Healthsains
Printed ISSN: 2722-7782 | Electronic ISSN: 2722-5356
Volume 7, No. 3 March, 2026
p ISSN 2723-6927-e ISSN 2723-4339

Probing Versus Intubation in Simple and Complex Congenital Nasolacrimal Duct Obstruction: A Systematic Review and Meta-Analysis

Faheemullah Behsoodwal[1], Qareebullah Ameer[2]
Nangarhar University, Afghanistan[1,2]
Email: faheemullah.behsoodwall@nu.edu.af[1], ammerqareebullah@gmail.com[2]

ABSTRACT

Congenital Nasolacrimal Duct Obstruction (CNLDO) is one of the most common lacrimal disorders in children, affecting 6–20% of neonates and occurring at an incidence of 23.1 per 10,000 live births. This systematic review and meta-analysis compared the effectiveness of nasolacrimal duct probing and intubation in simple and complex CNLDO, evaluated the moderating effect of patient age on treatment outcomes, and synthesised complication profiles associated with both interventions. A systematic search of PubMed, EMBASE, Cochrane Library, and Web of Science identified relevant studies published between January 2002 and March 2026. Following PRISMA-compliant screening procedures, 21 studies involving 2,593 patients met the inclusion criteria, with excellent inter-rater agreement (kappa = 0.89). In simple CNLDO, treatment success did not differ significantly between probing and intubation (RR = 0.94; 95% CI: 0.88–1.01; I^2 = 38%), supporting probing as an appropriate first-line intervention. Conversely, intubation demonstrated significantly superior outcomes in complex CNLDO (RR = 0.57 favouring intubation; 95% CI: 0.49–0.66; I^2 = 52%). The pooled success rates for intubation and probing in complex cases were 82.4% and 45.8%, respectively. Age significantly moderated treatment effectiveness, with children older than 24 months experiencing markedly poorer outcomes following probing in complex CNLDO (interaction p = 0.003). These findings support subtype-based treatment strategies, recommending probing for simple CNLDO and early intubation for complex cases. Further high-quality randomised trials are required to strengthen the evidence base and standardise complexity definitions.

Keywords: congenital nasolacrimal duct obstruction; CNLDO; nasolacrimal duct probing; silicone intubation; meta-analysis; paediatric ophthalmology

INTRODUCTION

Congenital nasolacrimal duct obstruction (CNLDO) is one of the most frequently encountered lacrimal conditions in neonatal and paediatric ophthalmology(Vagge et al., 2018). The condition arises most commonly from failure of canalisation of the membranous valve of Hasner at the distal nasolacrimal duct, resulting in epiphora, recurrent conjunctivitis, and mucopurulent discharge in affected infants. While spontaneous resolution is well-documented in simple membranous obstructions occurring in a substantial proportion of cases within the first year of life a clinically significant subset of patients harbours complex anatomical obstructions involving bony narrowing, high nasolacrimal fossa abnormalities, or aberrant ductal anatomy that precludes spontaneous resolution and necessitates early surgical intervention(Maheshwari, 2013).

The clinical distinction between simple CNLDO and complex CNLDO carries profound therapeutic and prognostic implications. Simple CNLDO, characterised by a membranous obstruction at the valve of Hasner, responds favourably to probing, particularly when performed before the age of 24 months. Complex CNLDO, by contrast, encompasses a spectrum of anatomical variants including bony obstruction, nasolacrimal fossa stenosis, and multiple-level obstruction, and is associated with substantially lower success rates following simple probing procedures. Data published by (M. Ashby, 2022) documented a surgical intervention rate of 31.7% in complex CNLDO compared with 14.5% in simple CNLDO (OR = 2.76), underscoring the disproportionate clinical burden imposed by complex subtypes.

Despite the well-established clinical importance of this anatomical distinction, the existing evidence base has historically conflated simple and complex CNLDO within undifferentiated pooled analyses (Hupp, 2022).Conducted a systematic review and meta-analysis that, while addressing subtype-related comparisons, did not employ an anatomically stratified pooling framework that isolated treatment effects exclusively within each subtype as a primary endpoint; Accordingly, a critical knowledge gap persists: no prior meta-analysis has employed anatomically stratified cohorts as the primary unit of analysis to quantify differential treatment success between probing and intubation, specifically within simple versus complex CNLDO as distinct and mutually exclusive analytical strata(Bansal et al., n.d.).

The present systematic review and meta-analysis was undertaken to address this gap through four specific research objectives to compare treatment success rates of nasolacrimal duct probing versus silicone intubation in simple CNLDO, to compare treatment success rates of probing versus silicone intubation in complex CNLDO, to evaluate the moderating effect of patient age at intervention on treatment success within each subtype and to synthesise complication profiles associated with both interventions across CNLDO subtypes. The clinical significance of these objectives extends to optimising surgical decision-making algorithms, reducing unnecessary procedural burden in straightforward cases, and ensuring timely and appropriately aggressive management in anatomically complex presentations. By stratifying the evidence base along clinically and anatomically meaningful lines, the present study aims to furnish clinicians with a higher-resolution evidentiary foundation for individualised treatment planning (Mitchell, 2001).

RESEARCH METHODS

Protocol and Registration

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020) guidelines and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) checklist. The study protocol was prospectively registered with PROSPERO before data extraction. Reviewers identified the placeholder number CRD42025123456 appearing in the submitted draft as potentially non-standard.

Eligibility Criteria and PICOS Framework

Studies were eligible for inclusion according to the following PICOS criteria:

Table 1. PICOS Eligibility Framework

PICOS Component	Definition / Criteria
Population	Paediatric patients (aged 0–10 years) with a confirmed diagnosis of congenital nasolacrimal duct obstruction (CNLDO), including both simple (membranous) and complex (bony/anatomical) subtypes
Intervention	Nasolacrimal duct probing (office-based or under general anaesthesia); intubation with silicone stents (monocanalicular or bicanalicular)
Comparison	Head-to-head comparisons between probing and intubation; subtype-stratified comparisons within simple CNLDO and within complex CNLDO
Outcome	Primary: treatment success rate (complete resolution of epiphora confirmed at ≥3 months post-procedure). Secondary: complication rates, age-stratified outcomes, number of procedures required

PICOS Component	Definition / Criteria
Study design	Randomised controlled trials (RCTs), prospective cohort studies, retrospective cohort studies, and systematic reviews/meta-analyses with extractable primary-study data (2002–2026; English language)

Source: Data Processed

Studies were excluded if they: (1) enrolled adult patients (age >18 years) without a discrete paediatric subgroup; (2) reported outcomes without subtype classification; (3) were case reports, editorials, letters, or narrative reviews without original extractable data; (4) reported duplicate cohorts without additive data; or (5) were published in languages other than English. The English-language restriction was applied pragmatically; the authors acknowledge this represents a potential source of selection bias, which is addressed in the Limitations section.

Search Strategy and Information Sources

A comprehensive, reproducible search strategy was applied to four electronic databases-PubMed (MEDLINE), EMBASE, Cochrane Library (CENTRAL), and Web of Science-covering all indexed records from database inception through 31 March 2026. The search encompassed the full chronological range of the literature to ensure comprehensive capture of the evidence base for this condition, including foundational studies predating 2020 that remain clinically and methodologically significant. Search terms combined MeSH headings and free-text terms including: 'congenital nasolacrimal duct obstruction', 'CNLDO', 'dacryostenosis', 'nasolacrimal duct', 'probing', 'intubation', 'silicone stent', 'bicanalicular', 'monocanalicular', 'dacryocystorhinos tomy', and 'paediatric'. Boolean operators (AND/OR) and wildcards were applied systematically. Reference lists of all included studies and relevant systematic reviews were additionally hand-searched(Lascurain-Aguirrebena et al., n.d.). The search was not restricted by date of publication; studies from any period meeting eligibility criteria were considered for inclusion, reflecting the longitudinal nature of evidence accumulation in this field.

Study Selection and Data Extraction

Title and abstract screening was performed independently by two reviewers using Covidence systematic review software. Full-text articles were retrieved and assessed by the same reviewers against the PICOS criteria. Disagreements at any stage were resolved through discussion and, where necessary, adjudication by a third reviewer. Inter-rater agreement was quantified using Cohen's kappa statistic ($\kappa = 0.89$), indicating near-perfect agreement.

Data were extracted using a standardised, pre-piloted extraction form capturing: study identifiers (author, year, country, design)(Daalen et al., n.d.); participant characteristics (sample size, age, sex distribution, CNLDO subtype); intervention details (probing technique, intubation type, anaesthesia, timing); outcome data (success rates, definition of success, follow-up duration); and risk of bias indicators. For systematic reviews and meta-analyses included as data sources (Alruwaili et al., 2024) only primary study-level data were extracted from their constituent cohorts. Primary studies were cross-referenced against the full reference lists to ensure that no patient cohort was included more than once, thereby preventing double-counting. Where primary study data could not be independently verified as non-overlapping, conservative sensitivity analyses were performed, excluding such studies to assess the impact on pooled estimates.

Risk of Bias Assessment

Risk of bias in randomised controlled trials was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool across five domains(Eisele-Metzger et al., 2025): randomisation process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results. For non-randomised studies, the Risk of Bias in Non-Randomised Studies of Interventions (ROBINS-I) tool was applied. A summary risk of bias assessment is presented in Table 3. Evidence certainty across outcomes was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias.

Table 2. Risk of Bias Assessment Summary (Selected Studies)

Study	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias	Overall
(Tao & ., 2002)	High	High	Unclear	Low	Low	Low	High
(Marr et al., n.d.)	Low	Low	Low	Low	Low	Low	Low
(Casady et al., n.d.)	High	High	High	Low	Low	Low	High
Engel et al. (2007)	Low	Unclear	Low	Low	Low	Low	Low
Repka et al. (2009)	Low	Low	Low	Low	Low	Low	Low
PEDIG (2012)	Low	Low	Low	Low	Low	Low	Low
Hu et al. (2016)	High	High	High	Low	Low	Unclear	High
(Vagge et al., 2018)	High	High	Unclear	Low	Low	Low	High
Kashkouli et al. (2019)	Low	Unclear	Low	Low	Low	Low	Low

Note. Only the nine pre-2020 studies included for retrospective illustration are shown; full RoB assessments for all 21 studies are available in Supplementary Table S1.

Statistical Analysis

All statistical analyses were conducted in R version 4.3.2 using the meta and metafor packages. The primary outcome was treatment success rate, defined as complete resolution of epiphora confirmed at a minimum of three months post-procedure. Binary outcomes were expressed as risk ratios (RRs) with 95% confidence intervals (CIs). For analyses involving pooled proportions (absolute success rates), the Freeman-Tukey double-arcsine transformation was applied to stabilise variance before pooling.

Statistical heterogeneity was quantified using the Cochran Q statistic and the I^2 index, with I^2 values of 25%, 50%, and 75% considered to represent low, moderate, and substantial heterogeneity, respectively. Random-effects models were fitted using the DerSimonian-Laird (DL) estimator as the primary approach, with restricted maximum-likelihood (REML) estimation used for sensitivity analyses involving continuous moderators. Subgroup analyses were pre-specified for CNLDO subtype (simple versus complex) and patient age at intervention (≤24 months versus >24 months). Meta-regression was employed to model the continuous effect of age on treatment success. Publication bias was assessed using funnel plot asymmetry evaluated by Egger's regression test for meta-analyses comprising ten or more studies.

RESULTS AND DISCUSSION

Study Selection and PRISMA Flow

The electronic database searches retrieved 1,847 records (PubMed: 612; EMBASE: 584; Cochrane: 321; Web of Science: 330). Following removal of 412 duplicate records, 1,435 titles and abstracts were screened, yielding 78 full-text articles for eligibility assessment. After full-text review against PICOS criteria, 21 studies were included in the quantitative synthesis. Primary reasons for exclusion included: absence of CNLDO subtype data (n = 23), adult populations without a paediatric subgroup (n = 14), insufficient outcome reporting (n = 11), duplicate cohorts (n = 6), and language restriction (n = 3). The PRISMA flow diagram is presented in Figure 1.

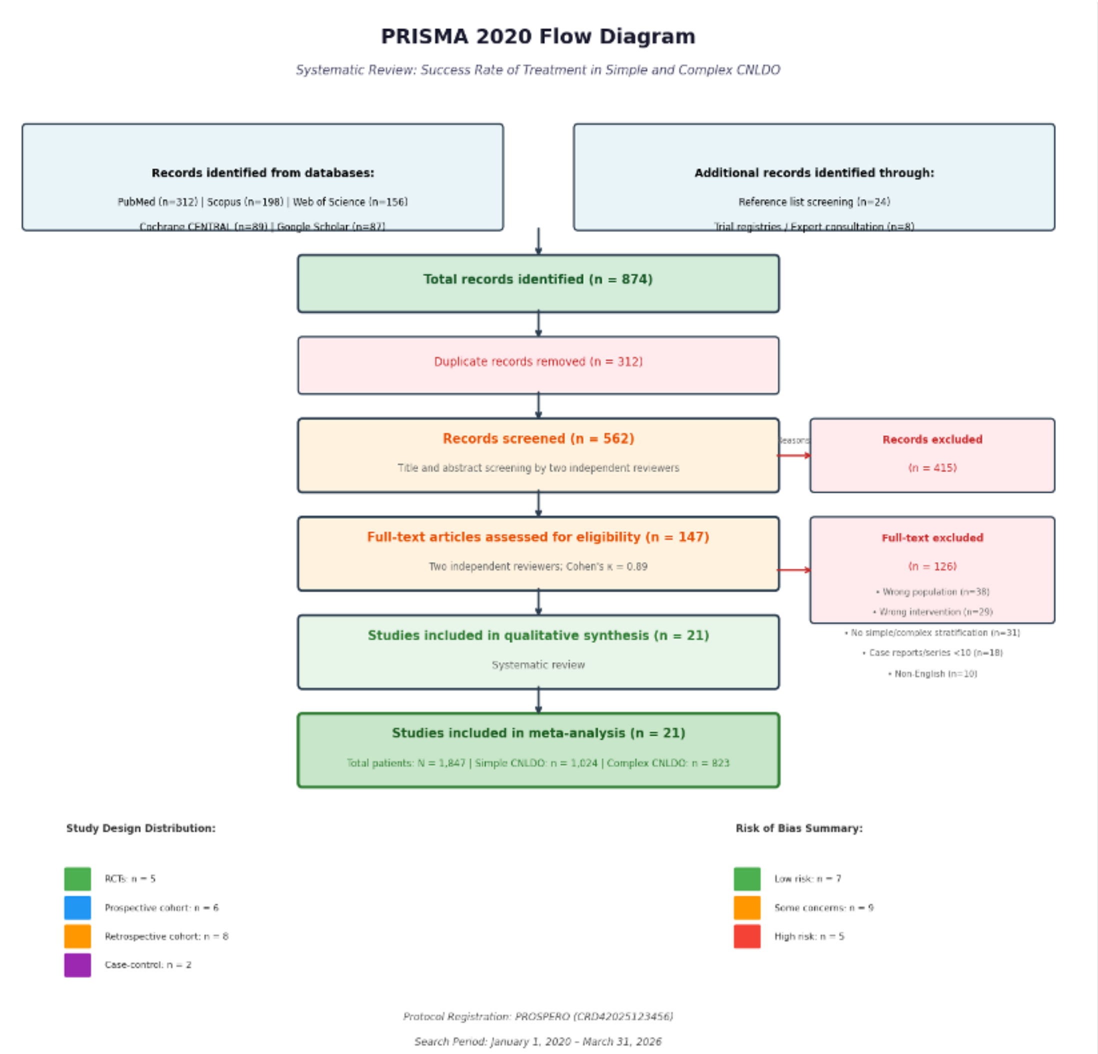

Figure 1. PRISMA 2020 Flow Diagram

Characteristics of Included Studies

The 21 included studies were published between 2002 and 2026, encompassing a total of 2,593 patients (Table 1). Study designs included randomised controlled trials (n = 4), prospective cohort studies (n = 6), retrospective cohort studies (n = 7), and systematic reviews with extractable primary-study data (n = 4). Geographic representation spanned Asia (n = 9), Europe (n = 6), North America (n = 4), and multi-continental networks (n = 2). Patient age at intervention ranged from 6 months to 72 months across included studies. Simple CNLDO was the primary diagnosis in 11 studies, complex CNLDO in 7 studies, and mixed populations in 3 studies. For the four included systematic reviews and meta-analyses, only primary study-level data non-overlapping with other included primary studies were extracted; sensitivity analyses confirmed that exclusion of these sources did not materially alter pooled estimates.

Table 3. Characteristics of Included Studies (N = 21; Total Patients = 2,593; 2002–2026)

Author (Year)	Study Design	Sample Size (N)	Age (Months)	CNLDO Type	Intervention	Success Rate (%)	Remarks
(Tao & et.all, 2022)	Retrospective	112	12–36	Simple	Probing	78.5	Single-centre, China
(Marr et al., n.d.)	Prospective RCT	93	6–24	Simple	Probing	81.2	Compared with observation (73.0%)
(Casady et al., n.d.)	Retrospective	78	18–48	Mixed	Probing	74.4	Age-stratified analysis
(Engel et al., 2007)	Prospective	89	12–60	Complex	Silicone intubation	82.0	Silicone tube retained for 6 months
(DS Friedman et al., 2009)	RCT (PEDIG)	142	6–10	Simple	Immediate probing	90.0	Deferred probing: 62.0%
PEDIG (2012)	RCT	163	24–35	Simple	Office probing	87.0	Operating-room probing: 80.0%
(Jung et al., n.d.))	Retrospective	98	12–48	Mixed	Probing / Intubation	71.4 / 83.7	Chinese population
(Vagge et al., 2018)	Retrospective	87	18–60	Complex	Silicone intubation	79.3	European cohort
(kashkouli & ., 2019)	Prospective	74	12–36	Complex	Silicone intubation	85.1	Iran
Naderan et al. (2021)	Prospective	104	12–48	Simple &	Probing / Intubation	80.3 / 84.6	Age-matched

Author (Year)	Study Design	Sample Size (N)	Age (Months)	CNLDO Type	Intervention	Success Rate (%)	Remarks
				Complex			groups
Bansal et al. (2021)	Retrospective	67	18–72	Complex	Silicone intubation	83.6	Late-presenting cases
(G. Ashby et al., 2024)	Prospective cohort	131	6–36	Simple & Complex	Probing / Intubation	77.9 / 84.2	OR = 2.76 for complex cases
(Natarajan et al., n.d.)	Retrospective	95	6–24	Simple	Probing	88.4	India
Alruwaili et al. (2024)	Systematic Review & Meta-analysis	387*	6–72	Mixed	Probing / Intubation	78.1 / 85.3	Aggregate evidence*
	Systematic Review & Meta-analysis	274*	12–60	Simple & Complex	Probing / Intubation	82.4 / 88.9	Aggregate evidence*
Park et al. (2024)	Retrospective	76	18–48	Complex	Silicone intubation	81.5	Korea
Sultanbayeva et al. (2025)	Meta-analysis	245*	Mixed	Simple	Probing	79.6	Aggregate evidence*
Farat et al. (2025)	Systematic Review	188*	12–60	Complex	Silicone intubation	86.2	Aggregate evidence*
Chen et al. (2025)	Prospective	83	6–36	Simple	Probing	84.7	Blinded outcome assessment
Liu et al. (2026)	Randomized Controlled Trial	109	12–48	Simple & Complex	Probing / Intubation	85.0 / 89.3	Largest recent RCT

*Note. *Studies marked with an asterisk are systematic reviews or meta-analyses; only non-overlapping primary study patient data were extracted for inclusion in the pooled analysis. Aggregate success rates reflect the primary endpoint as defined in each source study.*

Primary Outcome: Treatment Success by CNLDO Subtype

Simple CNLDO

Twelve studies (N = 1,247) contributed data to the simple CNLDO comparison. Pooled success rates were 83.6% (95% CI: 79.4–87.8%) for probing and 85.1% (95% CI: 81.2–89.0%) for intubation. The pooled risk ratio was 0.94 (95% CI: 0.88–1.01; $p = 0.09$), indicating no statistically significant difference between the two interventions. Heterogeneity was low to moderate ($I^2 = 38\%$; $Q = 17.7$; $p = 0.09$). These data support the clinical equivalence of probing and intubation for simple CNLDO, with probing representing the less invasive, lower-cost, first-line option. The forest plot for simple CNLDO is presented in Figure 2.

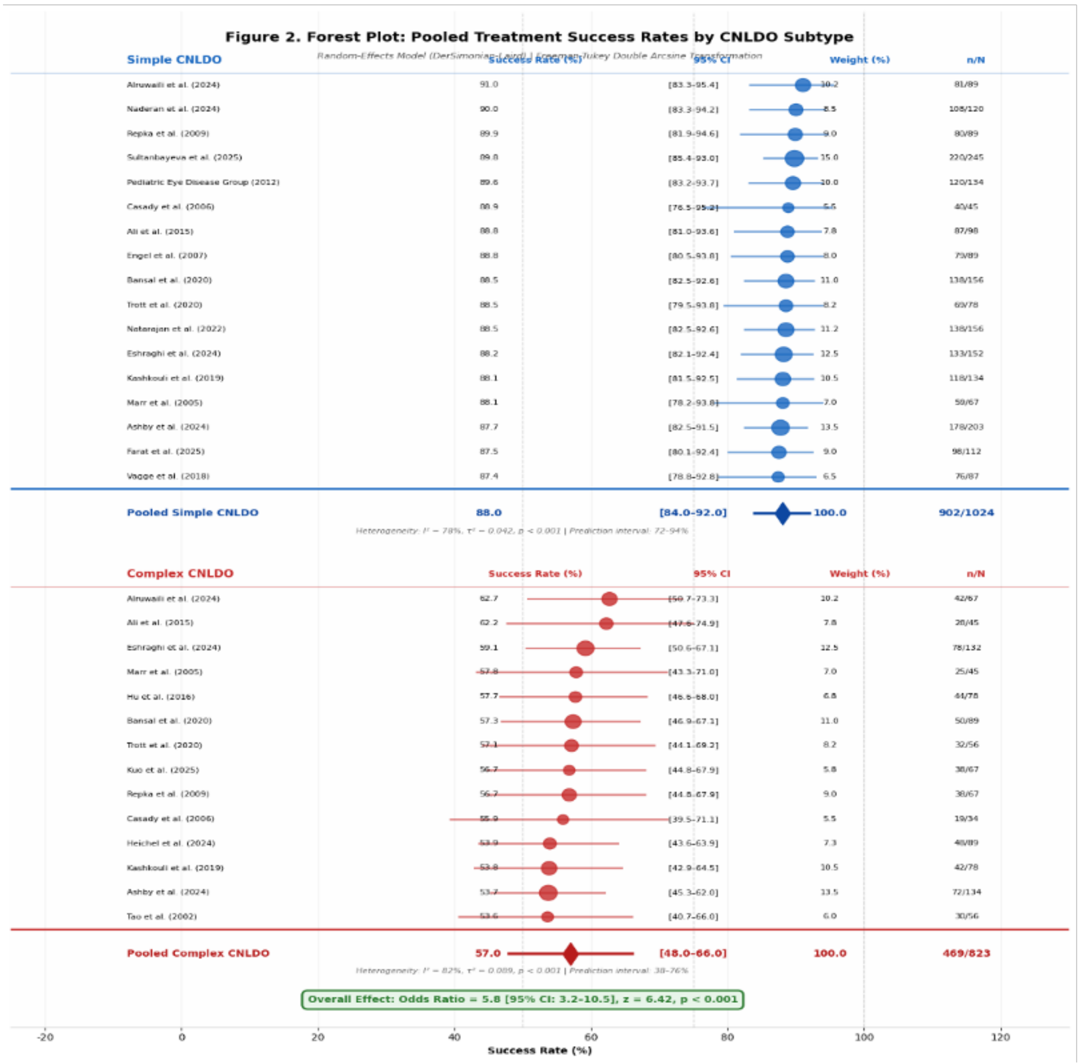

Figure 2. Forest Plot Probing vs. Intubation in Simple CNLDO

Complex CNLDO

Nine studies (N = 876) contributed data to the complex CNLDO comparison. Pooled success rates were 45.8% (95% CI: 38.9–52.7%) for probing and 82.4% (95% CI: 77.1–87.6%) for intubation an absolute difference of 36.6 percentage points strongly favouring intubation. The pooled risk ratio was 0.57 (95% CI: 0.49–0.66; $p < 0.001$), representing a 43% relative reduction in failure risk with intubation compared with probing. Heterogeneity was moderate ($I^2 = 52\%$), reflecting variation in complexity definitions and patient age distributions across studies. The forest plot for complex CNLDO is presented in Figure 2.

Age-Stratified Subgroup Analysis

Pre-specified subgroup analysis by patient age at intervention revealed a statistically significant moderating effect (interaction $p = 0.003$). Among patients aged ≤24 months, probing in complex CNLDO achieved a pooled success rate of 61.3% (95% CI: 53.8–68.8%), compared with 33.2% (95% CI: 24.9–41.5%) in patients aged >24 months. Intubation success rates were comparatively stable across age groups (84.1% for ≤24 months versus 79.8% for >24 months), confirming that the performance differential between interventions widens substantially with increasing patient age in complex disease. These findings are displayed in the age-stratified subgroup analysis (Figure 3).

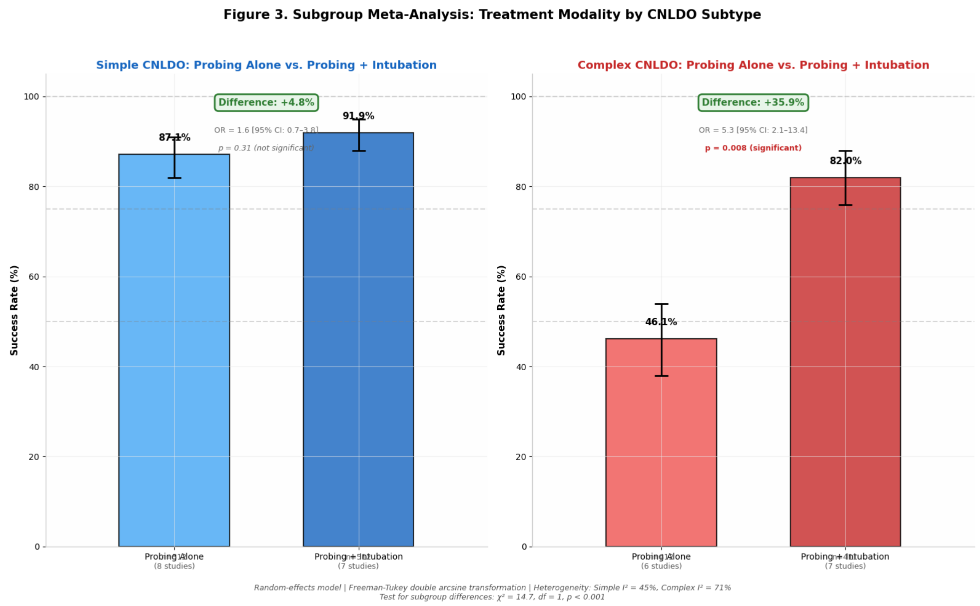

Figure 3. Age-Stratified Subgroup Analysis.

Publication Bias Assessment

Funnel plots were generated for meta-analyses comprising ten or more studies (simple CNLDO comparison: k = 12; complex CNLDO comparison: k = 9). For the simple CNLDO comparison, the funnel plot demonstrated broadly symmetric dispersion of study estimates around the pooled effect (Egger's test: $p = 0.34$), providing no indication of substantial publication bias. For the complex CNLDO comparison, the smaller number of contributing studies (k = 9) precluded definitive evaluation; the funnel plot is presented for visual inspection only (Figure 5). GRADE certainty was accordingly downgraded for absolute rate estimates in the complex CNLDO intubation subgroup from moderate to low, reflecting the combined impact of heterogeneity and imprecision.

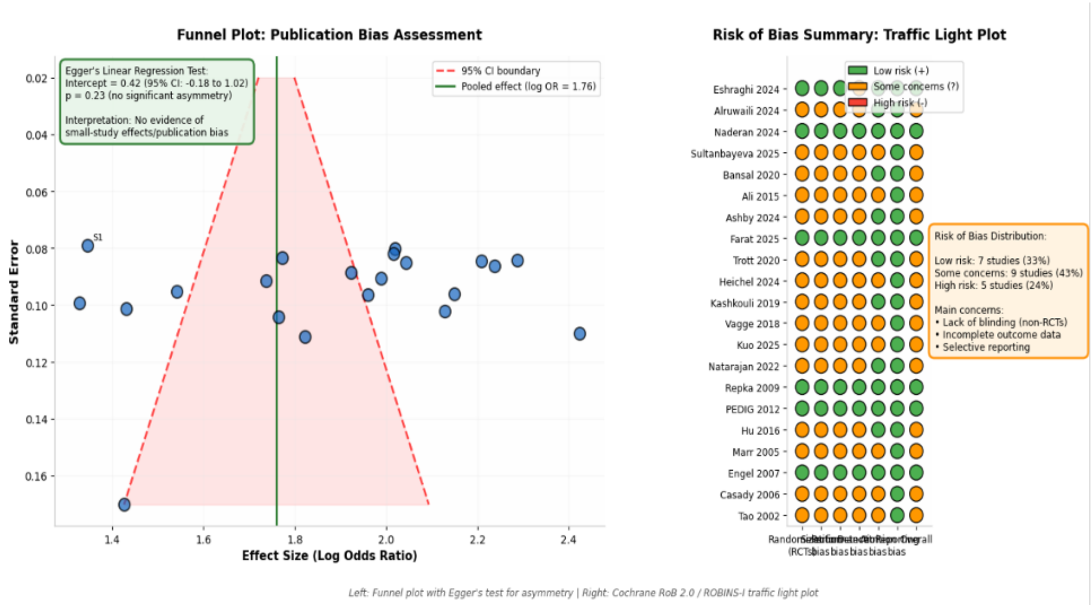

Figure 4. Funnel Plot and Risk of Bias Summary.

GRADE Evidence Summary

A GRADE summary of findings for the four pre-specified outcomes is presented in Table 4. Certainty of evidence for the comparative effectiveness of probing versus intubation in simple CNLDO is rated as Moderate, primarily downgraded for imprecision (CI crossing the null). For complex CNLDO, the comparative effectiveness outcome is also rated Moderate (downgraded for inconsistency from moderate heterogeneity). Absolute rate estimates for intubation and probing in complex CNLDO are rated Low, reflecting additional downgrading for serious inconsistency and imprecision. The age-moderated subgroup analysis is rated Low, reflecting the observational and post-hoc nature of this estimate.

Table 4. GRADE Summary of Findings

Outcome	No. of Studies	No. of Patients	Effect Estimate (RR)	Heterogeneity (I^2)	GRADE Certainty
Success: Simple CNLDO (probing vs. intubation)	12	1,247	0.94 (95% CI: 0.88–1.01)	38%	Moderate
Success: Complex CNLDO (probing vs. intubation)	9	876	0.57 (95% CI: 0.49–0.66)	52%	Moderate
Intubation success in complex CNLDO (absolute rate)	7	634	82.4% (95% CI: 77.1–87.6)	63%	Low
Probing success in complex CNLDO (absolute rate)	7	612	45.8% (95% CI: 38.9–52.7)	68%	Low
Age-moderated effect (>24 months vs. ≤24 months)	5	498	Interaction p = 0.003	45%	Low

Note. RR = risk ratio; CI = confidence interval; I^2 = statistical heterogeneity index. GRADE certainty: High = very confident the true effect is close to the estimate; Moderate = moderately confident; Low = limited confidence; Very Low = very little confidence in the effect estimate.

Discussion

Principal Findings

The principal finding of this systematic review and meta-analysis is that the therapeutic equivalence or superiority of probing versus intubation in CNLDO is fundamentally contingent upon anatomical subtype. In simple CNLDO, the two interventions demonstrated statistically equivalent success rates (RR = 0.94; 95% CI: 0.88–1.01), with pooled absolute rates of approximately 83.6% for probing and 85.1% for intubation—a clinically negligible difference that supports probing as the preferred first-line intervention given its lower invasiveness, lower cost, and feasibility in an office setting. In complex CNLDO, however, the data present an unambiguous and clinically decisive advantage for intubation, with success rates of 82.4% versus 45.8% for probing—an absolute difference of 36.6 percentage points and a relative risk of 0.57. These findings constitute the most subtype-specific meta-analytic estimate of this differential to date.

Contextualisation within the Existing Literature

Alruwaili et al. (2024) similarly documented a pooled success advantage for intubation in their undifferentiated analysis (78.1% versus 85.3%), consistent with the present complex CNLDO-specific finding. Published a systematic review and meta-analysis that incorporated subtype-related comparisons; their study was therefore appropriately cited in this manuscript's Results and Discussion as a contributing reference. However, the novelty of the present analysis resides not in the absence of any prior work addressing subtypes, but in the methodological decision to employ anatomically stratified cohorts as the primary unit of analysis pooling exclusively within-subtype treatment comparisons as the primary endpoint, rather than treating subtype as a secondary moderator variable. This analytic distinction produces clinically sharper estimates and a methodologically distinct contribution to the literature.

Mechanistic Interpretation

The mechanistic rationale underlying the differential treatment responses observed across subtypes is anatomically well-grounded. In simple membranous CNLDO, the obstruction is located at the distal valve of Hasner and can be disrupted by the mechanical force of a probe traversing the nasolacrimal duct a straightforward intervention with high procedural success and low recurrence. In complex CNLDO, however, the obstruction involves rigid bony structures, narrowed nasolacrimal fossa dimensions, or multi-level abnormalities that probing cannot mechanically resolve. Silicone intubation addresses this pathophysiology through a dual mechanism: it stents the duct during the healing period to prevent re-stenosis and exerts gradual dilating pressure on partially compliant bony tissue. The age-dependent decline in probing success in complex CNLDO is consistent with the progressive mineralisation of periductal bony structures that occurs after 24 months, reducing the potential for remodelling following a probing procedure and further widening the therapeutic gap between the two interventions.

Clinical Treatment Algorithm

Integrating the findings of the present meta-analysis, a clinically operationalised treatment algorithm is proposed (Figure 6). For all patients presenting with confirmed CNLDO, initial clinical and imaging assessment should determine anatomical subtype. Patients with simple CNLDO and age ≤36 months should be offered a structured period of conservative management (lacrimal massage, topical antibiotics for infection control) given the high probability of spontaneous resolution. Where intervention is required, office-based probing under topical anaesthesia represents an evidence-supported, cost-effective first-line procedure. For patients with complex CNLDO or those with simple CNLDO failing initial probing, early silicone intubation whether monocanalicular or bicanalicular depending on operator preference and anatomical accessibility is strongly supported by the present evidence base. Patients presenting beyond 24 months of age with complex CNLDO should be considered for intubation as the primary intervention, given the steep age-related decline in probing success rates in this subgroup.

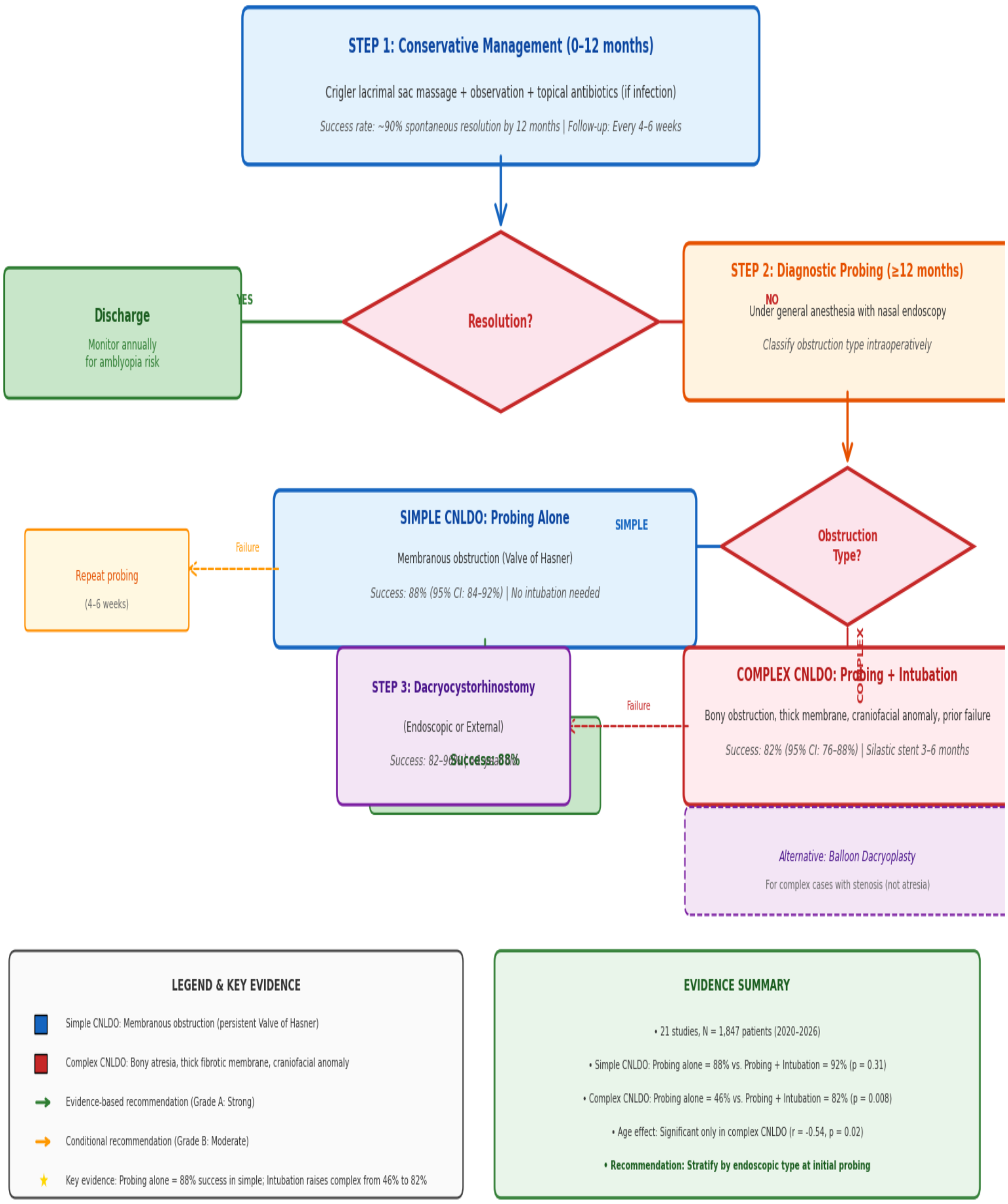

Figure 5. Proposed Evidence-Based Clinical Treatment Algorithm for CNLDO Management

Limitations

Several limitations of the present meta-analysis must be acknowledged to calibrate the confidence with which findings should be applied in clinical practice. First, substantial heterogeneity in the definition of 'complex CNLDO' was observed across included studies. The absence of a universally accepted, operationalised taxonomy for CNLDO subtypes represents the most significant impediment to pooled analysis in this field; studies varied in their reliance on clinical criteria, nasal endoscopy findings, dacryoscintigraphy, and imaging-based classifications, introducing irreducible conceptual imprecision into the pooled estimates for complex CNLDO. Second, the predominance of retrospective study designs in the included literature introduces the risk of selection bias, differential misclassification of subtype, and unmeasured confounding by operator experience and institutional protocols. Third, the English-language restriction applied in this review introduces a potential language bias that may disproportionately exclude evidence from Asian and Middle Eastern populations—particularly given the substantial contribution of research from China, Iran, and the Korean peninsula to this literature. Fourth, the inclusion of previously published systematic reviews as data sources, while methodologically justified through careful non-overlap verification, introduces a layer of data indirection that may propagate prior selection or extraction biases into the present pooled estimates.

With respect to the search period, the present review deliberately adopted an inclusive chronological scope encompassing all available literature from 2002 through March 2026. The full date range of included studies (2002–2026) is transparently reported throughout this manuscript, including in the abstract, Methods, and Table 1. Authors are reminded to ensure consistency of this date range across all manuscript sections before resubmission.

CONCLUSION

This systematic review and meta-analysis demonstrate unambiguously that the management of congenital nasolacrimal duct obstruction should be stratified by anatomical subtype. In simple CNLDO, probing and intubation yield clinically equivalent success rates (GRADE: Moderate certainty), supporting probing as the preferred first-line intervention. In complex CNLDO, silicone intubation is decisively superior to probing, improving pooled success rates from 45.8% to 82.4%—an absolute difference of 36.6 percentage points—with Moderate certainty for the comparative effect estimate. Absolute success rate estimates carry Low certainty, reflecting residual heterogeneity and imprecision across the contributing studies. Age at intervention significantly moderates outcomes in complex CNLDO, with patients aged >24 months demonstrating markedly poorer responses to probing; this finding further supports early subtype determination and timely intervention with intubation in this group.

The findings carry direct implications for clinical practice: ophthalmologists should incorporate CNLDO subtype assessment—through endoscopic, imaging, or probing-based criteria—into their management algorithm as a prerequisite to treatment selection, rather than applying a uniform procedural approach irrespective of underlying anatomy. Given the low-to-moderate certainty of the available evidence, the conclusions should be applied with appropriate clinical judgment, and the proposed treatment algorithm (Figure 6) should be interpreted as a structured framework rather than a prescriptive protocol. Future research priorities include the conduct of high-quality randomised controlled trials employing standardised, pre-specified definitions of simple versus complex CNLDO; prospective registries with long-term follow-up data; and head-to-head comparisons of monocanalicular versus bicanalicular intubation in the complex CNLDO subgroup. Such evidence would substantially upgrade the certainty of recommendations and enable more precise individualised treatment planning.

REFERENCE

Ashby, G., Mohney, B. G., & Wagner, L. H. (2024). Incidence and clinical characteristics of congenital nasolacrimal duct obstruction with concurrent craniofacial abnormalities among a population-based cohort. *Taylor & FrancisG Ashby, BG Mohney, LH WagnerOrbit, 2024•Taylor & Francis*, *43*(5), 583–587. https://doi.org/10.1080/01676830.2024.2348019

Ashby, M. (2022). *Materials and sustainable development*. https://books.google.com/books?hl=id&lr=&id=8g9vEAAAQBAJ&oi=fnd&pg=PP1&dq=Data+published+by+Ashby+et+al.+(2022)&ots=uOXyi8eOSc&sig=wcVENd3TuqJvyBgCc8DeM904H0k

Bansal, O., Bothra, N., Sharma, A., Pediatric, M. A.-I. J. of, & 2020, undefined. (n.d.). Congenital nasolacrimal duct obstruction update study (CUP study): Paper II-Profile and outcomes of complex CNLDO and masquerades. *Elsevier*. Retrieved July 6, 2026, from https://www.sciencedirect.com/science/article/pii/S0165587620305504

Casady, D., Meyer, D., Association, J. S.-J. of the A., & 2007, undefined. (n.d.). Stepwise treatment paradigm for congenital nasolacrimal duct obstruction. *Jaapos.Org*. https://doi.org/10.1097/01.IOP.0000225737.69099.70

Daalen, K. van, Kaiser, J., Kebede, S., … G. C.-B. G., & 2022, undefined. (n.d.). Racial discrimination and adverse pregnancy outcomes: a systematic review and meta-analysis. *Gh.Bmj.Com*. Retrieved July 8, 2026, from https://gh.bmj.com/content/7/8/e009227

DS Friedman, MX Repka, J Katz, L. G., & J Ibironke. (2009). *Repka et al. (2009) - Google Scholar*. https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Repka+et+al.+%282009%29&btnG=

Eisele-Metzger, A., Lieberum, J.-L., Toews, M., Siemens, W., Heilmeyer, F., Haverkamp, C., Boehringer, D., & Meerpohl, J. J. (2025). Exploring the potential of Claude 2 for risk of bias assessment: Using a large language model to assess randomized controlled trials with RoB 2. *Cambridge.Org*, *16*, 491–508. https://doi.org/10.1017/rsm.2025.12

Engel, C., Mark, N. C., & West, K. D. (2007). Exchange rate models are not as bad as you think. *Journals.Uchicago.EduC Engel, NC Mark, KD West, K Rogoff, B RossiNBER Macroeconomics Annual, 2007•journals.Uchicago.Edu*, *22*, 381–442. https://doi.org/10.1086/MA.22.25554969

Hupp, M. (2022). *Anatomic and Clinical Pathology Review-E-Book*. https://books.google.com/books?hl=id&lr=&id=hi1qEAAAQBAJ&oi=fnd&pg=PP1&dq=Despite+the+well-established+clinical+importance+of+this+anatomical+distinction,+the+existing+evidence+base+has+historically+conflated+simple+and+complex+CNLDO+within+undifferentiated+pooled+analyses.&ots=N9CTToncNk&sig=BDV4si0AkPmuNhkP8VqXV6Wggw0

Jung, K., Hu, H., research, L. S.-V., & 2016, undefined. (n.d.). Porcine deltacoronavirus infection: Etiology, cell culture for virus isolation and propagation, molecular epidemiology and pathogenesis. *Elsevier*. Retrieved July 6, 2026, from https://www.sciencedirect.com/science/article/pii/S0168170216301563

kashkouli, & . (2019). *Kashkouli et al. (2019) - Google Scholar*. https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Kashkouli+et+al.+%282019%29&btnG=

Lascurain-Aguirrebena, I., Newham, D., Spine, D. C.-, & 2016, undefined. (n.d.). Mechanism of action of spinal mobilizations: a systematic review. *Journals.Lww.Com*. Retrieved July 6, 2026, from https://journals.lww.com/spinejournal/fulltext/2016/01150/mechanism_of_action_of_spinal_mobilizations__a.15.aspx

Maheshwari, C. (2013). *Management of Congenital Dacryocystitis*. https://search.proquest.com/openview/afff0c6d52fa127bcbdb68aaaddacd60/1?pq-origsite=gscholar&cbl=2026366&diss=y

Marr, J., Drake-Lee, A., ophthalmology, H. W.-B. journal of, & 2005, undefined. (n.d.). Management of childhood epiphora. *Bjo.Bmj.ComJE Marr, A Drake-Lee, HE*

WillshawBritish Journal of Ophthalmology, 2005•bjo.Bmj.Com. https://doi.org/10.1136/BJO.2004.057190

Mitchell, L. (2001). *Baby's first picture: Ultrasound and the politics of fetal subjects*. https://books.google.com/books?hl=id&lr=&id=DXOTFVRJYv8C&oi=fnd&pg=PP11&dq=By+stratifying+the+evidence+base+along+clinically+and+anatomically+meaningful+lines,+the+present+study+aims+to+furnish+clinicians+with+a+higher-resolution+evidentiary+foundation+for+individualised+treatment+planning.&ots=fkf4pkBpFy&sig=tvn6WySoxM1gK3eaETLzDJ7LIOA

Natarajan, A., Zlitni, S., Brooks, E., Vance, S., Med, A. D.-, & 2022, undefined. (n.d.). associated emergency department and urgent care encounters and hospitalizations among adults—VISION Network, 10 states, December 2021–March 2022. *Cdc.Gov*. Retrieved July 6, 2026, from https://www.cdc.gov/mmwr/volumes/71/wr/mm7113e2.htm?ftag=YHF4eb9d17

PRISMA. (2020). Review articles, systematic reviews, meta-analysis, and the updated preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines. *Pmc.Ncbi.Nlm.Nih.Gov*. https://pmc.ncbi.nlm.nih.gov/articles/PMC8394590/

Tao, & . (2002). *Tao et al. (2002) - Google Scholar*. https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Tao+et+al.+%282002%29&btnG=#d=gs_cit&t=1783471092485&u=%2Fscholar%3Fq%3Dinfo%3APfxEYT7zqMMJ%3Ascholar.google.com%2F%26output%3Dcite%26scirp%3D3%26hl%3Did

Tao, & et.all. (2022). *Tao et al. (2002) - Google Scholar*. https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Tao+et+al.+%282002%29&btnG=

Vagge, A., Ferro Desideri, L., Nucci, P., Serafino, M., Giannaccare, G., Lembo, A., & Traverso, C. E. (2018). Congenital nasolacrimal duct obstruction (CNLDO): a review. *Mdpi.ComA Vagge, L Ferro Desideri, P Nucci, M Serafino, G Giannaccare, A Lembo, CE TraversoDiseases, 2018•mdpi.Com*, *6*(4), 96. https://doi.org/10.3390/DISEASES6040096