Spine Deformity (2023) 11:1019–1026
https://doi.org/10.1007/s43390-023-00658-1

CASE SERIES

Incidence, etiology and time course of delays to adult spinal deformity surgery: a single-center experience

Lisa DePledge[1,2] · Philip K. Louie[1] · Cari E. Drolet[1] · Jesse Shen[1] · Venu M. Nemani[1] · Jean-Christophe A. Leveque[1] · Rajiv K. Sethi[1,2]

Received: 30 August 2022 / Accepted: 28 January 2023 / Published online: 11 February 2023

Abstract

Purpose We sought to determine the incidence, origin, and timeframe of delays to adult spinal deformity surgery so that institutions using preoperative multidisciplinary patient assessment teams might better anticipate and address these potential delays.

Methods Complex spine procedures for treatment of adult spinal deformity from 1/1/18 to 8/31/21 were identified. Procedures for infection, tumor, and urgent/emergent cases were excluded. Operations delayed due to COVID or those that were performed outside of our established perioperative care pathway were also excluded. The electronic health record was used to identify the etiology and timeline of all pre- and peri-operative delays.

Results Of 235 patients scheduled for complex spine surgery, 193 met criteria for inclusion. Of these patients, 35 patients experienced a surgical delay (18.1%) with a total of 41 delays recorded. Reasons for delay include medically unoptimized (25.6%), intraoperative complication (17.9%), patient directed delay (17.9%), patient illness/injury (15.4%), scheduling complication (10.3%), insurance delay/denial (5.1%), and unknown (2.6%). Twenty-four delays experienced by 22 individuals occurred within 7 days of their scheduled surgery date.

Conclusion At a single multidisciplinary center, most delays to adult spinal deformity surgery occur before a patient is admitted to the hospital, and for recommendations of additional medical workup/clearance. We suspect that the preoperative protocol might increase pre-admission delays for unoptimized patients, as the protocol is intended to ensure patients receive surgery only when they are medically ready. Further research is needed to determine the economic and system impact of delays related to a preoperative optimization protocol weighed against the reduction in adverse events these protocols can provide.

Keywords Adult spinal deformity · Delays · Cancellations · Multidisciplinary conference

Introduction

Adult spinal deformity (ASD) encompasses a broad range of conditions including scoliosis, kyphosis, flatback, and other conditions that result in spinal malalignment and disability. The prevalence of ASD and the rate of complex reconstructive surgery have steadily increased in recent decades in part due to an increasing population over the age of 65 [1–3]. These complex reconstructive procedures are associated with high rates of perioperative adverse events. Subsequently, there has been a growing body of literature describing methods to mitigate these risks [4–6]. One method adopted by many healthcare systems to reduce risk and increase value is the creation of multidisciplinary teams to help manage these complex patients [7].

In 2010, the Seattle Spine Team at Virginia Mason developed a systems-based approach to minimize complication rates in surgery for ASD [8]. This three-pronged approach includes a live multidisciplinary screening conference, the use of two attending surgeons for complex cases and an intra-operative protocol for the management of coagulopathy. The live preoperative conference aim to

✉ Philip K. Louie
Louie.philip@gmail.com

1 Center for Neurosciences and Spine, Department of Neurosurgery, Virginia Mason Franciscan Health, Seattle, WA, USA

2 School of Medicine, University of Washington, Seattle, WA, USA

address particular presurgical checklist items (appointments, testing, evaluation, imaging, procedures) have been completed as well as to identify modifiable comorbid medical conditions that can be optimized prior to surgery with the goal of improving overall surgical outcomes. In 2017, an analysis of this approach demonstrated a significant reduction in postoperative complications including cardiovascular events, wound infections, perioperative infections and implant failures [9].

While complication rates have decreased with this systems-based approach, surgical delays have been noted to persist by our team. Surgical delays which occur, after admission for non-elective surgical care have been shown to be negatively associated with surgical outcomes, complications, and mortality [5]. While less studied, surgical delays that occur in the days leading up to elective surgery may also have a negative effect on outcomes and can lead to inefficient use of surgeons, hospital space, and surgical staff. Elucidating the etiology of such delays provides the opportunity to anticipate and minimize these delays.

This is a descriptive study investigating all delays patients experienced between the date of initial scheduling for surgery to the actual date of surgery with an emphasis on delays that occurred within 7 days of the originally scheduled surgical date. The aim of this study was to determine the etiology, incidence, and time course of all delays to adult spinal deformity surgery. To our knowledge, the incidence and etiology of delays that occur prior to complex spinal reconstructive surgery have not yet been reported in the literature.

Methods

Study design

This study is a retrospective case series. A comprehensive list of complex spine procedures (defined as instrumentation on six or more vertebral levels) from January 2018 to August 2021 was obtained from a prospectively maintained database at a single institution. The electronic health record (EHR) was used to gather demographic information (including age, gender, ASA classification), surgical information (date of surgery (DOS), date/time of admission and discharge, operation(s) performed), medical/surgical history including any history of prior spine operations, readmissions, complications, return to the operating room (OR), use of intensive care unit (ICU), pre-operative visit history (including the number of total pre-operative encounters), and the number of times each patient was discussed at the multidisciplinary conference.

Inclusion/exclusion criteria

Complex spinal surgery was defined as an operation that required either 6 or more levels of vertebral fusion or more than 3 levels of vertebral fusion in a patient with multiple comorbidities [10]. All urgent/emergent cases were excluded. Elective cases were excluded if the primary diagnosis was infection or tumor/metastasis, if the procedure was delayed due to COVID, or if the procedure was performed outside of our established care pathway [8]. All patients who had documentation describing presentation at the multidisciplinary spine conference or who had preoperative workup consistent with our standard preoperative protocol were deemed to have followed the established care pathway. If there was insufficient evidence of full standard preoperative workup and/or presentation at conference, the patient was excluded from analysis (Fig. 1).

Identifying delays, their etiologies, and timeframes

The primary researcher identified delays by reading through all documents, notes, and messages listed in the EHR between the first encounter discussing surgery and the day surgery was performed. Confirmed surgical dates listed in the EHR were noted. Documents that most reliably listed the planned surgical date were the pre-operative clinic visit notes, anesthesia assessments, transfusion reports, PCP H&Ps, PM&R consultation documents, and most commonly, phone messages between patients, schedulers, medical assistants, advanced practice providers, and surgeons.

If no conflicting dates were found, the patient was designated as proceeding without a delay. If multiple proposed surgical dates were listed, the researcher investigated reasons for the inconsistency. Any tentative date changes were not considered delays; rather, only changes to officially scheduled surgical dates were considered true surgical delays. A surgery date was considered confirmed when the surgery scheduler or a member of the preoperative surgical team (surgeons, anesthesia), documented the official surgical date. When a delay to a confirmed surgical date was identified, the researcher would determine the etiology of delay. All equivocal delays and etiologies were discussed with the surgical team to confirm or clarify the data.

All reasons for delay were identified and subsequently aggregated into the following categories: additional medical workup/clearance required, intraoperative complications, patient directed delays, patient illness/injury, scheduling complications, and insurance denial/delay [9, 11, 12]. The day each delay occurred was determined by

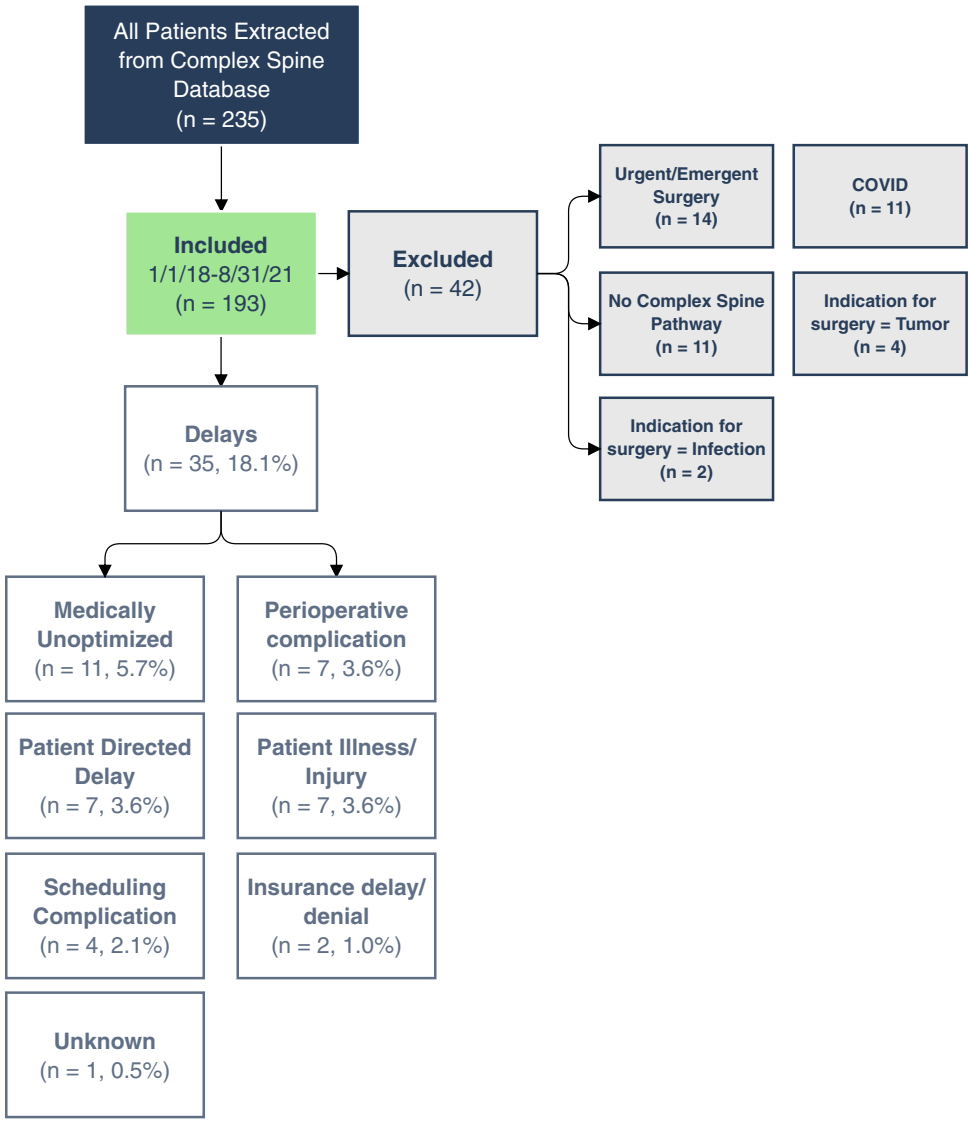

Fig. 1 Flowchart demonstrating patients included in the study, divided into groups based on the category of surgical delay/ cancellation

Table 1 Timeframe between delay and initially scheduled date of surgery

Reason for delay	*f*	*f* with unknown date of delay	Mean # days between delay and DOS	STDEV (days)	*f* delays within 7 days of DOS
Medically unoptimized	11	0	13.0	12.8	3
Intraoperative complication	8	0	0.0	0.0	7
Patient directed delay	7	1	21.2	27.6	3
Patient illness/injury	7	0	3.4	3.4	7
Scheduling complication	5	2	13.3	12.9	1
Insurance delay/denial	2	0	16.5	21.9	1
Unknown	1	0	7.0	N/A	1

All intraoperative delays occurred on the day of surgery, so the mean # of days between delay and DOS are 0

f frequency of delay

Table 2 Turnaround time; time from date of delay to the date surgery was performed

Reason	Average (days)	Range (days)	STDEV (days)	*f*	*f* unknown[a]
Medically unoptimized	118.4	4, 325	95.4	11	0
Intraoperative complication	43.8	4, 105	35.9	8	2
Patient directed delay	105.8	5, 185	70.8	7	1
Patient illness/injury	118.3	7, 386	130.1	7	0
Scheduling complication	29.7	14, 45	15.5	5	2
Insurance delay/denial	161.5	19, 304	201.5	2	0
Unknown	36.0	36, 36	0.0	1	0

[a]*f* unknown*n* = frequency of delays in which the turnaround time could not be calculated; may have been caused by an unknown date of delay or an unknown eventual date of surrey (if the even)

timestamps of the first relevant documentation detailing the reason for surgical delay. If no specific day could be identified, the date of delay was listed as unknown. The number of days between the date of delay and the initially scheduled date of surgery was calculated as the timeframe between delay and surgery (Table 1). The number of days between the date of delay and the date surgery was performed was also calculated (Table 2).

Statistical analysis

The total number, etiology, and timeframe of delays were counted and tallied manually. We used a logistic regression to examine whether the following factors significantly predicted whether a patient experienced a delay: patient sex, psychiatric history, diabetes diagnosis, age, distance from the hospital, BMI, and time measured in days (i.e., whether patient delays became more or less likely over the study time frame). This regression may represent model overfitting, and is not intended to draw definitive conclusions, but instead has been used in an attempt to describe the data. We used Fisher's exact test to examine whether experiencing one or more delays was related to ASA score.

Results

In total, 235 patients receiving complex spine surgery for adult spinal deformity were identified between 1/1/2018 and 8/31/2021 and 193 met our criteria. Patients were 20–84 years old ($M = 64.35$, SD = 21.21), over half were female ($n = 116$, 60.1%), the majority identified as White ($n = 178$, 92.2%), 84 (43.52%) had a history of psychiatric disorder, and 22 (11.4%) had been diagnosed with diabetes. Patients lived 0.3–2521.8 miles ($M = 150.6$, SD = 147.7) from the hospital. Surgery occurred between 19 and 1260 days from the initial consult ($M = 150.6$, SD = 147.7) and patients had between 1 and 56 encounters between their initial consult and surgery ($M = 9.2$, SD = 6.5). Most patients had an ASA score of 3 ($n = 106$, 54.9%), followed by 2 ($n = 83$, 43.0%), and 4 ($n = 2$, 1.0%).

Out of the sample of 193 patients, 35 had a surgical delay (18.1%). The etiologies of delay, from most to least prevalent, included a need for further medical workup/clearance, intraoperative complication, patient illness/injury, patient directed delay, scheduling complication, insurance delay/denial, and unknown. The unknown reasons were those not clearly explained in the electronic medical record. Four of the 35 patients experienced multiple types of delays, so the total number of delays experienced was 41. Tables 3 and 4 demonstrates the number and frequency of patients who

Table 3 Delay incidence by category; prior to stage 1

Category	*n* (%)	% of cohort with delays
Medically unoptimized	10	25.6
Intraoperative complication	7	17.9
Patient directed delay	7	17.9
Patient illness/injury	6	15.4
Scheduling complication	4	10.3
Insurance	2	5.1
Unknown	1	2.6

Percentages based on cohort of patients experiencing any delay ($n = 35$). Because some individuals experienced more than 1 delay, the sum of *n* in this table is > the total number of individuals who experienced a delay

n number of patients experiencing category of delay

Table 4 Delay incidence by category; between stage 1 and stage 2

Category	*n* (%)	% of cohort with delays
Medically unoptimized	1	2.6
Patient illness/injury	1	2.6

Percentages based on cohort of patients experiencing any delay ($n = 35$)

n number of patients experiencing category of delay

Table 5 Specific reasons for delays by category; medically unoptimized

Delay category	Delay descriptions	*n*	Between stages?
Medically unoptimized	Nicotine use	2	No
	Alcohol use	1	No
	Opioid use	1	No
	Blood thinner use	1	No
	High BMI	1	No
	Low Hct	1	Yes
	Newfound anemia	1	No
	Elevated BP and A1c	1	No
	Another medical condition	1	No
	Need for further workup	1	No

n number of individuals experiencing delay

experienced each type of delay. The specific descriptions aggregated into each category is listed in Tables 5 and 6.

Of 41 total delays, there were 24 delays experienced by 22 individuals (9.8% of the patient population) within 7 days of their scheduled surgery date. Two individuals experienced two delays within 7 days of surgery (one individual experienced two delays of the same etiology, and the other had two causes for delay). Nine patients (4.7% of the patient population) experienced a surgical delay after admission to the hospital for surgery. The reasons for delay after admission include intraoperative complications ($f = 8$) patient illness/injury ($f = 1$), and medical optimization ($f = 1$). The timeframe by which three unique delays occurred could not be determined from the EHR. The number of days between date of delay and DOS are reported in aggregate in Tables 3 and 4.

We used a logistic regression to examine whether experiencing at least one delay was predicted by any of our demographic variables (sex, psychiatric history, diabetes, age, distance from the hospital, BMI, and time), and none were found to be statistically significant. A Fisher's exact test indicated that ASA was not significantly related to experiencing one or more surgical delays, $p = 0.25$. This test was run to serve as a proxy for medical complexity, as has been used in previous studies [5, 13, 14].

Table 6 Specific reasons for delays by category; logistical issues

Delay category	Delay descriptions	*f*	Between stages?
Intraoperative complication	Loss of neuromonitoring	4	No
	Inability to obtain LE potentials	1	No
	Positioning difficulties	1	No
	Concern for generalized tonic–clonic seizure	1	No
	Profound hypotension	1	No
Patient directed delay	Pt life circumstance	2	No
	Medically cleared but denied surgery due to another medical condition	2	No
	Denied component of preoperative pathway—psychiatric workup	1	No
	Desire to change surgical approach	1	No
	Discomfort with COVID visitor policy	1	No
Patient illness/injury	ED visit close to surgical date	1	No
	TIA	1	No
	Rib & pelvic fractures	1	No
	Cold w/ productive cough	1	No
	Need for cardiac workup	1	Yes
	DVT	1	No
	IVC filter placement complication	1	No
Scheduling complication	Surgeon availability	2	No
	Coordination of postoperative healthcare needs	1	No
	Unknown reason	2	No
Insurance	Delay	1	No
	Denial	1	No
Other	Other	1	No

Frequency, *f*, is used instead of number of individuals, *n*, due to four individuals experiencing more than one type of delay. Thus, the frequency of delays > number of individuals experiencing a delay

Discussion

Our institutional preoperative workflow with a multidisciplinary patient assessment team has been shown to improve outcomes for patients undergoing surgery for adult spinal deformity [8, 9]. However, surgical delays remain a roadblock to optimal surgical outcomes and potentially hospital resource utilization [14]. In this study, we meticulously investigated the preoperative workup of 235 patients and detailed exactly why surgical delays occurred in our institution.

Incidence and etiology

Our incidence of delay to surgery was 18.1%. This included delays occurring prior to hospital admission (13.4%) as well as those occurring after admission for surgery (4.7%). One multi-center study investigating the incidence of surgical delays for adult spinal deformity and reported an incidence of delay to surgery of 15.6%, although this study only assessed delays that occurred after admission to the hospital for surgery and used the ACS-NSQIP database which limited the ability to identify the etiology of the delay. Our post-admission delays affected a much lower percentage (4.7%) of our surgical population, which may represent one advantage of the extensive pre-surgical evaluation our patients undergo, but direct comparison of the cause of delays in our population and those within the Wade et al. study is not possible [5]. Given that those authors reported worse outcomes associated with delays after hospital admission, we propose that shifting any delay from a post-admission one to a pre-admission one may be a worthy price to pay in the pursuit of reduced delays after hospital admission and their worsened surgical outcomes [8, 9]. Recent literature that similarly investigates the incidence of surgical delays generally focuses on the risk factors and outcomes of surgical delays without detailing the cause for such delays [5, 13, 14]. In our study, we found that the most common etiology of a delay was a need for further medical workup and/or clearance. Because our multidisciplinary optimization pathway is designed to only allow surgery once a thorough medical evaluation has been completed, it was not surprising that the most common etiology of delay was need for additional medical workup, typically entailing cardiac workup via stress test or pulmonary evaluation via pulmonary function tests. Because these delays presumably prevent operations from occurring before patients are medically ready, it may not be necessary to minimize this etiology of delay, but to acknowledge that they may increase the amount of time that should be allotted between an initial surgical evaluation and a proposed surgical date.

However, of 11 delays that occurred due to need for further medical workup, 3 occurred within 7 days of the scheduled surgery date. These specific instances include: continued use of nicotine, use of a blood thinner, and new-found anemia. Delays this close to the surgical date are more likely to lead to underutilized OR time and staff that could have otherwise been dedicated to another patient. Given this drawback, situations resulting in delay close to the surgical data should be avoided if possible.

Describing delays: avoidable or inevitable?

To improve the preoperative workflow, we thought it important to identify avoidable delays. In an effort to categorize, we deemed that delays may be avoidable, inevitable, or those that could be either depending on the circumstance. Delays that are inevitable are the most intuitive to identify. There will always be a baseline rate of events that occur outside a patient or hospital's control, such as motor vehicle accidents or family emergencies.

Delays that are avoidable are generally secondary to factors within patients' or the surgical team's control, such as scheduling complications, communications with insurance companies, and timely assessment and treatment of medical conditions. While the EHR was vague in terms of the details of insurance delay or denial, in our experience, these occur due to lack of clarity in clinical documentation, paperwork processing delays in the setting of short staffing, description of radiographic results, and communication barriers between clinical team and insurance company. We deem that this category of delay has the potential to be avoided. Delays secondary to modifiable factors discussed in preoperative appointments are not as straightforward (Table 2). Within this category, specific to instances where additional medical workup/clearance was recommended, we have identified two reasons why delays might occur: (1) the need for a change (lowering BMI, cessation of tobacco/alcohol/opioids, etc.) was not appropriately emphasized in preoperative discussions, or (2) the required medical change was unrealistic for the patient to achieve within the available time frame (i.e. inability to wean opiates/tobacco/alcohol, weight loss, etc.). Because it is common practice to discuss all additional medical workup/clearance needs with multiple providers, we suspect that reason 2 is a more likely culprit for delays due to need for additional medical workup/clearance particularly for those that occur within 7 days of scheduled surgery. In light of this, we recommend that providers spend time discussing what changes are realistic for patients, and if a necessary change is deemed difficult, to have frequent follow up to assess for progress well in advance of the scheduled surgical date.

Finally, there is a category of delay that may or may not be avoidable, such as due to new, concerning lab values

(additional medical workup/clearance recommended) or intraoperative positioning difficulties (intraoperative delay). Using newfound anemia as an example; it is the case that this finding may not have been detected early enough to have made the necessary change to make the patient medically ready for surgery. Alternatively, it could be the case that this anemia was not present until soon before surgery, and thus would be an inevitable delay. Similarly, positioning difficulties may have been detectable in the office through discussing the patient's position during surgery, or it may have been unrealistic to practice such positioning in the clinic. While many delays will fall within this gray zone of having the potential to be either avoidable or inevitable, we believe that awareness of etiologies of delays will allow ours and similar systems to better anticipate and mitigate the impact of such delays.

Based on our surgical team's observations, we hypothesize that delays that occur within 7 days of the scheduled surgical date commonly result in open schedules for ORs and underutilized surgical staff. Intraoperative delays and patient illness/injury were most commonly responsible for delays to surgery within 1 week of scheduled surgery date (Table 1). We suspect that these delays were unpredictable and could not have been avoided with additional medical workup/clearance. Further research is needed to determine how these delays impact complications and costs for both the patient and the hospital. Should these delays prove a significant impact on outcomes and hospital costs, methods to mitigate the impact of these delays should be investigated.

Limitations

Although the COVID-19 pandemic did not change the preoperative workflow for patients with adult spinal deformity, it may have impacted which surgical cases were attempted. On one hand, surgeons may have preferentially attempted cases that were less likely to experience complications, delays, and need postoperative intensive care. On the other hand, it is possible that only the most severe cases that could not wait until after the pandemic were prioritized. COVID-19 protocol went into effect on March 14, 2020, but surgical delays were no more likely to occur earlier compared to later in the study time period. Lastly, this was a single-center review of a standardized multidisciplinary team and may not be representative of all spine centers.

Conclusions

In a multidisciplinary spine care system, preoperative medical evaluation reduces the incidence of delays to surgery after hospital admission compared to prior reports. The most common etiology of delay was the recommendation of additional medical workup/clearance and peri-operative medical complications. Delays for additional medical workup may not need to be avoided, and inevitable delays should be expected at tertiary or quaternary centers that employ multidisciplinary processes to optimize patients. However, from the patient perspective, these delays result in prolonged disability from their spinal deformity and can be an inconvenience to the patient and their caregivers. Because neither delays due to intraoperative complications nor illness/injury can be predicted, we suspect that these delays are inevitable, and any system employing a multidisciplinary protocol for adult spinal deformity surgery should anticipate a baseline incidence of inevitable delays. A subset of seemingly inevitable delays occurs within 7 days of surgery date, and additional research is needed to determine the medical and financial impact of such delays. Finally, many delays have the capacity to be either avoidable or inevitable, and by being aware of the etiologies of delays, multidisciplinary teams may hone their focus in the attempt to minimize the incidence of delays, particularly within 7 days of surgery. Surgical teams should rigorously build teams that support and standardize the preoperative medical optimization of patients undergoing spinal reconstruction for ASD. To the authors' knowledge, this is the first study to outline the incidence, etiologies, and time course of surgical delays in spinal deformity surgery.

Author contributions Data collection: Depledge, Louie, Drolet, Shen, Nemani, Leveque, Sethi. Writing–original draft preparation: Depledge, Louie, Drolet, Shen. Approval of final version of manuscript: Depledge, Louie, Drolet, Shen, Nemani, Leveque, Sethi. Agree to be accountable for the work: Depledge, Louie, Drolet, Shen, Nemani, Leveque, Sethi.

Funding No funding was obtained for this study.

Data availability All data is available upon request.

Declarations

Conflict of interest The authors have no conflicts of interest to disclose directly related to the content of this manuscript.

Ethical approval IRB 21-004.

Informed consent Per our IRB office, informed consent was not applicable for this study.

References

1. Diebo BG, Shah NV, Boachie-Adjei O, Zhu F, Rothenfluh DA, Paulino CB, Schwab FJ, Lafage V (2019) Adult spinal deformity. Lancet. https://doi.org/10.1016/S0140-6736(19)31125-0
2. Lutz W, Sanderson W, Scherbov S (2008) The coming acceleration of global population ageing. Nature. https://doi.org/10.1038/nature06516

3. Fehlings MG, Tetreault L, Nater A, Choma T, Harrop J, Mroz T, Santaguida C, Smith JS (2015) The aging of the global population. Neurosurgery. https://doi.org/10.1227/NEU.0000000000000953
4. Friedman GN, Benton JA, Echt M, De la Garza RR, Shin JH, Coumans J-VCE, Gitkind AI, Yassari R, Leveque J-C, Sethi RK, Yanamadala V (2020) Multidisciplinary approaches to complication reduction in complex spine surgery: a systematic review. Spine J. https://doi.org/10.1016/j.spinee.2020.04.008
5. Wade SM, Fredericks DR, Elsenbeck MJ, Morrissey PB, Sebastian AS, Kaye ID, Butler JS, Wagner SC (2022) The incidence, risk factors, and complications associated with surgical delay in multilevel fusion for adult spinal deformity. Glob Spine J. https://doi.org/10.1177/2192568220954395
6. Shuman WH, Neifert SN, Gal JS, Martini ML, Schupper AJ, Steinberger JM, Maron SZ, Lamb CD, Rothrock RJ, McNeill IT, Cho SK, Caridi JM (2020) Adult spinal deformity surgery: the effect of surgical start time on patient outcomes and cost of care. Spine Deform. https://doi.org/10.1007/s43390-020-00129-x
7. Frimpong JA, Myers CG, Sutcliffe KM, Lu-myers Y (2017) When health care providers look at problems from multiple perspectives, patients benefit. Harv Bus Rev
8. Sethi RK, Pong RP, Leveque J-C, Dean TC, Olivar SJ, Rupp SM (2014) The Seattle spine team approach to adult deformity surgery: a systems-based approach to perioperative care and subsequent reduction in perioperative complication rates. Spine Deform. https://doi.org/10.1016/j.jspd.2013.12.002
9. Sethi R, Buchlak QD, Yanamadala V, Anderson ML, Baldwin EA, Mecklenburg RS, Leveque JC, Edwards AM, Shea M, Ross L, Wernli KJ (2017) A systematic multidisciplinary initiative for reducing the risk of complications in adult scoliosis surgery. J Neurosurg Spine. https://doi.org/10.3171/2016.11.SPINE16537
10. Halpin RJ, Sugrue PA, Gould RW, Kallas PG, Schafer MF, Ondra SL, Koski TR (2010) Standardizing care for high-risk patients in spine surgery: the Northwestern high-risk spine protocol. Spine (Phila Pa 1976). https://doi.org/10.1097/BRS.0b013e3181e8abb0
11. Sethi RK, Burton DC, Wright AK, Lenke LG, Cerpa M, Kelly MP, Daniels AH, Ames CP, Klineberg EO, Mundis GM, Bess S, Hart RA (2019) The role of potentially modifiable factors in a standard work protocol to decrease complications in adult spinal deformity surgery: a systematic review, part 2. Spine Deform. https://doi.org/10.1016/j.jspd.2019.03.001
12. Sethi RK, Yanamadala V, Shah SA, Fletcher ND, Flynn J, Lafage V, Schwab F, Heffernan M, DeKleuver M, Mcleod L, Leveque JC, Vitale M (2019) Improving complex pediatric and adult spine care while embracing the value equation. Spine Deform. https://doi.org/10.1016/j.jspd.2018.08.006
13. Renfree SP, Makovicka JL, Chung AS (2019) Risk factors for delay in surgery for patients undergoing elective anterior cervical discectomy and fusion. J Spine Surg. https://doi.org/10.21037/jss.2019.10.09
14. Wagner SC, Butler JS, Kaye ID, Sebastian AS, Morrissey PB, Kepler CK (2018) Risk factors for and complications after surgical delay in elective single-level lumbar fusion. Spine (Phila Pa 1976). https://doi.org/10.1097/BRS.0000000000002282