Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Surgery for Idiopathic Normal Pressure Hydrocephalus: A Systematic Review to Inform a Core Outcome Set

Anand S Pandit

a.pandit@ucl.ac.uk

2. Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, UK. https://orcid.org/0000-0003-4936-4916

Yousif Aldabbagh

3. Department of Neurosurgery, Leeds General Infirmary, Leeds, UK

Marimo Rossiter

4. UCL Medical School, University College London, London, UK

Udhay S Cheema

4. UCL Medical School, University College London, London, UK

Jasneet Dhaliwal

4. UCL Medical School, University College London, London, UK

Ameerah Parvez

4. UCL Medical School, University College London, London, UK

Anca-Mihaela Vasilica

4. UCL Medical School, University College London, London, UK

Nabeela Farooq

4. UCL Medical School, University College London, London, UK

Lewis Thorne

2. Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, UK.

Laurence D Watkins

2. Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, UK.

Ahmed K Toma

2. Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, UK.

Systematic Review

Keywords: Idiopathic normal pressure hydrocephalus, iNPH; core outcome set, COS

Posted Date: June 8th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9774069/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: The authors declare no competing interests.

Abstract

Background:

Idiopathic normal-pressure hydrocephalus (iNPH) is primarily treated with cerebrospinal fluid shunt surgery, which can improve gait, cognition, and continence in selected patients. However, outcome reporting remains highly heterogeneous, limiting evidence synthesis, trial comparison, and guideline development. We conducted a systematic review to map outcomes reported after iNPH shunt surgery and quantify their variability, providing an empirical foundation for core outcome set (COS) development.

Methods:

MEDLINE, Embase, and Web of Science were searched from inception to 31 December 2025 for primary studies reporting outcomes after surgical cerebrospinal fluid diversion in adults with iNPH. Studies required ≥ 10 operated patients. Study selection and data extraction were performed in duplicate. Reported outcomes were catalogued, harmonised, and mapped to COMET-aligned domains. Descriptive statistics summarised study characteristics, outcome measures, and follow-up duration. No meta-analysis was performed because the review focused on outcome reporting rather than treatment effect.

Results

We included 645 studies published between 1971 and 2025, comprising > 175,000 operated patients across 48 countries. Most were prospective cohorts (52.2%) or retrospective cohorts (43.4%); 2.8% were randomised trials. Median follow-up was 12 months. After de-duplication, 567 unique outcomes were harmonised into 285 standardised outcome measures across 16 domains and 75 subdomains. Commonly reported domains included multidomain iNPH grading scales, adverse events/complications, cognitive/neuropsychological outcomes, and gait/balance outcomes. In contrast, urinary-specific outcomes and health-related quality of life were reported in fewer than 10% of studies, and societal/carer impact outcomes were rare. Substantial heterogeneity persisted in instruments, definitions, and assessment timepoints, although use of validated instruments increased over time.

Conclusions

Outcome reporting after iNPH shunt surgery remains fragmented and incompletely patient-centred. These findings provide a comprehensive empirical basis for COS development, including stakeholder prioritisation of minimum outcomes and timepoints to improve comparability, reduce reporting bias, and strengthen future iNPH research.

Introduction

Normal-pressure hydrocephalus (NPH) is a progressive neurological disorder characterised by the clinical triad of gait disturbance, cognitive impairment, and urinary incontinence, accompanied by ventriculomegaly in the absence of elevated cerebrospinal fluid (CSF) pressure [1]. The prevalence of NPH increases with age, affecting up to 7.7% of individuals over 85 years, and is associated with significant morbidity and mortality if left untreated [1–3].

CSF diversion via shunt surgery remains the mainstay of therapy, with ventriculo-peritoneal and lumbo-peritoneal shunts being the most commonly employed modalities [4,5]. When patients are appropriately selected, shunt surgery leads to symptomatic improvement in 70–80% of cases, with low rates of mortality and serious complications [4–9]. Despite the established efficacy of shunt surgery, outcome reporting in NPH remains highly heterogeneous. Studies vary widely in their choice of outcome measures, timing of assessments, and definitions of clinical improvement, complicating the synthesis of evidence and the development of robust clinical guidelines [6,8]. While gait velocity and functional scales are frequently used, cognitive and urinary outcomes, health-related quality of life (HRQoL), and adverse event rates are inconsistently reported [10,11]. The American Academy of Neurology has emphasised the need for standardised outcome assessment to improve comparability and guide clinical decision-making [7]. Recent multi-centre prospective studies and randomised trials have further highlighted the importance of using validated instruments and standardised follow-up protocols to assess both short- and long-term outcomes following shunt surgery [12–14]. The lack of consensus on outcome reporting in NPH is a barrier to evidence synthesis, meta-analysis, and the development of best practice recommendations.

The Core Outcome Measures in Effectiveness Trials (COMET) Initiative advocates for the development of core outcome sets (COS). These are consensus-based, minimum agreed sets of outcomes to be measured and reported in all clinical trials for a given condition [12–16]. COS methodology has improved outcome reporting in other neurological and neurosurgical fields, such as pituitary and peripheral nerve surgery, enhancing the relevance and comparability of research findings [17–19].

This systematic review aims to comprehensively map the heterogeneity in reported outcomes following surgery for iNPH, providing the evidentiary foundation for the development of a COS in accordance with COMET guidance. By identifying and appraising the range of outcome measures used in the literature, this work will inform the subsequent consensus process and facilitate the adoption of standardised, stakeholder-informed outcome reporting in iNPH research and clinical practice.

Methods

Reporting Guidelines and Registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol was prospectively registered with both the Core Outcome Measures in Effectiveness Trials (COMET) Initiative database and

PROSPERO (registration number CRD42023407330), in keeping with international recommendations for transparency in outcome-focused systematic reviews and core outcome set development. As this study involved analysis of published, anonymised data only, formal institutional ethical approval was not required.

Search Strategy

A comprehensive literature search was performed in Embase, Ovid MEDLINE, and Web of Science from database inception to October, 2024 and then repeated in December 2025. Searches were restricted to English-language publications. The strategy combined controlled vocabulary and free-text terms relating to *idiopathic normal pressure hydrocephalus*, *surgery*, *shunting*, and specific cerebrospinal fluid diversion procedures. Full search strategies for each database are provided in Supplementary Table 1.

Eligibility Criteria

Studies were eligible for inclusion if they reported postoperative outcomes following surgical cerebrospinal fluid diversion in adult patients (≥ 18 years) with idiopathic normal pressure hydrocephalus and included at least 10 operated iNPH patients. Eligible study designs included prospective and retrospective cohort studies, randomised controlled trials, and other observational designs reporting surgical outcomes.

Studies enrolling mixed populations were included only if outcome data for the iNPH subgroup were separately extractable. Exclusion criteria included case reports, review articles of any type, conference abstracts, paediatric-only studies, studies evaluating medical (non-surgical) management alone, and studies restricted to obstructive or secondary forms of hydrocephalus. In line with COMET guidance, studies reporting postoperative radiological outcomes without accompanying clinical or functional outcome assessment were also excluded.

Study Selection and Data Extraction

All records were imported into Covidence (Veritas Health Innovation, Melbourne, Australia) and deduplicated prior to screening. Two reviewers independently screened titles and abstracts for eligibility, with disagreements resolved through consensus or adjudication by a third reviewer. Full-text screening followed the same process. The study selection process is summarised in the PRISMA flow diagram (Fig. 1).

Data extraction was performed independently in duplicate using a piloted extraction form within Covidence, with all extracted data cross-checked by a third reviewer for accuracy and completeness. Extracted variables included study characteristics (author, journal, year of publication, country, study design, and study period), participant and intervention details (sample size and type of surgical

procedure), duration and timing of follow-up, and all postoperative outcomes reported. Where authors explicitly designated primary and secondary outcomes, this information was recorded.

As this review represents the first phase in the development of a core outcome set for iNPH, particular emphasis was placed on capturing outcome definitions verbatim and documenting how outcomes were measured and categorised. Outcome categories were harmonised using a COMET-aligned taxonomy with consensus. Legacy and modality-based categories were systematically reclassified.

Measurement type was accorded to each standardised outcome. These were further categorised based on whether it was (i) a clearly identifiable named tool; (ii) it has a fixed scoring structure; (iii) it has a clear development or validation source and (iv) it has broad use in multiple papers related to NPH.

Data Synthesis and Analysis

Descriptive analyses were conducted using Microsoft Excel and Python. We summarised the frequency of individual outcome measures and outcome domains across studies and examined their distribution by publication decade, study design, sample size, and follow-up duration. No meta-analysis or pooled effect estimates were planned, as the primary objective was to catalogue and characterise outcome reporting rather than to evaluate treatment efficacy.

Formal risk-of-bias assessment and certainty grading were not undertaken, as this review focused on mapping outcome heterogeneity rather than synthesising intervention effects. Results are presented in accordance with PRISMA guidance, with accompanying tables and data visualisations (including temporal trends in outcome reporting and distributions of follow-up duration) used to illustrate key patterns and gaps in the literature.

Results

Study selection and characteristics

From 6,945 records identified through the database searches, 645 studies were ultimately deemed eligible and included in this review (Fig. 1). These studies span over five decades (publication years 1971–2025) and represent a large body of clinical evidence on shunt surgery for iNPH. The study designs included 338 prospective cohort studies (52.24%), 280 retrospective cohort studies (43.4%), 18 randomised controlled trials (2.8%), and 9 cross-sectional or other observational studies (1.4%). The majority of studies reported short- to medium-term follow-up (median 12 months, IQR 3–12). Ventriculoperitoneal shunting was the most commonly reported intervention (n = 418, 64%), followed by lumboperitoneal (n = 61, 9%) and ventriculoatrial shunts (n = 22, 3%) and a small number evaluated endoscopic third ventriculostomy (n = 8, ~ 1%). A substantial proportion of studies reported unspecified or mixed shunt types (n = 130, ~ 20%), limiting interpretability of outcome comparisons across interventions. Studies were conducted across 54 countries and published in over 150 different journals.

In aggregate, the included studies encompass over 175,000 patients who underwent shunt surgery for iNPH, with a median of 41 patients per study (IQR 21–88).

Outcome yield and standardisation

Following outcome extraction, 567 unique outcomes were identified after de-duplication (Supplementary Table 2). Outcomes were subsequently merged, cleaned, and grouped using a standardised taxonomy. For example, different phrasings related to the same construct were grouped, such as *CSF dynamics, CSF flow, CSF outflow resistance (R_out), CSF outflow conductance (C_out)*, and *CSF flow rate*, while instrument-specific outcomes but in different formats such as *MMSE* and its associated non-English language versions were merged together to form a standardised outcome. Finally, subsidiary biomarker analyses were grouped where conceptually appropriate. For example, outcomes such as t-*tau, p-tau, amyloid β1–42*, and *Aβ42* were harmonised within a broader CSF biomarker outcome relevant for dementia. This approach minimised semantic redundancy while maintaining clinically relevant distinctions. In this way, 285 standardised outcome measures were described, which will be taken forward to the next stage of the COS process.

COMET domains and subdomains

Sixteen COMET-aligned domains are described which map to 75 unique subdomains (Fig. 2, Supplementary Table 2). The median number of standardised outcomes per core domain was 13.5 (8.75–17.5). The cognitive and neuropsychological function domain contained the greatest number of standardised outcomes (n = 81), whereas survival/mortality was represented by only two outcomes.

The most frequently represented COMET domain was Adverse Events and Complications in 318 studies (49.3%) and Cognitive and Neuropsychological Function in 299 (46.4%). Mobility, Gait and Balance and Healthcare Utilisation and Economic Impact were also common, appearing in 255 (39.5%) and 253 (39.2%) studies respectively. Neuroimaging was reported in 208 studies (32.2%), and Patient Reported Symptoms and Experience in 173 (26.8%). Mid-frequency domains included Survival or Mortality (139, 21.6%), Functional Status / Independence (133, 20.6%), and Physiological Markers (129, 20.0%). By contrast, several domains were relatively under-represented, including Urinary function (59, 9.1%), Quality of Life (52, 8.1%), Biological Markers (42, 6.5%), Motor (35, 5.4%), Emotional Functioning and Wellbeing (29, 4.5%), and Societal and Carer Impact (14, 2.2%). Overall, the literature remained weighted toward multidomain clinical grading, complications, cognition, gait, and service-related outcomes, with comparatively sparse reporting of patient-centred, emotional, biological, and societal endpoints.

Average follow-up duration varied across domains and was calculated only from studies with extractable follow-up data. The longest mean follow-up was seen in Survival / Mortality (27.1 ± 43.7 months), followed by Adverse Events and Complications (18.4 ± 30.5 months), Healthcare Utilisation and Economic Impact (17.5 ± 27.8 months), and Patient Reported Symptoms and Experience (17.2 ± 32.6 months). Intermediate mean follow-up durations were seen for Functional Status / Independence (15.0 ±

18.5 months), Multidomain grade (13.6 ± 16.2 months), Physiological Markers (13.4 ± 19.0 months), Urinary function (13.4 ± 17.5 months), Neuroimaging (13.1 ± 20.6 months), Mobility, Gait and Balance (12.9 ± 20.6 months), and Cognitive and Neuropsychological Function (11.9 ± 15.2 months). Shorter mean follow-up was observed for Quality of Life (11.2 ± 10.2 months), Emotional Functioning / Wellbeing (10.7 ± 10.8 months), Societal and Carer Impact (9.8 ± 13.3 months), Biological Markers (9.3 ± 9.5 months), and Motor (8.8 ± 9.1 months).

Measurement instruments and measurement-type heterogeneity

For commonly reported outcomes, multiple instruments were frequently used to assess the same underlying construct. For example, *balance* subdomain outcomes were measured using a range of instruments: dynamic balance (performance-based), posturography (device-derived), Berg balance scale (clinician-administered / performance-based). This demonstrates that single outcome constructs were often represented by multiple distinct measurement approaches. On the other hand, subdomains such as *executive function* were all assessed by a clinician-administered, performance-based instrument which was also the commonest measurement overall (30.3%). Standalone performance-based measurements comprised 13.4% of outcomes, clinician-rated and patient-reported (PROs) were 12.3%, whereas clinician-recorded, imaging, administrative or health record, laboratory-based, device-derived and observer reported (ObsRO) were all less than 5%.

Many outcomes were subjective and non-validated rather than using validated instruments or scores, including those which described NPH cardinal symptoms: gait, cognition and urinary function (Supplementary Table 2). Of the 285 outcomes, 140 (49%) were estimated to be validated instruments (e.g. *Timed up and Go Test*), 82 (29%) were considered standardised quantitative measures (e.g. *Evans index*), 45 (16%) were structured non-validated measures (e.g. *requirement for walking aids*), and 17 were unclear or represented a narrative outcome (e.g. *operative adverse effects*).

Temporal and geographic heterogeneity

Publication output increased substantially over time, rising from 1 study in 1970–1974 to 175 studies in 2020–2024 (Fig. 4). Growth was modest before 2000, then accelerated after 2000, particularly after 2010. Domain emphasis shifted over time. Before 2000, studies were relatively more weighted toward Neuroimaging (59.7% of studies), Physiological Markers (41.7%), and Patient Reported Symptoms and Experience (45.8%). From 2010 onward, reporting was relatively more concentrated on Mobility, Gait and Balance (45.2%), Multidomain grades (49.0%), Cognitive and Neuropsychological Function (48.1%),. In relative terms, the strongest increase was in Mobility, Gait and Balance, whereas Neuroimaging, Physiological Markers and Patient Reported Symptoms and Experience became less dominant. Notably there was a greater proportion of standardised extracted outcomes over time - in particular greater use of validated instruments. In contrast, the proportion of unclear or narrative outcomes remained fairly stable.

The evidence base was internationally broad, with 48 countries represented in the spreadsheet as the corresponding author country of origin (Fig. 5). With that said, output was still concentrated in a relatively small number of high-contributing countries, particularly the USA, Japan, Sweden, and Germany. More specifically, Quality of Life reporting was strongly concentrated in Germany, Biological Markers in Sweden, and Societal and Carer Impact in Sweden and Japan.

Discussion

Summary of results

In the largest mapping review to date of postoperative outcome reporting in iNPH shunt studies, we identified a mature and rapidly expanding literature but persistent fragmentation in what outcomes are measured, how they are measured, and when they are measured. Publication volume rose sharply after 2010, and the evidence base is broadly international but concentrated in a small number of high-output countries, including the United States, Japan, Sweden, and Germany.

Across 645 included studies, we extracted 567 unique outcomes, which remained highly redundant and semantically inconsistent until harmonised into 285 standardized measures that were mapped to 16 COMET-aligned domains. The literature prioritised multidomain clinician-rated iNPH grading scales, adverse events/complications and revisions, cognitive/neuropsychological outcomes, and gait/balance outcomes. Patient-centred life impact outcomes—especially urinary-specific endpoints, HRQoL, emotional function, and societal/carer burden—were underreported. This mismatch suggests that the current literature prioritises clinician-observed and technically measurable outcomes over aspects of disease burden that are highly relevant to patients and families [11]. Follow-up was most often limited to the first postoperative year, with substantially longer follow-up mainly confined to survival or mortality reporting. These findings mirror the challenges repeatedly noted in evidence synthesis for iNPH, where between-study heterogeneity and the absence of long-term randomised data constrain results validity.

Interpretation and context

Three underreported outcome categories represent the most clinically meaningful evidence gaps in current iNPH surgical research. Firstly, patient-centred life impact outcomes are consistently underrepresented. HRQoL reporting remains uncommon despite evidence that iNPH substantially impairs HRQoL and that long-term follow-up of HRQoL after shunting is rare in the broader literature [20]. This matters because symptom-level change does not always translate into better participation, independence, or perceived wellbeing—particularly in older, comorbid patients. Secondly, urinary outcomes are frequently missing as standalone outcomes. Even when continence is included within composite disease-specific scales, urinary-specific measures (validated questionnaires, diaries, urodynamics) are rarely reported, reducing interpretability for patients in whom urinary symptoms are a primary driver of disability and caregiver burden. Patient-prioritisation work suggests that continence outcomes are important to patients and carers [11], strengthening the argument that urinary function

requires explicit representation in future COS. Thirdly, societal and caregiver outcomes are nearly absent. This is a major limitation for a condition that often affects older adults with complex support needs; the absence of outcomes capturing caregiver strain, social reintegration, or service use limits the ability of clinicians and systems to evaluate broader value and to design patient-centred care pathways.

We also identified several sources of heterogeneity that a COS should explicitly address. Single constructs (e.g., gait improvement) were represented by many different outcomes, instruments and thresholds for clinically meaningful change - limiting cross-study comparability. Next, most studies were focused on early postoperative improvement, but late outcomes: durability of response, delayed cognitive trajectories and late shunt malfunction were inconsistently captured. Finally, there was clear geographical clustering with certain domains concentrated to specific countries suggesting that local practice patterns may influence outcome selection.

The practical consequence of the heterogeneity described is that 'success' after iNPH shunting is not operationalised in a consistent, reproducible way across studies, even when the same core symptom domains are used. This is particularly problematic in iNPH, where clinical decision-making hinges on balancing short-term symptomatic gains against complication risk and long-term durability. Contemporary guidelines emphasise structured evaluation of gait, cognition, and continence—domains that define the syndrome—yet our findings show that urinary function and HRQoL are not measured or reported with the same consistency [7].

Several developments underscore why standardisation in iNPH is now particularly pertinent. Firstly, large multicentre networks aim to standardise post-surgical assessment with defined follow-up windows, demonstrating feasibility for routine collection of multi-domain outcomes after shunting. Second, recent trials and comparative systematic reviews increasingly call for standardised assessment scores and longer-term follow-up to resolve uncertainties around comparative effectiveness, complications, and durability of benefit [4]. Third, validated disease-specific composite scales exist—such as the iNPH scale covering gait, cognition, and continence—but their uptake is incomplete or are paired with heterogeneous adjunct testing [21]. For neurosurgeons and multidisciplinary iNPH teams, the clinical relevance of this work lies in enabling future trials, device evaluations, and registry studies to use a common reporting scheme: a minimum set of outcomes that represent both benefit (function and life impact) and harm (complications and revisions), captured at timepoints that reflect early response and longer-term durability. These would be adapted appropriately for patient-centred and research-focused priorities.

Our results provide empirical justification for a COS in iNPH shunt research. The COMET Handbook highlights that inconsistent outcome selection, and measurement can make synthesis difficult or impossible and can contribute to outcome reporting bias—problems that lead to avoidable research waste and reduce clinical utility [16]. A COS is intended to define the minimum outcomes that should be measured and reported across studies, without preventing investigators from adding additional outcomes tailored to specific hypotheses [16]. This rationale aligns with patterns seen across other areas of surgical research. Multiple fields have documented outcome heterogeneity and responded by

developing COS through systematic review plus stakeholder consensus. Examples include COS initiatives in oesophageal cancer resection surgery, pituitary surgery and nerve injury surgery [17,19,22]

Limitations and strengths of this research

This review should be interpreted with several limitations. We restricted inclusion to English-language studies, and we excluded radiological-only reports without accompanying clinical or functional outcomes; both choices may omit some potentially informative work but reflect the objective of identifying outcomes specifically relevant to patient benefit and harm. Consistent with the review's aim (mapping outcomes rather than estimating treatment effect), we did not perform risk-of-bias assessment; therefore, we cannot comment on whether study quality influenced outcome choice or selective reporting. As with all outcome-mapping reviews, our extraction is limited to what authors reported; outcomes measured but not published remain unobserved, and reporting bias may therefore contribute to apparent underrepresentation of certain domains. Finally, mapping to domains required judgement despite use of a standardised taxonomy; however, we minimised misclassification through duplicate extraction and consensus-based harmonization.

We also acknowledge several strengths. This is, to our knowledge, the most comprehensive synthesis of iNPH shunt outcome reporting conducted to date, spanning five decades and a large international evidence base. We applied a transparent, COMET-aligned taxonomy, generated a harmonised long-list of standardised outcomes suitable for Delphi prioritisation, and quantified both temporal and geographic patterns in reporting. By distinguishing validated instruments from non-validated or narrative outcomes using an objective rubric, we provide actionable insight into where measurement standardisation remains deficient.

Conclusion

Outcome reporting after iNPH shunt surgery remains heterogeneous and incompletely patient-centred. The field continues to prioritise clinician-rated global improvement, gait outcomes, complications, and cognition, while underreporting urinary-specific outcomes, HRQoL, emotional wellbeing, and caregiver impact—domains that are central to lived experience and real-world value.

The next phases should follow COS development standards and proceed from this long list to stakeholder prioritisation and consensus, including neurosurgeons, neurologists, geriatricians, therapists, nurses, patients, and carers. A parallel step will be to identify 'how to measure' each core domain, using established guidance for selecting instruments for COS and, where needed, developing or refining measures to improve feasibility and responsiveness in iNPH populations [23]. Because COS uptake is often incomplete, implementation planning should be embedded early, with engagement of registries, societies, and journal editors [24].

References

1. Andrén K, Wikkelsø C, Tisell M, Hellström P. Natural course of idiopathic normal pressure hydrocephalus. J Neurol, Neurosurg Psychiatry. 2014;85(7):806. doi:10.1136/jnnp-2013-306117
2. Iseki C, Takahashi Y, Adachi M, et al. Prevalence and development of idiopathic normal pressure hydrocephalus: A 16-year longitudinal study in Japan. Acta Neurol Scand. 2022;146(5):680-689. doi:10.1111/ane.13710
3. Andrén K, Wikkelsø C, Hellström P, Tullberg M, Jaraj D. Early shunt surgery improves survival in idiopathic normal pressure hydrocephalus. Eur J Neurol. 2021;28(4):1153-1159. doi:10.1111/ene.14671
4. Palermo M, Trevisi G, Signorelli F, et al. Advancing treatment strategies for idiopathic normal pressure hydrocephalus: a systematic review on studies comparing ventricular and lumbo-peritoneal shunts. Neurosurg Rev. 2025;48(1):426. doi:10.1007/s10143-025-03582-2
5. Toma AK, Papadopoulos MC, Stapleton S, Kitchen ND, Watkins LD. Systematic review of the outcome of shunt surgery in idiopathic normal-pressure hydrocephalus. Acta Neurochir. 2013;155(10):1977-1980. doi:10.1007/s00701-013-1835-5
6. Salih A, Arif A, Varadpande M, et al. The effectiveness of various CSF diversion surgeries in idiopathic normal pressure hydrocephalus: a systematic review and meta-analysis. eClinicalMedicine. 2024;77:102891. doi:10.1016/j.eclinm.2024.102891
7. Halperin JJ, Kurlan R, Schwalb JM, Cusimano MD, Gronseth G, Gloss D. Practice guideline. Neurology. 2015;85(23):2063-2071. doi:10.1212/wnl.0000000000002193
8. Pearce RKB, Gontsarova A, Richardson D, et al. Shunting for idiopathic normal pressure hydrocephalus. Cochrane Database Syst Rev. 2024;2024(8):CD014923. doi:10.1002/14651858.cd014923.pub2
9. Giordan E, Palandri G, Lanzino G, Murad MH, Elder BD. Outcomes and complications of different surgical treatments for idiopathic normal pressure hydrocephalus: a systematic review and meta-analysis. J Neurosurg. 2019;131(4):1024-1036. doi:10.3171/2018.5.jns1875
10. Torregrossa F, Buscemi F, Gulino V, Campisi BM, Teresi G, Grasso G. Health-Related Quality of Life and Role of Surgical Treatment in Idiopathic Normal Pressure Hydrocephalus: A Systematic Review. World Neurosurg. 2023;179:197-203.e1. doi:10.1016/j.wneu.2023.08.105
11. Toma AK, Tarnaris A, Kitchen ND, Watkins LD. Working towards patient oriented outcome assessment in normal pressure hydrocephalus, what is the most important? Acta Neurochir. 2011;153(1):177-180. doi:10.1007/s00701-010-0781-8
12. Williams MA, Nagel SJ, Golomb J, et al. Safety and effectiveness of the assessment and treatment of idiopathic normal pressure hydrocephalus in the Adult Hydrocephalus Clinical Research Network. J Neurosurg. 2022;137(5):1289-1301. doi:10.3171/2022.1.jns212782
13. Luciano MG, Williams MA, Hamilton MG, et al. A Randomized Trial of Shunting for Idiopathic Normal-Pressure Hydrocephalus. N Engl J Med. 2025;393(22):2198-2209. doi:10.1056/nejmoa2503109

14. Trungu S, Scollato A, Ricciardi L, et al. Clinical Outcomes of Shunting in Normal Pressure Hydrocephalus: A Multicenter Prospective Observational Study. J Clin Med. 2022;11(5):1286. doi:10.3390/jcm11051286
15. Kearney A, Gargon E, Mitchell JW, et al. A systematic review of studies reporting the development of core outcome sets for use in routine care. J Clin Epidemiology. 2023;158:34-43. doi:10.1016/j.jclinepi.2023.03.011
16. Williamson PR, Altman DG, Bagley H, et al. The COMET Handbook: version 1.0. Trials. 2017;18(Suppl 3):280. doi:10.1186/s13063-017-1978-4
17. Valetopoulou A, Newall N, Khan DZ, et al. A core outcome set for pituitary surgery research: an international delphi consensus study. Pituitary. 2025;28(4):88. doi:10.1007/s11102-025-01553-w
18. Horsfall HL, Lawrence A, Venkatesh A, et al. Reported outcomes in transsphenoidal surgery for pituitary adenomas: a systematic review. Pituitary. 2023;26(2):171-181. doi:10.1007/s11102-023-01303-w
19. Wilson TJ, Ali ZS, Davis GA, et al. Core outcomes in nerve surgery: development of a core outcome set for brachial plexus and upper extremity nerve injuries. J Neurosurg. 2024;141(2):474-483. doi:10.3171/2023.11.jns232272
20. Junkkari A, Sintonen H, Danner N, et al. 5-Year health-related quality of life outcome in patients with idiopathic normal pressure hydrocephalus. J Neurol. 2021;268(9):3283-3293. doi:10.1007/s00415-021-10477-x
21. Hellström P, Klinge P, Tans J, Wikkelsø C. A new scale for assessment of severity and outcome in iNPH. Acta Neurol Scand. 2012;126(4):229-237. doi:10.1111/j.1600-0404.2012.01677.x
22. Avery KNL, Chalmers KA, Brookes ST, et al. Development of a Core Outcome Set for Clinical Effectiveness Trials in Esophageal Cancer Resection Surgery. Ann Surg. 2018;267(4):700-710. doi:10.1097/sla.0000000000002204
23. Kirkham JJ, Davis K, Altman DG, et al. Core Outcome Set-STAndards for Development: The COS-STAD recommendations. PLoS Med. 2017;14(11):e1002447. doi:10.1371/journal.pmed.1002447
24. Khan K. The CROWN Initiative: Journal editors invite researchers to develop core outcomes in women's health. Post Reprod Heal. 2015;21(3):82-84. doi:10.1177/2053369115590372

Figures

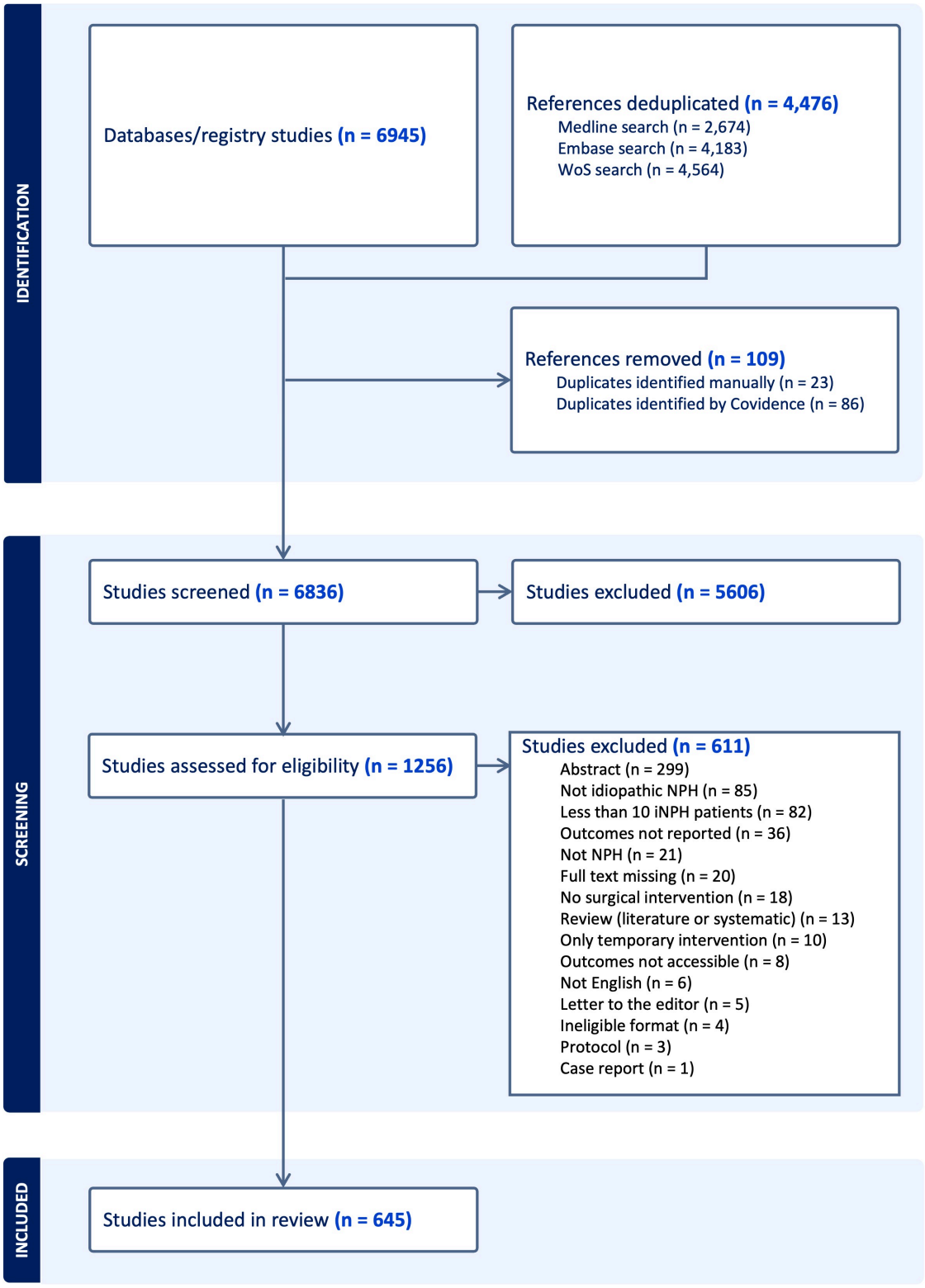


Figure 1

PRISMA flowchart

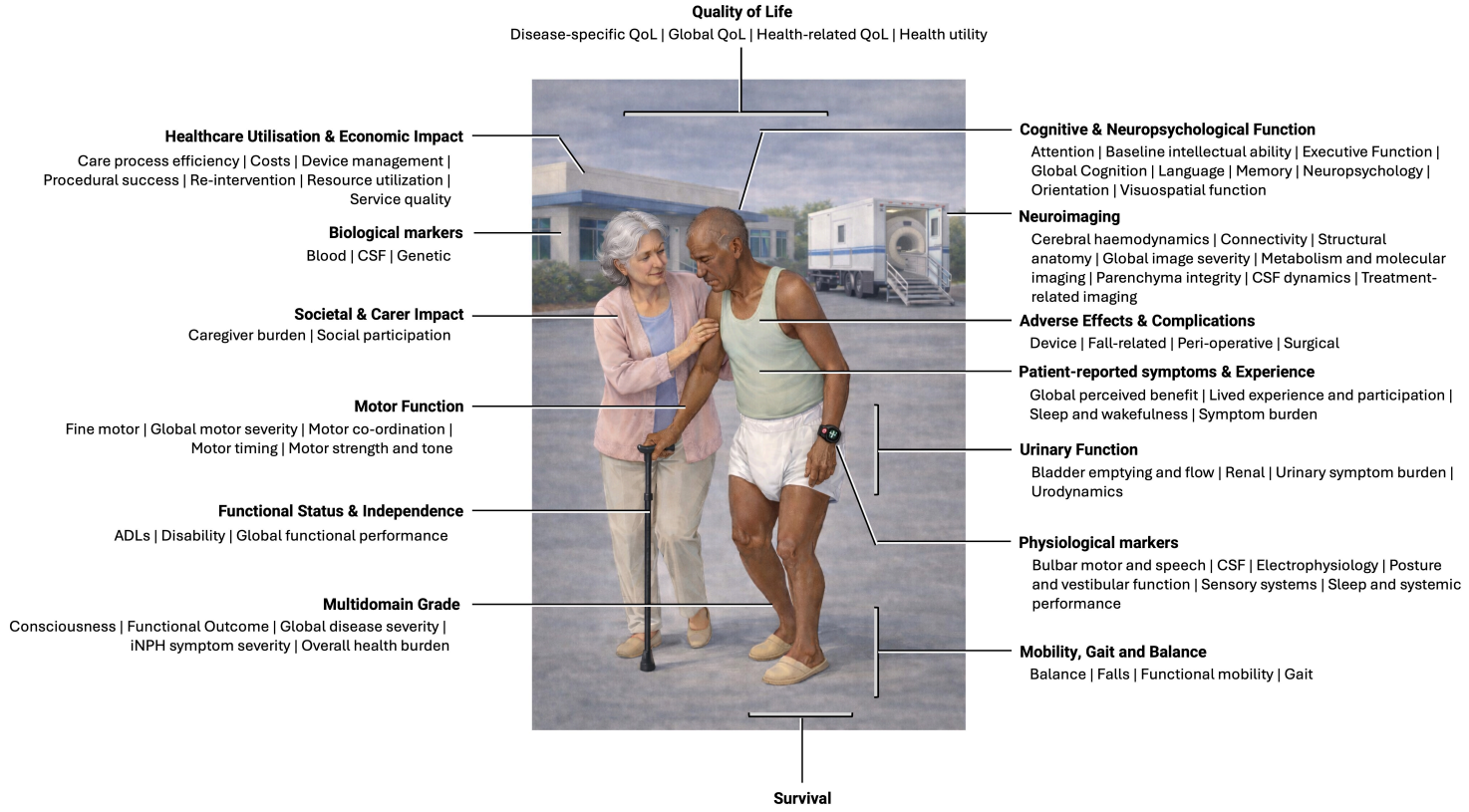


Figure 2

COMET-aligned domains and subdomains. Produced using MS PowerPoint, GIMP and ChatGPT 5.3

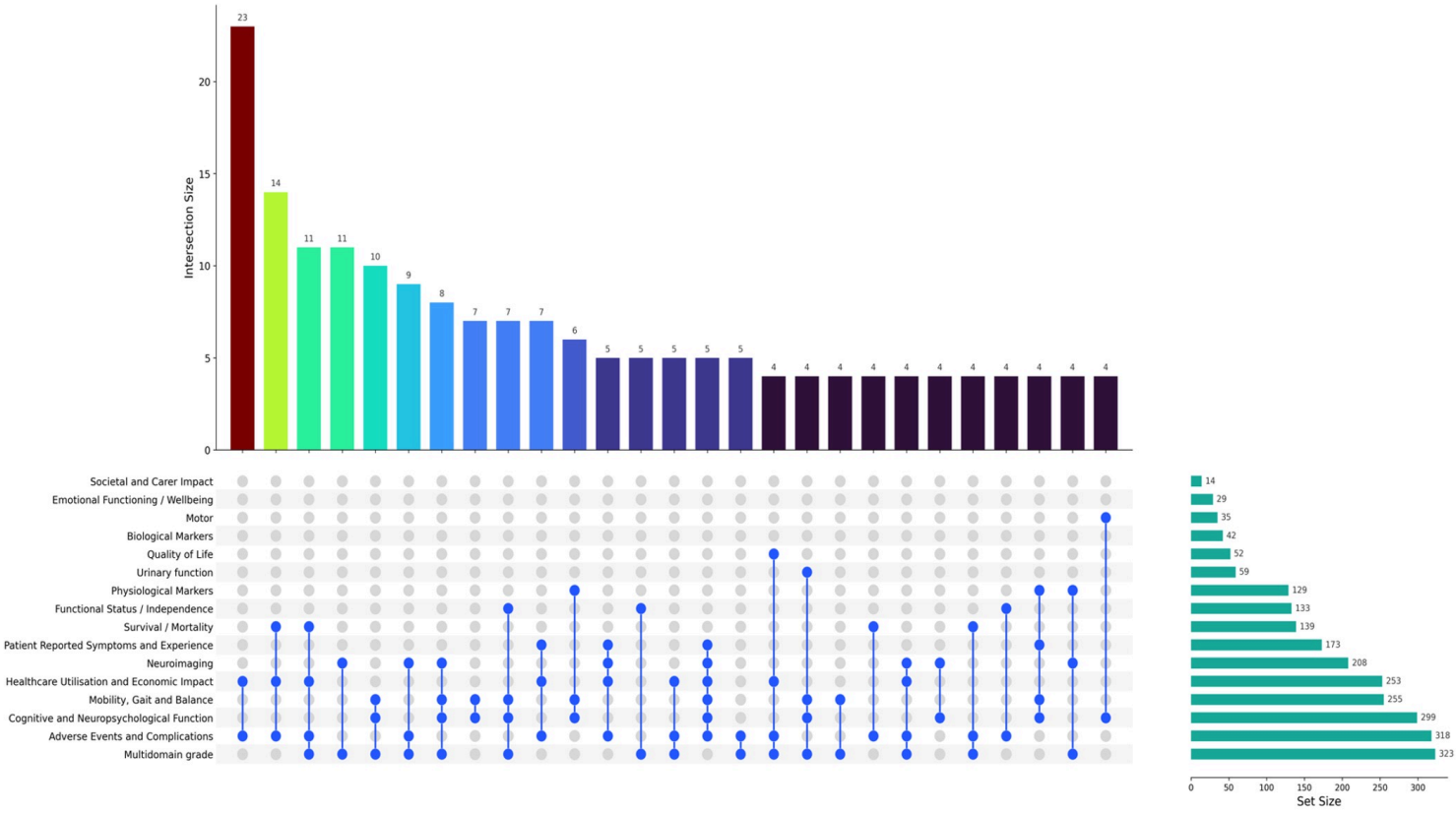


Figure 3

UpSet plot with teal horizontal bars (right) showing the cumulative total number of studies measuring each domain. The dot matrix (bottom) indicates which domains were measured together within the same study, and the vertical bars above show how many studies reported each such combination

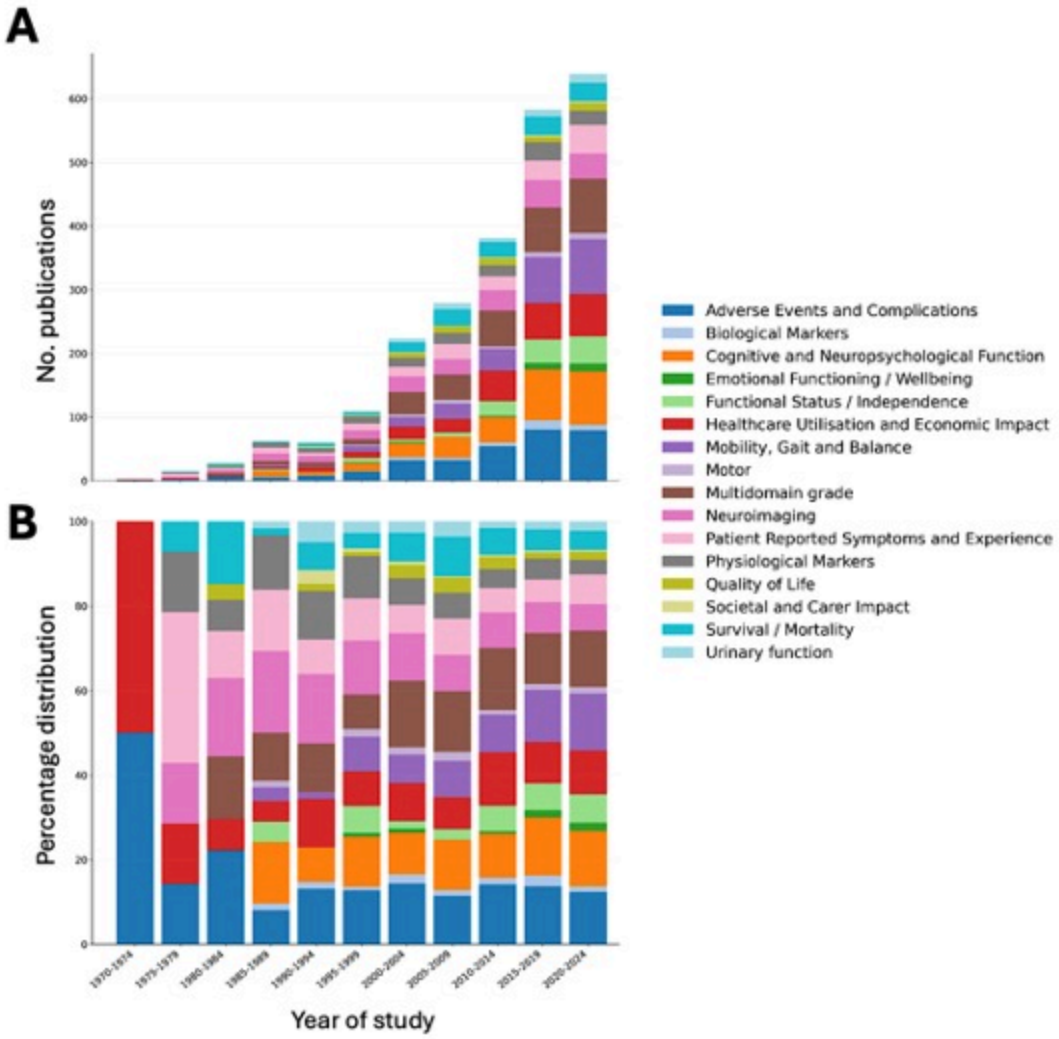


Figure 4

Stacked bar charts showing publication trends over time with (A) number of publications per 5-year bins and (B) % distribution with color coding corresponding to COMET-aligned domain

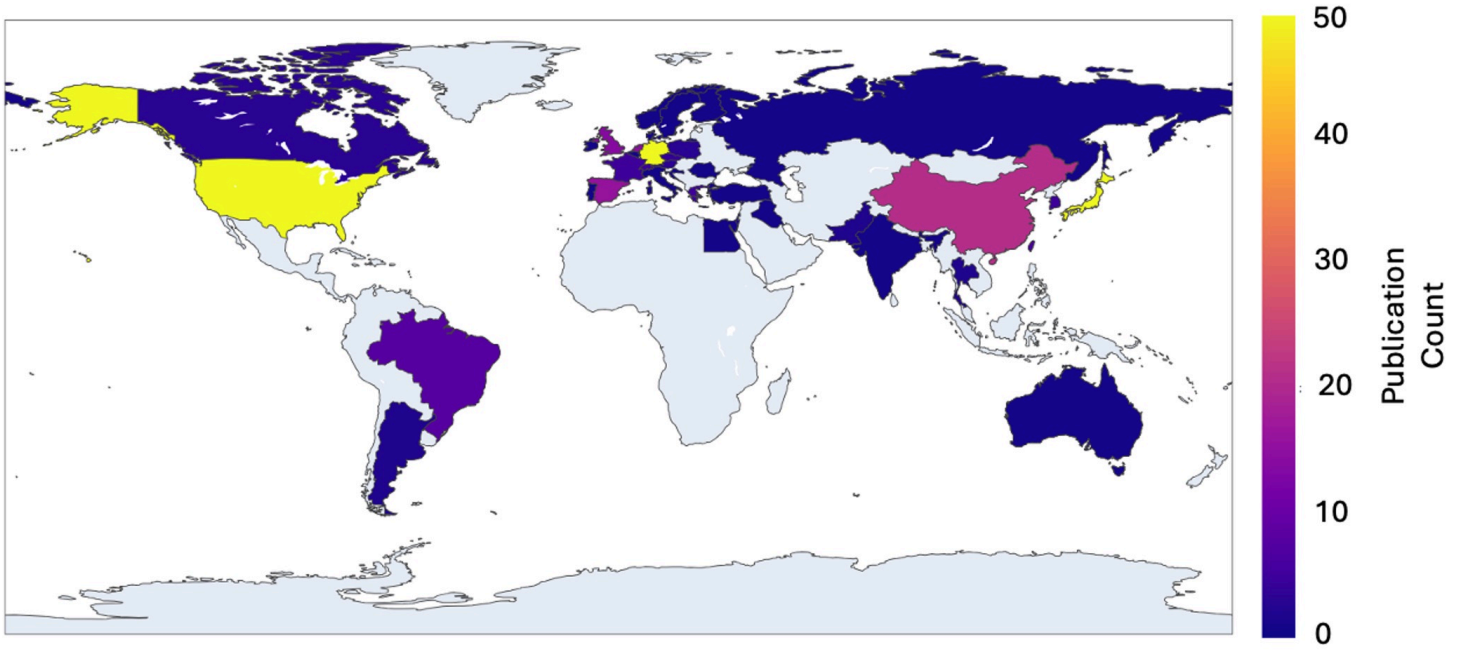


Figure 5

Geographical distribution of iNPH studies with post-surgical outcomes. Independent of study type, only the corresponding author's country of origin is highlighted.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SuppTable1.xlsx
- SuppTable2.xlsx