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How common is ureteral stricture after laser ureteroscopy, and what drives it? A systematic review and meta-analysis

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Abstract

Purpose.

De novo ureteral stricture is a serious late complication of ureteroscopic laser lithotripsy, and reported rates vary widely because prior syntheses rarely confirm the laser. We aimed to determine the laser-confirmed incidence, compare holmium:YAG (Ho:YAG) with thulium fibre laser (TFL), and identify risk factors.

Methods.

Following PRISMA 2020, we searched four databases and restricted the primary analysis to laser-confirmed ureteral-stone cohorts. Proportions were pooled with a generalised linear mixed model, and exposures reported by two or more studies as odds ratios. Risk of bias used ROBINS-I and RoB 2, and certainty used GRADE.

Results.

Thirty-one studies were included. In the primary pool (11 studies, 3097 patients), pooled incidence was 2.97% (95% CI 1.82 to 4.82), similar when renal stones were included (3.03%) and after excluding the highest risk-of-bias study (2.61%). Ho:YAG (2.68%) and TFL (1.76%) did not differ ($p = 0.61$), though all TFL cohorts had three-month follow-up. Moderate-to-severe hydronephrosis was strongly associated with stricture (OR 7.86, 95% CI 3.84 to 16.10), and laser showed a trend toward more strictures than pneumatic lithotripsy (Peto OR 3.19, 95% CI 1.60 to 6.37). Endoscopic and reconstructive management succeeded in 60.87% and 95.20%.

Conclusion.

Ureteral stricture complicates 2.97% of ureteroscopic laser lithotripsy procedures for ureteral stones. Ho:YAG and TFL did not differ, and the higher risk with laser than pneumatic energy suggests laser dose, not medium, is the modifiable determinant. Moderate-to-severe hydronephrosis was a strong risk factor. Lower power and frequency with continuous irrigation are advised.

Introduction

Urolithiasis is among the most common urological conditions, affecting 1 to 20% of the population and rising over recent decades [1]. Ureteroscopy with intracorporeal laser lithotripsy is now first-line treatment for most ureteral stones, owing to high stone-free rates and safety [1]. The holmium:YAG (Ho:YAG) laser has long been the reference source, and the thulium fibre laser (TFL) more recently

entered practice [2]. Because laser energy is delivered directly against the ureteral wall, the ureter is vulnerable to injury, and as volume grows even an uncommon complication affects many patients.

De novo ureteral stricture is among the most serious late complications, since it may progress silently to obstruction, hydronephrosis, and loss of renal function [3]. Reported incidence after ureteroscopy varies widely, from under 1% in registry cohorts to 34.1% in a small impacted-stone series [4], with reviews citing an upper bound near 24% [5]. Strictures arise from mucosal and mural injury evolving into fibrosis, often months after an uncomplicated procedure, and because early strictures are asymptomatic, detection depends on imaging surveillance that varies between centres. Concern has grown because contemporary series report higher rates than older cohorts, alongside the shift to high-power lithotripsy.

Contemporary estimates converge near 3% [6, 7]. The most comprehensive synthesis pooled 43 studies of ureteroscopy, percutaneous nephrolithotomy, and shock wave lithotripsy, reporting a post-ureteroscopy rate of 1.9%, rising to 2.7% over the most recent five years [6]. It did not require laser confirmation, and its ureteroscopy pool mixed procedures with and without lithotripsy and different lithotripters, so no estimate confined to laser-treated ureteral stones is available. This gap matters, because recent data suggest risk may depend less on which laser is used than on how much energy is delivered [8, 9].

We conducted a systematic review and meta-analysis restricted to laser-confirmed cohorts to determine the incidence of ureteral stricture after ureteroscopic laser lithotripsy for ureteral stones. Secondary objectives were to compare Ho:YAG with TFL, relate laser settings to incidence, map stricture distribution, and summarise management success.

Materials and Methods

Protocol and registration

This review followed PRISMA 2020 [10] and PRISMA-S [11], with full strategies in Supplementary File 1. The protocol was registered with PROSPERO (CRD420261445119).

Eligibility criteria

Eligible studies enrolled adults undergoing ureteroscopic laser lithotripsy for urinary calculi and reported de novo ureteral stricture, defined as a new stricture absent before treatment. The exposure was intracorporeal laser lithotripsy of a confirmed type, Ho:YAG or TFL. Randomised and observational studies were eligible, and stone location was not a filter. Studies were excluded when the laser modality or its denominator could not be separated, when no stricture endpoint was reported, when adult and paediatric data could not be separated, when follow-up was insufficient, or when journal credibility could not be verified (Supplementary File 2).

Information sources and search

We searched PubMed, Wiley Online Library, Google Scholar, and the Cochrane Library with controlled vocabulary and free-text terms for ureteroscopy, urinary calculi, and ureteral stricture. The last search was on 5 July 2026, from database inception, with no language restriction.

Study selection and data extraction

Records were deduplicated and screened by title and abstract by two reviewers, and full texts assessed against the criteria. Two reviewers extracted eight predefined fields per study, including stricture incidence by laser type, location, settings, impaction, ureteroscope type, stone location, and irrigation. All values were verified against source full texts, disagreements resolved by consensus under senior supervision.

Risk of bias

Two reviewers assessed risk of bias using ROBINS-I for non-randomised studies [12] and RoB 2 for randomised trials [13]. A sensitivity analysis removing serious-rated studies from the primary pool was prespecified (Supplementary File 3).

Analytical structure

Five datasets were analysed separately, because definitions, denominators, and follow-up differed: a strict primary pool of laser-confirmed ureteral-stone cohorts, a broader pool adding renal and mixed cohorts, an exploratory Ho:YAG versus TFL pool, and endoscopic and reconstruction management strata. Location and settings were summarised descriptively. Exposures reported by two or more laser-confirmed studies with extractable two-by-two data were pooled as exploratory odds ratios.

Statistical analysis

Proportions were pooled with a generalised linear mixed model (random-effects logit link) [14], which retains zero-event studies, with exact Clopper-Pearson per-study intervals [15]. Heterogeneity used I-squared, tau-squared, and a 95% prediction interval, with a DerSimonian-Laird cross-check [16]. Laser-type subgroup difference used a chi-square test and small-study effects Peters' test [17]. Odds ratios were pooled by random-effects DerSimonian-Laird [16], with a 0.5 continuity correction for zero cells and the Peto odds ratio for rare events [18]. Analyses used R (RStudio) with the meta package, two-sided p below 0.05 significant. A large language model assisted only with language editing.

Certainty of evidence

Certainty was rated with GRADE [19]. As incidence is a frequency question studied by observational cohorts, it started high under the GRADE prognosis framework [20], downgraded for risk of bias, inconsistency, indirectness, imprecision, and publication bias as applicable (Supplementary File 4).

Results

Study selection

The search identified 693 records (PubMed 212, Wiley 143, Google Scholar 335, Cochrane 3). After 609 were removed before screening (320 duplicates), 84 were screened and 41 excluded. Of 43 full texts assessed, 12 were excluded, leaving 31 studies (Fig. 1).

Study characteristics

The 31 studies [8, 9, 21–49] were published between 2001 and 2026 and comprised 6 randomised trials and 25 observational studies. Ho:YAG predominated, with TFL in five cohorts. Follow-up ranged from 3 to 36 mo in incidence cohorts (Supplementary File 5).

Primary incidence of ureteral stricture

In the strict pool of laser-confirmed ureteral-stone cohorts (11 studies, 127 strictures among 3097 patients), pooled incidence was 2.97% (95% CI 1.82 to 4.82), with substantial heterogeneity (I-squared 78.8%) and a 95% prediction interval of 0.4 to 18.0% (Table 1). Adding renal stones gave 3.03% (13 studies), so the estimate is not sensitive to stone site.

Table 1
Incidence of de novo ureteral stricture after ureteroscopic laser lithotripsy

Study (Year)	Strictures, n	Patients, N	Incidence, % (95% CI)	Follow-up (mo)
Primary pool (ureteral-stone cohorts)				
Cheung (2001) [21]	1	134	0.75 (0.02 to 4.09)	8.9
Parker (2004) [22]	2	109	1.83 (0.22 to 6.47)	≥ 6
Jiang (2007) [23]	5	692	0.72 (0.24 to 1.68)	6
Binbay (2011) [25]	0	40	0.00 (0.00 to 8.81)	16
Li L (2015) [27]	24	493	4.87 (3.14 to 7.16)	12
Hu (2017) [29]	4	158	2.53 (0.69 to 6.35)	30 (med)
Shen (2021) [33]	29	447	6.49 (4.39 to 9.18)	36 (med)
Para (2023) [8]	4	240	1.67 (0.46 to 4.21)	3
He (2024) [39]	6	106	5.66 (2.11 to 11.91)	12
Li P (2024) [41]	28	427	6.56 (4.40 to 9.34)	12
Li G (2026) [46]	24	251	9.56 (6.22 to 13.89)	NR
Pooled incidence	**127**	**3097**	**2.97 (1.82 to 4.82); I^2 = 78.8%**	
Secondary pool (adds renal stones)				
Aykanat (2022) [34]	5	320	1.56 (0.51 to 3.61)	12
Villani (2025) [9]	10	158	6.33 (3.08 to 11.33)	3
Pooled incidence	**142**	**3575**	**3.03 (1.92 to 4.76); I^2 = 78.2%**	

mo, months; n, number of events; N, denominator; CI, confidence interval; NR, not reported. All pooled p < 0.001.

Comparative analyses

Four exposures were pooled as odds ratios (Table 2). Preoperative moderate-to-severe hydronephrosis was strongly associated with stricture versus mild hydronephrosis (OR 7.86, 95% CI 3.84 to 16.10, I-squared 0%). Laser carried numerically more strictures than pneumatic lithotripsy (OR 2.57, 95% CI 0.66 to 10.01, and Peto OR 3.19, 95% CI 1.60 to 6.37), driven by Li L et al. (4.9% versus 1.0%). Proximal stones showed a non-significant tendency to higher odds than distal (OR 2.03, 95% CI 0.56 to 7.36). Reconstruction exceeded endoscopic success (OR 9.30, 95% CI 2.44 to 35.49), confounded by indication and exploratory.

Table 2
Comparative meta-analyses

Study (Year)	Exposed, n/N	Comparator, n/N	OR (95% CI)
Energy source: laser versus pneumatic			
Binbay (2011) [25]	0/40	1/40	0.33 (0.01 to 8.22)
Li L (2015) [27]	24/493	5/489	4.95 (1.87 to 13.09)
Mohapatra (2026) [47]	2/97	1/81	1.68 (0.15 to 18.92)
Pooled	**26/630**	**7/610**	**2.57 (0.66 to 10.01); p = 0.17, I^2 = 32%**
Preoperative hydronephrosis: moderate-to-severe versus mild			
Shen (2021) [33]	22/120	8/349	9.57 (4.13 to 22.16)
Al-Nabulsi (2021) [32]	7/103	3/194	4.64 (1.17 to 18.35)
Pooled	**29/223**	**11/543**	**7.86 (3.84 to 16.10); p < 0.001, I^2 = 0%**
Stone location: proximal versus distal			
Al-Nabulsi (2021) [32]	5/124	2/127	2.63 (0.50 to 13.80)
Fam (2015) [26]	2/21	2/28	1.37 (0.18 to 10.60)
Pooled	**7/145**	**4/155**	**2.03 (0.56 to 7.36); p = 0.28, I^2 = 0%**
Management success: reconstruction versus endoscopic			
Srougi (2015) [28]	9/11	4/8	4.50 (0.57 to 35.52)
Xiong (2020) [31]	36/37	42/69	23.14 (2.99 to 178.88)
Li X (2022) [35]	39/40	2/2	5.27 (0.17 to 165.32)
Pooled	**84/88**	**48/79**	**9.30 (2.44 to 35.49); p < 0.001, I^2 = 0%**

n, events; N, group total; OR, odds ratio; CI, confidence interval.

Incidence by laser type

In the widened pool, incidence was 2.68% (95% CI 1.77 to 4.05) for Ho:YAG (18 studies) and 1.76% (95% CI 0.35 to 8.34) for TFL (4 studies), with no significant subgroup difference (chi-square 0.25, p = 0.61). The TFL estimate rested on four studies, two with no events, all with three-month follow-up, indicating no demonstrable difference rather than superiority of either (Supplementary File 8).

Laser settings

Across primary-pool cohorts reporting settings, pulse energy ranged from 0.4 to 2.0 J and frequency from 5 to 25 Hz, with no consistent relationship to incidence, though higher-incidence cohorts tended toward higher frequency (Supplementary File 6). The highest incidence, 9.56% in Li G et al., arose in the cohort combining the highest frequency (25 Hz), 20 W power, long-pulse mode, and the only gravity-fed irrigation, the highest thermal exposure in the pool, though that cohort was enriched for severe disease with fuller ascertainment. Within one study, Villani et al. reported a nine-fold higher rate with high-power presets than conservative presets (9 of 79 versus 1 of 79).

Treatment outcomes

Success differed markedly by modality and was not pooled across strata. Endoscopic management achieved 60.87% (95% CI 50.6 to 70.3, 4 studies) and reconstruction 95.20% (95% CI 89.7 to 97.8, 7 studies) (Supplementary File 9). Modality is selected by stricture length, so the strata were not compared directly.

Stricture location

Among 8 studies with a usable segmental breakdown (61 strictures), the distribution was proximal 41.27%, mid 26.76%, and distal 32.79%, indicating proximal predominance (exploratory, Supplementary File 7).

Risk of bias

Overall risk of bias was moderate for most studies. Of 6 randomised trials, two were low and four raised some concerns, and of 25 non-randomised studies, 21 were moderate and 4 serious. Excluding the single serious-rated study in the primary pool (Li G 2026) changed incidence only marginally, from 2.97% to 2.61% (95% CI 1.5 to 4.6) (Supplementary File 3).

Publication bias and certainty of evidence

Peters' test showed no small-study effects for the primary outcome ($p = 0.64$). Certainty was moderate for the primary incidence, low for Ho:YAG versus TFL, and moderate for both management estimates (Supplementary File 4).

Discussion

Isolating the laser-attributable rate

Reported stricture rates after ureteroscopy span 0.2 to 24%, too wide to guide practice [6], largely from mixed modalities, inconsistent ascertainment, and variable follow-up. The most comprehensive prior synthesis did not require laser confirmation, and its holmium subgroup of 1.6% rested on the few cohorts that identified it [6]. By restricting inclusion to laser-confirmed cohorts and the primary pool to ureteral-stone populations, we isolated the laser-attributable rate. Our 2.97% exceeds it, so modality-mixing and low-ascertainment registries dilute rather than inflate the true rate.

Laser medium versus laser dose

The field is divided over whether TFL is more injurious than Ho:YAG. We found no difference (2.68% versus 1.76%, p = 0.61), but this is not equivalence: every TFL cohort had only 3-mo follow-up, four studies, two with no events, and the first randomised comparison favoured Ho:YAG (4.62% versus 1.67%) [8]. The more useful distinction is dose. Within TFL, conservative presets produced a nine-fold lower stricture rate than high-power presets without loss of stone clearance [9], and the only randomised trial of laser dose found strictures in 3 of 75 high-power versus 1 of 73 low-power cases [49]. TFL may appear more injurious not through its wavelength but because it runs at higher power and frequency, at manufacturer defaults that lack consensus [50]. Pneumatic lithotripsy, which adds almost no heat, carried lower stricture risk despite similar stone clearance (Peto OR 3.19, Table 2), consistent with the only dedicated meta-analysis (OR 3.38, 95% CI 1.56 to 7.31) [51].

This raises a question the incidence figure cannot answer: why the ureter, not the kidney, carries the risk. The renal collecting system is a large, well-irrigated space in which heat disperses, whereas the ureter is a narrow channel that holds the fibre close to the wall and clears heat poorly. Thermal dose in an impacted-stone model rose with power and activation time and fell steeply with irrigation, from 309.80 to 11.11 CEM43 minutes as flow rose from 10 to 20 mL/min at 40 W [52]. An impacted stone, which obstructs flow, may act less as a separate risk factor than as an amplifier of thermal dose, reframing impaction as thermal rather than mechanical.

A practical recommendation on safe laser settings

If dose drives injury, it can be modified. In vitro, ureteral temperature passes the 43 degree Celsius injury threshold within seconds at 10 W or higher, rising with power, frequency, continuous firing, and reduced irrigation [53, 54, 55]. In practice this means keeping power low, firing in short bursts, and never letting irrigation stop [54, 56]. Our cohorts agree: the lowest-incidence used conservative settings with pump irrigation, the highest ran at 20 W with frequencies up to 25 Hz (Supplementary File 6). A reasonable starting point is pulse energy 0.8 to 1.0 J, frequency 10 Hz or below, power 12 W or below, and pump irrigation.

Risk factors for stricture

Preoperative hydronephrosis was the strongest signal. Moderate-to-severe hydronephrosis showed the strongest association with stricture (Table 2), agreeing with Moretto et al. and now shown within laser-confirmed cohorts [6]. It likely marks a more impacted, inflamed, or long-standing stone, so the wall is damaged before lithotripsy. Proximal stones showed a non-significant tendency toward higher odds than distal (Table 2), and strictures clustered proximally (41.27%, Supplementary File 7), where impaction is commoner and the wall thinner. Villani et al. found only 40% of strictures at the original stone site, suggesting heat spreads beyond it [9].

Management outcomes

The two management figures are not directly comparable, because treatment choice depends on stricture length, so reconstruction's higher success partly reflects the easier, shorter strictures it receives. Endoscopy is reasonable for short strictures but fails often enough, at 39%, that longer ones are better repaired by reconstruction (60.87% versus 95.20%, Supplementary File 9), the definitive option once a stricture has formed.

Strengths and limitations

The review's strengths are clear: every cohort was laser-confirmed, all data checked against source papers, and each outcome kept in its own dataset. Its limitations reflect the evidence: most studies were retrospective, strictures often found only once symptomatic, follow-up frequently short, and heterogeneity high. The comparative analyses rest on few studies, the management comparison is confounded by indication, and the Ho:YAG versus TFL comparison carries low certainty. What is needed now is prospective study, with imaging-confirmed strictures, a standard definition, full reporting of settings and irrigation, and follow-up of at least 12 mo, extending to 18 mo after intraoperative complications or a large proximal stone [57, 58].

Conclusion

Across laser-confirmed cohorts, ureteral stricture complicates 2.97% of ureteroscopic laser lithotripsy procedures for ureteral stones, a central estimate rather than a precise risk given how rates varied with follow-up intensity. Moderate-to-severe hydronephrosis was the strongest risk factor. We could not separate Ho:YAG from TFL, but the wider evidence points to the energy delivered rather than the laser itself, so keeping power and frequency low with continuous irrigation is a sensible precaution until trials test this directly. Prospective studies that image every patient and report laser settings in full are now the priority.

Declarations

Competing interests.

The authors declare no competing interests.

Ethics approval.

Not applicable. This systematic review and meta-analysis of previously published data did not involve new studies of human or animal subjects.

Consent to participate

and for publication. Not applicable.

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Author Contribution

A.A.S. and S.K.L. designed the study, ran the searches, selected studies, extracted data, and assessed risk of bias. A.A.S. did the statistical analysis and wrote the first draft. I.W. supervised the work and revised the manuscript. All authors approved the final version.

Data Availability

All data analysed in this review were extracted from the included published studies and are available within the article and its Supplementary Files.

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Figures

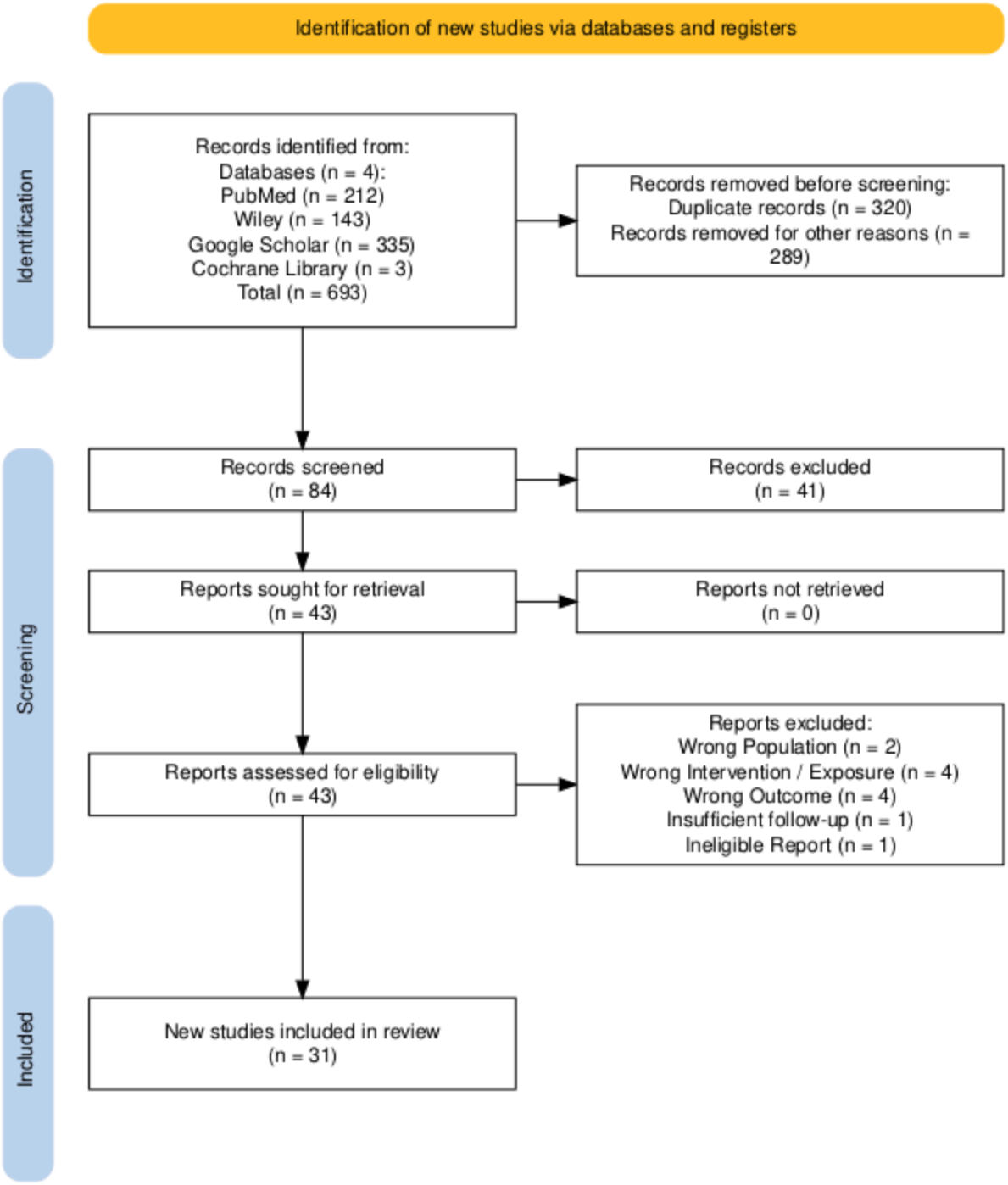


Figure 1

PRISMA 2020 flow diagram of study identification, screening, and inclusion

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