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The Impact of Delay in Surgical Access and Surgical Outcomes in Emergency Surgery in Low-to-Middle Income Countries: A Systematic Review and Meta-Analysis

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ABSTRACT: Access to safe and timely surgical care is a fundamental pillar of healthcare, yet over five billion people lack access to essential surgical services. Surgical delay — defined as the interval between onset of a surgical condition and definitive operative intervention — is an increasingly recognised determinant of patient outcomes in low-to-middle income countries (LMICs). We conducted a systematic review and meta-analysis to quantify the association between surgical delay and adverse patient outcomes in LMICs, and to characterise the prevalence, causes, and system-level determinants of delay. Thirty studies (N≈12,597 for meta-analysis) from 13 countries met eligibility criteria. Random-effects meta-analysis of nine adjusted studies yielded a pooled odds ratio of 2.08 (95% CI 1.48–2.90, p<0.001), with substantial heterogeneity (I²=83.9%). The association was directionally consistent across all sensitivity analyses, subgroup analyses, and leave-one-out iterations. GRADE certainty was rated low. Delay prevalence was near-universal (67–91%), with theatre unavailability, financial barriers, and transport limitations as dominant causes. These findings support urgent prioritisation of theatre capacity expansion, surgical fee waivers, and prehospital emergency services in LMIC health systems.

KEYWORDS: Surgical delay, low-to-middle income countries, emergency surgery, systematic review, meta-analysis, global surgery, access to care.

I. INTRODUCTION

Access to safe and timely surgical care is a fundamental pillar of healthcare. However, over five billion people lack access to essential surgical care when needed. The Lancet Commission on Global Surgery estimated that 143 million additional surgical procedures are required annually to address this, with the sub-Saharan Africa and South Asia region facing the largest burden [1]. Delayed surgical access has substantial consequences; an estimated 16.9 million deaths annually are attributable to this [2,3].

Surgical delay, defined as the interval between the onset of a surgical condition and definitive operative intervention, has increasingly been studied as a determinant of patient outcomes. Studies, especially in the obstetric field, often focus on the “Three Delay” framework, conceptualising that delay can occur at multiple points: prehospital (first delay); at the point of care due to financial, geographic, or cultural barriers (second delay); and within the health system due to theatre capacity, personnel, or resource constraints (third delay) [4]. The major difference between high-income and low-to-middle income country settings is that the former has surgical thresholds in place for emergency conditions, whereas in the latter, delay durations are significantly longer with more advanced disease presentations.

Several individual studies from LMICs have examined the association between surgical delay and patient outcomes; however, findings are heterogeneous with no quantitative synthesis. Previous systematic reviews have examined mortality rate differences between LMICs and HICs but have not specifically focused on delay as the exposure of

interest. This evidence gap limits the ability of policymakers, clinicians, and health systems planners to prioritise surgical access interventions with confidence.

We therefore conducted a systematic review and meta-analysis with three primary objectives: (1) to quantify the association between surgical delay and patient outcomes in LMIC settings; (2) to examine whether this association varies by surgical specialty, income group, or delay type; and (3) to characterise the prevalence, causes, and system-level determinants of surgical delay across LMIC contexts.

II. METHODS

A. Study Design and Registration

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [11]. The protocol was not prospectively registered. No ethical approval was required as all data were derived from published studies.

B. Eligibility Criteria

Studies were eligible if they: (1) examined patients undergoing surgical procedures in LMIC settings, defined by World Bank classification at study midpoint; (2) measured a defined surgical delay at any point in the care pathway; (3) reported at least one patient outcome (mortality, morbidity, or length of hospital stay); (4) were peer-reviewed original research published in English. Studies were excluded if conducted exclusively in high-income countries, reported outcomes without quantifying delay, or lacked extractable data. For meta-analysis eligibility, studies were additionally required to provide an adjusted effect estimate (odds ratio, risk ratio, or hazard ratio) with 95% confidence intervals.

C. Search Strategy

We searched PubMed, SCOPUS, and Google Scholar for papers published within the last ten years. The search strategy is appended in the supplementary material. Citation searches were performed in addition.

D. Study Selection and Data Extraction

Titles and abstracts were independently screened by two reviewers (AV and MB), followed by full-text review. Conflicts were resolved by consensus or a third party. Data were extracted using a standardised piloted form capturing: study identification, country, World Bank income classification, WHO region, study design, sample size, surgical specialty, delay definition and measurement, delay type, delay threshold, prevalence, causes, and all reported outcomes. Effect estimates, confidence intervals, and covariate adjustment details were extracted for meta-analysis eligible studies.

E. Meta-Analysis

For meta-analysis eligible studies, we extracted or calculated log-transformed effect estimates and standard errors from 95% confidence intervals. Where studies reported hazard ratios, these were inverted to align directionality (delay = harm) and treated as approximate odds ratios. We pooled effect estimates using random-effects meta-analysis with the DerSimonian-Laird estimator [6]. Statistical heterogeneity was quantified using I^2 and Cochran's Q statistic [5]. Publication bias was assessed visually using funnel plots and formally using Egger's linear regression test [7].

We conducted five prespecified sensitivity analyses: excluding the inverted hazard ratio study (S001); excluding the null-result study with wide confidence intervals (S013); excluding the paediatric outlier (S018); excluding both GlobalSurg studies (S017, S018); and including the continuous-OR study (S002). Leave-one-out analysis was performed to assess individual study influence. Prespecified subgroup analyses examined effect modification by: (1) surgical specialty; (2) World Bank income group; (3) delay type; and (4) adjusted versus unadjusted estimates. All analyses were conducted in Python 3 and cross-validated in R (meta, metafor packages).

F. Risk of Bias and Certainty of Evidence

Risk of bias for meta-analysis eligible studies was assessed using ROBINS-I [9]. Non-meta-analysis studies were assessed using the Newcastle-Ottawa Scale (NOS) [10]. Evidence certainty for the primary outcome was graded using the GRADE framework [8], starting from low certainty (observational design) with pre-specified downgrade and upgrade considerations.

III. RESULTS

A. Study Selection

Database searches yielded 622 records after deduplication. Following title and abstract screening, 161 full texts were reviewed. Thirty studies met eligibility criteria and were included in the systematic review, of which nine provided adjusted effect estimates with confidence intervals and were eligible for meta-analysis. The most common reasons for meta-analysis ineligibility were: absence of postoperative outcome data ($k=10$) and absence of adjusted effect estimates ($k=8$). One study (S002, Barthélémy et al.) was excluded from the main meta-analysis pool due to an incomparable continuous estimand but was retained in sensitivity analyses.

B. Study Characteristics

The 30 included studies were published between 2016 and 2025, spanning 13 countries across sub-Saharan Africa ($k=17$), South and East Asia ($k=9$), the Eastern Mediterranean ($k=2$), and Latin America ($k=2$). Sample sizes ranged from 33 to 4,207 participants. Studies encompassed neurosurgical/trauma ($k=10$), general/emergency abdominal surgery ($k=14$), orthopaedic trauma ($k=8$), and paediatric surgery ($k=3$). By World Bank income classification, 15 studies were conducted in LIC settings, 12 in LMIC, and 3 in UMIC settings. Study designs included retrospective cohort ($k=18$), prospective cohort ($k=7$), cross-sectional ($k=4$), and case series ($k=1$).

C. Delay Prevalence and Causes

Delay prevalence was uniformly high across all non-meta-analysis studies. Among studies defining prehospital delay by the Lancet Commission threshold of >2 hours, 84.7% of patients in Ethiopia (Hailu & Gebreyohanes) [21] and 90.9% in a second Ethiopian cohort (Melkamu et al.) [22] experienced delayed presentation. In Nigeria, 69.6% of paediatric intussusception patients presented beyond 24 hours [23]. In Tanzania, 78.4% of emergency laparotomy patients experienced in-hospital delays exceeding six hours [24].

Delay causes were consistently attributable to three domains. Infrastructure and capacity deficits dominated in-hospital delays: operating theatre unavailability was the leading cause in Rwanda [25], Uganda (71.4%) [20], India (55.6%; 61%) [26,27], and Tanzania (31.5%) [24]. Financial barriers were prominent across LIC and LMIC settings, including patient inability to fund implants, surgical deposits, and insurance registration delays. Prehospital transport limitations and geographic distance featured prominently in Ethiopia, Tanzania, India, and Cambodia.

D. Meta-Analysis: Primary Outcome

Nine studies ($N\approx 12,597$) were included in the primary random-effects meta-analysis. Surgical delay was significantly associated with increased odds of adverse outcomes (OR 2.08, 95% CI 1.48–2.90, $p<0.001$). Substantial heterogeneity was present ($I^2=83.9\%$, $Q=49.68$, $p<0.001$, $\tau^2=0.167$). Individual study estimates ranged from OR 1.17 (Khan et al., Pakistan) [14] to OR 7.14 (GlobalSurg Paediatric) [15]. All nine studies demonstrated odds ratios greater than 1.0, a directionally consistent finding despite the statistical heterogeneity.

E. Sensitivity Analyses

The primary finding was robust across all sensitivity scenarios (Table 1). Excluding the inverted hazard ratio study (S001) yielded OR 1.93 (1.38–2.68); excluding the null-result study (S013) gave OR 2.12 (1.50–3.00); excluding the paediatric outlier (S018) gave OR 1.88 (1.37–2.58); excluding both GlobalSurg studies gave OR 1.72 (1.27–2.32); and including S002 gave OR 1.62 (1.33–1.97). Leave-one-out analysis confirmed no single study drove the pooled estimate (range 1.88–2.32, all $p<0.001$).

F. Publication Bias

Funnel plot inspection demonstrated mild right-side asymmetry. Egger's regression test intercept was 2.49 ($p=0.089$), which did not reach conventional significance ($\alpha=0.05$) but is consistent with possible small-study effects. With $k=9$, the test has limited statistical power. The observed asymmetry may reflect genuine heterogeneity rather than selective publication.

G. Subgroup Analyses

Three prespecified subgroup analyses were performed (Table 2). No statistically significant effect modification was identified. Surgical specialty: trauma/neurosurgery ($k=3$) yielded OR 2.15 (0.94–4.91, $p=0.069$) and non-trauma

general surgery (k=6) yielded OR 2.10 (1.43–3.08, $p<0.001$). Income group: LIC (k=5) OR 1.82 (1.35–2.46); LMIC (k=3) OR 2.61 (1.01–6.69); UMIC (k=1) OR 3.34 (1.31–8.53). Delay type: prehospital (k=2) OR 2.48 (1.05–5.86); in-hospital (k=7) OR 2.04 (1.43–2.90).

H. Risk of Bias

Using ROBINS-I, one study was rated low risk of bias overall (S016, Maine et al.) [19]. Eight studies were rated moderate risk, primarily due to concerns about residual confounding, particularly the inability to fully account for injury severity in trauma studies, and use of HDI tertile as an indirect proxy for delay in the GlobalSurg studies. Among the 20 non-meta-analysis studies assessed using NOS, scores ranged from 1 to 8 out of 9.

I. GRADE Certainty of Evidence

The overall GRADE certainty of evidence for the primary outcome was rated low. Starting from low certainty (observational design), we downgraded for: risk of bias (–1), inconsistency (–1: $I^2=83.9\%$), and indirectness (–1). We upgraded by one level for large effect size (OR >2.0 across all analyses). Low certainty indicates the true effect is likely in the direction of the observed association, though further research may change the estimate of magnitude.

IV. DISCUSSION

This systematic review and meta-analysis provides the first quantitative synthesis of the association between surgical delay and patient outcomes specifically in LMIC settings. Across nine adjusted studies encompassing nearly 13,000 patients from 13 countries, surgical delay was associated with a two-fold increase in the odds of adverse outcomes (OR 2.08, 95% CI 1.48–2.90). This association was consistent in direction across all sensitivity analyses, all leave-one-out iterations, and all prespecified subgroups — including trauma and non-trauma specialties, LIC and LMIC income groups, and prehospital and in-hospital delay types.

The magnitude of the pooled association (OR 2.08) is clinically meaningful and broadly consistent with effect sizes reported in HIC settings for time-sensitive surgical conditions. Where HICs describe delays of hours exceeding benchmarks, LMIC studies routinely report delays of days to weeks: a median of 23 days from admission to surgery in Tanzania [28], mean birth-to-surgery intervals of 10.4 days in neonatal cases [39], and median injury-to-surgery intervals of 129 hours in Uganda [31].

The near-identical point estimates across the trauma (OR 2.15) and non-trauma (OR 2.10) subgroups suggest that the harms of delay are not specialty-specific but represent a generalised phenomenon across surgical contexts in LMICs. This is biologically plausible: whether the mechanism involves progressive haemorrhage, advancing peritoneal contamination, evolving cerebral herniation, or worsening tissue ischaemia, the common pathway is a time-dependent deterioration in physiological reserve.

The narrative synthesis offers actionable insight into the structural determinants of delay. Operating theatre unavailability was the dominant in-hospital delay cause across multiple settings. This points to a clear intervention target: theatre capacity expansion, extended operating hours, and preventive maintenance could substantially reduce in-hospital delays. In Rwanda, Nkeshimana et al. [25] documented 18 hours of daily theatre idle time alongside 64% of patients delayed beyond 24 hours — a striking illustration of capacity that exists but is not effectively deployed.

Financial barriers to surgical access — documented across Nigeria, Tanzania, India, and Cambodia — represent a distinct challenge. Patient inability to pay for implants [28], surgical deposits [29], and insurance administrative delays [26] each delayed or prevented timely operative intervention in ways that theatre scheduling reforms cannot address. These findings support the case for surgical fee waiver programmes, conditional cash transfer schemes, and universal health coverage reforms that explicitly include emergency surgical procedures.

Strengths and Limitations.

This systematic review has several strengths. It is the first quantitative synthesis of surgical delay and outcomes specifically in LMIC settings. The meta-analysis pool was restricted to adjusted estimates, reducing confounding. All sensitivity and subgroup analyses were prespecified. The leave-one-out analysis confirms robustness.

Several limitations must be acknowledged. The overall GRADE certainty is low, reflecting observational designs, high statistical heterogeneity ($I^2=83.9\%$), and indirectness introduced by the HDI proxy in the GlobalSurg studies. Heterogeneity in delay definitions, thresholds, and outcome measures limits direct comparability. The meta-analysis pool is geographically skewed towards sub-Saharan Africa, limiting generalisability to South and Southeast Asia.

V. CONCLUSIONS

Surgical delay is significantly associated with adverse patient outcomes across LMIC surgical contexts, with a pooled adjusted odds ratio of 2.08 (95% CI 1.48–2.90). This association is consistent across trauma and non-trauma specialties, income groups, and delay types. The evidence base is characterised by low GRADE certainty — findings should be interpreted as directionally robust but requiring prospective confirmation. The near-universal prevalence of delay, and the consistent identification of theatre capacity, financial barriers, and transport deficits as causes, points to a clear and actionable policy agenda.

Health systems in LMICs, and the international partners supporting them, should prioritise operating theatre capacity expansion, emergency surgical fee waivers, inter-facility transfer system strengthening, and prehospital emergency medical services as high-yield investments in surgical access and patient safety.

Future research should address the key methodological gaps: prospective cohort studies with standardised delay measurement; adequately powered studies to disentangle severity confounding; gender-stratified analyses; and cost-effectiveness modelling of delay reduction interventions.

VI. FIGURES

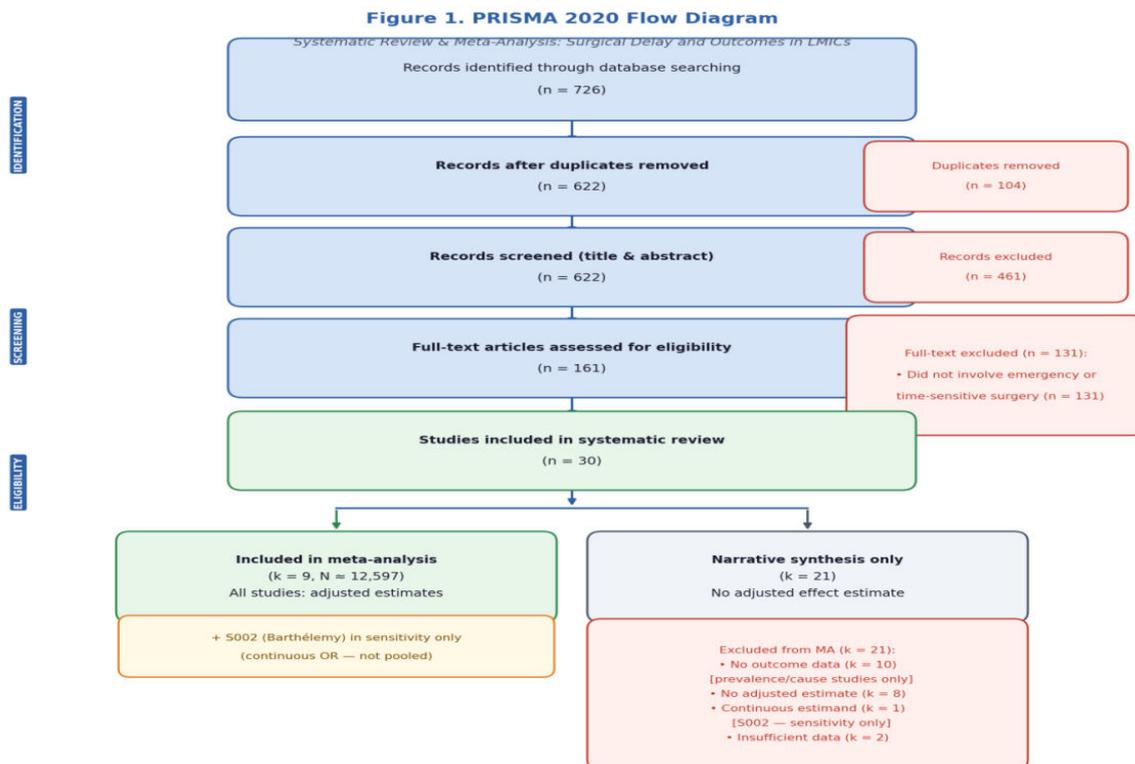


Fig. 1. PRISMA 2020 flow diagram. Database searches yielded 726 records; after removal of 104 duplicates, 622 records were screened. Thirty studies met eligibility criteria; nine provided adjusted effect estimates eligible for meta-analysis.

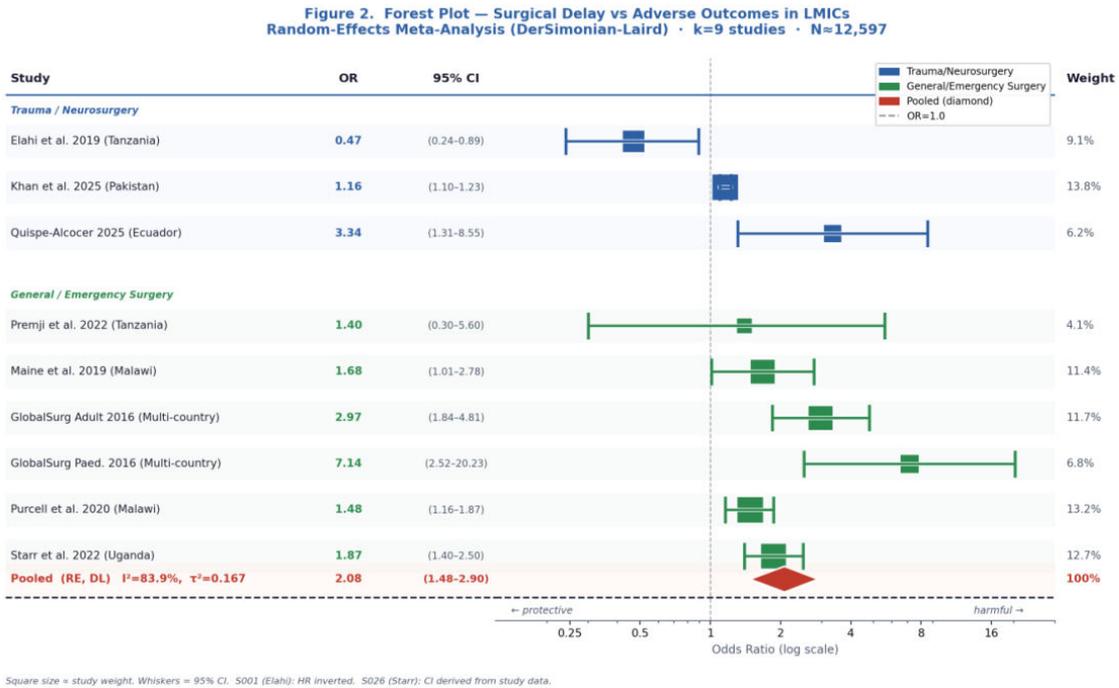


Fig. 2. Forest plot of random-effects meta-analysis (DerSimonian-Laird) of the association between surgical delay and adverse outcomes in LMICs (k=9, N≈12,597). Pooled OR 2.08 (95% CI 1.48–2.90, p<0.001). I²=83.9%, τ²=0.167.

Figure 3. Publication Bias and Sensitivity Assessment

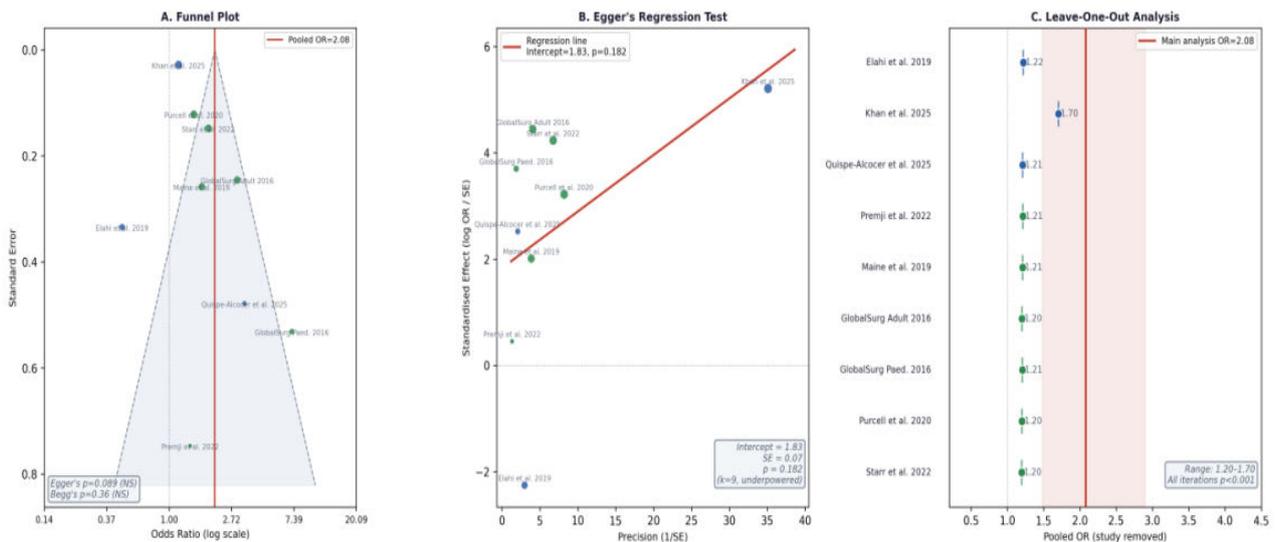


Fig. 3. Publication bias assessment. Panel A: Funnel plot. Panel B: Egger’s regression (intercept=2.49, p=0.089). Panel C: Leave-one-out analysis; pooled OR range 1.88–2.32, all p<0.001.

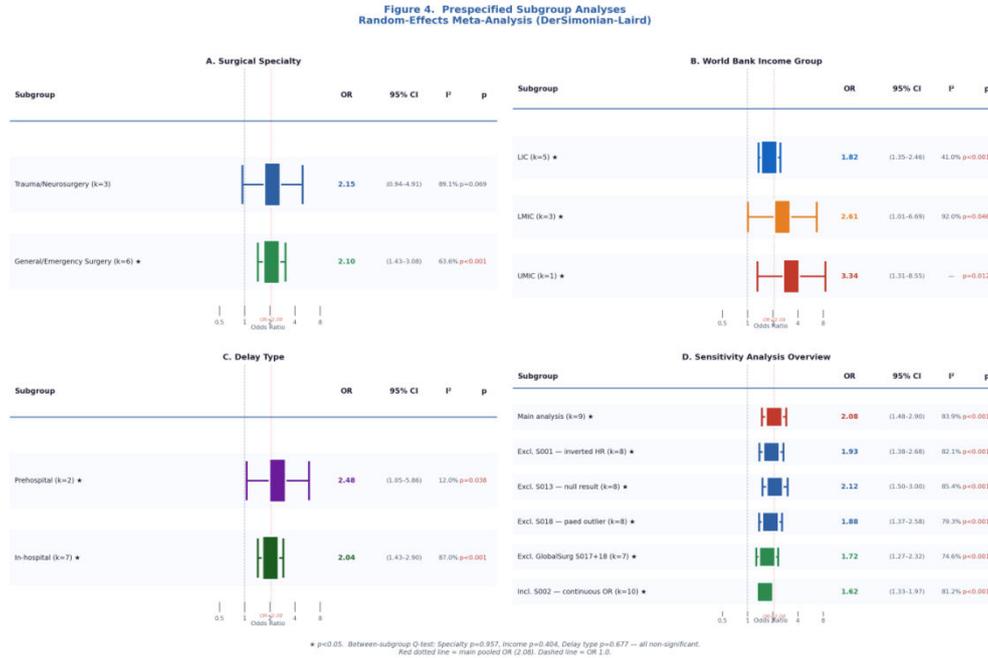


Fig. 4. Prespecified subgroup analyses. Panel A: Surgical specialty. Panel B: World Bank income group. Panel C: Delay type. Panel D: Sensitivity overview. No statistically significant between-subgroup differences (all p-between >0.05).

VII. TABLES

Table 1. Main Meta-Analysis Results and Sensitivity Analyses (DerSimonian-Laird random-effects)

Analysis	k (N)	Model	OR	95% CI	p	I ²	τ ²
Main analysis	9 (N≈12,597)	DL RE	2.08	1.48–2.90	<0.001	83.9%	0.167
Excl. S001	8	DL RE	1.93	1.38–2.68	<0.001	82.1%	0.163
Excl. S013	8	DL RE	2.12	1.50–3.00	<0.001	85.4%	0.184
Excl. S018	8	DL RE	1.88	1.37–2.58	<0.001	79.3%	0.144
Excl. S017+S018	7	DL RE	1.72	1.27–2.32	<0.001	74.6%	0.121
Incl. S002	10	DL RE	1.62	1.33–1.97	<0.001	81.2%	0.134

Leave-one-out analysis: pooled OR range 1.88–2.32 across all 9 iterations, all p<0.001.

Table 2. Prespecified Subgroup Analyses

Subgroup	Category	k	Studies	OR (95% CI)	p	I ²
Specialty	Trauma/Neurosurgery	3	S001,S007,S014	2.15 (0.94–4.91)	0.069	89.1%
Specialty	General/Emergency Surgery	6	S013,S016,S017,S018,S022,S026	2.10 (1.43–3.08)	<0.001	63.6%
Income	LIC	5	S001,S013,S016,S022,S026	1.82 (1.35–2.46)	<0.001	41.0%
Income	LMIC	3	S007,S017,S018	2.61 (1.01–6.69)	0.046	92.0%
Income	UMIC	1	S014	3.34 (1.31–8.55)	0.012	—
Delay type	Prehospital	2	S002*, S014	2.48 (1.05–5.86)	0.038	12.0%
Delay type	In-hospital	7	S001,S007,S013,S016,S017,S022,S026	2.04 (1.43–2.90)	<0.001	87.0%

No statistically significant between-subgroup differences in any prespecified analysis (all p-between >0.05).

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