SYSTEMATIC / NARRATIVE REVIEW ARTICLE

Global trends in the utilisation of NOMS framework for spinal metastasis management: A systematic review

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ABSTRACT

Introduction: Traditional risk stratification systems based on the clinicopathological criteria have limitations and may not accurately predict outcomes for all patients. The neurologic, oncologic, mechanical, and systemic (NOMS) framework aims to optimise treatment outcomes and improve patient care. Here, we aimed to provide a comprehensive overview of the NOMS framework within the context of spinal metastasis.

Materials and Methods: The study rigorously followed the guidelines set by PRISMA. We conducted an extensive search and be as transparent as possible across well-regarded databases such as PubMed and Euro PMC. The primary outcome measure focused on examining the feasibility of implementing the NOMS framework for patients with spinal metastasis in real-world clinical settings, and this measure was predefined and justified.

Results: This systematic review included three studies involving 300 participants with spinal metastases at the cervicothoracic junction. The studies examined surgical interventions like decompression, fusion and corpectomy within the NOMS framework. Across the studies, the NOMS approach is consistently associated with adverse outcomes, including complication rates, surgical revisions, hardware complications, deformities, tumour recurrence and variable survival rates. It is also linked to hospital stays, ICU durations and specific discharge statuses. Another study focused on spinal metastasis patients undergoing endoscopic surgery, highlighting the NOMS framework's connection to recurrence rates, performance metrics, neurological status, pain management, functional recovery and quality of life. In addition, other studies explored navigated instrumentation, with a primary focus on screw placement accuracy. All three studies demonstrated methodological rigor by reporting adequate allocation concealment.

Conclusion: NOMS framework consistently associates with adverse spinal metastasis surgery outcomes.

KEYWORDS:
NOMS framework, spinal metastasis, management, outcomes

INTRODUCTION

The neurologic, oncologic, mechanical, and systemic (NOMS) framework provides a systematic approach to the care of patients with spinal metastatic tumours, allowing for dynamic integration of novel systemic and radiation options.[1,2] It considers the unique challenges posed by spinal metastasis, such as the potential for neurologic compromise, the impact on oncologic management, the mechanical stability of the spine and the systemic effects of the disease. By considering these factors, the NOMS framework aims to optimise treatment outcomes and improve patient care.[1]

The adoption of the NOMS framework for managing spinal metastasis has gained global recognition and has been integrated into treatment protocols by various healthcare institutions.[3] Various decision-making algorithms, such as the NOMS framework, the spine instability neoplastic score (SINS) and the Tokuhashi score, assist in surgical decision-making.[4] Patient's tolerance to treatment procedures should be considered prior to the treatment.[5] Thus, NOMS framework serves as a comprehensive tool to steer treatment decisions, ensuring the inclusion of all pertinent factors in the decision-making process.[6,7]

The clinical burden of metastasis to the spine is substantial, with a reported 1-year prevalence of chronic spinal pain at 19%.[8] Additionally, spinal infections contribute to prolonged hospital stays, imposing significant financial strains on healthcare systems. Internationally, healthcare costs exceeding 10% of household income, termed high burden households, constitute approximately 30% of total household financial burdens.[8] Such financial strains can lead to material consequences like bankruptcy or psychological impacts. To effectively manage spinal metastasis, the NOMS decision framework integrates considerations of neurologic, oncologic, mechanical and systemic factors to guide treatment strategies. Rehabilitation interventions are pivotal within the NOMS framework, emphasising treatment tolerance and facilitating recovery.

We aimed to provide a comprehensive overview of the NOMS framework within the context of spinal metastasis. We examined the existing literature to evaluate the effectiveness of the NOMS framework in guiding treatment decisions and improving patient outcomes.[1,9] Additionally, we will explore the incorporation of other risk stratification tools, such as the

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SINS, in conjunction with the NOMS framework to further refine risk assessment.[10] The findings of this review will provide valuable insights for clinicians and researchers in the field, ultimately leading to improved patient care and outcomes.

MATERIALS AND METHODS

The study rigorously followed the guidelines set by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), ensuring a systematic and comprehensive approach.[11] It is worth mentioning that this research was not funded by any external sources, maintaining its impartiality. We conducted an extensive search and be as transparent as possible across well-regarded databases such as PubMed and Euro PMC. Detailed search queries are shown in Table I.

The study focused on patients with spinal metastasis (P) and utilised the NOMS framework (I) as an intervention for reasons that will be explained later. Since evaluating the feasibility of implementing the NOMS framework in clinical settings was the primary objective (O), there was no specific comparator (C). Noteworthy is that during database searches, date restrictions, limits based on language or type of studies were not applied, instead, a thorough approach using controlled vocabulary, keywords and synonyms were undertaken.

After conducting the initial search, duplicate records were eliminated using the deduplication feature in rayyan.ai. The remaining eligible studies then underwent a two-step screening process. In the first step, titles and abstracts were assessed for relevance, and articles meeting predetermined inclusion and exclusion criteria were selected for full-text review. It is important to highlight that all authors participated in both stages of screening, with any conflicts or discrepancies resolved through discussion to reach a consensus.

The inclusion criteria of the study comprised of publications available in English or translated into English, with both full-text and abstracts accessible. These publications specifically focused on evaluating the feasibility of implementing the NOMS framework for patients with spinal metastasis in clinical settings. Exclusion criteria consisted of abstracts without corresponding full-text articles, secondary literature, studies that did not assess the feasibility of the NOMS framework for this patient population in clinical settings, and studies that did not report on the specified outcomes.

For the final analysis, selected articles were assessed. This assessment covered various aspects such as bibliographic data, study design, participant characteristics and intervention details (if applicable), as well as outcome data. The primary outcome measure focused on examining the feasibility of implementing the NOMS framework for patients with spinal metastasis in real-world clinical settings, and this measure was predefined and justified.[1]

We evaluated the quality and potential bias of each included study using Newcastle–Ottawa scale (NOS) for non-randomised intervention studies. The overall risk of bias in this systematic review was assessed by considering the cumulative risk identified across all included studies.

The analysis of the data was conducted descriptively. Weighted means were calculated and reported along with range values when applicable. Due to variations in study designs and implementation, a meta-analysis was not performed, and the data were not combined.

RESULTS

In the context of search queries, a comprehensive search was conducted across scholarly databases, resulting in the identification of a cumulative total of 70 publications. This dataset encompassed records procured from two primary sources, namely PubMed and Euro PMC, comprising 14 and 56 records, respectively. Prior to the formal screening phase, diligent efforts were made to identify and eliminate any duplicate records, amounting to a total of three such records, in order to maintain the integrity of the dataset. Following this initial curation process, a refined dataset of 67 records remained, all of which were subjected to rigorous scrutiny for adherence to predetermined eligibility criteria. A substantial portion of these records, totalling 58, were excluded from the analysis due to non-conformity with the inclusion criteria. Subsequently, among the records that successfully cleared this preliminary screening, active efforts were exerted to retrieve nine reports deemed relevant to the research objectives. Nonetheless, it is noteworthy that one report proved unobtainable. Consequently, a total of eight reports were meticulously assessed for their eligibility, resulting in the exclusion of five reports. Of these, four were excluded for their failure to engage with the NOMS framework, while one was dismissed for its identification as a meeting abstract. This systematic review incorporated a select group of three studies (n = 300), which were found to align closely with the predefined inclusion criteria.[12–14] Detailed study flow is presented in Figure 1.

The research endeavours took place in a range of geographical settings. Hubertus et al.[13] involved collaboration among seven academic institutions across Europe, fostering a multinational research effort.[13] In contrast, Suvithayasiri et al.[14] spanned multiple countries, including South Korea, Thailand, Taiwan, Mexico, Brazil, Argentina, Chile and India, reflecting a global scope.[14] On the other hand, Hubertus et al.[12] was specifically conducted in Berlin, Germany, focusing on a more localised context.[12] The total number of participants in each study varied, with Hubertus et al.[13] encompassing a substantial cohort of 238 individuals, Suvithayasiri et al.[14] involving 29 participants, and Hubertus et al.[12] comprising a cohort of 33 subjects.[12–14] The temporal aspect also varied, with Hubertus et al.[13] extending over a comprehensive 14-year period, Suvithayasiri et al.[14] spanning a decade, and Hubertus et al.[12] being conducted within a relatively shorter 3-year timeframe.[12–14]

The assessment of outcomes within the NOMS framework revealed noteworthy distinctions across the studies. Hubertus et al.[13] harnessed the NOMS framework to prognosticate the overall complication rate during hospitalisation (n = 82; 34%; p = 0.026), alongside secondary outcomes

Table I: Detailed search queries

Database	Search permuatations	Total study retrieved
PubMed	"NOMS"[All Fields] AND ("framework"[All Fields] OR "framework s"[All Fields] OR "frameworks"[All Fields]) AND ((("spinal"[All Fields] OR "spinalization"[All Fields] OR "spinalized"[All Fields] OR "spinally"[All Fields] OR "spinals"[All Fields]) AND ("metastasi"[All Fields] OR "neoplasm metastasis"[MeSH Terms] OR ("neoplasm"[All Fields] AND "metastasis"[All Fields]) OR "neoplasm metastasis"[All Fields] OR "metastasis"[All Fields])) OR (("spinal"[All Fields] OR "spinalization"[All Fields] OR "spinalized"[All Fields] OR "spinally"[All Fields] OR "spinals"[All Fields]) AND ("metastasation"[All Fields] OR "metastasic"[All Fields] OR "metastasing"[All Fields] OR "metastasise"[All Fields] OR "metastasised"[All Fields] OR "metastasises"[All Fields] OR "metastasising"[All Fields] OR "metastasization"[All Fields] OR "metastasizes"[All Fields] OR "metastasizing"[All Fields] OR "neoplasm metastasis"[MeSH Terms] OR ("neoplasm"[All Fields] AND "metastasis"[All Fields]) OR "neoplasm metastasis"[All Fields] OR "metastase"[All Fields] OR "metastases"[All Fields] OR "metastasize"[All Fields] OR "metastasized"[All Fields]))	14
Euro PMC	"NOMS framework" AND "spinal metastasis" OR "spinal metastases"	56

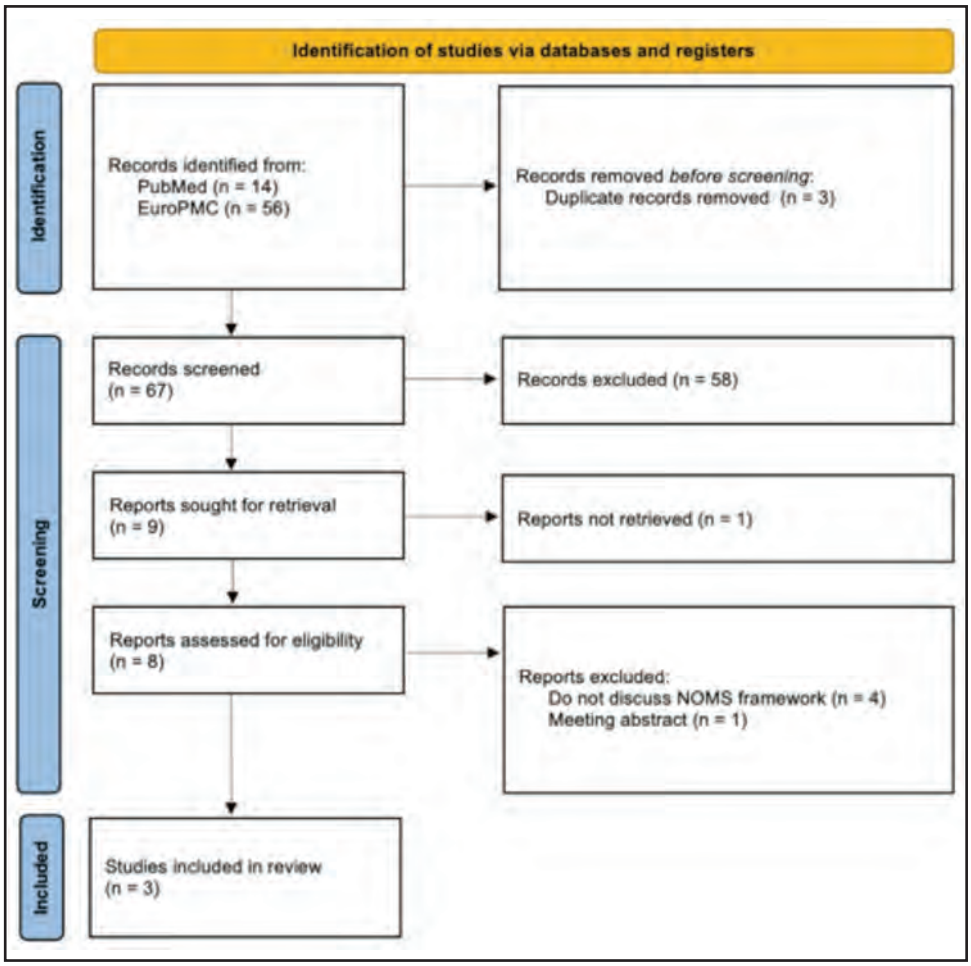

Fig. 1: PRISMA flow diagram of current systematic review.

encompassing surgical revision rate (n = 1; 3.4%), hardware failure (n = 8; 18%; p < 0.0001), postoperative mortality (n = 12; 5%; p = 0.7792), length of hospital stay (15 ± 9 days; p < 0.0001), and ICU duration (1 ± 4 days; p < 0.0001).[13] Conversely, Suvithayasiri et al.[14] primarily explored the symptomatic tumour recurrence rate using the NOMS framework, demonstrating correlations with performance status – Eastern Cooperative Oncology Group (ECOG) (p < 0.05), neurological status – Oswestry Disability Index (ODI) and Neck Disability Index (NDI) (p < 0.05), pain levels – Numeric Rating Scale (NRS) and Visual Analogue Scale (VAS) (p < 0.05) and quality of life determined by EuroQoL 5-Dimension 5-Levels (EQ5D5L) with p value less than 0.05.[14] Lastly, Hubertus et al.12 primary outcome of interest was the evaluation of CFRP pedicle screw placement accuracy (n = 69 vs 68 vs 25; 74% vs 69% vs 49% for intraoperative CT vs

Table II. Characteristics of included study that assess the NOMS framework in spinal metastasis patients (n = 300)

Study ID, NOS	Location of study was conducted	Total cohort	Study duration	Patients	Interventions	Outcomes	Allocation concealment
Hubertus 202113 7 (good)	Seven academic institutions across Europe	238	2005 - 2019	Metastases at the CTJ (C7–T2)	Posterior decompression only, posterior decompression and fusion, anterior corpectomy and fusion, and anterior corpectomy and 360° fusion	**Primary:** The overall complication rate during the hospital stay. Secondary: Surgical revision rate, hardware failure, secondary deformity, local tumour recurrence, postoperative survival, length of hospital stay, length of stay on an intensive care unit (ICU), and discharge status	A – Adequate
Suvithayasiri 202314 6 (good)	South Korea, Thailand, Taiwan, Mexico, Brazil, Argentina, Chile, and India	29	2012 - 2022	Patients with spinal metastases who underwent endoscopic spine surgery	Uniportal and biportal endoscopy	**Primary:** Symptomatic tumour recurrence rate Secondary: Performance status, neurological status, pain levels, functional disability, and quality of life.	A – Adequate
Hubertus 202212 6 (good)	Berlin	33	2018 - 2021	Navigated instrumentation using carbon fibre reinforced (CFRP) polyether ether ketone (PEEK) pedicle screw implants with or without combined corpectomy	Radiolucent carbon-fibre reinforced PEEK implants	**Primary:** The accuracy of CFRP pedicle screw placement Secondary: The assessability of the screws, duration of surgery, number of intraoperative scans per patient, number of navigated screws per patient, number of instrumented segments per patient, and the inter-observer reliability between resident and expert observers	A – Adequate

robotic CT vs cone beam CT group, respectively, with a p value of < 0.001), with the NOMS framework aiding in the stratification of secondary outcomes including screw assessability (n = 92 vs 90 vs 48, p = 0.047), surgery duration (n = 248 min vs 202 min vs 193 min, p = 0.731), intraoperative scans (n = 2 vs 2 vs 2, p = 0.698), navigated screws (n = 8 vs 8 vs 8, p = 0.836), instrumented segments (n = 5 vs 5 vs 5, p = 0.835), and inter-observer reliability by Landis & Koch > 0.6.[12] This framework facilitated a comprehensive understanding of the multifaceted dimensions of each study's research questions and outcomes, enriching their respective findings. It is worth noting that allocation concealment was reported as adequate in all three studies, emphasizing the commitment to methodological rigour.

DISCUSSION

These studies highlight the importance of considering the NOMS framework in the treatment decision-making process for spinal metastases. While surgical management plays a significant role, the use of minimally invasive treatment modalities such as stereotactic body radiotherapy (SBRT) is also gaining prominence.[6] The NOMS framework provides a comprehensive approach that takes into account the neurologic, oncologic, mechanical and systemic factors to guide treatment decisions and optimise patient outcomes.[15]
Support for the feasibility of implementing the NOMS framework in clinical settings for spinal metastasis patients lies in its standardisation capabilities. NOMS offers a uniform approach to documenting interventions and outcomes, which proves particularly beneficial for conditions as intricate as spinal metastasis, necessitating consistent and well-documented care.[1,15,16] Moreover, NOMS promotes evidence-based practice by facilitating systematic recording and tracking of intervention outcomes by clinicians. This, in turn, fosters a more informed approach to patient care, aligning with the goal of delivering tailored care to meet the unique requirements of spinal metastasis patients.[1,7,9] The framework further emphasises patient-centred care by honing in on outcomes and interventions that directly address individual patient needs, further enhancing the patient's experience. Additionally, NOMS empowers data-driven decision-making by allowing healthcare providers to collect and analyse data. This, in turn, aids in making informed decisions about spinal metastasis patient care, potentially leading to more effective care plans and improved patient outcomes.[15,17] Lastly, it serves as a catalyst for interdisciplinary collaboration, facilitating communication and fostering a holistic care approach among healthcare professionals when dealing with the multifaceted needs of spinal metastasis patients.

However, there are opposing views regarding the feasibility of implementing the NOMS framework in clinical settings for spinal metastasis patients. Critics contend that its comprehensive nature can be intricate and time-consuming, potentially adding to clinician's workloads in fast-paced clinical environments, potentially diminishing consistent utilisation.[7,18] Furthermore, the framework's implementation may necessitate significant resources in the form of training, technology and data collection and analysis infrastructure, which may not be readily available in all healthcare facilities. Concerns also arise regarding potential data overload, as NOMS generates substantial data.[15] Without efficient data management systems, healthcare providers may encounter difficulties in extracting meaningful insights from the vast amount of information, which could impede practical application. Integration challenges may also emerge when attempting to align the NOMS framework with existing electronic health record systems or other documentation tools, potentially resulting in redundant efforts and documentation inconsistencies.[15,19] Furthermore, the framework's applicability in the context of spinal metastasis patients may be questioned due to limited research directly addressing this patient population. The absence of specific evidence regarding its effectiveness for these patients raises concerns about its appropriateness. Lastly, the complexity of spinal metastasis patient needs may not be fully encompassed by the NOMS framework, necessitating potential customisations to adequately address the unique challenges posed by this patient group.[15,17]

Both Hubertus et al.[12] and Suvithayasiri et al.[14] investigated the application of the NOMS framework to analyse spine metastasis encounter several limitations. Hubertus et al.[12] acknowledge the retrospective design and small sample size of their study, along with the absence of systematic outcome assessments such as pain and quality of life scores, as well as follow-up on implant durability. They also face challenges in comparing individual radiation exposure due to different dosage units recorded by various modalities. Similarly, Suvithayasiri et al.[14], in their retrospective study, encounter inherent biases and suggest the necessity for a control group to better demonstrate the efficacy of the endoscopic spine surgery (ESS) technique. They also note variations in practice, equipment settings, and learning curves among surgeons, alongside potential selective bias in patient inclusion, posing significant challenges. Additionally, the poor prognosis of spinal metastasis patients impacts dropout rates, although mean survival time remains consistent with previous literature.

Clinical Implications

Clinicians can employ the NOMS framework to assess the comprehensive needs of spinal metastasis patients, encompassing physical, psychological and social aspects, and monitor their progress throughout hospitalisation. Additionally, NOMS can facilitate the development of standardised care plans tailored to the specific nursing interventions and outcomes relevant to spinal metastasis patients, ensuring consistent and evidence-based care.2[0] Additionally, clinician can use NOMS to evaluate patients' educational requirements regarding their condition, treatment choices and self-management strategies, enabling the creation of customised education plans.[3] The framework also aids in symptom tracking and gauging the effectiveness of interventions, allowing for timely adjustments to treatment plans.

At rehabilitation facilities, NOMS can measure and document the functional outcomes of spinal metastasis patients, guiding physical therapy and rehabilitation efforts.[19] Furthermore, it plays a crucial role in tracking pain-

related outcomes, facilitating the assessment of pain management intervention effectiveness. In palliative care settings, NOMS assists in assessing and documenting changes in patients' quality of life over time, guiding interventions to enhance comfort and well-being.[3,21] Additionally, it aids in documenting communication and collaboration among the healthcare team, ensuring that palliative care goals align with the patient's preferences.

The NOMS framework can standardise data collection on nursing outcomes and interventions, enhancing research reliability.[17,19] Researchers can leverage NOMS to generate the evidence on the efficacy of various nursing interventions and their impact on patient outcomes.20 NOMS can support care continuity for chronic spinal metastasis patients by documenting long-term outcomes and interventions.

Future Directions

The NOMS framework can potentially lead to improved patient-centred care by emphasising nursing outcomes and interventions.[7] This might pave the way for more personalised and effective care tailored to the unique needs and preferences of spinal metastasis patients. Second, as healthcare technology and data analytics continue to advance, there is potential for enhanced data collection and analysis using digital solutions. This could offer deeper insights into which nursing interventions yield the best outcomes for these patients, ultimately improving the quality of care. Third, interdisciplinary collaboration is vital for the complex care of spinal metastasis patients, involving nurses, physicians, physical therapists, social workers and others. NOMS could serve as a shared language, facilitating communication and collaboration among healthcare professionals.[19] Fourth, the framework may contribute to evidence-based practice by standardising the measurement and reporting of nursing outcomes, supporting the generation of evidence that informs best practices and guidelines for spinal metastasis patient care. Fifth, the rise of telehealth and remote monitoring highlights the potential for adapting the NOMS framework to enable remote assessment and monitoring. This could lead to more timely interventions and reduced reliance on in-person visits. Sixth, healthcare organisations might incorporate NOMS into their quality improvement initiatives, using it to track nursing outcomes and interventions over time. This data-driven approach can help identify areas for enhancement, ultimately elevating the quality of care delivered to spinal metastasis patients. Finally, NOMS can also be used to assess patient education needs and track patient self-management outcomes, potentially empowering spinal metastasis patients to actively engage in their care and make informed decisions.[3,15,20]

CONCLUSION

The neurologic, oncologic, mechanical, and systemic (NOMS) framework serves as a steadfast and invaluable tool in the realm of spinal metastasis surgery research, consistently demonstrating its capacity to elucidate associations with adverse surgical outcomes.[12,13] Within the context of investigations into spinal metastasis surgery, the NOMS framework has emerged as a comprehensive and structured approach that facilitates the categorisation and evaluation of critical parameters and endpoints.[15] Its unwavering utility lies in its ability to provide a standardised platform for defining nomenclature, thereby ensuring a common language for researchers and clinicians to communicate effectively. Furthermore, the framework extends its utility into the realm of outcomes assessment, systematically encompassing various dimensions of surgical efficacy and patient well-being. By meticulously considering a spectrum of parameters and management strategies, the NOMS framework not only establishes a robust foundation for research endeavours but also consistently unveils vital insights into the relationships between these multifaceted variables and the occurrence of adverse surgical outcomes.[15] Its enduring relevance underscores its significance as an indispensable tool in advancing our understanding of spinal metastasis surgery and enhancing the management of this complex clinical scenario.

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