of settings mutually exclusive to OR and IR.

Table 2. Frequency of WSS Events Across Year of Occurrence, Facility Type, and Hospital Bed Size

Facility Type and Hospital Bed Size	Unique Facilities	Event Year										Total
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
ASF	91	19	15	20	12	12	11	12	14	12	13	140
Acute Care Hospital	146	64	56	60	63	46	38	41	49	62	45	524
1 to 100 beds	41	13	7	11	9	2	2	1	11	10	8	74
101 to 200 beds	44	4	10	10	12	9	9	13	8	13	6	94
201 to 300 beds	24	8	5	11	11	10	8	7	6	9	6	81
over 300 beds	37	39	34	28	31	25	19	20	24	30	25	275
Total	237	83	71	80	75	58	49	53	63	74	58	664

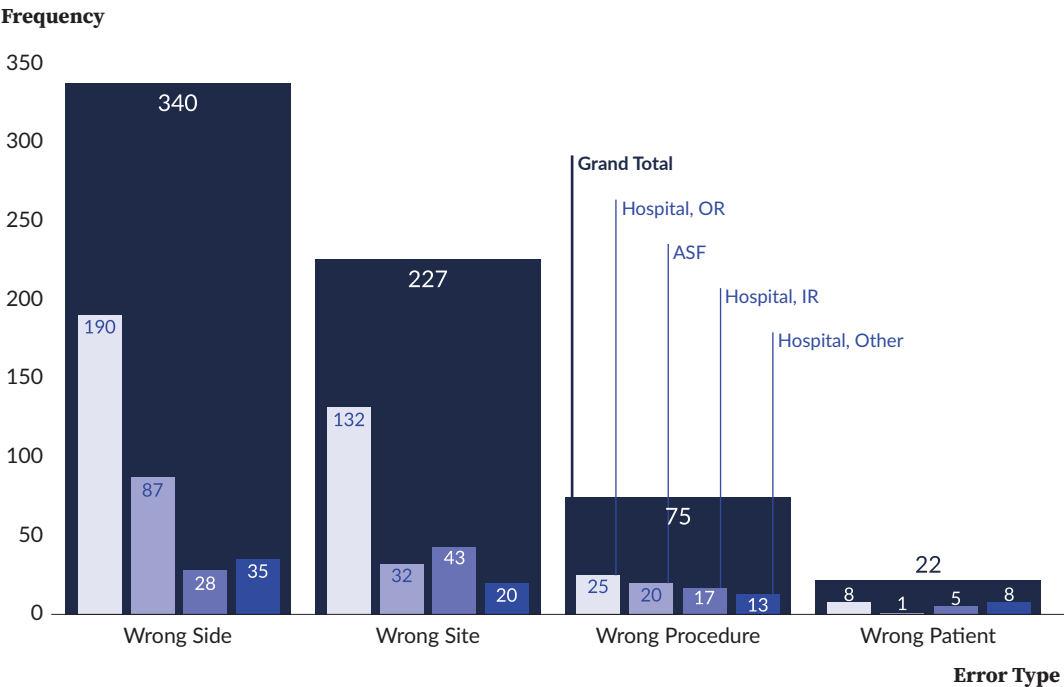
Note: The Acute Care Hospital category encompasses children's hospitals, critical access hospitals, and long-term acute care hospitals. All ambulatory surgical facilities (ASFs) included in the analysis were individually licensed. The "Unique Facilities" column shows the number of distinct licensed facilities that reported at least one WSS.

Figure 2. Frequency of WSS Events Across Year of Occurrence and Error Type



Note: The bars indicate the total annual frequency aggregated across all error types, while each line illustrates the yearly frequency specific to an individual error type.

Figure 3. Frequency of WSS Events Across Error Type, Facility Type, and Hospital Procedure Location



Note: The figure displays the frequency of WSS during 2015–2024. For each error type, the main bar reflects the grand total of events across the four nested bars. The acute care hospital category encompasses children’s hospitals, critical access hospitals, and long-term acute care hospitals. OR=operating room, ASF=individually licensed ambulatory surgical facilities, IR=interventional radiology, Other=variety of settings mutually exclusive to OR and IR.

Table 3 displays the distribution of WSS events by error type and clinician specialty. The most frequently involved specialties were interventional radiology (14%, 92 of 664), pain management (13%, 83 of 664), and orthopedics (11%, 73 of 664). The table shows that certain specialties were associated with a broader range of errors, while others were largely related to a single error type. For instance, spinal surgery was overwhelmingly associated with wrong-site errors, accounting for 94% (58 of 62) of events reported by that specialty. In contrast, interventional radiology reported a relatively high percentage of multiple error types, including wrong-site (48%, 44 of 92), wrong-side (29%, 27 of 92), and wrong-procedure errors (20%, 18 of 92).

Table 4 reveals that the most commonly affected body regions were the spine (23%, 155 of 664), head/neck (19%, 127 of 664), upper extremity (13%, 86 of 664), and lower extremity (12%, 79 of 664). The data also suggests that some body regions were associated with a variety of error types, whereas others tended to be related to a single type. For instance, WSS events involving the head and neck region frequently consisted of wrong-side (57%, 72 of 127), wrong-site (25%, 32 of 127), and wrong-procedure errors (16%, 20 of 127). In contrast, the urinary system was primarily associated with wrong-side errors (87%, 45 of 52).

To gain a deeper understanding of the characteristics of WSS events, we analyzed the frequency of WSS by specific body part within each body region, as detailed in **Online Supplement Appendix S5**. Of the 664 event reports reviewed, 34 did not specify the affected body part. Among the remaining 630 reports, 62 distinct body parts were identified as being involved in WSS

events. Within each anatomical region, one specific body part accounted for approximately one-third or more of the reported events. For instance, in the chest/thorax region, the pleural cavity was involved in 49% (32 of 65) of the events. Similarly, in the lower extremity region, the knee was associated with 42% (33 of 79) of the events. These findings suggest that certain body parts may be more susceptible to WSS events than others.

Table 5 reveals the relationship between error types, procedure groups, and specific procedures. The procedure groups most frequently related to WSS events were injections (31%, 204 of 664), spinal (12%, 82 of 664), and vascular (8%, 56 of 664). The data suggest that while some procedure groups were associated with a wide range of error types, others were predominantly associated with a single category. For instance, vascular procedures were linked to all four error types, whereas urological procedures were almost exclusively associated with wrong-side errors. Additionally, the table highlights patterns in the types of errors linked to certain procedure groups—for example, lower extremity orthopedic/podiatric procedures were for the most part associated with wrong-side errors, while upper extremity orthopedic procedures were primarily linked to wrong-site errors. Finally, wrong-procedure and wrong-patient errors were the least common overall. Notably, vascular procedures accounted for the largest share of both wrong-procedure errors (29%, 22 of 75) and wrong-patient errors (27%, 6 of 22).

Table 3. Frequency of WSS Events Across Error Type and Clinician Specialty

Clinician Specialty	Error Type				Total
	Wrong Side	Wrong Site	Wrong Procedure	Wrong Patient	
Anesthesia	57	3	4	1	65
Dermatology	1	19	-	-	20
Ear, Nose, and Throat	4	5	2	1	12
Emergency Medicine	6	4	-	-	10
Foot/Ankle	5	3	-	-	8
Gastroenterology	-	4	2	2	8
General Surgery	18	14	14	1	47
Gynecology	1	1	3	2	7
Interventional Cardiology	5	-	-	3	8
Interventional Radiology	27	44	18	3	92
Neurosurgery	7	1	-	-	8
Oncology	3	4	2	-	9
Ophthalmology	38	2	7	2	49
Oral Surgery	1	3	1	-	5
Orthopedics	26	38	8	1	73
Other (7 specialties)	7	2	3	3	15
Pain Management	66	13	3	1	83
Physical Medicine/Rehab	4	-	1	-	5
Plastic Surgery	1	3	-	-	4
Spinal Surgery	3	58	1	-	62
Thoracic Surgery	6	3	2	-	11
Urology	48	-	2	2	52
Vascular	6	3	2	-	11
Total	340	227	75	22	664

Note: Clinician specialties with a total frequency of three or fewer are categorized as “Other.” Within each variable, categories were mutually exclusive. For instance, WSS events attributed to the Anesthesia category do not include those assigned to Pain Management, and vice versa. It is important to note that many of the WSS events involving injections were performed by either anesthesiologists or pain management specialists. Dash indicates a zero frequency.

Table 4. Frequency of WSS Events Across Error Type and Body Region

Body Region	Error Type				Total
	Wrong Side	Wrong Site	Wrong Procedure	Wrong Patient	
Abdomen	4	6	4	2	16
Breast	6	23	1	-	30
Chest/Thorax	40	12	10	3	65
Digestive System	-	3	7	3	13
Extremity, Lower	59	14	5	1	79
Extremity, Upper	28	43	11	4	86
Head/Neck	72	32	20	3	127
Hip/Pelvis	14	3	2	-	19
Reproductive System	3	5	6	3	17
Spine	66	82	6	1	155
Urinary System	45	2	3	2	52
Unspecified	3	2	-	-	5
Total	340	227	75	22	664

Note: The data represent the body region where the WSS occurred, which may differ from the originally intended site. Events categorized under the “unspecified” body region refer to reports in which the affected area was not clearly identified. Categories within each variable are defined in a mutually exclusive manner. For example, WSS events involving the Breast category are not included in the Chest/Thorax category, and vice versa. Dash indicates a zero frequency.

In **Table 5**, we further analyze the distribution of WSS events within each procedure group by compiling the frequency of specific procedures. Within the total sample of WSS reports, 13 lacked sufficient detail to determine the specific procedure performed and were categorized as unspecified. Among the remaining reports (651 of 664), 117 unique procedures were identified as being associated with WSS events. Blocks (anesthetic/pain) emerged as the most frequently reported specific procedures across all events. In nearly every procedure group—except for lower extremity orthopedic/podiatry and the “other” category—one specific procedure accounted for at least 35% of the WSS events within that group. For example, spinal decompression/stabilization (e.g., discectomy, laminectomy, foraminotomy, corpectomy, and fusion) alone were linked to 60% (49 of 82) of WSS events involving spinal procedures.

It is important to note that the number of WSS events reported for each procedure group in **Table 5** may be lower than the corresponding frequency in the body region categories presented in **Table 4**. These discrepancies are due to the procedure groups being categorized independently of clinician specialty or anatomical location. For instance, **Table 4** reports that 155 WSS events involved the spine region, while **Table 5** reports 82 events within the spinal procedure group. This difference is attributable to nearly half of WSS events that occurred in the spine region but were classified under other procedure groups, such as biopsy, excision, or injection. For a cross-tabulation of WSS events by procedure group and body region, refer to **Online Supplement Appendix S9**.

Discussion

As demonstrated by the current study and numerous recent studies of WSS,⁴⁻¹⁵ these “never events” persist as a substantial challenge within the healthcare community despite decades of effort to improve education, awareness, and perioperative intervention. The present WSS study expands upon our previous study³ by extending the observation period from five to 10 years and including visuals that allow for analysis of novel combinations of variables. The present study also helps to characterize the occurrence of WSS in a more comprehensive manner by using a large sample of facilities. To our knowledge, this study, with a sample of 664 WSS events across 237 hospitals and ASFs, is the second largest sample of WSS events examined in a single study, following a prior PSA study.³⁰

Since our last study and review of WSS literature,³ we identified 12 additional studies published in recent years.⁴⁻¹⁵ These studies varied most notably by data source, time period of events, number of institutions reporting events, types of clinician specialties/procedures included, severity of outcome, and coding of clinically related variables. Due to the methodological differences, none of the 12 studies allow for a full comparison with our findings. For example, to the best that we can determine, only our study systematically explored the relation between WSS and facility type, hospital procedure location, and hospital bed size.

Table 5. Frequency of WSS Events Across Error Type, Procedure Group, and Specific Procedure

Procedure Group	Specific Procedure	Error Type				Grand Total
		Wrong Side	Wrong Site	Wrong Procedure	Wrong Patient	
Biopsy	Biopsy	10	30	4	-	44
	Total	10	30	4	-	44
Excision	Excision	4	20	1	-	25
	Total	4	20	1	-	25
Injection	Block (Anesthetic/Pain)	120	16	4	4	144
	Steroid	23	10	4	-	37
	Radiation (Tracer/Therapy)	4	1	-	-	5
	Other (6 unique procedures)	7	2	-	-	9
	Unspecified	7	2	-	-	9
	Total	161	31	8	4	204
Ophthalmic	Laser Surgery	14	1	4	-	19
	Resection/Recession	3	1	2	-	6
	Other (6 unique procedures)	6	-	1	2	9
	Unspecified	1	-	-	-	1
	Total	24	2	7	2	35
Orthopedic, Upper Extremity	Pulley Release	1	9	1	-	11
	Carpal Tunnel	-	2	3	-	5
	Other (12 unique procedures)	-	13	3	-	16
	Total	1	24	7	-	32
Orthopedic/Podiatry, Lower Extremity	Arthroscopy	5	-	-	-	5
	Other (13 unique procedures)	12	4	1	-	17
	Total	17	4	1	-	22
Other	MOHS Procedure	1	7	-	-	8
	Frenulectomy	-	5	1	-	6
	Drain Placement	4	1	-	-	5
	Needle Localization	-	4	-	-	4
	Other (29 unique procedures)	11	13	18	7	49
	Total	16	30	19	7	72
Spinal	Decompression/Stabilization	1	47	1	-	49
	Kyphoplasty	-	10	-	-	10
	Radiofrequency Ablation	6	2	-	-	8
	Spinal Cord Stimulator Related	4	1	-	-	5
	Other (5 unique procedures)	4	3	-	-	7
	Unspecified	-	3	-	-	3
	Total	15	66	1	-	82
Thoracic	Chest Tube Insertion	12	2	1	-	15
	Thoracentesis	10	-	1	-	11
	Other (8 unique procedures)	9	2	1	1	13
	Total	31	4	3	1	39

Table 5. (continued).

Procedure Group	Specific Procedure	Error Type				Grand Total
		Wrong Side	Wrong Site	Wrong Procedure	Wrong Patient	
Urological	Endoscopy With Stent	32	-	-	-	32
	Endoscopy Without Stent	9	-	-	2	11
	Other (6 unique procedures)	7	1	2	-	10
	Total	48	1	2	2	53
Vascular	Vascular Access–Related	4	12	21	3	40
	Angiogram	3	-	-	1	4
	Cardiac Catheterization	1	-	1	2	4
	Other (7 unique procedures)	5	3	-	-	8
	Total	13	15	22	6	56
Grand Total		340	227	75	22	664

Note: The data represent the procedure that was actually performed, which may have differed from the procedure that was originally intended. Specific procedures with a frequency of three or fewer are categorized as "Other." The "Unspecified" subcategory consists of WSS events where the report lacked sufficient detail to identify the specific procedure performed. Within the Spinal procedure group, the decompression/stabilization-specific procedure includes discectomy, laminectomy, foraminotomy, corpectomy, and fusion. Event frequencies per category are mutually exclusive to other categories. Dash indicates a zero frequency.

Your Role to Ensure Correct-Site Surgery

Please visit PSA's eLearning site for a no-cost, 30-minute education program about wrong-site surgery at patientsafetyeducation.org/courses/wss/. No-cost continuing education credits are offered to registered nurses in Pennsylvania.⁴⁶

In the current study, there was a high degree of fluctuation in the frequency of WSS events across the 10-year period, and the lowest frequencies corresponded with a period of heightened challenges and concern associated with COVID-19 (i.e., coronavirus disease 2019).^{43,44} The decrease in the average number of WSS events per week from 2015–2019 (1.41 WSS events per week) to 2020–2024 (1.14 WSS events per week) likely is at least in part explained by a reduction in procedures being performed during 2020 and 2021.⁴⁵ The decline in WSS reports during 2020 and 2021 resembles a pattern reported by other studies of WSS events.^{8,12} Overall, based on visual analysis of the data, there was no discernable trend, increasing or decreasing, in the frequency of WSS events across the 10-year period.

Per subcategory of variable targeted in the current study, it is difficult to conclude whether or not there is a true change in trend due to the relatively low volume of event reports. For example, wrong-procedure errors were a frequency of 10 to 11 per year during 2015–2018 and five to eight per year in 2021–2024. While this finding may suggest that there is a downward trend across the 10-year period, the small number of events is one of several reasons that prevent confidence in such a conclusion.

We explored the distribution of WSS events by error type, as did five other studies; however, each of those studies had notable methodological differences with our study. For example, a couple of the studies combined wrong-side and wrong-site errors into a single category,^{8,12} and several studies merged error type and procedure type (e.g., wrong digit, wrong organ).^{11,13,14} Nevertheless, a majority of the studies, like ours, found that wrong-side and wrong-site errors were more frequent than wrong-procedure and wrong-patient errors.^{8,12-14} In contrast, one study reported more wrong-procedure and wrong-patient errors than side and site errors, but this finding could be explained by the study using insurance claims as the data source, instead of patient safety event reports.¹¹

Three prior studies reported that the orthopedics specialty and neurosurgery specialty were frequently associated with WSS events.^{5,7,11} Our findings were similar when including the spinal surgery specialty, which includes surgeons trained in orthopedics and/or neurosurgery. We found that the urology specialty was also frequently related with WSS events, and this finding is consistent with two recent studies.^{5,7} In contrast with the recent studies,^{5,7,11} the current study found that interventional radiology, anesthesia, and pain management were among the specialties most frequently associated with WSS events. It is unclear why the other recent studies had dissimilar findings, but it could be because two of the studies used insurance claims as a data source^{7,11} and the third study had a relatively small WSS sample size (n=22).⁵

Our study examined the relation between WSS and both body region and specific body part. We identified only two recent studies^{6,9} that also explored the relation, and both narrowed the scope to the spine region. Similar to our findings, one study reported that the lumbar portion was most frequently associated with WSS events,⁹ while another study found, consistent with our results, that the thoracic portion was least frequently associated.⁶

The present study explored the relation between WSS and 34 categories of specific procedures, nested across 11 categories of procedure groups. Among the recent WSS studies, we identified one that reported specific spinal procedures⁹ and another that reported specific urological procedures.⁸ Unfortunately, our study of spinal procedures was not as specific as the comparison study;⁹ nevertheless, like in their study, a majority of our procedures were types of spinal decompression/stabilization procedures. Similarly, the recent study⁸ of urological procedures also used greater specificity in their categories of procedures; yet, both the comparison study and our study found that a majority of the WSS events involved endoscopy with or without a stent.

Strategies to Mitigate Risk of Wrong-Site Surgery

Since our last study,³ the Patient Safety Authority and the Pennsylvania Department of Health published *Final Recommendations to Ensure Correct Surgical Procedures and Correct Nerve Blocks*.¹⁸ The evidence-based recommendations cover the following perioperative topics: preoperative verification and reconciliation, site marking, time-out and intraoperative verification, and accountability. The recommendations are intended to provide a foundation of principles that, if fully implemented, should substantially reduce the likelihood of WSS. However, these recommendations are not exhaustive, and we encourage practitioners to pursue additional strategies specific to their specialty.

Limitations and Future Research

We did not calculate a rate of WSS events, due to an absence of reliable denominator data (i.e., frequency of invasive operative procedures performed). Given our lack of WSS rate, WSS being a relatively infrequent type of patient safety event, and challenges in meeting statistical test assumptions, we did not conduct statistical analyses of WSS occurrence. While our sample size of WSS event reports is noteworthy, relative to other studies, the depth of clinical details in our WSS reports was often lacking, which also prevented a study of the root causes and other clinically relevant variables (e.g., patient body mass index, patient diagnosis, surgeon experience, whether the patient had an anatomical variation, and how the error was detected).

Conclusion

We identified 664 WSS events that occurred in Pennsylvania during the 10-year period of 2015–2024, which was an average of 1.28 per week. These “never events” were reported across 237 facilities, and our analysis revealed that the frequency of WSS was highly dependent on a range of variables, including facility type, hospital bed size, hospital procedure location, error type, clinician specialty, body region/part, and procedure. The 16 visuals (figures, tables, and appendices) in this manuscript allow for a thorough analysis that will help readers understand the extent to which WSS has a multifactorial relationship with the variables targeted in this study. Stakeholders could leverage these findings, along with other data sources (e.g., facility-specific data), to identify WSS-related factors to target and inform interventions to enhance patient safety.

Notes

This analysis was exempted from review by the Advarra Institutional Review Board.

Data used in this study cannot be made public due to their confidential nature, as outlined in the Medical Care Availability and Reduction of Error (MCARE) Act (Pennsylvania Act 13 of 2002).¹⁶

Artificial intelligence (OpenAI’s ChatGPT 4.1) was used only to improve sentence clarity. No AI was used for data analysis, interpretation, or generation of original content. The authors take full responsibility for the accuracy and integrity of the manuscript.

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**Online Supplement to “Wrong-Site Surgery: A Study of 664 Events From
237 Facilities Across a 10-Year Period”**

Article available at doi.org/10.33940/001c.156001

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This supplementary material has been provided by the authors to give readers additional information about wrong-site surgery (WSS) findings in the study. The nine appendices present visualizations and cross-tabulations of variables such as year of event occurrence, facility type, error type, and body region, which offer a more comprehensive understanding of the patterns and characteristics of WSS events.

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Appendices

Appendix S1. Frequency of WSS Events Across Year of Occurrence and Clinician Specialty

Appendix S2. Frequency of WSS Events Across Year of Occurrence, Body Region, and Specific Body Part

Appendix S3. Frequency of WSS Events Across Year of Occurrence, Procedure Group, and Specific Procedure

Appendix S4. Frequency of WSS Events Across Facility Type and Clinician Specialty

Appendix S5. Frequency of WSS Events Across Error Type, Body Region, and Specific Body Part

Appendix S6. Frequency of WSS Events Across Facility Type, Procedure Group, and Specific Procedure

Appendix S7. Frequency of WSS Events Across Body Region and Clinician Specialty

Appendix S8. Frequency of WSS Events Across Procedure Group and Clinician Specialty

Appendix S9. Frequency of WSS Events Across Procedure Group and Body Region

Appendix S1. Frequency of WSS Events Across Year of Occurrence and Clinician Specialty

Clinician Specialty	Event Year										Total
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Anesthesia	6	5	6	8	9	8	5	4	7	7	65
Dermatology	3	-	3	1	2	-	6	4	1	-	20
Ear, Nose, and Throat	1	-	4	2	-	2	1	2	-	-	12
Emergency Medicine	2	-	-	-	-	1	-	1	4	2	10
Foot/Ankle	1	3	-	-	2	-	1	-	1	-	8
Gastroenterology	2	-	-	2	-	-	-	3	-	1	8
General Surgery	7	9	5	6	6	3	7	1	2	1	47
Gynecology	1	1	1	-	1	-	-	1	-	2	7
Interventional Cardiology	-	-	-	-	1	1	-	3	1	2	8
Interventional Radiology	5	13	13	11	10	5	8	5	15	7	92
Neurosurgery	-	1	1	1	1	-	-	3	1	-	8
Oncology	-	1	-	1	-	-	-	3	3	1	9
Ophthalmology	6	6	7	2	1	3	6	6	8	4	49
Oral Surgery	-	-	1	-	1	1	-	1	-	1	5
Orthopedics	13	5	8	12	6	5	4	9	5	6	73
Other (7 specialties)	-	3	1	1	-	3	-	1	2	4	15
Pain Management	12	10	13	8	10	6	5	6	6	7	83
Physical Medicine/Rehab	-	-	2	-	-	-	1	1	-	1	5
Plastic Surgery	-	-	-	-	-	-	-	1	3	-	4
Spinal Surgery	12	9	4	7	2	6	6	5	6	5	62
Thoracic Surgery	3	1	2	1	-	1	-	1	1	1	11
Urology	6	3	6	10	6	4	2	2	7	6	52
Vascular	3	1	3	2	-	-	1	-	1	-	11
Total	83	71	80	75	58	49	53	63	74	58	664

Note: Clinician specialties with a frequency of three or fewer are categorized as "Other." The "Other" category consisted of seven different clinician specialties. Within each variable, event frequencies were categorized in a mutually exclusive manner. For instance, WSS events attributed to the Anesthesia category do not include those assigned to Pain Management, and vice versa.

Appendix S2. Frequency of WSS Events Across Year of Occurrence, Body Region, and Specific Body Part

Body Region	Specific Body Part	Event Year										Grand Total
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Abdomen	Abdominal Cavity	1	3	-	1	1	-	1	-	1	-	8
	Liver	-	1	1	-	1	2	-	-	-	1	6
	Other (2 distinct parts)	1	-	-	-	-	1	-	-	-	-	2
	Total	2	4	1	1	2	3	1	-	1	1	16
Breast	Breast	-	2	5	3	7	1	4	1	5	2	30
	Total	-	2	5	3	7	1	4	1	5	2	30
Chest/Thorax	Pleural Cavity	5	3	3	1	1	4	3	4	4	4	32
	Chest	5	1	3	-	2	-	-	2	3	2	18
	Other (5 distinct parts)	-	-	3	-	1	2	2	2	2	3	15
	Total	10	4	9	1	4	6	5	8	9	9	65
Digestive System	Lower Gastrointestinal Tract	1	2	1	1	-	-	-	-	-	1	6
	Upper Gastrointestinal Tract	1	-	-	1	-	-	-	2	-	1	5
	Other (2 distinct parts)	-	-	-	-	-	-	1	1	-	-	2
	Total	2	2	1	2	-	-	1	3	-	2	13
Extremity, Lower	Knee	8	2	3	6	5	1	2	4	1	1	33
	Foot	2	2	-	-	3	1	2	2	1	-	13
	Leg	-	1	-	3	-	2	2	2	2	1	13
	Thigh	1	1	2	1	3	-	1	-	-	-	9
	Unspecified	2	1	3	-	-	-	-	-	-	-	6
	Other (3 distinct parts)	-	1	1	-	-	-	-	2	1	-	5
	Total	13	8	9	10	11	4	7	10	5	2	79
Extremity, Upper	Finger	2	2	4	4	2	-	4	2	3	2	25
	Arm	-	6	2	3	1	-	1	1	-	1	15
	Shoulder	-	1	2	2	-	2	1	-	3	4	15
	Hand	1	1	1	2	-	1	1	1	-	2	10
	Elbow	2	-	-	1	1	-	-	1	1	1	7
	Thumb	1	-	-	1	-	2	-	3	-	-	7
	Wrist	2	1	-	1	-	-	-	-	1	1	6
	Unspecified	-	1	-	-	-	-	-	-	-	-	1
	Total	8	12	9	14	4	5	7	8	8	11	86
Head/Neck	Eye	6	6	7	2	1	3	7	6	9	4	51
	Neck	2	3	2	4	2	4	3	1	5	-	26
	Thyroid	1	4	2	1	1	2	-	-	1	-	12
	Scalp	1	-	-	1	1	-	-	3	1	-	7
	Skull	-	1	-	-	1	-	-	3	1	-	6
	Tongue	-	-	1	-	1	2	-	1	-	-	5
	Ear	2	-	1	-	-	-	-	-	-	1	4
	Other (10 distinct parts)	-	-	5	4	-	1	2	1	1	2	16
	Total	12	14	18	12	7	12	12	15	18	7	127
Hip/Pelvis	Hip	2	-	-	1	1	-	2	2	-	2	10
	Other (4 distinct parts)	2	-	1	2	-	2	-	-	1	1	9
	Total	4	-	1	3	1	2	2	2	1	3	19
Reproductive System	Female	2	1	1	-	1	-	-	2	2	3	12
	Male	1	-	2	1	-	-	1	-	-	-	5
	Total	3	1	3	1	1	-	1	2	2	3	17

Spine	Lumbar	11	11	11	8	4	10	7	6	10	5	83
	Cervical	3	5	1	2	4	-	3	5	4	3	30
	Thoracic	1	-	3	4	1	2	-	-	2	4	17
	Other (2 distinct parts)	-	1	-	-	-	1	1	-	-	-	3
	Unspecified	6	3	3	4	4	1	-	-	1	-	22
	Total	21	20	18	18	13	14	11	11	17	12	155
Unspecified	Unspecified	3	-	1	-	1	-	-	-	-	-	5
	Total	3	-	1	-	1	-	-	-	-	-	5
Urinary System	Ureter	4	3	5	8	6	2	1	2	7	6	44
	Kidney(s)	1	1	-	2	1	-	1	1	-	-	7
	Bladder	-	-	-	-	-	-	-	-	1	-	1
	Total	5	4	5	10	7	2	2	3	8	6	52
Grand Total		83	71	80	75	58	49	53	63	74	58	664

Note: The data represent the body region where the WSS occurred, which may differ from the originally intended site. Specific body parts with a frequency of four or fewer are categorized as “Other.” Events categorized under the “Unspecified” body region refer to reports in which the affected area was not clearly identified. Categories within each variable are defined in a mutually exclusive manner. For example, WSS events involving the Breast category are not included in the Chest/Thorax category, and vice versa. Dash indicates a zero frequency.

Appendix S3. Frequency of WSS Events Across Year of Occurrence, Procedure Group, and Specific Procedure

Procedure Group	Specific Procedure	Event Year										Grand Total
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Biopsy	Biopsy	2	8	6	4	7	3	3	4	4	3	44
	Total	2	8	6	4	7	3	3	4	4	3	44
Excision	Excision	3	4	1	3	2	3	4	1	3	1	25
	Total	3	4	1	3	2	3	4	1	3	1	25
Injection	Block (Anesthetic/Pain)	15	12	16	18	16	14	14	11	9	19	144
	Steroid	6	3	6	4	2	3	4	2	4	3	37
	Unspecified	4	1	-	1	1	-	-	1	1	-	9
	Radiation (Tracer/Therapy)	1	-	1	-	1	-	1	-	-	1	5
	Other (6 unique procedures)	-	1	4	1	1	-	1	1	-	-	9
	Total	26	17	27	24	21	17	20	15	14	23	204
Ophthalmic	Laser Surgery	2	1	5	1	1	2	2	2	2	1	19
	Resection/Recession	-	2	-	-	-	-	-	1	2	1	6
	Other (6 unique procedures)	1	-	-	-	-	-	1	2	4	1	9
	Unspecified	-	1	-	-	-	-	-	-	-	-	1
	Total	3	4	5	1	1	2	3	5	8	3	35
Orthopedic, Upper Extremity	Pulley Release	2	-	1	2	-	1	1	3	1	-	11
	Carpal Tunnel	1	-	-	1	-	-	1	-	1	1	5
	Other (12 unique procedures)	3	1	4	-	2	-	1	2	1	2	16
	Total	6	1	5	3	2	1	3	5	3	3	32
Orthopedic/ Podiatry, Lower Extremity	Arthroscopy	1	-	-	1	1	-	-	1	1	-	5
	Other (13 unique procedures)	3	3	1	2	3	2	-	1	1	1	17
	Total	4	3	1	3	4	2	-	2	2	1	22
Other	MOHS Procedure	-	-	1	-	1	-	4	1	1	-	8
	Frenulectomy	-	-	1	1	1	2	-	1	-	-	6
	Drain Placement	-	2	1	-	-	-	-	-	2	-	5
	Needle Localization	-	-	2	2	-	-	-	-	-	-	4
	Other (29 unique procedures)	6	4	9	5	3	-	2	11	5	4	49
	Total	6	6	14	8	5	2	6	13	8	4	72
Spinal	Decompression/Stabilization	10	8	3	4	2	4	6	5	6	1	49
	Kyphoplasty	-	-	1	3	-	1	-	-	2	3	10
	Radiofrequency Ablation	-	1	-	-	3	-	-	2	1	1	8
	Spinal Cord Stimulator Related	-	-	1	1	-	1	-	-	1	1	5
	Other (5 unique procedures)	2	1	-	-	1	1	-	-	1	1	7
	Unspecified	2	1	-	-	-	-	-	-	-	-	3
	Total	14	11	5	8	6	7	6	7	11	7	82
Thoracic	Chest Tube Insertion	4	2	2	-	-	2	2	2	-	1	15
	Thoracentesis	-	1	1	-	1	2	1	2	1	2	11
	Other (8 unique procedures)	3	1	1	-	1	1	1	-	4	1	13
	Total	7	4	4	-	2	5	4	4	5	4	39
Urological	Endoscopy With Stent	3	2	4	5	4	2	1	2	5	4	32
	Endoscopy Without Stent	1	1	1	3	2	-	-	-	1	2	11
	Other (6 unique procedures)	1	1	-	2	1	2	1	1	1	-	10
	Total	5	4	5	10	7	4	2	3	7	6	53

Vascular	Vascular Access–Related	5	8	4	8	1	2	2	2	7	1	40
	Angiogram	1	-	1	-	-	-	-	2	-	-	4
	Cardiac Catheterization	-	-	1	-	-	1	-	-	1	1	4
	Other (7 unique procedures)	1	1	1	3	-	-	-	-	1	1	8
	Total	7	9	7	11	1	3	2	4	9	3	56
Grand Total		83	71	80	75	58	49	53	63	74	58	664

Note: The data represent the procedure that was actually performed, which may have differed from the procedure that was originally intended. Specific procedures with a frequency of three or fewer are categorized as "Other." The "Unspecified" subcategory consists of WSS events where the report lacked sufficient detail to identify the specific procedure performed. Within the spinal procedure group, the decompression/stabilization-specific procedure includes discectomy, laminectomy, foraminotomy, corpectomy, and fusion. Event frequencies per category are mutually exclusive to other categories. Dash indicates a zero frequency.

Appendix S4. Frequency of WSS Events Across Facility Type and Clinician Specialty

Clinician Specialty	Facility Type		Total
	ASF	Hospital	
Anesthesia	11	54	65
Dermatology	5	15	20
Ear, Nose, and Throat	5	7	12
Emergency Medicine	-	10	10
Foot/Ankle	2	6	8
Gastroenterology	3	5	8
General Surgery	2	45	47
Gynecology	-	7	7
Interventional Cardiology	-	8	8
Interventional Radiology	-	92	92
Neurosurgery	-	8	8
Oncology	-	9	9
Ophthalmology	40	9	49
Oral Surgery	2	3	5
Orthopedics	25	48	73
Other (7 specialties)	-	15	15
Pain Management	36	47	83
Physical Medicine/Rehab	2	3	5
Plastic Surgery	1	3	4
Spinal Surgery	3	59	62
Thoracic Surgery	-	11	11
Urology	3	49	52
Vascular	-	11	11
Total	140	524	664

Note: The acute care hospital category encompasses children's hospitals, critical access hospitals, and long-term acute care hospitals. All ambulatory surgical facilities (ASFs) included in the analysis were individually licensed. Clinician specialties with a frequency of three or fewer are categorized as "other." The "Other" category consisted of seven different clinician specialties. Within each variable, categories were mutually exclusive. For instance, WSS events attributed to the Anesthesia category do not include those assigned to Pain Management, and vice versa.

Appendix S5. Frequency of WSS Events Across Error Type, Body Region, and Specific Body Part

Body Region	Specific Body Part	Error Type				Grand Total
		Wrong Side	Wrong Site	Wrong Procedure	Wrong Patient	
Abdomen	Abdominal Cavity	4	1	2	1	8
	Liver	-	4	1	1	6
	Other (2 distinct parts)	-	1	1	-	2
	Total	4	6	4	2	16
Breast	Breast	6	23	1	-	30
	Total	6	23	1	-	30
Chest/Thorax	Pleural Cavity	28	2	2	-	32
	Chest	7	4	7	-	18
	Other (5 parts)	5	6	1	3	15
	Total	40	12	10	3	65
Digestive System	Lower Gastrointestinal Tract	-	3	2	1	6
	Upper Gastrointestinal Tract	-	-	4	1	5
	Other (2 distinct parts)	-	-	1	1	2
	Total	-	3	7	3	13
Extremity, Lower	Knee	29	2	1	1	33
	Foot	6	6	1	-	13
	Leg	10	3	-	-	13
	Thigh	6	1	2	-	9
	Unspecified	5	-	1	-	6
	Other (3 distinct parts)	3	2	-	-	5
	Total	59	14	5	1	79
Extremity, Upper	Finger	-	25	-	-	25
	Arm	7	2	3	3	15
	Shoulder	13	2	-	-	15
	Hand	3	4	2	1	10
	Elbow	2	3	2	-	7
	Thumb	3	3	1	-	7
	Wrist	-	3	3	-	6
	Unspecified	-	1	-	-	1
	Total	28	43	11	4	86
Head/Neck	Eye	39	3	7	2	51
	Neck	9	8	9	-	26
	Thyroid	10	1	1	-	12
	Scalp	1	6	-	-	7
	Skull	6	-	-	-	6
	Tongue	-	4	1	-	5
	Ear	2	1	1	-	4
	Other (10 distinct parts)	5	9	1	1	16
	Total	72	32	20	3	127
Hip/Pelvis	Hip	7	2	1	-	10
	Other (4 distinct parts)	7	1	1	-	9
	Total	14	3	2	-	19

Reproductive System	Female	1	5	4	2	12
	Male	2	-	2	1	5
	Total	3	5	6	3	17
Spine	Lumbar	38	41	4	-	83
	Cervical	6	22	2	-	30
	Thoracic	3	14	-	-	17
	Other (2 distinct parts)	2	1	-	-	3
	Unspecified	17	4	-	1	22
	Total	66	82	6	1	155
Unspecified	Unspecified	3	2	-	-	5
	Total	3	2	-	-	5
Urinary System	Ureter	42	-	-	2	44
	Kidney(s)	3	1	3	-	7
	Bladder	-	1	-	-	1
	Total	45	2	3	2	52
Grand Total		340	227	75	22	664

Note: The data represent the body region where the WSS occurred, which may differ from the originally intended site. Specific body parts with a frequency of four or fewer are categorized as "other." Events categorized under the "unspecified" body region refer to reports in which the affected area was not clearly identified. Categories within each variable are defined in a mutually exclusive manner. For example, WSS events involving the breast category are not included in the chest/thorax category, and vice versa. Dash indicates a zero frequency.

Appendix S6. Frequency of WSS Events Across Facility Type, Procedure Group, and Specific Procedure

Procedure Group	Specific Procedure	Facility Type		Grand Total
		ASF	HSP	
Biopsy	Biopsy	1	43	44
	Total	1	43	44
Excision	Excision	2	23	25
	Total	2	23	25
Injection	Block (Anesthetic/Pain)	51	93	144
	Steroid	11	26	37
	Unspecified	2	7	9
	Radiation (Tracer/Therapy)	-	5	5
	Other (6 unique procedures)	2	7	9
	Total	66	138	204
Ophthalmic	Laser Surgery	19	-	19
	Resection/Recession	5	1	6
	Other (6 unique procedures)	6	3	9
	Unspecified	-	1	1
	Total	30	5	35
Orthopedic, Upper Extremity	Pulley Release	7	4	11
	Carpal Tunnel	2	3	5
	Other (12 unique procedures)	5	11	16
	Total	14	18	32
Orthopedic/ Podiatry, Lower Extremity	Arthroscopy	2	3	5
	Other (13 unique procedures)	2	15	17
	Total	4	18	22
Other	MOHS Procedure	4	4	8
	Frenulectomy	3	3	6
	Drain Placement	-	5	5
	Needle Localization	-	4	4
	Other (29 unique procedures)	6	43	49
	Total	13	59	72
Spinal	Decompression/stabilization	1	48	49
	Kyphoplasty	-	10	10
	Radiofrequency Ablation	2	6	8
	Spinal Cord Stimulator-Related	1	4	5
	Other (5 unique procedures)	2	5	7
	Unspecified	1	2	3
	Total	7	75	82
Thoracic	Chest Tube Insertion	-	15	15
	Thoracentesis	-	11	11
	Other (8 unique procedures)	-	13	13
	Total	-	39	39

Urological	Endoscopy With Stent	2	30	32
	Endoscopy Without Stent	1	10	11
	Other (6 unique procedures)	-	10	10
	Total	3	50	53
Vascular	Vascular Access–Related	-	40	40
	Angiogram	-	4	4
	Cardiac Catheterization	-	4	4
	Other (7 unique procedures)	-	8	8
	Total	-	56	56
Grand Total		140	524	664

Note: The acute care hospital category encompasses children's hospitals, critical access hospitals, and long-term acute care hospitals. All ambulatory surgical facilities (ASFs) included in the analysis were individually licensed. The data represent the procedure that was actually performed, which may have differed from the procedure that was originally intended. Specific procedures with a frequency of three or fewer are categorized as "Other." The "Unspecified" subcategory consists of WSS events where the report lacked sufficient detail to identify the specific procedure performed. Within the Spinal procedure group, the decompression/stabilization-specific procedure includes discectomy, laminectomy, foraminotomy, corpectomy, and fusion. Event frequencies per category are mutually exclusive to other categories. Dash indicates a zero frequency.

Appendix S7. Frequency of WSS Events Across Body Region and Clinician Specialty

Clinician Specialty	Body Region												Total
	Abdomen	Breast	Chest/ Thorax	Digestive System	Extremity, Lower	Extremity, Upper	Head/ Neck	Hip/ Pelvis	Repro- ductive System	Spine	Unspec- ified	Urinary system	
Anesthesia	-	2	4	-	30	17	4	2	-	5	1	-	65
Dermatology	-	-	4	-	-	2	12	-	-	1	1	-	20
Ear, Nose, and Throat	-	-	1	-	-	-	11	-	-	-	-	-	12
Emergency Medicine	-	-	7	-	-	1	1	1	-	-	-	-	10
Foot/Ankle	-	-	-	-	8	-	-	-	-	-	-	-	8
Gastroenterology	-	-	-	5	-	-	-	-	2	-	-	1	8
General Surgery	6	10	11	4	2	-	9	-	1	1	1	2	47
Gynecology	-	-	-	-	-	-	-	-	7	-	-	-	7
Interventional Cardiology	-	-	4	1	3	-	-	-	-	-	-	-	8
Interventional Radiology	8	17	15	1	5	9	17	4	-	13	-	3	92
Neurosurgery	-	-	1	-	-	-	7	-	-	-	-	-	8
Oncology	-	1	-	1	1	-	1	2	3	-	-	-	9
Ophthalmology	-	-	-	-	-	-	49	-	-	-	-	-	49
Oral Surgery	-	-	-	-	-	-	5	-	-	-	-	-	5
Orthopedics	-	-	-	-	23	48	-	2	-	-	-	-	73
Other (7 specialties)	-	-	7	1	-	3	4	-	-	-	-	-	15
Pain Management	-	-	-	-	1	-	2	6	-	72	2	-	83
Physical Medicine/Rehab	-	-	-	-	2	1	1	-	-	1	-	-	5
Plastic Surgery	-	-	-	-	-	3	1	-	-	-	-	-	4
Spinal Surgery	-	-	-	-	-	-	-	-	-	62	-	-	62
Thoracic Surgery	1	-	10	-	-	-	-	-	-	-	-	-	11
Urology	-	-	-	-	-	-	-	2	4	-	-	46	52
Vascular	1	-	1	-	4	2	3	-	-	-	-	-	11
Total	16	30	65	13	79	86	127	19	17	155	5	52	664

Note: The data represent the body region where the WSS occurred, which may differ from the originally intended site. Events categorized under the "Unspecified" body region refer to reports in which the affected area was not clearly identified. Categories within each variable are defined in a mutually exclusive manner. For example, WSS events involving the Breast category are not included in the Chest/Thorax category, and vice versa. Clinician specialties with a frequency of three or fewer are categorized as "Other." The "Other" category consisted of seven different clinician specialties. Dash indicates a zero frequency.

Appendix S8. Frequency of WSS Events Across Procedure Group and Clinician Specialty

Clinician Specialty	Procedure Group											Total
	Biopsy	Excision	Injection	Ophthalmic	Orthopedic, Upper Extremity	Orthopedic/ Podiatry, Lower Extremity	Other	Spinal	Thoracic	Urological	Vascular	
Anesthesia	-	-	63	-	-	-	-	-	-	-	2	65
Dermatology	4	5	-	-	-	-	11	-	-	-	-	20
Ear, Nose, and Throat	1	-	3	-	-	-	7	-	1	-	-	12
Emergency Medicine	-	-	1	-	-	-	-	-	7	-	2	10
Foot/Ankle	1	-	2	-	-	5	-	-	-	-	-	8
Gastroenterology	1	-	-	-	-	-	6	-	-	1	-	8
General Surgery	3	11	5	-	-	-	12	-	8	2	6	47
Gynecology	1	-	-	-	-	-	6	-	-	-	-	7
Interventional Cardiology	-	-	1	-	-	-	1	-	1	-	5	8
Interventional Radiology	29	2	14	-	-	-	11	5	8	1	22	92
Neurosurgery	-	1	-	-	-	-	7	-	-	-	-	8
Oncology	2	1	1	-	-	-	4	-	-	-	1	9
Ophthalmology	-	-	14	35	-	-	-	-	-	-	-	49
Oral Surgery	-	1	-	-	-	-	4	-	-	-	-	5
Orthopedics	1	-	23	-	32	17	-	-	-	-	-	73
Other (7 specialties)	1	-	1	-	-	-	1	-	6	-	6	15
Pain Management	-	-	67	-	-	-	-	16	-	-	-	83
Physical Medicine/Rehab	-	-	5	-	-	-	-	-	-	-	-	5
Plastic Surgery	-	3	1	-	-	-	-	-	-	-	-	4
Spinal Surgery	-	-	1	-	-	-	-	61	-	-	-	62
Thoracic Surgery	-	-	-	-	-	-	-	-	8	-	3	11
Urology	-	1	-	-	-	-	2	-	-	49	-	52
Vascular	-	-	2	-	-	-	-	-	-	-	9	11
Total	44	25	204	35	32	22	72	82	39	53	56	664

Note: The data represent the procedure that was actually performed, which may have differed from the procedure that was originally intended. Clinician specialties with a frequency of three or fewer are categorized as "Other." The "Other" category consisted of seven different clinician specialties. Within each variable, categories were mutually exclusive. For instance, WSS events attributed to the Anesthesia category do not include those assigned to Pain Management, and vice versa. Dash indicates a zero frequency.

Appendix S9. Frequency of WSS Events Across Procedure Group and Body Region

Body Region	Procedure Group											Total
	Biopsy	Excision	Injection	Ophthalmic	Orthopedic, Upper Extremity	Orthopedic/ Podiatry, Lower Extremity	Other	Spinal	Thoracic	Urological	Vascular	
Abdomen	5	1	-	-	-	-	6	-	-	-	4	16
Breast	10	7	7	-	-	-	6	-	-	-	-	30
Chest/Thorax	3	1	5	-	-	-	3	-	39	-	14	65
Digestive System	-	-	-	-	-	-	13	-	-	-	-	13
Extremity, Lower	4	1	48	-	-	20	-	-	-	-	6	79
Extremity, Upper	2	2	36	-	32	-	1	-	-	-	13	86
Head/Neck	12	8	27	35	-	-	29	-	-	-	16	127
Hip/Pelvis	1	-	10	-	-	2	1	-	-	2	3	19
Reproductive System	2	2	-	-	-	-	12	-	-	1	-	17
Spine	4	2	67	-	-	-	-	82	-	-	-	155
Unspecified	-	1	4	-	-	-	-	-	-	-	-	5
Urinary system	1	-	-	-	-	-	1	-	-	50	-	52
Total	44	25	204	35	32	22	72	82	39	53	56	664

Note: The data represent the procedure that was actually performed or the body region where the WSS occurred, which may have differed from the procedure or body regions that was originally intended. Events categorized under the “unspecified” body region refer to reports in which the affected area was not clearly identified. Categories within each variable are defined in a mutually exclusive manner. For example, WSS events involving the Breast category are not included in the Chest/Thorax category, and vice versa. Dash indicates a zero frequency.