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Mapping healthcare services and practice variations in spinal care across countries: The Spine Atlas Initiative

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ABSTRACT

Introduction: Inspired by cancer registration, the Spine Atlas Initiative (SAI) aims to create a global, standardised framework for mapping spine care services and treatment variations across countries. This initiative seeks to improve understanding of spine pathology trends and treatment patterns internationally.

Research question: How can a standardised international data collection and visualisation framework enhance the understanding of spine care variations and inform healthcare practices?

Material and methods: The SAI will conduct international data calls, focusing on specific spinal pathologies, beginning with lumbar degenerative spondylolisthesis (LDS) in 2025. Participants, including hospitals, registries, and practitioners, will report 7 mandatory and 7 optional data parameters. Data will be collected through templates, the Spine Tango platform, or existing registry formats. Data quality and representativeness will be strictly evaluated to ensure comparability across regions.

Results: The 2025 LDS data call has attracted over 280 surgeons from 50 countries, which expressed their interest to participate. The collected data will provide valuable insights into variations in LDS treatment practices and outcomes across different regions.

Discussion and conclusion: The SAI offers a collaborative, low-barrier approach to data collection, providing a platform for international research and comparison. The initiative will enhance understanding of treatment variability and outcomes, foster evidence-based improvements in clinical practice, and guide healthcare policy. Future data calls will expand to cover other spinal pathologies and non-surgical treatments, contributing to a global research network and improving spine care worldwide.

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1. Introduction

It is well documented, that cancer registration has been crucial for quality improvement, cancer research and for setting priorities in the health services. The data gives an overarching perspective to all key stakeholders on the treated study population and applied treatments, which is essential for their actions. For example, Cancer in Five Continents is a long-standing initiative, starting with the first publication in 1966 (Doll et al., 1966) in five-year intervals to make comparable data on cancer incidence from a wide range of geographical locations worldwide available (Ferlay et al., 2024a). Over the years data collection and quality increased significantly, resulting in more detailed analyses and data collections such as for cancer survival by the CONCORD study (Allemani et al., 2018). Web-based information platforms such as the Global Cancer Observatory (GCO) (Ferlay et al., 2024b) provide global and interactive up-to-date cancer statistics to inform the public, cancer control and cancer research, and focuses on the visualisation of cancer indicators.

The Spine Atlas Initiative (SAI) was inspired by these efforts, adapting them to the current situation and needs in spine care. Each data call within the SAI will provide a unique source of comparable treatment data for researchers worldwide. Each subsequent data call will facilitate the understanding of the evolving magnitude and patterns of spine pathologies in different regions/countries. A strict evaluation of the data quality will ensure comparability across different periods and regions. This paper lays out a common approach for cross-border data exchange including an approach for combining data from existing registries, aiming for maximal coverage with minimal efforts.

Spinal treatment has witnessed significant advancements over the past decades (Shetty and Raja, 2023), and there is considerable variation in treatment practices, both across and within countries (Weeks et al., 2014; Macêdo Filho et al., 2020; Debono et al., 2018; Cardinal et al., 2022; Austevoll et al., 2020). This disparity may be related to differences in patient demographics, their health problems, and expectations (Cardinal et al., 2022). Furthermore, a growing range of available implants, varying regulatory protocols, differences in clinical practices, training of physicians, local healthcare systems, insurance policies, budgetary constraints and financial incentives further shape treatment accessibility and delivery (Shetty and Raja, 2023; Austevoll et al., 2020; Debono et al., 2018; Macêdo Filho et al., 2020; Weeks et al., 2014; Lønne et al., 2019). Finally, controversy about the effectiveness and safety of spine implants also impacts clinical decision-making. These factors result in substantial heterogeneity that remains underexplored, with limited cross-border data on treatment numbers and types.

New knowledge about variation in these parameters could therefore aid in understanding disparities in surgical outcomes and the quality of spine treatment across countries.

Currently, there is no standardised multinational epidemiological or health services research platform on spinal treatments. To our knowledge, only three studies based on the national spine registries from Denmark, Norway and Sweden have been published from 2011 to 2013. These countries are quite homogeneous concerning socioeconomic, demographic, health- and welfare parameters. Still, they found significant differences in patient selection and treatment of degenerative disc disease (Andersen et al., 2019), lumbar spinal stenosis (Lønne et al., 2019) and disc herniation (Lagerbäck et al., 2019). This underscores the need for a systematic, cross-institutional, and cross-country assessment of spinal care. To enable the detection of possible unwarranted variation, countries and institutions outside Scandinavia where variability might be higher should be included.

Understanding treatment variations is critical for addressing challenges across multiple domains:

1.1. Epidemiology

To describe the burden of pathologies within and between countries, patient populations, surgical indications, and hospital/country variations and understand the distribution of spinal pathologies that are treated across countries.

1.2. Health policy

To inform the development of spinal care structures, workforce planning, and training programs within individual countries and internationally. Additionally, to identify and understand unwarranted variations in the availability, accessibility, and organisation of spinal cord injury services — including surgical and non-surgical treatments — across healthcare systems.

1.3. Clinical practice

To foster harmonisation of spinal treatment according to guidelines, increasing effectiveness and safety for patients. Surgical practice and other therapies can vary greatly for spine conditions, even within the same geographical region and among colleagues at the same institution.

1.4. Research

To document the baseline status before initiating new projects, to take into account the level of variation of treatments and patient populations across countries for inferences regarding study results, to establish a network of spine treatment specialists and further research collaboration, and to provide a growing research database.

1.5. Pathology and therapy registration

To further develop and harmonise the registration of spinal pathologies and therapies across European countries.

1.6. Spine registries

Data extractions, mappings and data comparisons will support the harmonisation of the data structure within spine registries, which established an International Spine Registries (ISR) working group in 2023 for this purpose. The Spine Atlas Initiative follows the recommendation of the ISR, by applying the ISR standardised core dataset developed in Frankfurt in 2023.

1.7. Goal of the spine atlas initiative

The goal of the SAI is to establish a standardised framework for data collection and visualisation across spine care services. This framework is designed to support health services research and epidemiological studies, enable benchmarking across regions and systems, and provide actionable insights to administrators and policymakers to guide the harmonisation and improvement of spine care practices.

2. Methods

2.1. Organisational structure

The SAI is led by a principal investigator (PI) and supported by a multidisciplinary international steering committee comprising experts in epidemiology, clinical research, spine registries, orthopaedic surgery, neurosurgery, and other professions. The PI oversees the initiative's overall strategy, while the steering committee provides guidance on methodological approaches and data evaluation. This structure ensures that the initiative maintains scientific rigour, fosters collaboration among stakeholders, and adapts to emerging challenges. With the planned expansion of data calls and diversification of covered topics, it is planned to split off the scientific tasks into scientific committees for each data call while the steering committee will focus more on planning, advocacy, and dissemination.

2.2. Study framework

The Spine Atlas Initiative (SAI) is a framework for international data calls. Each data call will have an adapted protocol based on the Spine Atlas protocol. The data calls will each have their inclusion criteria and will be limited to one pathology per data call. They will be designed as international cross-sectional or cohort studies with or without follow-ups, collecting data on patients treated within a 3-month window. This approach was chosen by the steering committee to maximise population coverage, by minimising the burden of data collection on treating professionals. To provide a snapshot of the real situation by country, priority was given on reducing individual efforts, to motivate participation from a wide variety of practitioners, including those that would not typically participate in research studies. In future, the time period to be covered for each pathology and/or treatment will be defined individually, based on the participation patterns in the previous data calls. For rare pathologies and treatments longer time periods to be covered will certainly be required.

2.3. Recruitment of participants

Participants include private practitioners, individual hospitals, and established regional or national spine registries. As a result, participation can be at the personal, hospital or spinal registry level.

The SAI team developed a detailed communication strategy for the recruitment of participants. The participants are recruited via different channels including the official website of SAI (EUROSPINE, 2025), meetings, presentations at conferences, social media, and direct mailings to members of EUROSPINE the Spine Society of Europe. We reach out to existing spine registries, national societies, such as members of the European Spine Society Advisory Board (EUSSAB), EUROSPINE and members of the European Association of Neurosurgical Societies (EANS) members, as well as individual hospitals, practitioners and other relevant stakeholders specific to chosen data call topics. Participants who register for participation in a data call are also provided with advocacy material to promote the SAI.

2.4. Data collection

For each data collection, a list of parameters will be divided into a mandatory and optional set, to facilitate participation for those with limited resources. The mandatory data parameters will include demographic information, pathology classification(s), and treatment measures. Optional parameters capture additional clinical and demographic predictors. Data definitions are detailed in an accompanying codebook. An example from the first data call is shown in Table 1.

Data submission options include:

- An Excel template with secure file transfer.
- Online case report forms via the Spine Tango platform.
- Existing registry datasets adhering to standardised formats.

SAI participants are also required to answer a survey on the data collection, the health system, and the quality of the data, see Appendix B Participants survey. These surveys will capture essential information about institutional coverage, the completeness of submitted datasets, and potential biases in the data collection process.

Overall efforts for SAI participants are kept as low as possible. Besides the data collection, submission and answering of the survey, they must clarify ethical issues and may have to seek authorisation from the ethics committee or institutional review board. If applicable in their country the need to collect patient consent. The SAI provides templates and helpful resources to facilitate this step.

Table 1
List of parameters for the SAI data call 2025 on adult surgical LDS patients.

Parameter	Details
Mandatory Parameters	
1. Patient age at surgery date	In whole years
2. Patient gender	
3. Surgery date	Feb–Apr 2025
4. Primary spine surgery	At the operated level
5. Type of spinal stenosis	Central or lateral, foraminal
6. Grade of LDS	(a) By Meyerding OR (b) in mm
7. Surgical measures	(a1) Decompression type and (a2) Level(s) (b1) Fusion type and (b2) Level(s) (c1) Stabilisation rigid type and (c2) Level(s) (d1) Dynamic stabilisation and (d2) Level(s) (e1) Other surgical treatment and (e2) Level(s)
Optional Parameters	
8. Additional spinal pathology	
9. ASA status	
10. Number of previous spine surgeries	At the same or adjacent level
11. Duration of symptoms	
12. Height and weight	(a) Height (b) Weight (c) OR alternatively BMI
13. Current smoker status	
14. Implant data	(a) Manufacturers (b) Article numbers

2.5. Statistical methods

For each data call, the SAI steering committee will decide which analyses will be done specifically and develop a protocol including a statistical analysis plan (SAP) employing a variety of descriptive and comparative analyses.

For each data call, we will describe the data collection outcome including measures for coverage, representativeness, potential biases, completeness etc.

The steering committee will decide, based on the participant survey, which countries have sufficient data representativeness to be included as a separate entity in the data analyses. Representativeness will be assessed separately for single parameters where participants indicated to have incomplete data parameters.

2.6. Data usage and retention

Hospital-level data will remain confidential and disclosed only with explicit authorisation of the hospital. Data will be securely stored on a Swiss-based server with restricted access for 15 years to facilitate long-term research and follow-up studies. The SAI follows the applicable data protection regulations.

The results from each data call will be published in scientific journals, on the SAI website, in general media, in educational programs for health professionals and presented at conferences. Authorship of the first two main publications per data call will include participants who significantly contribute to the study. All other participants will be listed as the Spine Atlas Working Group (SAWG) ensuring appropriate recognition. Max. 2 persons per data contributor/institution will be named rotationally, while all other persons assisting in data contributions will be listed in the acknowledgements. Spine registries may be permitted to have more than 2 authors on a case-by-case basis.

Data reuse for subsequent analyses or publications will be governed by the steering committee, ensuring alignment with ethical standards and avoidance of duplication. Participants will retain the right to propose research projects using the pooled data, subject to committee approval, fostering transparency and collaboration.

2.7. Ethical considerations

The Spine Atlas Initiative (SAI) ensures that all submitted data is anonymised to protect patient privacy and confidentiality. Anonymised data collection ensures compliance with international privacy regulations. Participants are responsible for obtaining patient consent unless waived by local laws. The protocol was reviewed by the ethics committee of Eastern Switzerland, confirming no additional ethical approvals are required for anonymised data. BASEC submission no. AO_2024-00111.

For existing Spine Tango users, data usage and privacy protection are governed by the platform's Terms and Conditions. Additionally, all participants must confirm permission to use the submitted material by acknowledging the Terms and Conditions (Appendix C Terms and Conditions), ensuring patient consent was obtained unless exempted by local law, such as for anonymised data from national registries. Submitted data will not be used for any purpose beyond those outlined in the protocol without explicit participant approval.

2.8. *Risk and benefit evaluation*

The assessment of this study indicates minimal risks across various categories. Physically, the study poses no additional risk since it solely observes existing clinical practices without influencing treatment decisions. Psychologically, the risk remains low, as data collection follows standard (hospital) procedures, and obtaining patient consent is a routine process. However, in centres unfamiliar with obtaining specific consent for such studies, minor discomfort may occur.

Socially, privacy risks are mitigated through stringent data security measures, ensuring no invasion of privacy or potential harm to community standing. Legally, the study aligns with data protection regulations, requiring institutions to adhere to their own legal requirements, with collaboration governed by project terms and IT security protocols. Economically, the study imposes a minimal burden, with data entry requiring little effort.

Despite no direct benefits to individual participants, the study is expected to contribute significantly to the broader understanding of spinal pathology management. Insights from this research will aid in refining healthcare strategies, guiding policy development, and improving clinical decision-making on an international scale.

2.9. *Outcomes*

The outcomes will largely depend on the topic and nature of the respective data call. In principle, the primary aim will be to describe differences in patient populations, treatments and outcomes across participating countries. Secondary outcomes include:

- Benchmarking reports for individual hospitals
- Identification of predictors influencing treatment decisions
- Insights into potential predictors for variability in patient populations and treatment differences
- Variations in access to different forms of spine care
- Other outcomes depending on the nature of the specific data call

2.10. *Further information*

The SAI website (EUROSPINE, 2025) provides all the necessary details for the interested public. Participants in a data call have access to additional information tailored to each data call. A secure platform to manage their registration, download assets, upload data and the participant survey is currently under development.

3. Implementation, data call 2025 on lumbar degenerative spondylolisthesis

The data call of 2025 represents the SAI implementation and will evaluate patients operated for lumbar degenerative spondylolisthesis (LDS) between 1 February – April 30, 2025.

- Included are patients 18 years of age or older with Meyerding (Koslosky and Gendelberg, 2020) grades 1–4.
- Excluded are patients with Meyerding grades 0 (lysis) and 5 (ptosis) as well as surgeries including levels above L1.

Meyerding grade 0 spondylolisthesis is excluded because it is related to isthmic spondylolisthesis involving pars interarticularis defects (lysis), with no measurable forward slippage of one vertebra over another, which is a different condition from lumbar degenerative spondylolisthesis with a slippage of one vertebral body over another. The rationale for excluding LDS with Meyerding grade 5 (ptosis) relates to its rarity and the fact that surgery is an established standard of care.

The participants of the data call will collect and report 7 mandatory and 7 optional data parameters.

The initiative was first presented to a wider audience at the EUROSPINE Annual Meeting 2024 in Vienna and sparked immediate interest from a variety of stakeholders, including spine registries, spine surgeons, spine societies, MedTech, and notified bodies. Until the end of January, approximately 280 surgeons from 160 institutions from 50 countries completed the registration to participate in the SAI data call 2025 on LDS, see Fig. 1.

3.1. *Rationale for the focus on LDS*

LDS is a well-known lumbar spinal pathology that presents a common problem in daily spinal practice. It is characterised by slippage of one vertebral body over another due to disc degeneration and facet arthropathy, most commonly in combination with various degrees of spinal canal stenosis and/or foraminal stenosis at the affected level. The symptoms are usually a combination of stenotic-type radiating buttock and leg pain and mechanical low back pain. Conservative management is usually tried first, but if unsuccessful, surgery can be advocated for and has repeatedly demonstrated good results in various studies (Kleinstueck et al., 2012; Pearson et al., 2008). One of the controversies in spine surgery during the last decade has been whether to add a fusion to a surgical decompression or not in LDS cases. Although good quality randomised controlled trials (RCTs) are almost unanimous in demonstrating that fusion has no benefit over decompression only, some trials and meta-analyses still show contradictory results and conclusions (Weinstein et al., 2009; Kaiser et al., 2023; Arimbawa et al., 2023). In any case, it is not known to what extent current clinical practice varies in terms of the treatment provided.

3.2. *Data parameters*

The list of parameters is based on the harmonisation work and output of the ISRG and was further developed during the review rounds of the SAI proposal by the SAI steering committee, the Spine Tango Committee, the EUROSPINE Research Committee, the ISRG and other involved individuals.

The selection was based on the criteria to have a core mandatory dataset, which contains the most important information to describe the patient populations, type of LDS and surgical intervention.

The optional parameters were also kept minimal and contain predictors of surgical outcome as described previously in the literature and three additional questions on pathology and surgery. Outcomes are not included in the variable list. See the full list of parameters in Table 1.

The exact variable definitions are outlined in the Appendix A Codebook.

For the grade of LDS, surgical measures and levels and additional pathology multiple answers are allowed. Implant data should be given as lists if multiple implants are used.

4. Discussion

The Spine Atlas Initiative introduces a pragmatic, low-barrier

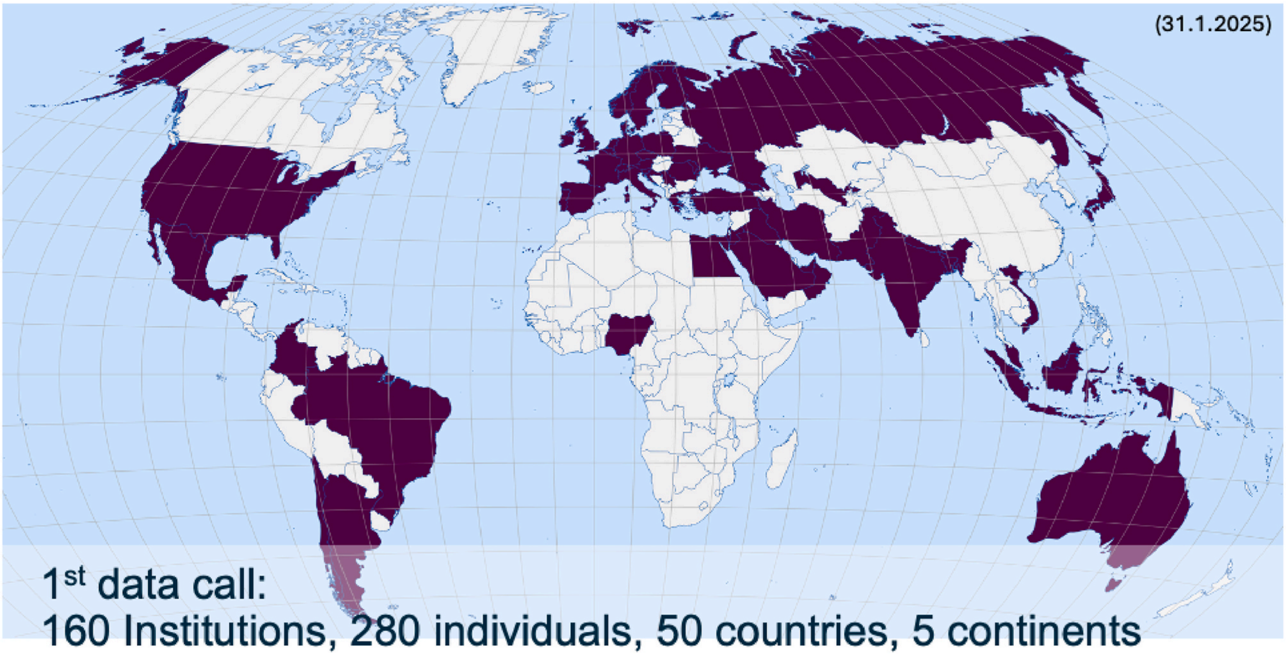

Fig. 1. Map of countries with registered participants to the SAI data call 2025.

framework for harmonised data collection and comparison across diverse healthcare systems. It fills a critical gap in global spine health services research by enabling cross-country comparison of treatment availability, patterns, and organisation—domains that have remained under-explored to date.

Participation in the SAI is designed to require minimal effort while offering significant benefits. Contributors join an international network of leading spine care professionals and researchers across Europe, receive benchmarking reports comparing their data with pooled international findings and participate as co-authors in high-impact publications. This facilitates both scientific collaboration and professional visibility.

The SAI will provide a comprehensive overview of patient populations, pathologies, and interventions across regions. These statistics will highlight key patterns and variations in demographic and clinical characteristics and contribute to evidence-based advancements in clinical practice and policy.

Comparative analyses for countries with sufficiently representative data will employ logistic regression models and other advanced statistical tools to identify predictors influencing decision-making in treatment paths and to assess variations between countries. Factors such as age, gender, comorbidities, other optional parameters and institutional practices will be considered to ensure nuanced and accurate analyses. Sensitivity analyses will be conducted to validate findings and identify any anomalies or inconsistencies.

The main indicators will be visualised on maps to provide an intuitive and accessible overview of geographic variation in spine care, making complex data easier to interpret for clinicians, researchers, and policymakers. This visual approach supports rapid identification of disparities, facilitates benchmarking, and aids in communicating findings to diverse stakeholders involved in healthcare planning and decision-making.

By focusing on LDS in its first data call, a common yet inconsistently managed spinal condition, the initiative aims to generate new actionable insights into patient selection and surgical practice variation to inform clinicians, administrators and policymakers. Challenges include ensuring data representativeness and addressing potential biases.

Future rounds of data collection will expand the SAI to other spinal pathologies and non-surgical forms of treatment, further strengthening the evidence base and promoting global collaboration in spine care research. A strict evaluation of the data quality will ensure comparability across different periods and regions.

5. Conclusion

The SAI addresses a critical need in spine care by enabling international comparison of treatment practices and healthcare provision. It generates new, high-value knowledge on disparities in spine care delivery. These insights will directly support clinicians in refining practice, inform administrative planning, and enable policymakers to address systemic disparities. In doing so, the initiative provides a foundation for harmonising spine care delivery and driving quality improvement across health systems.

This collaborative, registry-friendly approach has already drawn strong interest from individual spine specialists and established registries alike. It represents a missing but essential step toward advancing health services research in spine care.

We warmly invite spine professionals worldwide to join this initiative and contribute to shaping the future of spinal healthcare.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bas.2025.105622.

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