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Systematic Reviews /Meta-analyses

Disparities in postoperative complications and perioperative events based on insurance status following elective spine surgery: A systematic review and meta-analysis

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ABSTRACT

Background: Increasing evidence demonstrates disparities among patients with differing insurance statuses in the field of spine surgery. However, no pooled analyses have performed a robust review characterizing differences in postoperative outcomes among patients with varying insurance types.
Methods: A comprehensive literature search of the PUBMED, MEDLINE(R), ERIC, and EMBASE was performed for studies comparing postoperative outcomes in patients with private insurance versus government insurance. Pooled incidence rates and odds ratios were calculated for each outcome and meta-analyses were conducted for 3 perioperative events and 2 types of complications. In addition to pooled analysis, sub-analyses were performed for each outcome in specific government payer statuses.
Results: Thirty-eight studies (5,018,165 total patients) were included. Compared with patients with private insurance, patients with government insurance experienced greater risk of 90-day re-admission (OR 1.84, p<.0001), non-routine discharge (OR 4.40, p<.0001), extended LOS (OR 1.82, p<.0001), any postoperative complication (OR 1.61, p<.0001), and any medical complication (OR 1.93, p<.0001). These differences persisted across outcomes in sub-analyses comparing Medicare or Medicaid to private insurance. Similarly, across all examined outcomes, Medicare patients had a higher risk of experiencing an adverse event compared with non-Medicare patients. Compared with Medicaid patients, Medicare patients were only more likely to experience non-routine discharge (OR 2.68, p=.0007).
Conclusions: Patients with government insurance experience greater likelihood of morbidity across several perioperative outcomes. Additionally, Medicare patients fare worse than non-Medicare patients across outcomes, potentially due to age-based discrimination. Based on these results, it is clear that directed measures should be taken to ensure that underinsured patients receive equal access to resources and quality care.

Introduction

An increasing amount of evidence has unveiled the prevalence of disparities among patients with difference insurance statuses in the United States healthcare system [1]. Insurance status has been identified as a major determinant of quality care and outcomes across multiple medical fields [2–4]. While many studies highlight increased adverse events among uninsured patients versus private insurance, a growing number of studies show that those with government insurance also experience inferior care and outcomes compared with private insurance [5–7]. In

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particular, government insurance has been linked to worse outcomes in several surgical specialties [8], including oncologic [9], gynecologic [10], and orthopedic [11] surgery. As the number of Americans with government insurance rapidly increases [12], the expanding disparity between the care of privately and government insured patients is an increasing concern.

Several cohort studies have reported disparities in perioperative events and postoperative complications for patients with government insurance following spine surgery. Among patients undergoing ACDF at a single institution, Medicaid and Medicare patients exhibited higher rates of extended LOS and non-routine discharge (NRD) compared with private insurance [13]. Medicaid and Medicare patients undergoing lumbar spinal fusion had a higher incidence of 90-day re-admission [14]. In a study on anterior cervical spine surgery, Medicaid and Medicare patients both had significantly greater odds of death [15]. Medicaid patients were found to have increased rates of any complication following elective spine surgery compared with private insurance, which was partly attributed to underinsurance and overlapping co-morbidities [16]. Both Medicare and Medicaid patients that underwent spinal fusion surgery had an increased incidence of neurologic medical complications [17].

Previous pooled analyses support the outcome disparity between privately and government insured patients following spine surgery. A 2015 meta-analysis of 31 studies with 3,567 patients by Cheriyan et al. [18] demonstrated that patients with Worker's Compensation had greater odds of experiencing an adverse event and not returning to work following spine surgery. Russo et al. [19] conducted a meta-analysis in 2021 of 26 studies with 2,668 patients, showing that patients with Worker's Compensation had higher rates of pain, disability, dissatisfaction, and delayed return to work after lumbar spine surgery, potentially due to a combination of more severe working environments and socioeconomic variables. Badin et al.[20] performed a systematic review in 2022 with 25 articles demonstrating that Medicaid patients have a higher rates of re-admission, reintubation, extended LOS, and non-home discharge compared with privately insured patients, likely because of lower access to spine surgery and decreased rates of reimbursement.

Although these previous systematic reviews performed robust analyses, all works included a relatively small number of studies and patients while reporting a limited number of outcomes, limiting their scope. Further, these studies at most analyze 2 surgery types, which–despite decreasing heterogeneity–limits the generalizability of their results. Prior works also largely examine the effects of one type of government insurance on outcomes, which further limits their applicability to patients with other forms of government insurance while also omitting more nuanced effects and characterizations of multiple insurance types on postoperative outcomes. The purpose of our review is to use a semi-automated AI-assisted review platform to broadly assess the effects of insurance status on perioperative events and postoperative complications following elective spine surgery. We sought to rigorously analyze and present associations between government and private insurance on patient health, along with sub-analyses highlighting complex relationships between various insurance types. Such findings would allow us to better characterize the landscape of pertinent studies on health outcomes and more accurately characterize intricate relationships between insurance type and adverse postoperative outcomes.

Methods

Literature search

A comprehensive literature search of the PUBMED, MEDLINE(R), ERIC, and EMBASE databases was performed using Nested Knowledge, a semi-automated cloud-based platform for systematic reviews and meta-analyses [21]. De-duplication of studies across multiple search results was automatically performed. A complete list of search terms, along with the corresponding database and date of search, is provided in Appendix A1. Nested Knowledge provides a semi-automated software platform for screening, tagging, and extracting data from studies during a literature search. The detailed methodology of this process is publicly available on the Nested Knowledge website (https://nested-knowledge.com/) [21]. This review was performed by 3 authors (NK, IA, and RM). This review was not registered.

Study selection

Only peer-reviewed, original articles were retrieved from the literature search. Inclusion criteria were as follows: (1) patients who underwent elective surgery on any region of the spine with any procedure (excluding cancer-related or trauma surgery); (2) studies that reported on any perioperative event or postoperative complication outlined in Table 2; and (3) studies that compared outcomes between private insurance and at least one government insurance (Government Insurance, Medicaid, Medicare, Veterans Affairs, Managed Care, and Triwest). Exclusion criteria were the following: (1) studies published before 2010; (2) studies that included less than 100 patients to reduce variance; (3) full texts were not available; (4) raw incidence data for insurance status was not reported in the figures, tables, or text; and (5) studies performed outside the United States. Notably, we also excluded studies that included an outcome that was reported by fewer than 4 of our total screened studies. As an extension, meta-analyses were only performed if there were at least 4 studies reporting on the same outcome. As a result, we did not examine mortality and re-operation rates, which are commonly assessed perioperative events but were not addressed by enough studies identified by our literature search. Studies were distinguished between those that reported on insurance status as an independent variable (Predictor Driven Data: PDD) and those that reported an outcome as an independent variable (Outcome Driven Data: ODD). This difference is documented in the "Variable Type" column of Table 1.

Outcome measures and categorization

Each included study was systematically tagged, and predefined data–including study size, database, surgery type, perioperative events, and postoperative complications–were extracted by 2 independent authors (NK and IA). Disagreements were settled by the senior author (MSF) (Table 1). A list of included and excluded outcomes and categorizations are summarized in Table 2 and Table 3. Definitions and justifications for included and excluded outcomes are provided below.

Three key perioperative events were identified after extraction and reported in our analysis: re-admission, non-routine or non-home discharge, and extended LOS. Data was extracted if the examined perioperative event occurred within 90 days of surgery, which is the perioperative period defined by Medicare. Therefore, if a study provided re-admission data for 0 to 30 days and 31 to 90 days after surgery, these values were combined to report a single value for 90-day readmission. These parameters were chosen because they are well-studied metrics for assessing the outcomes of major surgeries [22] and have been widely reported in previous systematic reviews on disparities in spine surgery [23,24].

Due to incongruous reporting of postoperative complications across included studies, data for all complications were tagged and extracted based on the most granular data that the study provided. Complications were then logically grouped into 2 categories: any complication and all medical complications (Table 2). Any complication refers to the singular value that studies reported after lumping all examined complications. For all medical complications, we combined values between the studies that reported on the incidence of a medical complication by insurance status. In total, the 7 studies in this category reported on the following medical complications: Neurologic, Sepsis, DVT/PE, Opioid Poisoning, Vision Loss, and ICU stay (Table 1). Each complication was documented as reported by the authors of a study, and complications

Table 1
Summary characteristics of the 38 included studies.

Journal Article	Study size (Private insurance / Government insurance / Medicare / Medicaid / Veterans affairs / Managed care / Triwest)	Database	Surgery type	Variable type	Perioperative outcome	Complication type
Akamnonu et al. 2015	833/-/324/-/-/-/-	SC	El. SS	ODD	Re-Ad	-
Best et al. 2015	1,096,251/-/266,288/91,354/-/-/-	NHDS	Spinal Fus.	ODD	NRD	-
Buchanan et al. 2019	358,603/-/310,808/7,730/-/-/-	HCUP	El. SS	ODD	Re-Ad	-
Chen et al. 2020	101,588/-/110,009/12,018/-/-/-	HCUP	Lum. Fus.	ODD	Re-Ad	-
Chotai et al. 2015	539/-/272/95/-/-/-	SC	El. Lum. Surg.	ODD	-	Any Comp.
De la Garza-Ramos et al. 2016	29,243/-/85/10,264/-/-/-	NIS	AIS Fus.	ODD	-	Med. Comp.: Visual Loss
Dial et al. 2020	1,063/-/666/73/-/-/-	SC	ACDF	ODD	Re-Ad, Extended LOS	-
Elia et al. 2020	3,240/-/2,094/675/-/-/-	HCUP	Lum. Fus.	ODD	Re-Ad	-
(a)Elsamadicy et al. 2019	54,388/-/66,049/7,981/-/-/-	HCUP	El. SS	ODD	Re-Ad	-
(b)Elsamadicy et al. 2019	2,425/-/7/1,087/-/-/-	KID	Post. Spinal Fus.	ODD	Extended LOS	-
(a)Elsamadicy et al. 2020	61,710/-/59,207/10,845/-/-/-	NIS	ACDF	ODD	Extended LOS	-
(b)Elsamadicy et al. 2020	6,674/-/3,156/1,277/-/-/-	HCUP	ACDF / CDA	ODD	Re-Ad	-
Feng et al. 2018	15,198/-/16,072/3,691/-/-/-	SPARCS	Cer. Fus.	ODD	-	Med. Comp.: Sepsis
Fields et al. 2021	1,586/-/3,393/271/-/-/-	HCUP	Cer. Fus.	ODD	Re-Ad	-
Gephart et al. 2012	4,607/-/2,688/-/-/-/-	NIS	Spinal Fus.	ODD	-	Med. Comp.: DVT/PE
Goyal et al. 2020	65,477/-/44,372/10,099/-/-/-	HCUP	ACDF	ODD	Re-Ad	-
Guan et al. 2018	127/4/77/9/-/-/-	QOD	Lum. Fus.	ODD	NRD	-
Hacquebord et al. 2013	609/-/367/367/44/-/-	SC	El. SS	ODD	-	Any Comp.
Huang et al. 2013	9,786/-/-/1,528/-/-/-	TRMS	SCS Surg.	PDD	Re-Ad	-
Hydrick et al. 2020	4,864/-/6,984/860/-/-/-	HCUP	Lum. Fus.	ODD	Re-Ad	-
Kim et al. 2022	65,574/-/18,839/4,930/-/-/-	SPARCS	El. SS	ODD	-	Med. Comp.: Opioid Poisoning
Kohls et al. 2018	189/-/51/58/-/-/-	SC	Lum. Disc.	ODD	Re-Ad	-
Lad et al. 2013	25,000/-/-/2,577/-/-/-	TRMS	Lam./Fus.	PDD	-	Any Comp.
Lee et al. 2020	19,039/-/33/9,807/-/-/-	HCUP	Spinal Fus.	ODD	Re-Ad	-
Lubelski et al. 2020	134/-/104/19/-/-/-	SC	El. SS	ODD	NRD, Extended LOS	-
Martini et al. 2021	5,585/-/3,227/1,017/-/-/-	SC	El. SS	ODD	Extended LOS	-
Memtsoudis et al. 2014	44,076/-/35,431/4,155/-/-/-	NC State	Lum. Spine Fus.	ODD	-	Med. Comp.: ICU
Mummaneni et al. 2021	553/42/441/78/-/-/-	QOD	Cer. Surg.	ODD	NRD	-
Nuño et al. 2013	4,783/-/3,107/732/-/-/-	NIS	Spinal Fus.	ODD	-	Any Comp.
Ogura et al. 2020	543/-/811/148/-/-/-	SC	Lum. Fus.	ODD	NRD	-
Parker et al. 2018	1,440/1,291/-/-/-/-/-	SC	El. SS	ODD	Re-Ad	-
Rasouli et al. 2020	637/-/452/155/-/1,129/-	SC	ACDF	PDD	Re-Ad, NRD, Extended LOS	Med. Comp.: ICU
Roddy et al. 2017	8,639/-/37/3,404/-/-/-	HCUP	Spinal Fus.	ODD	Re-Ad	-
Rubel et al. 2019	65,847/-/73,657/12,211/-/-/-	HCUP	Lum. Surg.	ODD	Re-Ad	-
Rumalla et al. 2017	33,985/-/23,210/4,835/-/-/-	HCUP	ACDF/TDR	ODD	Re-Ad	-
Sivaganesan et al. 2019	18,552/-/11,817/1,813/1,048/-/-	QOD	El. Lum. SS	ODD	Re-Ad	-
Taylor et al. 2021	21,692/-/17,235/4,411/-/-/-	HCUP	ACDF	ODD	Re-Ad	-
Thirumala et al. 2017	1,068,965/-/401,688/116,931/-/-/-	NIS	ACDF/Spinal Fus.	ODD	-	Med. Comp.: Neuro

Cer., Cervical; Comp., Complication; Disc., Discectomy; El., Elective; Fus., Fusion; HCUP, Healthcare Cost and Utilization Project; KID, Kids Inpatient Database; Lam., Laminectomy; LOS, Length of Stay; Lum., Lumbar; Med., Medical; Neuro, Neurologic; NHDS, National Hospital Discharge Survey; NC State, North Carolina State Database; NIS, Nationwide Inpatient Sample; NRD, Non-Routine Discharge; ODD, Outcome Driven Data; PDD, Predictor Driven Data; Post., Posterior; QOD, Quality and Outcomes Database; Re-Ad, Re-Admission; SC, Single Center; SCS, Spinal Cord Stimulation; SPARCS, Statewide Planning and Research Cooperative System; SS, Spine Surgery; Surg., Surgery; TRMS, Thomson Reuter's MarketScan

Table 2
Summary of postoperative complications and perioperative events collected from included studies. (n) represents the number of studies that reported each complication.

Outcome Type (total studies)	*Outcome Subtype Tier 1 (total studies)*	*Outcome Subtype Tier 2 (total studies)*
Perioperative Events (34)	90 Day Re-Admission (20)	–
	Non-Routine Discharge (8)	–
	Extended LOS (6)	–
Postoperative Complications (12)	Any Complication (5)	–
	Medical Complication (7)	Neuro (1)
		Sepsis (1)
		DVT (1)
		Opioid Poisoning (1)
		Vision Loss (1)
		ICU (2)

Table 3
Summary of postoperative complications and perioperative events reported in included studies but were not analyzed in this study. (n) represents the number of studies that reported each complication.

Outcome Type (total studies)	*Outcome Subtype Tier 1 (total studies)*	*Outcome Subtype Tier 2 (total studies)*
Perioperative Events (7)	LOS (2)	–
	Re-Operation (3)	–
	Mortality (1)	–
Postoperative Complications (6)	Medical Complications (1)	Pain (1)
	Surgical Complications (5)	Dysphagia (1)
		Neuro/Dural Injury (1)
		Postoperative Bleeding (1)
		Postoperative Infection (2)

were excluded if: (1) they were not medically relevant as determined by the senior author (MSF); or (2) had an iatrogenic cause (ie, dural tears) (Table 3).

Quality assessment and strength of evidence

The risk of bias of the included studies was assessed using the Newcastle-Ottawa Scale, which provides a ranking system to judge non-randomized studies based on study group selection, comparability between groups, and evaluation of outcome [25]. Authors GX and AK independently gauged the quality of all eligible works by assigning a score based on outlined criteria, with disagreements settled by the senior author (Appendix A2).

Statistical analysis

Statistical analyses were performed using RStudio 4.2.0 [26]. A total of 25 meta-analyses were performed for the following outcomes: 90-day re-admission, NRD, extended LOS, any complication, and all medical complications. For each of these 5 outcomes, meta-analyses of the following comparisons were performed: (1) private insurance vs. government insurance, which includes a pooled analysis of multiple types of government insurance (Medicaid, Medicare, Veterans Affairs, Managed Care, and Triwest); (2) sub-analysis comparing Medicaid to private insurance; (3) sub-analysis comparing Medicare to private insurance; (4) Medicare versus Medicaid; and (5) Medicare versus non-Medicare, which includes a pooled analysis of values reported for Private Insurance, Government Insurance, Medicaid, Veterans Affairs, Managed Care, and Triwest.

This study sought to investigate the effects of different insurance types on the incidence of specific adverse events. For the comparisons outlined above, odds ratios (OR) and 95% confidence intervals (CI) were calculated using the Mantel-Haenszel method for dichotomous outcomes. A CI with a lower bound greater than one, which corresponds to a p-value less than .05, indicates significantly greater odds of the government insurance group of interest experiencing an adverse event. Forest plots were generated to depict effect sizes. Heterogeneity in each meta-analysis was assessed by calculating the I^2 statistic. If there were low to moderate levels of heterogeneity among studies ($I^2 \leq 50\%$), a fixed-effect model was used. For the government versus private insurance comparison, funnel pots were generated for all outcomes to assess the risk of publication bias, where symmetric plots represent minimal publication bias (Appendix A3-7).

Results

Literature search results

Our literature search was based on predefined search queries retrieved a total of 1,959 unique results. A list of search terms is provided in Appendix A1. After abstract and full-text screening by 3 independent reviewers, 38 studies with 5,018,165 total patients were identified for inclusion in this review. Our PRISMA screening process is outlined in []Fig. 1. All studies were retrospective analyses, with each study reporting values for private insurance and at least one government insurance. Table 1 details study characteristics, which include the number of patients with a given insurance type, analyzed database, type of spine surgery, and reported perioperative events or postoperative complications.

Overview of findings

Table 4 summarizes the OR values, p-values, number of studies (k), and heterogeneity (I^2) for each of the 25 meta-analyses performed in this study. 5 meta-analyses compared government versus private insurance, 10 sub-analyses compared Medicare or Medicaid patients to private insurance, 5 meta-analyses compared Medicare versus Medicaid patients, and 5 meta-analyses compared Medicare to non-Medicare patients. Almost all analyses exhibited high heterogeneity ($I^2 \geq 50\%$), warranting a random effects model. However, 2 meta-analyses comparing NRD or any complication between Medicaid and private insurance patients displayed low heterogeneity ($I^2 < 50\%$), permitting a fixed effects model.

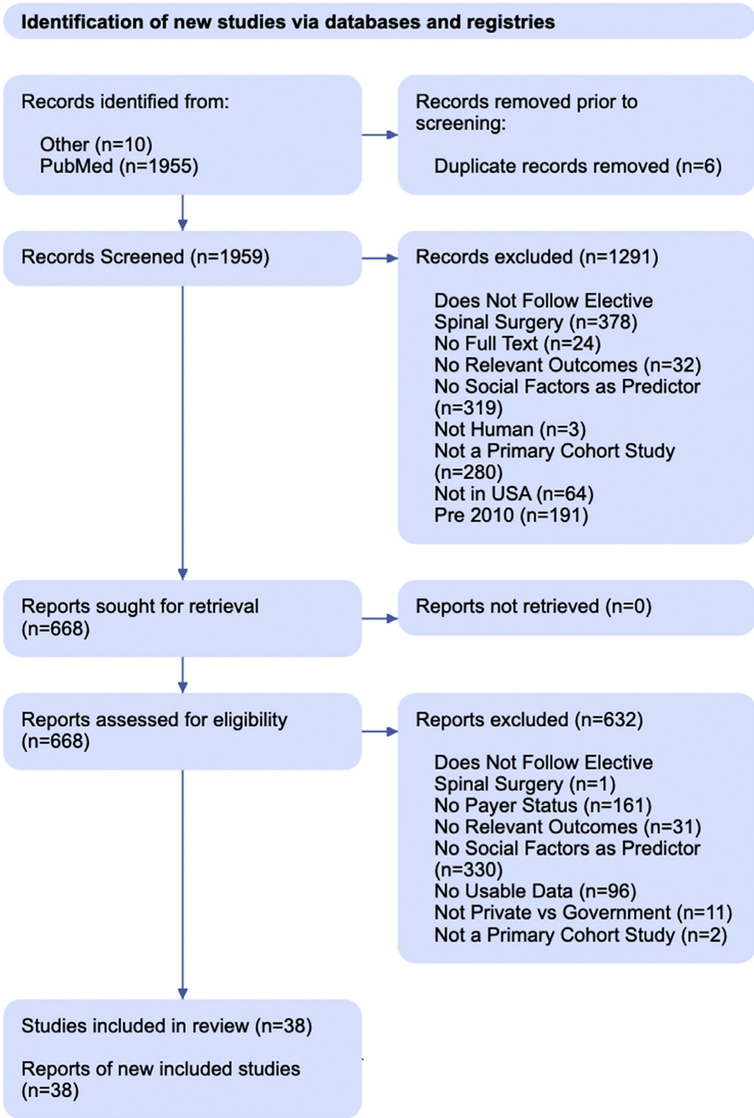

Fig. 1. PRISMA diagram depicting literature search and screening process.

Table 4
Summary of OR values, p-values, number of studies (k), and heterogeneity (I^2) for 5 outcomes and across 5 subsets of included studies: Government vs. Private, Medicaid vs. Private, Medicare vs. Private, Medicare vs. Medicaid, Medicare vs. Non-Medicare. OR values with significance (p<0.05) are bolded.

	Government vs. Private/Medicaid vs. Private/Medicare vs. Private/Medicare vs. Medicaid/Medicare vs. Non-Medicare			
	OR	p-value	k (studies)	I^2 (%)
Periop Events				
90 Day Re-Admission	**1.84**/**1.83**/**2.17**/1.21/**1.89**	<0.0001/0.0005/<0.0001/0.3355/<0.0001	20/18/18/17/18	97.1/98.4/97.0/98.4/96.4
Non-Routine Discharge	**4.40**/**2.59**/**5.87**/**2.68**/**5.21**	<0.0001/0/<0.0001/0.0007/<0.0001	6/6/6/6/6	84.9/1.0/75.3/68.1/81.4
Extended LOS	**1.82**/**2.32**/**1.98**/0.80/**1.76**	<0.0001/0.0003/<0.0001/0.2947/<0.0001	6/6/6/6/6	93.0/92.8/76.1/84.0/54.3
Postop Complications				
Any Complication	**1.61**/**1.44**/**1.97**/1.28/**1.76**	<0.0001/<0.0001/0.0007/0.2141/0.0006	4/4/3/3/3	65.7/0.0/88/77.1/85.2
All Medical Complications	**1.93**/**2.24**/**1.77**/0.78/**1.59**	<0.0001/<0.0001/<0.0001/0.3098/0.0001	7/6/7/6/7	96.2/94.8/95.5/89.7/93.5

Across all examined outcomes, patients with government insurance were more likely to experience an adverse event than private insurance, which largely persisted across Medicare and Medicaid sub-analyses. Three of the 5 OR values were higher for the Medicare sub-analysis compared with the Medicaid sub-analysis. We therefore sought to investigate if Medicare patients were generally more likely to experience adverse events. Although Medicare patients were only more likely to experience NRD compared with Medicaid patients, they were more likely than non-Medicare patients to experience all examined outcomes.

Perioperative events

Readmission

20 studies with 1,512,408 total patients were included in our meta-analysis for 90-day re-admission (Fig. 2). Pooled analysis demonstrates

Study	Database	Surgery Type	e(Private)	n(Private)	e(Gov)	n(Gov)	n(Total)	Weight	OR	95% CI
Rubel et al. 2019	HCUP	Lum. Surg.	1669	65847	2122	85868	151715	5.8%	0.97	[0.91; 1.04]
Fields et al. 2021	HCUP	Cer. Fus.	194	1586	462	3664	5250	5.4%	1.04	[0.87; 1.24]
Kohls et al. 2018	SC	Lum. Disc.	10	189	6	109	298	1.5%	1.04	[0.37; 2.95]
Huang et al. 2013	TRMS	SCS Surg.	217	9786	44	1528	11314	4.6%	1.31	[0.94; 1.82]
Hydrick et al. 2020	HCUP	Lum. Fus.	131	4864	277	7844	12708	5.2%	1.32	[1.07; 1.63]
Parker et al. 2018	SC	El. SS	95	1440	126	1291	2731	4.9%	1.53	[1.16; 2.02]
Akamnonu et al. 2015	SC	El. SS	25	833	16	324	1157	2.8%	1.68	[0.88; 3.19]
Lee et al. 2020	HCUP	Spinal Fus.	629	19039	559	9840	28879	5.6%	1.76	[1.57; 1.98]
Chen et al. 2020	HCUP	Lum. Fus.	8948	101588	18418	122027	223615	5.8%	1.84	[1.79; 1.89]
Rasouli et al. 2020	SC	ACDF	20	637	102	1736	2373	3.6%	1.93	[1.18; 3.14]
Dial et al. 2020	SC	ACDF	51	1063	66	739	1802	4.3%	1.95	[1.33; 2.84]
Sivaganesan et al. 2019	QOD	El. Lum. SS	334	18552	506	14678	33230	5.6%	1.95	[1.69; 2.24]
(a)Elsamadicy et al. 2019	HCUP	El. SS	2710	54388	7001	74030	128418	5.8%	1.99	[1.90; 2.09]
Roddy et al. 2017	HCUP	Spinal Fus.	318	8639	245	3441	12080	5.4%	2.01	[1.69; 2.38]
Goyal et al. 2020	HCUP	ACDF	2227	52828	3799	44385	97213	5.8%	2.13	[2.02; 2.24]
Rumalla et al. 2017	HCUP	ACDF/TDR	1461	33985	2446	28045	62030	5.8%	2.13	[1.99; 2.27]
Buchanan et al. 2019	HCUP	El. SS	1317	358603	2499	318538	677141	5.8%	2.15	[2.01; 2.29]
Elia et al. 2020	HCUP	Lum. Fus.	153	3240	290	2769	6009	5.3%	2.36	[1.93; 2.89]
(b)Elsamadicy et al. 2020	HCUP	ACDF / CDA	298	6674	505	4433	11107	5.5%	2.75	[2.37; 3.19]
Taylor et al. 2021	HCUP	ACDF	237	21692	921	21646	43338	5.5%	4.02	[3.48; 4.65]
Total (95% CI)								**100.0%**	**1.84**	**[1.58; 2.13]**

Random Effects Model: I² = 97.1%, p <0.0001, k = 20

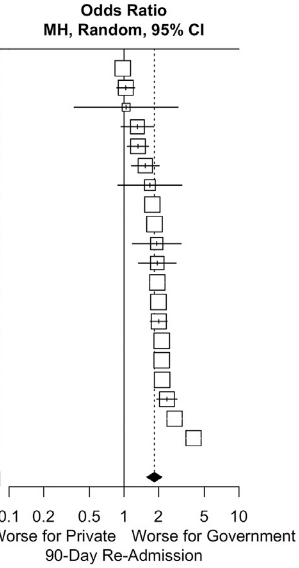

Fig. 2. Meta-analysis with a random effects model of all studies reporting 90-day re-admission complications for government versus private insurance cohorts. OR = odds ratio. e(Gov) = number of adverse events in government-insured patients. n(Gov) = sample size of government-insured patients. e(Private) = number of adverse events in privately insured patients. n(Private) = sample size of privately insured patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Non-Medicare)	n(Non-Medicare)	e(Medicare)	n(Medicare)	n(Total)	Weight	OR	95% CI
Rubel et al. 2019	HCUP	Lum. Surg.	1930	78058	1861	73657	151715	6.4%	1.02	[0.96; 1.09]
Fields et al. 2021	HCUP	Cer. Fus.	220	1857	436	3393	5250	6.2%	1.10	[0.92; 1.30]
Kohls et al. 2018	SC	Lum. Disc.	13	247	3	51	298	2.1%	1.12	[0.31; 4.10]
Taylor et al. 2021	HCUP	ACDF	656	26103	502	17235	43338	6.3%	1.16	[1.03; 1.31]
Hydrick et al. 2020	HCUP	Lum. Fus.	143	5724	265	6984	12708	6.1%	1.54	[1.25; 1.89]
Akamnonu et al. 2015	SC	El. SS	25	833	16	324	1157	4.3%	1.68	[0.88; 3.19]
Buchanan et al. 2019	HCUP	El. SS	1564	366333	2252	310808	677141	6.4%	1.70	[1.60; 1.82]
Chen et al. 2020	HCUP	Lum. Fus.	10669	113606	16697	110009	223615	6.4%	1.73	[1.68; 1.77]
(a)Elsamadicy et al. 2019	HCUP	El. SS	3514	62369	6197	66049	128418	6.4%	1.73	[1.66; 1.81]
Dial et al. 2020	SC	ACDF	57	1136	60	666	1802	5.5%	1.87	[1.29; 2.73]
Sivaganesan et al. 2019	QOD	El. Lum. SS	397	21413	443	11817	33230	6.3%	2.06	[1.80; 2.37]
Rumalla et al. 2017	HCUP	ACDF/TDR	1795	38820	2112	23210	62030	6.4%	2.06	[1.93; 2.20]
Goyal et al. 2020	HCUP	ACDF	2768	61017	3258	36196	97213	6.4%	2.08	[1.98; 2.19]
Elia et al. 2020	HCUP	Lum. Fus.	206	3915	237	2094	6009	6.1%	2.30	[1.89; 2.79]
Rasouli et al. 2020	SC	ACDF	80	1921	42	452	2373	5.4%	2.36	[1.60; 3.48]
(b)Elsamadicy et al. 2020	HCUP	ACDF / CDA	425	7951	378	3156	11107	6.3%	2.41	[2.08; 2.79]
Lee et al. 2020	HCUP	Spinal Fus.	1184	28846	4	33	28879	2.8%	3.22	[1.13; 9.18]
Roddy et al. 2017	HCUP	Spinal Fus.	549	12043	14	37	12080	4.2%	12.74	[6.52; 24.90]
Total (95% CI)								**100.0%**	**1.89**	**[1.50; 2.38]**

Random Effects Model: I² = 96.4%, p <0.0001, k = 18

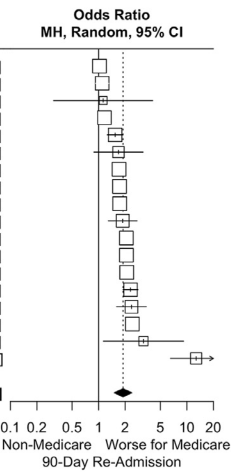

Fig. 3. Meta-analysis with a random effects model of all studies reporting 90-day re-admission complications for Medicare versus non-Medicare cohorts. OR = odds ratio. e(Medicare) = number of adverse events in Medicare patients. n(Medicare) = sample size of Medicare patients. e(Non-Medicare) = number of adverse events in non-Medicare patients. n(Non-Medicare) = sample size of non-Medicare patients. n(Total) = total sample size in study.

that the odds of a patient with government insurance having a 90-day re-admission was greater than a patient with private insurance (OR 1.84, p<.0001). This difference persisted across both sub-analyses comparing patients with either Medicaid (OR 1.83, p=.0005) or Medicare (OR 2.17, p<.0001) to those with private insurance, with the odds of experiencing a 90-day re-admission being greater among Medicare patients (Appendix B1.1 & B2.1). While there was no significant difference between Medicare and Medicaid patients in the likelihood of 90-day re-admission (Appendix B3.1), Medicare patients had significantly greater odds of a 90-day re-admission compared with non-Medicare patients (Fig. 3) (OR 1.89, p<.0001).

Nonroutine discharge

Six studies with 1,459,356 total patients were included in our meta-analysis for NRD (Fig. 4). A pooled analysis comparing patients with government insurance to those with private insurance showed a significantly greater odds of government-insured patients experiencing a NRD (OR 4.40, p<.0001). Compared individually to patients with private insurance, Medicaid (OR 2.59, p=0) and Medicare (OR 5.87, p<.0001) patients experienced a higher likelihood of a NRD, with the odds being higher for Medicare patients (Appendix B1.2 & B2.2). This is consistent with Medicare patients having significantly greater odds of NRD than Medicaid patients (Appendix B3.2) (OR 2.68, p=.0007). Figure 5 shows that Medicare patients had significantly greater odds of a NRD compared with non-Medicare patients (OR 5.21, p<.0001).

Extended LOS

Six studies with 149,542 total patients were included in our meta-analysis for extended LOS (Fig. 6). Pooled analysis showed that the odds of a patient with government insurance having an extended LOS was statistically greater than those with private insurance (OR 1.82, p<.0001). This difference persisted when comparing Medicaid (OR 2.32, p=.0003) or Medicare (OR 1.98, p<.0001) patients to privately insured patients (Appendix B1.3 & B2.3). There was no difference in the likelihood of an extended LOS between Medicare and Medicaid patients (Appendix B3.3) (OR 0.80, p=.2947). Compared with non-Medicare patients, Medicare patients had an increased likelihood of an extended LOS (Fig. 7) (OR 1.76, p<.0001).

Study	Database	Surgery Type	e(Private)	n(Private)	e(Gov)	n(Gov)	n(Total)	Weight	OR	95% CI
Rasouli et al. 2020	SC	ACDF	19	637	110	1736	2373	16.3%	2.20	[1.34; 3.61]
Guan et al. 2018	QOD	Lum. Fus.	27	127	37	90	217	14.8%	2.59	[1.42; 4.70]
Lubelski et al. 2020	SC	El. SS	16	134	42	123	257	14.1%	3.82	[2.01; 7.26]
Mummaneni et al. 2021	QOD	Cer. Surg.	24	553	101	561	1114	16.8%	4.84	[3.05; 7.68]
Best et al. 2015	NHDS	Spinal Fus.	19790	1096251	38194	357642	1453893	21.0%	6.50	[6.39; 6.62]
Ogura et al. 2020	SC	Lum. Fus.	23	543	263	959	1502	17.1%	8.54	[5.50; 13.28]
Total (95% CI)								**100.0%**	**4.40**	**[2.89; 6.71]**

Random Effects Model: I² = 84.9%, p <0.0001, k = 6

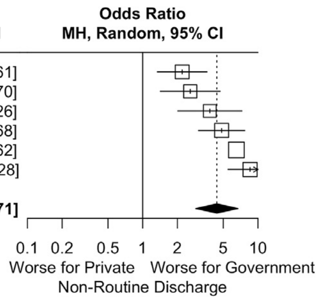

Fig. 4. Meta-analysis with a random effects model of all studies reporting non-routine discharge complications for government versus private insurance cohorts. OR = odds ratio. e(Gov) = number of adverse events in government-insured patients. n(Gov) = sample size of government-insured patients. e(Private) = number of adverse events in privately insured patients. n(Private) = sample size of privately insured patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Non-Medicare)	n(Non-Medicare)	e(Medicare)	n(Medicare)	n(Total)	Weight	OR	95% CI
Lubelski et al. 2020	SC	El. SS	23	153	35	104	257	13.8%	2.87	[1.57; 5.23]
Guan et al. 2018	QOD	Lum. Fus.	30	140	34	77	217	13.7%	2.90	[1.58; 5.31]
Rasouli et al. 2020	SC	ACDF	66	1921	63	452	2373	17.6%	4.55	[3.17; 6.54]
Mummaneni et al. 2021	QOD	Cer. Surg.	31	673	94	441	1114	16.6%	5.61	[3.66; 8.59]
Best et al. 2015	NHDS	Spinal Fus.	23946	1187605	34038	266288	1453893	21.0%	7.12	[7.00; 7.24]
Ogura et al. 2020	SC	Lum. Fus.	31	691	255	811	1502	17.2%	9.76	[6.61; 14.41]
Total (95% CI)								**100.0%**	**5.21**	**[3.56; 7.62]**

Random Effects Model: I² = 81.4%, p <0.0001, k = 6

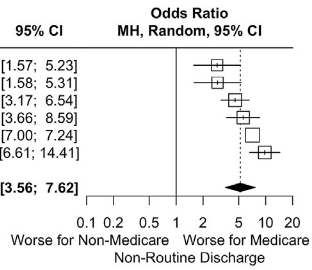

Fig. 5. Meta-analysis with a random effects model of all studies reporting non-routine discharge complications for Medicare versus non-Medicare cohorts. OR = odds ratio. e(Medicare) = number of adverse events in Medicare patients. n(Medicare) = sample size of Medicare patients. e(Non-Medicare) = number of adverse events in non-Medicare patients. n(Non-Medicare) = sample size of non-Medicare patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Private)	n(Private)	e(Gov)	n(Gov)	n(Total)	Weight	OR	95% CI
Rasouli et al. 2020	SC	ACDF	231	637	704	1736	2373	17.9%	1.20	[0.99; 1.45]
Lubelski et al. 2020	SC	El. SS	20	134	26	123	257	9.5%	1.53	[0.80; 2.91]
(b)Elsamadicy et al. 2019	KID	Post. Spinal Fus.	236	2425	166	1094	3519	17.5%	1.66	[1.34; 2.05]
Martini et al. 2021	SC	El. SS	1449	5585	1563	4244	9829	19.2%	1.66	[1.53; 1.81]
(a)Elsamadicy et al. 2020	NIS	ACDF	8894	61710	18286	70052	131762	19.5%	2.10	[2.04; 2.16]
Dial et al. 2020	SC	ACDF	87	1063	168	739	1802	16.3%	3.30	[2.50; 4.36]
Total (95% CI)								**100.0%**	**1.82**	**[1.38; 2.40]**

Random Effects Model: I² = 93.0%, p <0.0001, k = 6

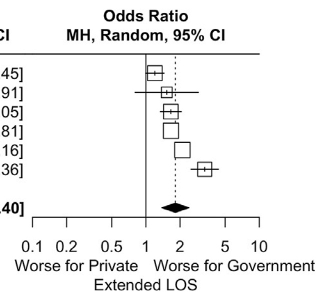

Fig. 6. Meta-analysis with a random effects model of all studies reporting extended LOS complications for government versus private insurance cohorts. OR = odds ratio. e(Gov) = number of adverse events in government-insured patients. n(Gov) = sample size of government-insured patients. e(Private) = number of adverse events in privately insured patients. n(Private) = sample size of privately insured patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Non-Medicare)	n(Non-Medicare)	e(Medicare)	n(Medicare)	n(Total)	Weight	OR
(b)Elsamadicy et al. 2019	KID	Post. Spinal Fus.	402	3512	0	7	3519	0.0%	0.00
Lubelski et al. 2020	SC	El. SS	28	153	18	104	257	6.6%	0.93
Martini et al. 2021	SC	El. SS	1782	6602	1230	3227	9829	26.3%	1.67
Rasouli et al. 2020	SC	ACDF	707	1921	228	452	2373	21.1%	1.75
(a)Elsamadicy et al. 2020	NIS	ACDF	11949	72555	15231	59207	131762	27.8%	1.76
Dial et al. 2020	SC	ACDF	113	1136	142	666	1802	18.1%	2.45
Total (95% CI)								**100.0%**	**1.76**

Random Effects Model: I² = 54.3%, p <0.0001, k = 6

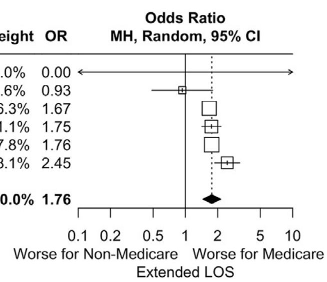

Fig. 7. Meta-analysis with a random effects model of all studies reporting extended LOS complications for Medicare versus non-Medicare cohorts. OR = odds ratio. e(Medicare) = number of adverse events in Medicare patients. n(Medicare) = sample size of Medicare patients. e(Non-Medicare) = number of adverse events in non-Medicare patients. n(Non-Medicare) = sample size of non-Medicare patients. n(Total) = total sample size in study. 95% CI = [1.45; 2.14].

Postoperative complications

Any complication

Four studies with 38,492 total patients were included in our meta-analysis for any complication (Fig. 8). Pooled analysis shows that patients with government insurance had greater odds of experiencing any complication compared with patients with private insurance (OR 1.61, p<.0001). As shown in Appendix B1.4 & B2.4, this difference persisted in sub-analyses of Medicaid (OR 1.44, p<.0001) and Medicare (OR 1.97, p=.0007) patients. Patients with Medicare were equally as likely to have

Study	Database	Surgery Type	e(Private)	n(Private)	e(Gov)	n(Gov)	n(Total)	Weight	OR	95% CI
Lad et al. 2013	TRMS	Lam./Fus.	2059	25000	288	2577	27577	32.2%	1.40	[1.23; 1.60]
Nuño et al. 2013	NIS	Spinal Fus.	459	4783	519	3839	8622	32.0%	1.47	[1.29; 1.68]
Chotai et al. 2015	SC	El. Lum. Surg.	50	539	58	367	906	13.2%	1.84	[1.23; 2.75]
Hacquebord et al. 2013	SC	El. SS	127	609	275	778	1387	22.7%	2.07	[1.62; 2.65]
Total (95% CI)								**100.0%**	**1.61**	**[1.35; 1.93]**

Random Effects Model: I² = 65.7%, p <0.0001, k = 4

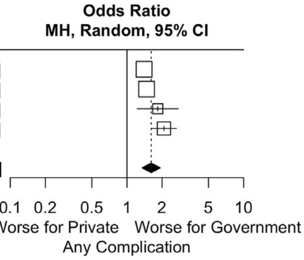

Fig. 8. Meta-analysis with a random effects model of all studies reporting any postoperative complications for government versus private insurance cohorts. OR = odds ratio. e(Gov) = number of adverse events in government-insured patients. n(Gov) = sample size of government-insured patients. e(Private) = number of adverse events in privately insured patients. n(Private) = sample size of privately insured patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Non-Medicare)	n(Non-Medicare)	e(Medicare)	n(Medicare)	n(Total)	Weight	OR	95% CI
Nuño et al. 2013	NIS	Spinal Fus.	555	5515	423	3107	8622	40.3%	1.41	[1.23; 1.61]
Chotai et al. 2015	SC	El. Lum. Surg.	65	634	43	272	906	25.3%	1.64	[1.09; 2.49]
Hacquebord et al. 2013	SC	El. SS	244	1020	158	367	1387	34.3%	2.40	[1.87; 3.09]
Total (95% CI)								**100.0%**	**1.76**	**[1.27; 2.43]**

Random Effects Model: I² = 85.2%, p = 0.0006, k = 3

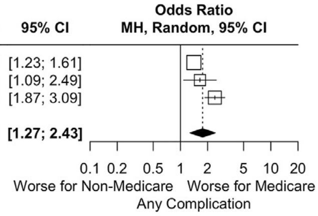

Fig. 9. Meta-analysis with a random effects model of all studies reporting any postoperative complications for Medicare versus non-Medicare cohorts. OR = odds ratio. e(Medicare) = number of adverse events in Medicare patients. n(Medicare) = sample size of Medicare patients. e(Non-Medicare) = number of adverse events in non-Medicare patients. n(Non-Medicare) = sample size of non-Medicare patients. n(Total) = total sample size in study.

Study	Database	Surgery Type	e(Private)	n(Private)	e(Gov)	n(Gov)	n(Total)	Weight	OR	95% CI
Rasouli et al. 2020	SC	ACDF	22	637	77	1736	2373	10.0%	1.30	[0.80; 2.10]
Memtsoudis et al. 2014	NC State	Lum. Spine Fus.	3913	44076	4871	39586	83662	20.1%	1.44	[1.38; 1.51]
Kim et al. 2022	SPARCS	El. SS	163	65574	100	23769	89343	15.9%	1.70	[1.32; 2.18]
Thirumala et al. 2017	NIS	ACDF/Spinal Fus.	6645	1068965	6529	518619	1587584	20.2%	2.04	[1.97; 2.11]
Gephart et al. 2012	NIS	Spinal Fus.	60	4607	84	2688	7295	13.6%	2.44	[1.75; 3.42]
Feng et al. 2018	SPARCS	Cer. Spine Fus.	21	15198	75	19763	34961	9.9%	2.75	[1.70; 4.47]
De la Garza-Ramos et al. 2016	NIS	AIS Fus.	35	29243	35	10349	39592	10.3%	2.83	[1.77; 4.53]
Total (95% CI)								**100.0%**	**1.93**	**[1.56; 2.39]**

Random Effects Model: I² = 96.2%, p <0.0001, k = 7

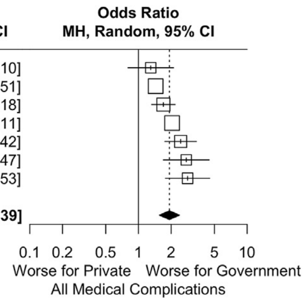

Fig. 10. Meta-analysis with a random effects model of all studies reporting all medical complications for government versus private insurance cohorts. OR = odds ratio. e(Gov) = number of adverse events in government-insured patients. n(Gov) = sample size of government-insured patients. e(Private) = number of adverse events in privately insured patients. n(Private) = sample size of privately insured patients. n(Total) = total sample size in study.

any complication postoperatively as Medicaid patients (Appendix B3.4) (OR 1.28, p=.2141), but were more likely to have any complication than non-Medicare patients in general (Fig. 9) (OR 1.59, p=.0001).

All medical complications

Seven studies with 1,844,810 total patients were included in our meta-analysis for all medical complications (Fig. 10). Pooled analysis demonstrated that government-insured patients had greater odds of having any medical complication than privately insured patients (OR 1.93, p<.0001). Subset-analyses showed a similar difference, where Medicaid (OR 2.24, p<.0001) and Medicare (OR 1.77, p<.0001) patients were more likely than privately insured patients to experience a medical complication (Appendix B1.5 & B2.5). Although the OR value for Medicaid patients was larger than that for Medicare patients, direct comparison showed that patients in both cohorts were equally as likely to have a medical complication (Appendix B3.5) (OR 0.78, p=.3098). Compared with non-Medicare patients, Medicare patients had significantly greater odds of experiencing a medical complication (Fig. 11) (OR 1.59, p=.0001).

Discussion

The primary aim of this study was to characterize the effects of insurance status on the likelihood of experiencing an adverse outcome following elective spine surgery. Pooled analysis showed that patients with government insurance were more likely to experience a 90-day re-admission, NRD, extended LOS, any complication, and any medical complication than those with private insurance. These findings persist in sub-analyses when comparing either Medicaid or Medicare patients to private insurance. Medicare patients were more likely than Medicaid patients to experience NRD, and were more likely than non-Medicare patients to experience all examined adverse perioperative events and postoperative complications.

Much of the current literature comparing outcomes in government and privately insured patients are consistent with our results. A pooled analysis found that Medicaid patients were more likely than private insurance to experience re-admission [20], similar to our findings. Individual studies also mirror our findings, reporting that Medicaid patients are more likely to experience any complication compared to private insurance [16,27]. Our results are echoed in studies comparing Medicare and privately insured patients, whereby Medicare patients are significantly more likely to experience 90-day re-admission [14,28], NRD [29], and extended LOS [13,30]. However, our pooled analysis clarifies discrepancies and contextualizes studies with discordant results. For example, Badin et al. [20] was unable to conclude the relationship between Medicaid status and NRD due to variability in included papers. However, our pooled analysis reports an increased likelihood of NRD among Medicaid patients versus private insurance, despite including studies that

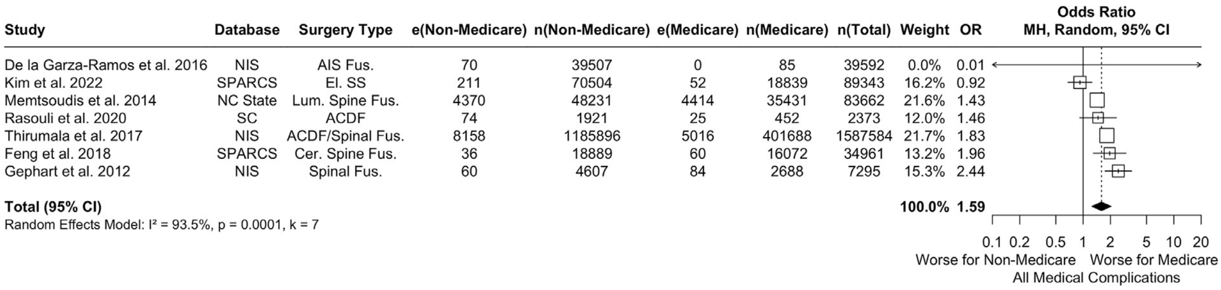

Fig. 11. Meta-analysis with a random effects model of all studies reporting all medical complications for Medicare versus non-Medicare cohorts. OR = odds ratio. e(Medicare) = number of adverse events in Medicare patients. n(Medicare) = sample size of Medicare patients. e(Non-Medicare) = number of adverse events in non-Medicare patients. n(Non-Medicare) = sample size of non-Medicare patients. n(Total) = total sample size in study. 95% CI = [1.25; 2.03].

found no significant difference in this relationship [13]. Additionally, Badin et al. [20] and Dial et al. [31] showed that Medicaid patients are at greater risk of a prolonged LOS compared with Medicare patients, while our results only trended towards a greater odds. Notably, Elsamadicy et al. [30] found that Medicare patients are significantly less likely than Medicaid patients to experience an extended LOS, which disagrees with the equivalency demonstrated by our pooled findings. Our study was unable to specific associations of other insurance types, such as Veterans Affairs, Managed Care, and Triwest, because of insufficient literature to perform sub-analyses. This deficit in the literature warrants future granular studies that include patient demographics with less represented types of government insurance.

While it is well-established in the current literature and in our results that government-insured patients are more likely to experience an adverse event than privately insured patients, the exact reason for this difference remains elusive. One explanation revolves around the concept of underinsurance [16], which is defined as insurance coverage that is inadequate to support healthcare costs [32]. Underinsurance is a prominent problem because it limits access to healthcare, particularly for individuals with low socioeconomic status, thereby creating disparities in financing care and predisposing to poor health outcomes [33]. Patients who are underinsured are found to be less healthy and at greater risk of increased disease severity, suboptimal surgical treatment, and mortality [34,35]. As a result, in the context of underinsurance, patients on government insurance may experience more adverse effects due to limited resources and access to care that contribute to health disparities [16,20].

Another potentially related reason for the difference between patients on government vs. non-government insurance is that patients on government insurance are more likely to experience complications due to their underlying co-morbidities. As patients on government insurance are more likely to exhibit pre-operative co-morbidities [13,36], they may be more likely to experience postoperative complications. The poorer health status of government-insured patients at baseline is likely due to limited access to resources and treatment over a lifetime of care [20,37], which stems from systemic socioeconomic differences that influence health outcomes [38,39]. Specifically for extended LOS, however, it has been proposed that the increased likelihood of an extended LOS among government insured patients is likely due to delays in insurance approval [31,40].

To our knowledge, this study is the first to compare Medicare and non-Medicare patients across a comprehensive set of postoperative outcomes. Medicare patients tend to be older than those with private or Medicaid insurance due to the age-eligibility criteria for the Medicare program [13,30]. Therefore, our comparison between Medicare and non-Medicare patients is functionally a comparison between older and younger patients. Our pooled analysis reported that for all examined outcomes, Medicare patients fared worse than non-Medicare patients. Li et al. [41] found that Medicare patients have increased likelihood of a venous thromboembolic event following spinal fusion surgery compared with non-Medicare patients, which is consistent with our finding that Medicare patients are more likely to experience a medical complication. Of note, the OR values for NRD were strikingly large in the Medicare vs. private and Medicare vs. non-Medicare comparisons (greater than 5). This suggests that Medicare patients are over 5 times more likely than privately insured or non-Medicare patients to get discharged to a non-home facility. This drastic increase in non-home discharge might be occurring to reduce extended LOS for Medicare patients [30], but we actually observed an increase in extended LOS in our data. This may be due to delays in Medicare insurance approval [31], or because elderly individuals are sicker than younger patients and require extended postoperative management [13].

Altogether, our results point to the unfortunate but likely possibility that Medicare patients are discriminated against in healthcare. Our results indicate that elderly patients on Medicare selectively compared with a younger group of patients not on Medicare are more likely to experience 90-day re-admission, NRD, extended LOS, any complication, and a medical complication–findings that extend in the fields of OBGYN [42], head and neck cancer [43], and orthopedics surgery [44]. This differential outcome could be explained by elderly patients generally experiencing more medical problems than younger individuals. However, Rogers et al. [45] demonstrated that elderly patients were more likely to self-report experiencing discrimination in healthcare, which was linked to developing a new or worsening disability. Such ageism is rooted in negative societal attitudes that are perpetuated by messaging in media [46], individual experiences with elderly, and even fear of death [47,48]. Such prejudice can result in healthcare professionals treating the elderly unequally or limiting access to health-care resources and shared decision making [49]. This can explain the significant increase in NRD among Medicare patients in our results, as elderly patients may not receive sufficient health resources to warrant a home discharge. Additionally, this unequal access to healthcare resources limits recovery potential [49], perhaps causing elderly patients to experience an extended LOS as we observe in our results.

Direct measures can improve the care for people on government insurance, especially elderly patients on Medicare. One approach to changing surgical care and combat discrimination is Enhanced Recovery After Surgery (ERAS). ERAS protocols are a multimodal, evidence-based perioperative care pathway that promotes recovery after surgery [50]. ERAS approaches are aimed at reducing postoperative complications and LOS, which we saw more prevalently in patients with government insurance, to ultimately reduce the cost of surgery [50]. In an urban patient population undergoing gynecologic surgery, Brown et al.[51] found that ERAS implementation was safe and effective in government-insured patients and was effective at reducing LOS, although it had no effect on re-admission rates. Pennington et al. performed a systematic review showing that ERAS significantly reduces LOS in adults following spine surgery, but does not address differences in postoperative complications or 30-day re-admissions [52]. ERAS may therefore be useful at reducing the differences in extended LOS seen government vs. privately insurance patients or Medicare vs. non-Medicare patients.

Limitations

This work has several limitations. Data collected in this study were from retrospective studies. Although we believe that the risk of bias was low to moderate according to our analysis using the Newcastle-Ottawa scale, retrospective data is inherently subject to confounding, allocation bias, and selection bias. For example, racial differences could be contributing to our results. It is well documented that African American patients are more likely to experience an adverse event following spine surgery, including outcomes that were examined in this study [24]. Since African Americans are more likely to be on government insurance than White patients [12,53], race could be a confounding variable that contributes to the increased likelihood of adverse outcomes that we found in government insured patients. We were unable to control for confounding variables in our statistical analysis because very few studies stratified results simultaneously by insurance and a confounding variable.

Another limitation of our study is the significant heterogeneity ($I^2 \geq 50\%$) seen in most of our meta-analyses. Much of the heterogeneity in our analyses stems from examining studies pertaining to elective spine surgery, which included all spine procedures–except those related to cancer or trauma–and all regions of the spine. Although additional sub-analyses are difficult due to the limited amount of literature reporting on insurance status and postoperative outcomes in spine surgery, future studies can reduce heterogeneity by performing sub-analyses by surgery type. Further, many included studies utilized the same database, analyzing overlapping patient populations. Several studies using high-volume registries reported on patients from the same database; for example, 14 studies used HCUP, 8 studies used NIS, and 5 studies used QOD. Although these studies had different selection criteria and study aims, the same patient may have been included more than once in the same analysis, falsely increasing homogeneity.

Finally, our pooled analysis contains values for all forms of government insurance that were reported in the included studies. However, only a few of the studies reported values for Veterans Affairs, Managed Care, and Triwest patients. Since these insurance types are underrepresented in our pooled analysis, our results may not be directly applicable to patients with these types of government insurance.

Funding

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Declarations of competing interests

None of the authors report any conflicts of interest relevant to this work.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2024.100315.

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