

Falling Out of Favor: Practice Patterns of Shock Wave Lithotripsy in the Era of Endourology: A FUTURE Worldwide Survey

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Abstract

Introduction:

Shock wave lithotripsy (SWL) has declined with the expansion of endourological techniques, but remains widely available. Contemporary data on SWL utilization, technical delivery, operator models, outcome assessment, and artificial intelligence (AI)-based tools are limited. This study evaluated current SWL practice patterns among urologists involved in stone disease management.

Methods:

A cross-sectional web-based survey was developed by the Kidney Stones Pillar of the FUTURE collaborative group and distributed through the Endourological Society mailing list and X platform between February and April 2026. The questionnaire assessed SWL utilization, decision-making, technical parameters, operator profile, follow-up, outcome definitions, and AI use. Categorical variables were summarized as frequencies and percentages.

Results:

A total of 156 responses from 32 countries were analyzed. Overall, 121 respondents (77.6%) used SWL in $\leq 15\%$ of stone cases, including 26 (16.7%) who did not use SWL. Among applicable respondents, 65.8% perceived a decline in SWL use over three years. Treatment selection was mainly based on guidelines and objective criteria (76.2%). Electromagnetic lithotripters were most common (51%), and most systems were ≥ 6 years old. Operator experience was perceived as highly influential, although formal training was inconsistent. AI access was limited, with 82.3% reporting no access and 8.5% regular clinical use.

Conclusion:

SWL is used for a minority of stone cases and is perceived to be declining. Contemporary practice shows variability in patient selection, technical delivery, operator models, training, and outcome assessment. Despite favorable perceptions of AI, real-world adoption remains limited.

Introduction

Shock wave lithotripsy (SWL) has historically played a central role in the management of urinary stone disease, offering a non-invasive treatment option with low morbidity and broad applicability. Since its introduction in 1980, SWL has become a first-line treatment for many patients with renal and ureteral stones, offering a non-invasive, day-case procedure that can often be performed without general anesthesia and allows rapid recovery [1]. However, over the past two decades, there has been a marked shift toward endourological techniques, particularly ureteroscopy (URS) and percutaneous nephrolithotomy (PCNL), driven by technological advancements and improved stone-free rates [2-4]. Consequently, several studies have documented a progressive decline in the use of SWL across different healthcare systems [2, 3].

Despite this trend, SWL remains widely available and continues to be selected for appropriately sized stones in favourable anatomical conditions, supported by international guideline recommendations [1, 5]. However, the extent to which contemporary real-world practice including patient selection, lithotripter technology, energy parameters, operator profile and adoption of artificial-intelligence-based decision support aligns with guideline recommendations is unknown. Factors such as patient selection, imaging assessment, technical execution, and operator experience may influence SWL outcomes and contribute to variability in clinical practice. In parallel, there is growing interest in digital tools that may assist with stone measurement, volume assessment, and outcome prediction. Whether these tools, including AI-based approaches, have been adopted in routine SWL practice remains unclear [6].

Previous studies have described changing trends in kidney and ureteral stone management, variability in treatment selection, and differences in outcomes across practice settings and health systems [2, 7-10]. However, contemporary international data specifically focused on SWL practice patterns remain limited. Therefore, the objective of this study was to provide an international SWL-specific snapshot through the Endourological Society FUTURE Collaborative, assessing three key domains: SWL utilization and perceived decline, technical heterogeneity in treatment delivery and outcome assessment, and access to AI-based tools together with perceived barriers to adoption. These data may inform future guideline updates, training programs, and technology investment decisions aimed at optimizing SWL patient selection and outcomes.

Methods

A cross-sectional, web-based survey was designed to evaluate contemporary clinical practice patterns related to SWL. The survey was developed by members of the Kidney Stones Pillar of the FUTURE (Endourological Society Research Committee) collaborative group.

The questionnaire was constructed to capture multiple domains of SWL practice, including global utilization and trends, decision-making criteria and patient selection, the use of objective parameters (e.g., stone size, Hounsfield units [HU], and stone volume), technical aspects of SWL delivery, operator profile and training, follow-up strategies and outcome definitions, and the use and perception of AI in SWL.

The survey consisted of multiple-choice and Likert-scale questions and was designed to be completed in approximately 5–8 minutes and distributed electronically through the Endourological Society network by email and the FUTURE collaborative group using X platform. The finalized survey underwent electronic pilot testing by the FUTURE collaborative group before public release, ensuring clarity and practical completeness. IP was restricted to avoid duplicate answers.

The survey was anonymous and did not collect identifiable personal or patient data. Participation was voluntary, and completion of the survey was considered to imply informed consent. Responses were collected between February 11 and April 14, 2026 using Google Forms. No financial incentives were provided for participation. Eligible participants included practicing urologists and trainees involved in the

management of urinary stone disease. No geographic restrictions were applied; however the survey was distributed only in English.

Collected data included the estimated proportion of patients treated with SWL, trends in its utilization over time, factors influencing treatment selection, objective parameters used for SWL indication, technical variables (including lithotripter type, shock wave frequency, ramping, anaesthesia, and number of shocks), operator characteristics (including who performs SWL, their training, and the perceived importance of experience), follow-up imaging and definitions of treatment success, estimated rates of secondary endoscopic intervention, and access to and use of AI tools, as well as perceived barriers to its adoption. The full list of questions is presented in Online Resource 1.

Descriptive statistics were used to summarize survey responses. Categorical variables were reported as frequencies and percentages. For Likert-scale questions, median and mean values were calculated. Multi-select questions were analysed by reporting the proportion of respondents selecting each option. In addition, the chi-square test was used to compare categorical variables between centres with and without fellowship programs. All analyses were performed using standard Excel spreadsheet software. The study was reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [11].

Results

A total of 156 responses were obtained from 32 countries. Most responses originated from Argentina (n=59, 37.8%), followed by Brazil (n=17, 10.9%) and the United States (n=15, 9.6%). The remaining responses were distributed across multiple countries, each contributing a small number of participants. Figure 1.

The distribution of SWL utilization is shown in Table 1; overall, 121 respondents (77.6%) reported using SWL in $\leq 15\%$ of their cases, including 26 (16.7%) who reported not using SWL in their current practice. Centres with a fellowship program reported a higher mean proportion of patients treated with SWL compared to those without a fellowship (17.4% vs 12.7%, respectively) however, no statistically significant differences were observed ($p = 0.24$). Respondents were asked whether SWL use had increased or decreased over the past three years. After excluding those for whom the question was not applicable, a total of 114 responses were analyzed; among these, 75 (65.8%) reported a decrease, 32 (28.1%) reported no change, while 7 (6.1%) reported an increase.

Treatment selection and SWL candidate assessment are summarized in Table 2. Respondents most commonly relied on guidelines and objective criteria when selecting between SWL, URS, and PCNL, although surgeon preference, patient preference, and resource availability remained influential. Stone density, maximum stone diameter, anatomical factors, skin-to-stone distance, and stone volume were the most frequently used parameters for SWL candidate selection. A threshold of >1000 HU was the most commonly reported unfavorable cutoff, and most respondents limited SWL use to renal stones <10 mm

or <15 mm. Stone measurement was usually performed using standard PACS-based CT measurements or visual/manual estimation, while dedicated segmentation software was rarely used.

Access to AI tools for stone evaluation was limited, with most respondents reporting no access (Table 3). Among those with access, SWL success prediction and stone segmentation/volume assessment were the most commonly reported applications. Despite limited current use, respondents generally perceived AI as potentially valuable for improving SWL patient selection. The main barriers to adoption were lack of availability, insufficient clinical validation, and workflow integration challenges.

Technical SWL delivery showed substantial heterogeneity across respondents (Table 4). Electromagnetic lithotripters were the most commonly used device type (51%), and most respondents reported using equipment aged ≥ 6 years. Oral analgesia was the most frequent anesthesia/analgesia modality (49.5%), whereas deep sedation and general anesthesia were less commonly used. Shock wave frequencies between 61 and 100 shocks/min predominated, and energy ramping was routinely or frequently used by most respondents. The most common number of shocks per session was 2001–3000. Stone localization was performed using combined fluoroscopy and ultrasound in 38.7% of cases, fluoroscopy alone in 37.1%, and ultrasound alone in 24.2%.

SWL was most performed by the treating urologist, reported by 48.8% of respondents. Nevertheless, in 20.7% of cases, the procedure was performed by another urologist within the team and interestingly, a substantial proportion of respondents (20.7%) reported that SWL was performed by a non-physician technician/operator. Less frequently, SWL was performed by trainees under supervision (9%), while unsupervised trainee involvement was very rare (0.8%). Respondents reported a strong perceived impact of operator experience on SWL outcomes. Overall, 72.8% of respondents rated the impact of operator experience as maximal (Likert score 5), while 20% reported a high impact (score 4). Only a small proportion (5.6%) reported neutral or low perceived impact (scores ≤ 3). Formal training or credentialing to perform SWL was not uniformly established across centers. 44.5% of respondents reported no formal training or credentialing in their institution while formal training programs were reported by 27.8%, and the same percentage reported informal training pathways.

Follow-up imaging and outcome definitions are summarized in Table 5. Post-treatment assessment showed substantial variability, with X-ray KUB alone, combined X-ray KUB and ultrasound, ultrasound alone, and non-contrast CT each used by approximately one-quarter of respondents. Most respondents defined SWL success as the presence of clinically insignificant residual fragments, whereas fewer used a stricter definition of complete stone clearance or a more pragmatic definition based on symptom improvement and reduction in stone burden.

The most reported reason for using SWL was its minimally invasive nature (86.8%), followed by patient preference (70.7%), good effectiveness in selected cases (41.9%), and avoidance of general anesthesia (28.7%), while lower overall cost (24.8%) and lower perceived risk (21.7%) were also reported, and limited access to URS or PCNL was less frequently cited (8.5%).

Discussion

This international survey provides a contemporary overview of the role of SWL in modern ureteral and kidney stone management. The findings suggest that SWL has not disappeared, but has clearly shifted from a dominant first-line modality to a selective, variably delivered treatment, with low utilization rates, continued perceived decline, and substantial heterogeneity in clinical practice

The present findings suggest that, among surveyed urologists, SWL is currently used in a minority of stone cases and is perceived to be declining, consistent with previous studies documenting a shift away from SWL toward endoscopic techniques, particularly ureteroscopy [2-4]. Most respondents reported using SWL in $\leq 15\%$ of cases, and nearly two-thirds indicated a decline in its use over recent years. Interestingly, the presence of an Endourology fellowship program did not significantly affect these numbers. These results are consistent with population-based and registry studies showing a progressive reduction in SWL utilization in favor of URS, likely driven by higher stone-free rates and greater predictability of outcomes [2-4]. Despite this decline, SWL remains widely available and continues to be used across a range of clinical settings. Its persistence appears to be related to its minimally invasive nature, avoidance of general anesthesia, low cost and acceptable efficacy in selected cases, as also reflected in current guideline recommendations [1, 5].

Regarding patient selection and decision-making, most respondents reported relying on guideline-based and objective criteria when selecting patients for SWL. The widespread use of stone size, HU, and anatomical factors aligns with established predictors of SWL success [12-15]. In particular, the predominance of a <10 mm size threshold and HU cut-offs around 1000 reflects adherence to evidence-based selection criteria [1, 5]. However, additional factors such as surgeon experience, patient preference, and resource availability were also frequently reported, indicating that real-world decision-making extends beyond purely objective parameters. Although many respondents reported considering stone volume in treatment selection, only a small proportion used dedicated volumetric software, with most relying on diameter-based or visual estimation. This finding underscores a disconnection between theoretical understanding and practical implementation. Previous studies have demonstrated the potential advantages of volumetric assessment over linear measurements in predicting SWL outcomes [16]. However, limited integration into routine workflows may explain its low adoption.

One interesting finding of this study is the limited adoption of AI in clinical practice. More than three-quarters of respondents reported no access to AI tools, and only a minority reported use of AI in clinical practice. This contrasts with the growing body of literature demonstrating the potential of AI for stone segmentation, composition analysis, and outcome prediction [17-22]. Despite this, real-world implementation remains limited. The main barriers identified, the lack of availability, insufficient validation, and workflow integration challenges, are consistent with those reported in other areas of urology and medical AI. Importantly, respondents expressed a generally positive perception of AI, suggesting potential for future adoption.

Our survey revealed substantial heterogeneity in SWL delivery parameters, including lithotripter type, shock wave frequency, ramping, anesthesia, and number of shocks per session. Previous studies have suggested that lower shock wave frequencies and ramping protocols may improve outcomes and reduce tissue injury [23-25]. However, the variability observed in this study suggests that these technical principles are not uniformly implemented. Another interesting finding is that SWL systems in current use tended to be rather old, with most respondents reporting equipment aged ≥ 6 years, with almost one third of machines older than 10 years.

The present study also highlights variability in operator models, with SWL performed by urologists and non-physician personnel. Respondents reported a strong perceived impact of operator experience on outcomes, consistent with prior reports suggesting that technical expertise influences treatment success [26]. However, formal training and credentialing were not consistently established.

Follow-up strategies and definitions of success varied considerably. Most respondents defined success as CIRFs, although stricter or symptom-based definitions were also reported. This lack of standardization is well described in the literature [27].

This study has several limitations inherent to survey-based research. First, selection bias is possible, as the survey was distributed through Endourological Society channels and may therefore have preferentially reached urologists with greater interest, expertise, or leadership roles in endourology and SWL. However, this population is also highly relevant for capturing contemporary specialist practice patterns and emerging trends in stone management. Second, although responses were obtained from 32 countries across all continents, a substantial proportion originated from Argentina and Brazil, which may limit the generalizability of the findings to other regions. Nevertheless, the inclusion of respondents from diverse geographic and economic settings supports the relevance of the observed patterns across different practice environments. Third, the survey was distributed only in English, which may have limited participation from non-English-speaking urologists and introduced language-related selection bias. However, English distribution allowed standardized administration of the questionnaire across an international cohort. Fourth, all data were self-reported and therefore subject to recall bias, reporting bias, and variation in individual interpretation of survey questions. Still, anonymous reporting may have encouraged respondents to provide a realistic description of their routine practice. Fifth, the cross-sectional design provides a snapshot of current SWL practice but does not allow assessment of causal relationships or objective temporal changes beyond self-reported trends. Sixth, the analysis was descriptive, and no multivariable adjustment was performed; therefore, associations between practice patterns, regional factors, equipment availability, and operator characteristics could not be formally explored. Finally, because the denominator of urologists who received or viewed the survey invitation is unknown, a formal response rate could not be calculated. Despite these limitations, this study provides a broad international overview of contemporary SWL practice and highlights areas of heterogeneity that may inform future research, training initiatives, and guideline development.

Despite these limitations, this study provides a broad international overview of contemporary SWL practice and highlights areas of heterogeneity with practical implications for multiple stakeholders. For guideline panels, the observed variability in patient selection, treatment parameters, and outcome definitions underscores the need for clearer and more implementable recommendations. For training programs, the limited availability of formal credentialing in many centers suggests an opportunity to develop structured SWL training pathways focused on patient selection, technical delivery, imaging, and outcome assessment. For lithotripter manufacturers, the finding that most installed systems are ≥ 6 years old highlights the need for continued investment in modernization, usability, imaging integration, and treatment optimization. For AI developers, the gap appears to be driven more by limited availability and validation than by lack of clinician interest, emphasizing the need for clinically validated, workflow-compatible tools for stone characterization and SWL success prediction. Future studies should combine international prospective data collection with standardized outcome definitions to evaluate how technical parameters, operator training, equipment characteristics, and digital tools influence SWL outcomes.

Conclusion

SWL remains widely available but is used in a minority of cases in contemporary practice. Its use is characterized by significant variability in patient selection, technical execution, and outcome assessment.

The limited adoption of AI, despite high perceived potential, highlights that field endourology is in need of translational validation to bring this technology into clinical practice.

These findings provide a contemporary, multi-continental baseline against which guideline updates, training reform and AI deployment in stone disease can be measured.

Declarations

Author Contribution

Conceptualization: HS, DC, BJ, PNM, SQ, KG. Methodology: HS, DC, BJ, PNM, SQ, KG. Survey administration and data collection: HS. Formal analysis and interpretation: HS, SQ, KG. Figures: SQ. Tables: KG. Writing – original draft: HS. Writing – review and editing: HS, DC, BJ, PNM, SQ, KG. Supervision: KG. All authors read and approved the final manuscript.

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Tables

Table 1
Estimated proportion of stone patients
treated with SWL

Domain	Variable	Response
SWL utilization	0%	16.7%
	1–5%	32.7%
	6–15%	28.2%
	16–30%	11.5%
	31–50%	7.1%
	> 50%	3.8%

Table 2
Treatment selection and candidate assessment for SWL

Domain	Variable	Response
Basis for treatment selection: SWL vs URS vs PCNL	Guidelines and objective criteria	76.2%
	Surgeon experience or preference	51.5%
	Patient preference	46.9%
	Resource or technology availability	43.8%
	Cost or reimbursement considerations	15.4%
Objective parameters used to select SWL candidates	Stone density, HU	80.8%
	Maximum stone diameter	79.2%
	Anatomical factors	70.8%
	Skin-to-stone distance	66.2%
	Stone volume	52.9%
	Body mass index	36.5%
	Degree of obstruction	26.0%
	Clinical symptoms	21.2%
Unfavorable HU threshold for SWL	> 1000 HU	56.6%
	> 1200 HU	10.9%
	> 800 HU	10.9%
	No fixed HU threshold	10.1%
	HU not used for treatment selection	11.6%
Ideal renal stone size for SWL	< 10 mm	58.8%
	< 15 mm	23.7%
	< 20 mm	12.2%
	I use different parameters	5.3%
For treatment selection criteria and objective parameters, respondents could select multiple answers; therefore, percentages represent the proportion of respondents selecting each option and do not add up to 100%.		

Domain	Variable	Response
Stone measurement method	Standard PACS-based CT measurements	41.7%
	Visual or manual estimation	37.9%
	Mixed approach	13.6%
	Dedicated software for stone volume or segmentation	6.8%
Use of stone volume measurement for treatment decision-making	Routinely used	45.2%
	Used in selected cases	17.3%
	Not used	37.5%
For treatment selection criteria and objective parameters, respondents could select multiple answers; therefore, percentages represent the proportion of respondents selecting each option and do not add up to 100%.		

Table 3
Access, perceived utility, and barriers to artificial intelligence adoption in SWL practice

Domain	Variable	Response
Access to AI tools for stone evaluation	No access	82.3%
	Research-only access	9.2%
	Clinical use	8.5%
Reported AI applications	SWL success prediction	15.5%
	Stone segmentation or volume assessment	12.2%
	Treatment selection	8.2%
	Complication prediction	1.0%
Perceived potential of AI to improve SWL patient selection	High perceived impact, Likert 4–5	66.3%
	Neutral, Likert 3	17.8%
	Low perceived impact, Likert 1–2	15.9%
	Median Likert score	4
Barriers to AI adoption	Lack of availability	50.0%
	Insufficient clinical validation	29.8%
	Workflow integration challenges	29.8%
	Cost	26.0%
	Training or time constraints	19.0%
	Legal or privacy concerns	9.6%
For AI applications and barriers to adoption, respondents could select multiple answers; therefore, percentages represent the proportion of respondents selecting each option and do not add up to 100%.		

Table 4
Technical characteristics of SWL delivery

Domain	Variable	Response
Type of lithotripter	Electromagnetic	51.0%
	Electrohydraulic	26.0%
	Piezoelectric	11.5%
	More than one type	4.8%
	Unknown	6.7%
Age of SWL equipment	< 5 years	21.6%
	6–10 years	45.1%
	> 10 years	33.3%
Anesthesia/analgesia modality	Oral analgesia	49.5%
	IV analgesia / conscious sedation	25.7%
	General anesthesia	12.9%
	Deep sedation	11.9%
Shock wave frequency	≤ 60 shocks/min	22.4%
	61–80 shocks/min	45.9%
	81–100 shocks/min	30.6%
	> 100 shocks/min	1.0%
Energy ramping	Always	54.2%
	Most cases	19.8%
	Selected cases	9.4%
	No	16.7%
Number of shocks per session	< 2000	15.8%
	2001–3000	61.0%
	3001–4000	20.7%
	> 4000	2.5%
Stone localization during SWL	Fluoroscopy + ultrasound	38.7%
	Fluoroscopy alone	37.1%

Domain	Variable	Response
	Ultrasound alone	24.2%

Table 5
Follow-up imaging and outcome definition after SWL

Domain	Variable	Response
Follow-up imaging modality	X-ray KUB alone	27.1%
	X-ray KUB + ultrasound	26.4%
	Ultrasound alone	23.3%
	Non-contrast CT	23.3%
Definition of SWL success	Clinically insignificant residual fragments (CIRF)	76.0%
	Complete stone clearance / zero fragments	17.8%
	Symptom improvement + reduction in stone burden	6.2%

Figures

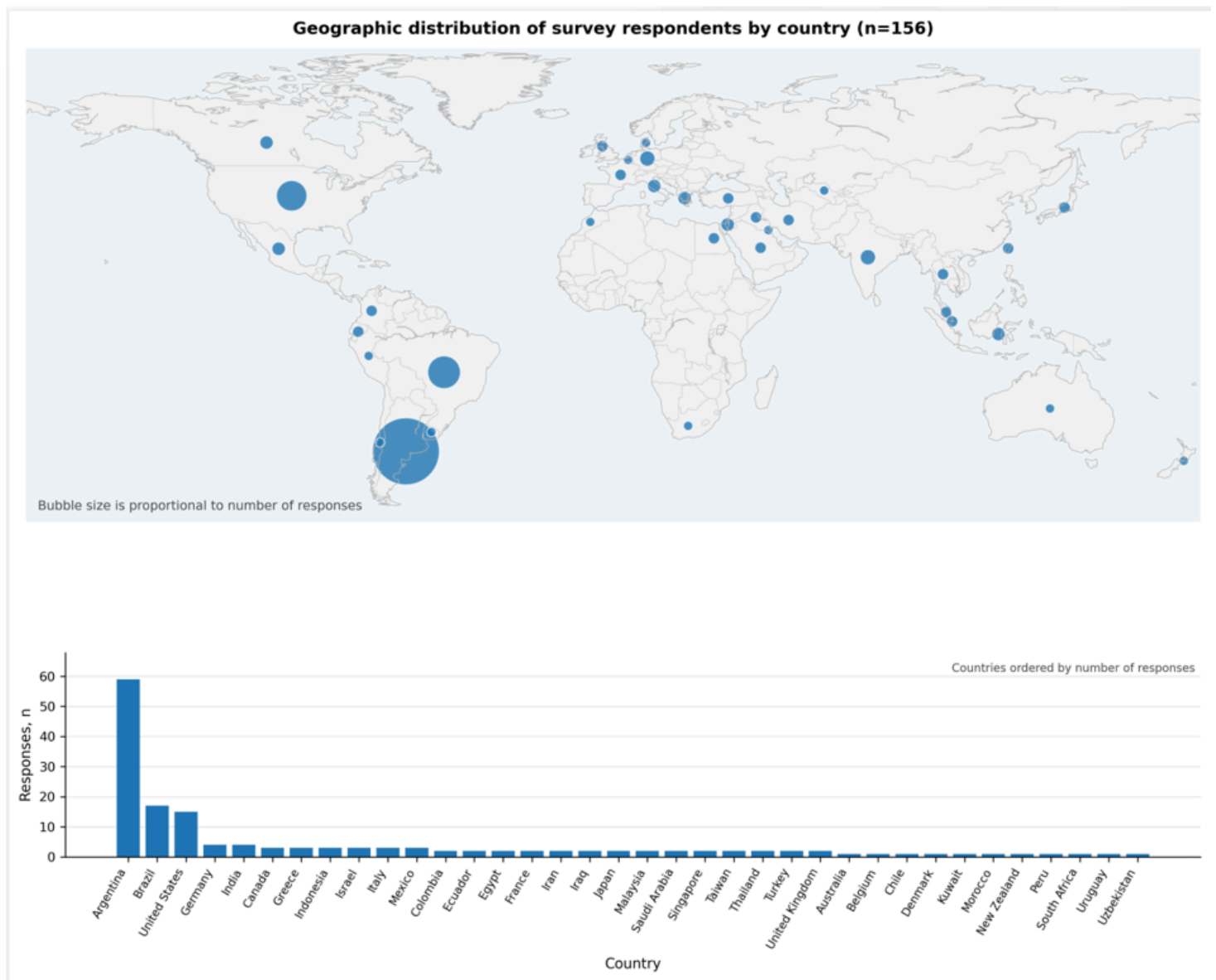


Figure 1

Geographic distribution of survey respondents

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