Check for updates

Global Spine Journal
2021, Vol. 0(0) 1–15
© The Author(s) 2021
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/21925682211058158
journals.sagepub.com/home/gsj

Research Practices and Needs Among Spine Surgeons Worldwide

Niccole Germscheid, MSc[1], Jason P. Y. Cheung, MBBS, MS, MD[2], Marko H. Neva, MD, PhD[3], F. Cumhur Öner, MD, PhD[4], Brian K. Kwon, MD, PhD[5], Marcelo Valacco, MD[6], Waleed Awwad, MD[7], Daniel M. Sciubba, MD[8], Stephen J. Lewis, MD[9], Laurence D. Rhines, MD[10], S. Tim Yoon, MD, PhD[11], Mauro Alini, PhD[12], Sibylle Grad, PhD[12], Charles G. Fisher, MD, MHSc[5], and Dino Samartzis, DSc[13]

Abstract

Objective: Resource allocation to research activities is challenging and there is limited evidence to justify decisions. Members of AO Spine were surveyed to understand the research practices and needs of spine surgeons worldwide.

Methods: An 84-item survey was distributed to the AO Spine community in September of 2020. Respondent demographics and insights regarding research registries, training and education, mentorship, grants and financial support, and future directions were collected. Responses were anonymous and compared among regions.

Results: A total of 333 spine surgeons representing all geographic regions responded; 52.3% were affiliated with an academic/university hospital, 91.0% conducted clinical research, and 60.9% had 5+ years of research experience. There was heterogeneity among research practices and needs across regions. North American respondents had more research experience ($P = .023$), began conducting research early on ($P < .001$), had an undergraduate science degree ($P < .001$), and were more likely to have access to a research coordinator or support staff ($P = .042$) compared to other regions. While all regions expressed having the same challenges in conducting research, Latin America, and Middle East/Northern Africa respondents were less encouraged to do research ($P < .001$). Despite regional differences, there was global support for research registries and research training and education.

Conclusion: To advance spine care worldwide, spine societies should establish guidelines, conduct studies on pain management, and support predictive analytic modeling. Tailoring local/regional programs according to regional needs is advised. These results can assist spine societies in developing long-term research strategies and provide justified rationale to governments and funding agencies.

[1]Research Department, AO Spine, AO Foundation, Davos, Switzerland
[2]Department of Orthopaedics & Traumatology, The University of Hong Kong, Hong Kong
[3]Department of Orthopaedic and Trauma Surgery, Tampere University Hospital, Tampere, Finland
[4]Department of Orthopaedics, University Medical Center Utrecht, Utrecht, The Netherlands
[5]Division of Spine, Department of Orthopaedics, University of British Columbia,Vancouver General Hospital Vancouver, BC, Canada
[6]Department of Orthopaedics, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina
[7]Department of Orthopaedics, College of Medicine, King Saud University, Riyadh, Saudi Arabia
[8]Department of Neurosurgery, Zucker School of Medicine at Hofstra, Northwell Health, Long Island Jewish Medical Center, North Shore University Hospital, Manhasset, NY, USA
[9]Department of Orthopaedics, University of Toronto, University Health Network, Toronto Western Hospital Toronto, ON, Canada
[10]Department of Neurosurgery, Division of Surgery, The University of Texas MD Anderson Cancer Center, Houston, TX, USA
[11]Department of Orthopaedics, Emory University, Atlanta, GA, USA
[12]AO Research Institute, Davos, Switzerland
[13]Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, IL, USA

Corresponding Author:
Dino Samartzis, Department of Orthopaedic Surgery, Rush University Medical Center, Orthopaedic building, Suite 204-G, 1611W Harrison Street, Chicago, IL 60612, USA.
Email: Dino_Samartzis@rush.edu

Creative Commons Non Commercial No Derivs CC BY-NC-ND: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 License (https://creativecommons.org/licenses/by-nc-nd/4.0/) which permits non-commercial use, reproduction and distribution of the work as published without adaptation or alteration, without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).

Keywords
spine, surgeon, research, region, global, survey, needs assessment

Introduction

Professional and academic health societies often have research as a core pillar of their mission, and thus are willing to invest in research activities. Nevertheless, resources for research activities are often scarce and can be costly; therefore, it is important that they be distributed efficiently. There are several competing areas where research resources could be allocated, from research training and educational activities to awarding research grants, making it challenging to know which areas to support and that will bring the most impact to the community. This challenge becomes even more difficult when serving members of an international community, where regional diversity may exist. Appropriation of research funds and targeted theme issues that are salient to a medical community may provide knowledge of regional and global research direction that may also feed into government (e.g., National Institutes of Health, European Horizon, etc.) and foundation support that can ultimately impact health policy. As such, it is imperative that an understanding of the research needs, areas of interest, and their global variation are well understood to maximize timely innovation and clinical impact in any medical field.

Spinal disorders and conditions are some of the most common in the medical field that has direct implications upon the entire human lifespan in any population. Various spine societies exist worldwide that are instrumental in the evolution of the field, and research-driven funded projects need to respond to the growing trends of the community in order to achieve adequate return on investment.[1] There is a lack of evidence available to guide spine society program directors and board members in research resource allocation. To date, no research needs assessment of the global community of spine surgeons has ever been conducted by any society. AO Spine, a clinical division of the AO Foundation, is an international community of spine surgeons and researchers focused on improving spine care worldwide.[2-7] In this study, we utilized the AO Spine network of spine surgeons and researchers to obtain their opinions and insights to help identify research priorities. To this end, we conducted a cross-sectional survey with the purpose of understanding the research practices and needs of spine surgeons and to identify regional variations and similarities.

Materials and Methods

Survey Design and Distribution

A needs assessment survey was developed by a group of 15 international spine surgeons and researchers representing all geographic regions and who were members of the AO Spine International Research Commission. Question selection was performed following various rounds to gain group consensus. The survey was created with SurveyMonkey Inc (San Mateo, CA) and consisted of 6 sections: respondent demographics and characteristics, research registries and data collection systems, research training and education, research mentorship, research grants and financial support, and future research directions (Supplementary Appendix SI). Questions were presented as single and multiple selection, ranking, Likert scale, and as open-ended. Branching logic was also applied to select questions, as necessary. The 84-item survey was distributed to members of the AO Spine community, the world's largest society of international spine surgeons (www.aospine.org), between September 3rd and the 24th of 2020. Individuals opting to receive email from AO Spine were targeted, which included approximately 4700 members. The responses obtained were anonymous.

Statistical Analyses

Standard descriptive statistics were used that consisted of the following: means and standard deviations or medians and ranges for continuous variables and absolute numbers and frequency distributions for categorical variables. Statistical differences were assessed for categorical variables with chi-squared and Fisher's exact tests where applicable and the Kruskal–Wallis test was used for ranking questions. Data analysis was conducted using Python 3.8 and the pandas, numPy, and SciPy modules. Fisher's exact analyses were performed with R version 4.0.2, where applicable. Significance was defined as $P < .05$.

Results

Respondent Demographics and Characteristics

A total of 333 respondents participated in the survey. Respondents were from all 5 AO Spine regions: Europe/Southern Africa (26.7%, 89/333), Asia Pacific (21.6%, 72/333), Latin America (20.4%, 68/333), the Middle East/Northern Africa (19.2%, 64/333), and North America (12.0%, 40/333). Overall, 72 countries were represented, where most respondents were from the United States (10.3%, 34/330) and India (7.0%, 23/330) (Supplementary Appendix SII). The practice focus of most respondents was degenerative spine (87.3%, 290/332), followed by spine trauma (72.9%, 242/332), spine deformities (55.4%, 184/332), spine tumors (50.3%, 167/332), and spinal cord injury (44.9%, 149/332). Respondent personal and practice demographics are outlined in Table 1. Most respondents were male (92.1%, 303/329), specialized in orthopedics (60.5%; 201/332), were affiliated with an academic/university hospital (52.3%, 174/333), and had a formal academic appointment (63.7%, 212/333). There were

Table 1. Respondent Personal and Practice Demographics.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Age (years) (n = 329)														
25–34	14	19.7	13	14.6	8	11.9	10	16.1	6	15.0	51	15.5	.794	[b]
35–44	24	33.8	35	39.3	29	43.3	22	35.5	13	32.5	123	37.4		
45–54	20	28.2	22	24.7	19	28.4	19	30.6	16	40.0	96	29.2		
55–64	13	18.3	16	18.0	8	11.9	8	12.9	5	12.5	50	15.2		
65+	0	0.0	3	3.4	3	4.5	3	4.8	0	0.0	9	2.7		
Gender (n = 329)														
Male	66	93.0	80	89.9	65	97.0	60	96.8	32	80.0	303	92.1	**.019**	[b]
Female	5	7.0	9	10.1	2	3.0	2	3.2	8	20.0	26	7.9		
Specialty (n = 332)														
Orthopedics	55	76.4	50	56.2	35	52.2	39	60.9	22	55.0	201	60.5	**.012**	[b]
Neurosurgery	14	19.4	31	34.8	31	46.3	24	37.5	15	37.5	115	34.6		
Trauma	1	1.4	5	5.6	1	1.5	1	1.6	0	0.0	8	2.4		
Pediatric surgery	0	0.0	1	1.1	0	0.0	0	0.0	0	0.0	1	0.3		
Other (please specify)	2	2.8	2	2.2	0	0.0	0	0.0	3	7.5	7	2.1		
Practice type (n = 333)														
Academic/University hospital	36	50.0	58	65.2	19	27.9	29	45.3	32	80.0	174	52.3	**.000**	[b]
Academic/Private combined	15	20.8	15	16.9	25	36.8	17	26.6	5	12.5	77	23.1		
Private	11	15.3	4	4.5	17	25.0	9	14.1	3	7.5	44	13.2		
Public local hospital	10	13.9	12	13.5	7	10.3	9	14.1	0	0.0	38	11.4		
Formal academic appointment? (n = 333)														
Yes	46	63.9	58	65.2	40	58.8	35	54.7	33	82.5	212	63.7	.058	[a]
No	26	36.1	31	34.8	28	41.2	29	45.3	7	17.5	121	36.3		
Patient case volume (n = 333)														
0–100	19	26.4	19	21.3	32	47.1	28	43.8	6	15.0	104	31.2	**.000**	[b]
101–200	25	34.7	31	34.8	29	42.6	19	29.7	5	12.5	109	32.7		
201–300	17	23.6	22	24.7	7	10.3	11	17.2	15	37.5	72	21.6		
301–400	3	4.2	11	12.4	0	0.0	3	4.7	12	30.0	29	8.7		
401–499	0	0.0	1	1.1	0	0.0	1	1.6	1	2.5	3	0.9		
500+	8	11.1	5	5.6	0	0.0	2	3.1	1	2.5	16	4.8		
Spine surgery experience (years) (n = 333)														
0–5	15	20.8	20	22.5	16	23.5	23	35.9	10	25.0	84	25.2	.612	[b]
6–10	21	29.2	23	25.8	15	22.1	9	14.1	12	30.0	80	24.0		
11–15	13	18.1	12	13.5	17	25.0	13	20.3	6	15.0	61	18.3		
16–19	8	11.1	13	14.6	9	13.2	6	9.4	3	7.5	39	11.7		
20+	15	20.8	21	23.6	11	16.2	13	20.3	9	22.5	69	20.7		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

significant differences between regions in respondent gender ($P = .019$), specialty ($P = .012$), practice type ($P < .001$), and patient case volume ($P < .001$).

Respondent research characteristics are shown in Table 2. Almost all respondents conducted clinical research (91.0%, 303/333); 23.4% (78/333) performed preclinical and 6.3% (21/333) did not perform research. Respondent research experience ranged from 0 to 20+ years with 60.9% (203/333) having more than 5 years of research experience. Most respondents did not hold an undergraduate science degree (70.3%, 234/333), spent 0–25% of time at work performing research (68.5%, 228/333), indicated their research productivity was growing (50.2%, 151/301), had co-authored a peer-reviewed publication (85.7%, 258/301) with 76.4% (230/301) having been first author and 57.7% (173/300) as last author, performed single center research (50.2%, 146/291), and did

Table 2. Respondent Research Characteristics.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Main research focus (n = 333)														
Preclinical (lab-based/animal)	2	2.8	2	2.2	3	4.4	1	1.6	1	2.5	9	2.7	.280	[b]
Clinical	52	72.2	59	66.3	46	67.6	49	76.6	28	70.0	234	70.3		
Preclinical (lab-based/animal) and clinical	16	22.2	21	23.6	10	14.7	11	17.2	11	27.5	69	20.7		
Do not perform research	2	2.8	7	7.9	9	13.2	3	4.7	0	0.0	21	6.3		
Research experience (years) (n = 333)														
0–5	28	38.9	29	32.6	39	57.4	27	42.2	7	17.5	130	39.0	**.023**	[b]
6–10	20	27.8	20	22.5	9	13.2	9	14.1	10	25.0	68	20.4		
11–15	9	12.5	13	14.6	11	16.2	10	15.6	9	22.5	52	15.6		
16–19	4	5.6	11	12.4	3	4.4	9	14.1	5	12.5	32	9.6		
20+	11	15.3	16	18.0	6	8.8	9	14.1	9	22.5	51	15.3		
Began conducting research (n = 302)														
Fellowship	7	10.0	6	7.5	2	3.6	6	10.5	1	2.6	22	7.3	**.000**	[b]
Graduate degree	13	18.6	6	7.5	5	8.9	12	21.1	3	7.7	39	12.9		
Medical school	9	12.9	15	18.8	8	14.3	3	5.3	9	23.1	44	14.6		
Post-training years	10	14.3	7	8.8	9	16.1	7	12.3	2	5.1	35	11.6		
Residency	28	40.0	35	43.8	28	50.0	19	33.3	4	10.3	114	37.7		
Undergraduate	3	4.3	11	13.8	4	7.1	10	17.5	20	51.3	48	15.9		
Hold an undergraduate science degree? (n = 333)														
Yes	27	37.5	17	19.1	11	16.2	11	17.2	33	82.5	99	29.7	**.000**	[a]
No	45	62.5	72	80.9	57	83.8	53	82.8	7	17.5	234	70.3		
Time at work spent performing research (%) (n = 333)														
0–25%	41	56.9	67	75.3	48	70.6	48	75.0	24	60.0	228	68.5	**.016**	[b]
26–50%	27	37.5	17	19.1	16	23.5	13	20.3	10	25.0	83	24.9		
51–75%	4	5.6	1	1.1	2	2.9	0	0.0	1	2.5	8	2.4		
76–100%	0	0.0	4	4.5	2	2.9	3	4.7	5	12.5	14	4.2		
Research productivity (n = 301)														
Growing	34	48.6	43	53.8	27	49.1	30	52.6	17	43.6	151	50.2	.833	[a]
At a steady state	26	37.1	26	32.5	19	34.5	16	28.1	12	30.8	99	32.9		
Declining	10	14.3	11	13.8	9	16.4	11	19.3	10	25.6	51	16.9		
Co-authored a peer-reviewed publication? (n = 301)														
Yes	58	82.9	73	91.2	45	81.8	44	77.2	38	97.4	258	85.7	**.019**	[b]
No	12	17.1	7	8.8	10	18.2	13	22.8	1	2.6	43	14.3		
Published a peer-reviewed publication as first author? (n = 301)														
Yes	57	81.4	67	83.8	30	54.5	41	71.9	35	89.7	230	76.4	**.000**	[b]
No	13	18.6	13	16.2	25	45.5	16	28.1	4	10.3	71	23.6		
Published a peer-reviewed publication as last author? (n = 300)														
Yes	42	60.0	45	56.2	28	51.9	31	54.4	27	69.2	173	57.7	.500	[a]
No	28	40.0	35	43.8	26	48.1	26	45.6	12	30.8	127	42.3		
Number of peer-reviewed publications (n = 301)														
0–5	32	45.7	23	28.7	31	56.4	30	52.6	4	10.3	120	39.9	**.000**	[b]

(continued)

Table 2. (continued)

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
6–10	7	10.0	12	15.0	15	27.3	6	10.5	6	15.4	46	15.3		
11–15	8	11.4	7	8.8	3	5.5	4	7.0	2	5.1	24	8.0		
16–19	2	2.9	5	6.2	0	0.0	4	7.0	4	10.3	15	5.0		
20+	21	30.0	33	41.2	6	10.9	13	22.8	23	59.0	96	31.9		
Single vs. Multi-center clinical research (n = 291)														
Single center	38	55.1	30	39.5	35	66.0	35	62.5	8	21.6	146	50.2	**.000**	[a]
Multi-center	12	17.4	15	19.7	6	11.3	8	14.3	6	16.2	47	16.2		
Both	19	27.5	31	40.8	12	22.6	13	23.2	23	62.2	98	33.7		
Access to a research coordinator or support staff to assist with research? (n = 275)														
Yes	31	47.0	25	33.3	15	29.4	15	31.9	20	55.6	106	38.5	**.042**	[a]
No	35	53.0	50	66.7	36	70.6	32	68.1	16	44.4	169	61.5		
Access to PhD/Masters Student(s) to assist with research? (n = 276)														
Yes	22	33.3	32	42.7	15	28.8	16	34.0	13	36.1	98	35.5	.579	[a]
No	44	66.7	43	57.3	37	71.2	31	66.0	23	63.9	178	64.5		
Access to residents or spine fellows to assist with research? (n = 276)														
Yes	43	65.2	45	60.0	31	59.6	26	55.3	28	77.8	173	62.7	.267	[a]
No	23	34.8	30	40.0	21	40.4	21	44.7	8	22.2	103	37.3		
Level of motivation to perform research (n = 275)														
Very high	10	15.2	21	28.0	14	26.9	18	39.1	14	38.9	77	28.0	**.032**	[b]
High	26	39.4	34	45.3	26	50.0	15	32.6	10	27.8	111	40.4		
Average	25	37.9	19	25.3	10	19.2	10	21.7	8	22.2	72	26.2		
Low	5	7.6	1	1.3	2	3.8	3	6.5	4	11.1	15	5.5		
Encouraged to do research (n = 275)														
Yes	45	68.2	45	60.0	21	40.4	16	34.0	28	80.0	155	56.4	**.000**	[a]
No	21	31.8	30	40.0	31	59.6	31	66.0	7	20.0	120	43.6		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

not have access to a research coordinator/support staff (61.5%, 169/275) or PhD/Masters student(s) (64.5%, 178/276), but had access to residents or spine fellows (62.7%, 173/276). When comparing regions, the number of years of research experience ($P = .023$), when respondents began conducting research ($P < .001$), whether they held an undergraduate degree ($P < .001$), and time at work spent performing research ($P = .016$) were significantly different. Most North American respondents (51.3%; 20/39) began conducting research early in their career, during undergraduate and 82.5% (33/40) held an undergraduate science degree. A large proportion of Latin American (57.4%; 39/68) and the Middle East/Northern Africa (42.2%; 27/64) respondents only had between 0 and 5 years of research experience. None of the Asia Pacific respondents spent 76–100% of their time at work on research, while in North America 12.5% (5/40) of respondents did. Regional differences were also present surrounding peer-reviewed publications, specifically having co-authored a peer-reviewed publication ($P = .019$), having been first author ($P < .001$), and the number of publications ($P < .001$). Latin American respondents were less likely to have published a peer-review publication as first author (45.5%, 25/55), and 59% (23/39) of North Americans produced 20+ peer-reviewed publications. North American respondents were more likely to perform both single and multi-center clinical research (62.2%, 23/37; $P < .001$) and had access to a research coordinator or

Table 3. Respondent Impressions of Research Registries.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		P-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Do you or your research group record your surgical cases, including patient-reported outcomes data, imaging, and clinical assessments for research purposes? (n = 275)														
Yes	52	78.8	62	83.8	42	80.8	28	59.6	32	88.9	216	78.5	**.014**	[b]
No	14	21.2	12	16.2	10	19.2	19	40.4	4	11.1	59	21.5		
How are your research records handled? (n = 214)														
Own personal or surgical group system	34	66.7	29	47.5	31	73.8	21	75.0	9	28.1	124	57.9	**.000**	[b]
Hospital, university, or department data storage system for research purposes	15	29.4	19	31.1	10	23.8	5	17.9	13	40.6	62	29.0		
National registry	2	3.9	9	14.8	1	2.4	2	7.1	5	15.6	19	8.9		
Other (please specify)	0	0.0	4	6.6	0	0.0	0	0.0	5	15.6	9	4.2		
Do you collect/bank blood (serum, plasma) and/or tissue samples for biomarker evaluation? (n = 272)														
Yes	15	23.1	20	27.8	6	11.5	13	27.7	16	44.4	70	25.7	**.014**	[a]
No	50	76.9	52	72.2	46	88.5	34	72.3	20	55.6	202	74.3		
Would you be interested in joining an international AO Spine-managed registry called AO Global Data (www.aoglobaldata.com)? (n = 273)														
Yes	50	76.9	35	47.9	42	80.8	37	78.7	16	44.4	180	65.9	**.000**	[b]
No	1	1.5	5	6.8	0	0.0	3	6.4	3	8.3	12	4.4		
Undecided	3	4.6	12	16.4	2	3.8	2	4.3	8	22.2	27	9.9		
I am not familiar with AO Global Data	11	16.9	21	28.8	8	15.4	5	10.6	9	25	54	19.8		
Would you be willing to pay a nominal fee for such a data collection system? (n = 272)														
Yes	23	35.4	21	28.8	27	51.9	17	37.0	9	25	97	35.7	.111	[a]
No	11	16.9	23	31.5	10	19.2	10	21.7	9	25	63	23.2		
Undecided	31	47.7	29	39.7	15	28.8	19	41.3	18	50	112	41.2		
How much in US Dollars are you willing to pay per year? (n = 96)														
$0–$500	20	90.9	14	66.7	23	85.2	15	88.2	2	22.2	74	77.1	**.003**	[b]
$500–$1000	2	9.1	2	9.5	3	11.1	1	5.9	3	33.3	11	11.5		
$1000–$2000	0	0.0	2	9.5	0	0.0	1	5.9	2	22.2	5	5.2		
$2000–$5000	0	0.0	3	14.3	1	3.7	0	0.0	1	11.1	5	5.2		
$5000–$10000	0	0.0	0	0.0	0	0.0	0	0.0	1	11.1	1	1.0		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

Table 4. Respondent Impressions of Research Training, Education, and Fellowships.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Does the institute where you work have a medical residency, postgraduate, or specialization program in research? (n = 271)														
Yes	35	53.8	41	56.9	26	50.0	25	54.3	27	75.0	154	56.8	.186	[a]
No	30	46.2	31	43.1	26	50.0	21	45.7	9	25.0	117	43.2		
Have you received research training in preclinical and/or clinical research? (n = 272)														
Yes	29	44.6	52	71.2	29	55.8	30	65.2	33	91.7	173	63.6	**.000**	[b]
No	36	55.4	21	28.8	23	44.2	16	34.8	3	8.3	99	36.4		
Do you feel you understand the fundamental principles in conducting successful research? (n = 171)														
Yes	24	82.8	50	96.2	25	86.2	25	89.3	32	97.0	156	91.2	.137	[b]
No	5	17.2	2	3.8	4	13.8	3	10.7	1	3.0	15	8.8		
Do you feel that you have enough knowledge and interest to teach preclinical and/or clinical research to others? (n = 266)														
Yes	28	43.1	42	57.5	28	56.0	22	51.2	29	82.9	149	56.0	**.004**	[a]
No	37	56.9	31	42.5	22	44.0	21	48.8	6	17.1	117	44.0		
In your opinion, do you think teaching other clinicians about preclinical and/or clinical research in your region would stimulate research? (n = 268)														
Yes	59	90.8	67	91.8	43	84.3	40	93.0	28	77.8	237	88.4	.170	[b]
No	6	9.2	6	8.2	8	15.7	3	7.0	8	22.2	31	11.6		
Would you benefit from having more research education course offerings, such as AO PEER face-to-face courses (www.aopeer.org), in your country/region? (n = 268)														
Yes	42	64.6	49	67.1	45	88.2	35	81.4	16	44.4	187	69.8	**.000**	[b]
No, I am not interested	4	6.2	5	6.8	2	3.9	0	0.0	8	22.2	19	7.1		
No, but I would participate in online AO PEER courses	11	16.9	7	9.6	2	3.9	4	9.3	1	2.8	25	9.3		
I am not familiar with AO PEER	8	12.3	12	16.4	2	3.9	4	9.3	11	30.6	37	13.8		
Would you participate in such research education courses? (n = 187)														
Yes, as a participant	32	76.2	38	77.6	27	60.0	22	62.9	10	62.5	129	69.0	.274	[b]
Yes, as faculty	8	19.0	9	18.4	10	22.2	11	31.4	5	31.2	43	23.0		
No	2	4.8	2	4.1	8	17.8	2	5.7	1	6.2	15	8.0		
In your opinion, would it be beneficial for your country/region to have the online AO PEER research education material translated in the local language? (n = 265)														

(continued)

Table 4. (continued)

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Yes	43	67.2	44	60.3	49	96.1	25	61.0	26	72.2	187	70.6	**.000**	[b]
No	21	32.8	29	39.7	2	3.9	16	39.0	10	27.8	78	29.4		
In your opinion, would your country/region benefit from having research fellowship opportunities in preclinical and/or clinical research? (n = 265)														
Yes	59	92.2	72	98.6	49	96.1	39	95.1	31	86.1	250	94.3	.085	[b]
No	5	7.8	1	1.4	2	3.9	2	4.9	5	13.9	15	5.7		
What type of research fellowships would your country/region benefit? (n = 249)														
Preclinical research fellowship with AO research Institute	3	5.1	2	2.8	4	8.2	3	7.7	1	3.2	13	5.2	.660	[b]
Clinical research fellowship with AO Innovation Translation Center	28	47.5	36	50.7	18	36.7	15	38.5	11	35.5	108	43.4		
Both	28	47.5	33	46.5	27	55.1	21	53.8	19	61.3	128	51.4		
Would you apply for a research fellowship? (n = 249)														
Yes	32	54.2	34	47.9	35	71.4	28	71.8	13	41.9	142	57.0	**.011**	[a]
No	27	45.8	37	52.1	14	28.6	11	28.2	18	58.1	107	43.0		
What is the desired length of a research fellowship? (n = 142)														
0–3 months	14	43.8	13	38.2	14	40.0	14	50.0	5	38.5	60	42.3	.607	[b]
3–6 months	9	28.1	11	32.4	11	31.4	6	21.4	1	7.7	38	26.8		
6–12 months	4	12.5	6	17.6	8	22.9	5	17.9	7	53.8	30	21.1		
12–24 months	2	6.2	3	8.8	0	0.0	1	3.6	0	0.0	6	4.2		
>2 years	2	6.2	1	2.9	1	2.9	1	3.6	0	0.0	5	3.5		
Other (please specify)	1	3.1	0	0.0	1	2.9	1	3.6	0	0.0	3	2.1		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

support staff (55.6%, 20/36; $P = .042$) compared to the other regions.

The research area of focus corresponded with practice focus, whereby spine degeneration (82.8%, 250/302), spine trauma (64.2%, 194/302), and spine deformities (48%, 145/302) were the most popular. Research was predominantly done locally (68%, 198/291) and nationally (41.2%, 120/291), and to a lesser extent at regional (32.6%, 95/291) and international (29.2%, 85/291) levels. Respondents performed research to advance the field, to benefit patients, and for personal gratification. Publishing in peer-reviewed journals was considered the most important research activity (1.56 ± .78; on a scale of −2 [least important] to +2 [most important]).

Challenges were innate in research, where 88.3% (294/299) of respondents indicated they had challenges in conducting research. The 3 main challenges for performing research at the place of work included a lack of funds (71.9%, 189/263), of infrastructure (i.e.,, clinical research support staff, ethics committee, etc) (63.5%, 167/263), and time to perform research (58.9%, 155/263). In addition, Asia Pacific responders also reported a lack of knowledge about statistical analysis (55.6%, 35/63) and Latin American responders reported a lack of incentive to perform research (66.7%, 34/51). The level of motivation to perform research was high or very high for 68.4% (188/275) of respondents and differed across regions ($P = .032$; Table 2). Only 56.4% (155/275) of respondents were supported and encouraged by their work environment to pursue their research efforts, where most North American responders were supported (80.0%, 28/35) while other regions to a lesser extent ($P < .001$; Table 2).

Table 5. Respondent Impressions of Research Mentorship.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Do you currently have or had a research mentor? (n = 264)														
Yes	28	43.8	38	52.8	22	43.1	14	34.1	25	69.4	127	48.1	**.023**	[a]
No	36	56.2	34	47.2	29	56.9	27	65.9	11	30.6	137	51.9		
Was this mentor instrumental in motivating you to pursue research? (n = 125)														
Yes	26	96.3	31	83.8	20	90.9	10	71.4	23	92.0	110	88.0	.189	[b]
No	1	3.7	6	16.2	2	9.1	4	28.6	2	8.0	15	12.0		
Are you currently a research mentor? (n = 263)														
Yes	23	36.5	36	50.0	18	35.3	17	41.5	23	63.9	117	44.5	**.042**	[a]
No	40	63.5	36	50.0	33	64.7	24	58.5	13	36.1	146	55.5		
Are you mentoring as part of a mentorship program? (n = 115)														
Yes	9	39.1	13	37.1	6	35.3	6	35.3	6	26.1	40	34.8	.902	[a]
No	14	60.9	22	62.9	11	64.7	11	64.7	17	73.9	75	65.2		
Would you make use of a program or material that support mentors in their mentorship activities? (n = 116)														
Yes	18	78.3	30	85.7	11	61.1	14	82.4	17	73.9	90	77.6	.354	[b]
No	5	21.7	5	14.3	7	38.9	3	17.6	6	26.1	26	22.4		
In your opinion, would it be beneficial to have an AO Spine research mentorship program in your country/region? (n = 262)														
Yes	58	92.1	65	91.5	51	100.0	39	95.1	31	86.1	244	93.1	.075	[b]
No	5	7.9	6	8.5	0	0.0	2	4.9	5	13.9	18	6.9		
Would you like to become a research mentor? (n = 243)														
Yes	43	74.1	49	76.6	43	84.3	31	79.5	20	64.5	186	76.5	.332	[a]
No	15	25.9	15	23.4	8	15.7	8	20.5	11	35.5	57	23.5		
Do you think a mentorship program by AO Spine should consist of in-person mentor-mentee meetings? (n = 243)														
Yes, at least once a year	38	65.5	39	60.9	27	52.9	25	64.1	22	71.0	151	62.1	.333	[b]
Yes, more than once a year	19	32.8	22	34.4	24	47.1	13	33.3	7	22.6	85	35.0		
No	1	1.7	3	4.7	0	0.0	1	2.6	2	6.5	7	2.9		
How often should a mentor-mentee meet (in-person or virtually) to discuss research progress? (n = 258)														
Once per month	20	32.3	22	31.9	20	39.2	23	56.1	18	51.4	103	39.9	.061	[b]
Every 3 months	32	51.6	29	42.0	27	52.9	14	34.1	12	34.3	114	44.2		
Once per year	4	6.5	3	4.3	2	3.9	2	4.9	1	2.9	12	4.7		
Twice per year	6	9.7	15	21.7	2	3.9	2	4.9	4	11.4	29	11.2		

(continued)

Table 5. (continued)

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Would it be beneficial for AO to identify, initiate, and grow research at a single or several key centers in your region that will then serve as research mentors for others? (n = 260)														
Yes	59	95.2	63	90.0	50	98.0	40	97.6	31	86.1	243	93.5	.116	[b]
No	3	4.8	7	10.0	1	2.0	1	2.4	5	13.9	17	6.5		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

Research Registries and Data Collection Systems

Respondents were asked about whether they or their research groups recorded surgical cases for research purposes and 78.5% (216/275) noted as such. Most individuals recorded their cases using their own personal or surgical group system (57.9%, 124/214), did not collect blood or tissue samples for biomarker evaluation (25.7%, 70/272), and expressed interest in joining an international-based registry (65.9%, 180/273). When asked about fees for a data collection system, 41.2% (112/272) of respondents were undecided, 23.2% (63/272) were not in favor of paying, and 35.7% (97/272) were willing to pay a nominal fee, where of those respondents who were willing to pay, 22.9% (22/96) would pay more than $500 USD per year to have access to a system which would have automated data collection processes and customizable reporting of their cases. There were significant differences across regions in whether surgical cases were recorded ($P = .014$) and how they were handled ($P < .001$) for research purposes, whether blood or tissue samples were collected ($P = .014$), whether there was an interest in joining or against joining an international-based registry ($P < .001$), and the amount one would pay to join per year ($P = .003$; Table 3).

Research Training and Education

In 56.8% (154/271) of cases, at the institutions where the respondents worked, there was a medical residency, postgraduate, or specialization program that had a focus on conducting research. Most respondents received research training (63.6%, 173/272). Of the respondents that received research training, 91.2% (156/171) felt they understood the fundamental principles in conducting successful research. Just over half of the respondents felt they had enough knowledge and interest to teach research to others (56%; 149/266), and 88.4% felt that teaching others about research would stimulate research. North America and Europe/Southern Africa had a higher percentage of respondents that received research training compared to the other regions ($P < .001$), and North American respondents felt they had enough knowledge and interest to teach research compared to other regions ($P = .004$; Table 4).

The 3 most popular research topics that respondents learned and studied were clinical study design and methodology (82.5%, 141/171), literature search and reviews (69.0%, 118/171), and research protocol development and writing (63.2%, 108/171). The 3 most popular research topics that respondents would like to continue to learn and study were clinical study design and clinical methodology (80.3%, 102/127), research protocol development and writing (67.7%, 86/127), and systematic reviews and meta-analyses (67.7%, 86/127).

Overall, 69.8% (187/268) of respondents felt it would be beneficial to have more research education course offerings where 69.0% (129/187) would participate as a participant, 70.6% (187/265) were in favor of having online research education material translated in the local language, and 94.3% (250/265) were in favor of having research fellowship opportunities. Research fellowships in both preclinical and clinical research settings were of interest to most (51.4%) (128/249). If available, most respondents would apply for a research fellowship (57.0%, 142/249) and 42.3% (60/142) desired a research fellowship length of 0–3 months. Regional differences occurred as to whether it would be beneficial to have more research education course offerings ($P < .001$), whether it would be beneficial to have online research education material translated in the local language ($P < .001$), and whether respondents would apply for a research fellowship ($P = .011$; Table 4). For the respondents in Latin America and the Middle East/Northern Africa, a higher percentage felt they would benefit from having more research education course offerings and would apply for a research

Table 6. Respondent Impressions of Research Grants and Financial Support.

	Asia Pacific		Europe and Southern Africa		Latin America		Middle East and Northern Africa		North America		Overall		*P*-value	
	N	%	N	%	N	%	N	%	N	%	N	%		
Have you ever applied for a research grant? (n = 261)														
Yes	25	40.3	49	69.0	16	31.4	7	17.1	31	86.1	128	49.0	**.000**	[a]
No	37	59.7	22	31.0	35	68.6	34	82.9	5	13.9	133	51.0		
How many research grants have you applied for? (n = 128)														
1	5	20.0	8	16.3	5	31.2	4	57.1	2	6.5	24	18.8	.249	[b]
2	5	20.0	7	14.3	3	18.8	0	0.0	4	12.9	19	14.8		
3	2	8.0	8	16.3	3	18.8	0	0.0	6	19.4	19	14.8		
4	0	0.0	5	10.2	1	6.2	0	0.0	1	3.2	7	5.5		
5+	13	52.0	21	42.9	4	25.0	3	42.9	18	58.1	59	46.1		
Are you currently holding a research grant? (n = 128)														
Yes, as a principal investigator	14	56.0	20	40.8	4	25.0	1	14.3	10	32.3	49	38.3	.111	[b]
Yes, as a co-investigator	3	12.0	9	18.4	0	0.0	2	28.6	6	19.4	20	15.6		
No	8	32.0	20	40.8	12	75.0	4	57.1	15	48.4	59	46.1		
Would it be beneficial to have more AO Spine research grants, such as the Young Research and Innovation Grant Award (YIRGA) and focussed grants, available in your country/region? (n = 261)														
Yes	61	98.4	67	94.4	49	96.1	38	92.7	35	97.2	250	95.8	.650	[b]
No	1	1.6	4	5.6	2	3.9	3	7.3	1	2.8	11	4.2		
If more grants were available in your country/region and you are eligible to apply, would you apply for such research grants? (n = 250)														
Yes	56	91.8	60	89.6	45	91.8	34	89.5	32	91.4	227	90.8	.986	[b]
No	5	8.2	7	10.4	4	8.2	4	10.5	3	8.6	23	9.2		

[a]chi-squared test
[b]Fisher's exact test
Bolded values indicate statistical significance at $P < .05$

fellowship compared to the other regions. Almost all Latin American respondents felt they would benefit from having online research education material translated in the local language (96.1%, 49/51).

Research Mentorship

Respondents were asked about their opinions regarding research mentorship (Table 5). Most did not have a research mentor (51.9%, 137/264) and 55.5% (146/263) were not research mentors themselves. Of those that had a mentor, 88.0% (110/125) felt the mentor was instrumental in them pursuing research. Of those mentoring, 65.2% (40/115) were not part of a mentorship program and 77.6% (90/116) indicated they would make use of a program or material that would support mentors. 93.1% (244/262) of respondents felt that it would be beneficial to have an international research mentorship program and 76.5% (186/243) of respondents would like to become research mentors. When considering a mentorship program, 62.1% (151/243) favored having in-person mentor-mentee meetings at least once a year and 44.2% (114/258) believed the mentor-mentee should meet every 3 months. There was strong support for AO to identify, initiate, and grow research at a single or several key centers across the regions that would then serve as research mentors for others (93.5%, 243/260). Regional differences were found in whether the respondent had a research mentor ($P = .023$) and was currently a research mentor ($P = .042$), where North America and Europe/Southern Africa had a higher percentage of respondents involved in research mentorship compared to the other regions.

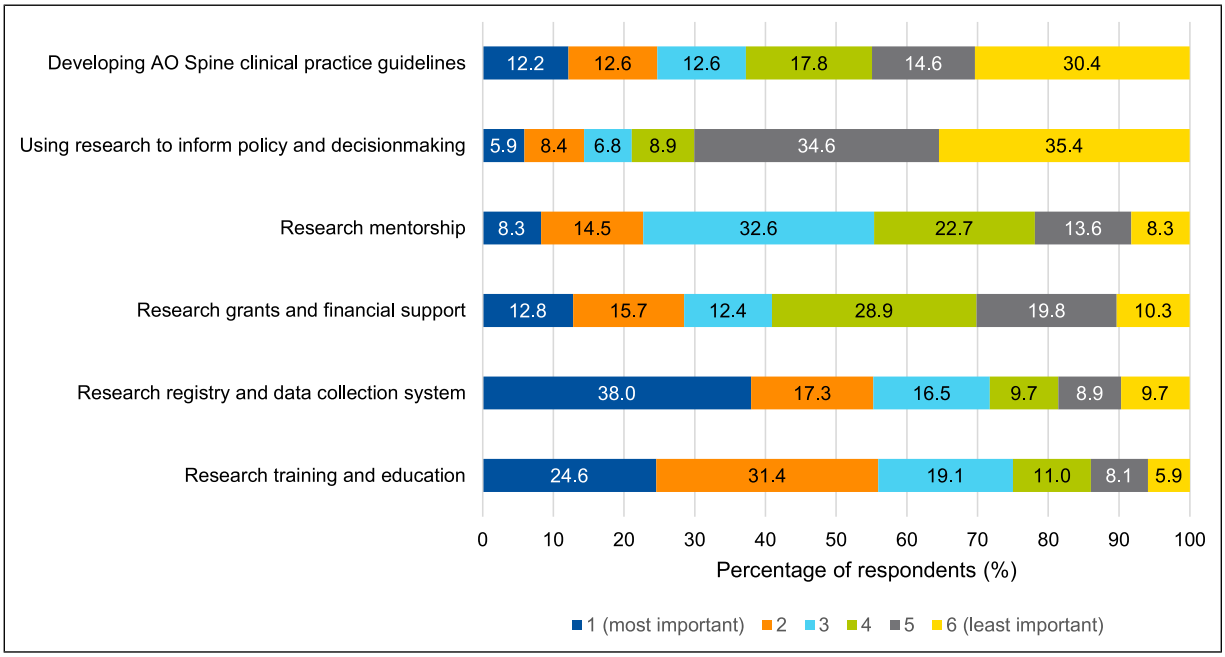

Figure 1. Respondent ranking of research activities they felt would be most beneficial for AO Spine to pursue to enhance and improve research globally.

Research Grants and Financial Support

Only 49.0% (128/261) of respondents had experience applying for a research grant, and of those that did, 46.1% (59/128) applied for 5+ grants and 53.9% (69/128) were currently holding a research grant as either a principal investigator or co-investigator. Almost all respondents (95.8%, 250/261) felt it would be beneficial to have more research grants, such as young investigator and focused grants, and 90.8% (227/250) of respondents would apply if eligible. There was a significant difference between regions in whether respondents had applied for a research grant, where a higher percentage of North American and European/Southern African respondents had applied compared to the other regions ($P < .001$; Table 6).

Future Research Directions

Respondents were asked about which research activities would be most beneficial for AO Spine to pursue to enhance and improve research locally/regionally and globally. The most important research activities were research registry and data collections systems as well as research training and education, where more than 50% of respondents ranked these as being 1 (most important) or 2 (Figure 1). There were significant differences across regions when comparing certain research activities that they felt would be most beneficial to pursue locally/regionally (Figure 2; $P < .001$–$P = .006$).

Respondents were also asked to select 3 areas they believed would be most impactful for advancing spine care worldwide and the top selections included guidelines (63.2%, 160/253), pain (44.3%, 112/253), and predictive analytic modeling (33.9%, 101/253; Figure 3).

Discussion

To our knowledge, this is the first study to report on the research practices and needs of spine surgeons worldwide and to assess regional differences. The results revealed that there is heterogeneity in spine surgeon research practices worldwide and distinct areas for future research were identified. There is a need for global research registries and data collection systems, and research training and education among spine surgeons. The top 3 areas to conduct a global research initiative for advancing spine care worldwide included establishing clinical practice guidelines, conducting studies centered around pain management, and supporting predictive analytic modeling.

Our survey provides insights into the differences in research practices of spine surgeons across regions. In contrast to the other regions, we found that most North American respondents began conducting research early in their career and received undergraduate science degrees. Many had more than 5 years of research experience and experience writing peer-reviewed publications as first author, including having co-authored more than 20+ publications. Most had personnel to assist with research and were encouraged to conduct

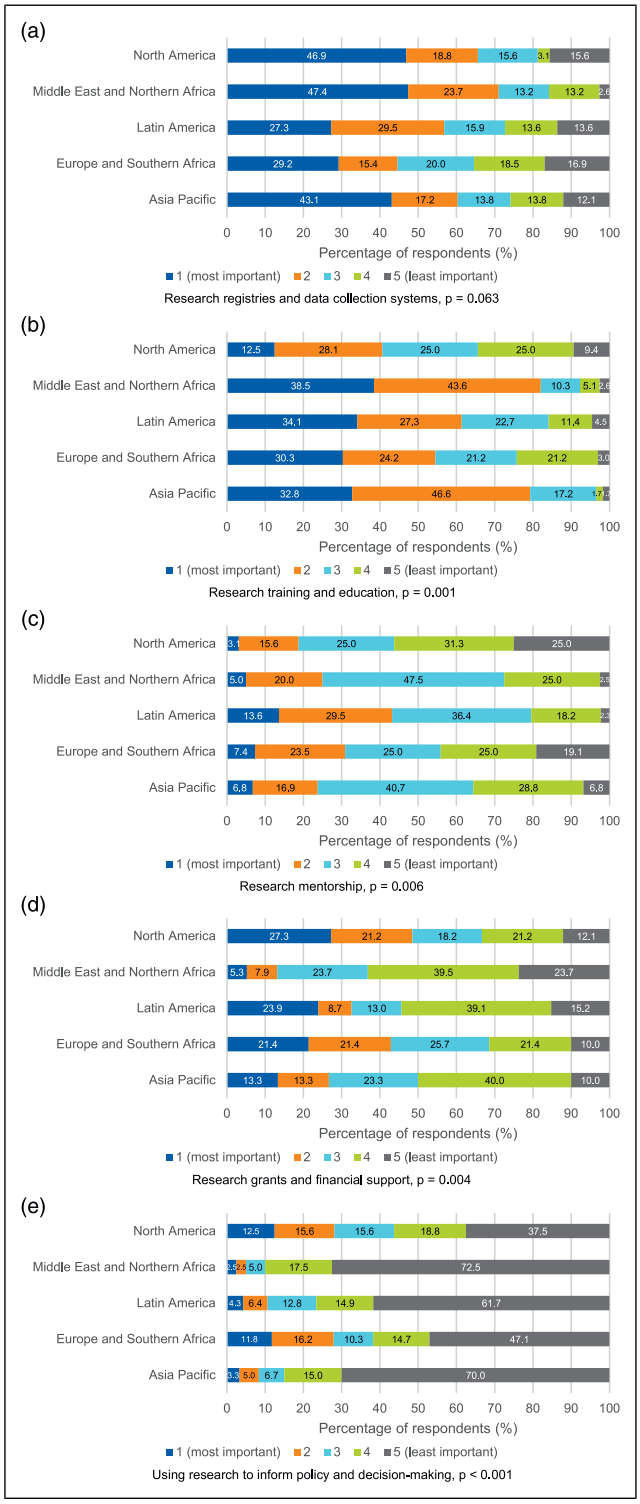

Figure 2. Respondent ranking of research activities they felt would be most beneficial for AO Spine to pursue to enhance and improve research locally/regionally, where A. represents research registries and data collection systems, B. represents research training and education, C. represents research mentorship, D. represents research grants and financial support, and E. represents using research to inform policy and decision-making.

research. These results show that the research culture and environment in North America appears to promote research and cultivates spine surgeon-researchers. This is consistent with the clinical training programs in the United States and the importance given to the physician-scientist.[8]

Despite the progressive research culture in North America, interestingly, all regions indicated that they share the same challenges for performing research: lack of funds, research infrastructure, and time. This is consistent with the fact that most spend between 0 and 25% of their working time on research and do not have access to trained research support personnel. Not having access to trained research coordinators/support staff is one of the key challenges in performing research for not only spine researchers, but all researchers. It is especially a major challenge for those in low- and medium-income countries. Building local capacity in these countries would improve their ability to conduct clinical research. Ntekim et al.[9] proposed a model for capacity building where higher income countries should partner with low- and medium-income countries by providing them funds, mentorship, and training. Interestingly, Latin America and Middle East/Northern Africa were less likely encouraged to engage in research. This is in accordance with the little investment Latin America makes in biomedical research.[10]

Even though several spine surgeons are recording their surgical cases for research purposes and large, international population-based databases do exist (e.g., Eurospine's Spine Tango, Swedish Spine Registry),[11,12] overall, there is still a strong will to establish more global spine research registries and data collect systems. This was unanimously supported across all regions. This need appears to be the highest in the Middle East/Northern Africa. To address this demand, AO Spine is developing an international musculoskeletal registry referred to as AO Global Data (www.aoglobaldata.com) which will be available to all AO Spine members and will provide a platform for clinicians to capture spine patients and their patient-reported outcomes. AO Spine has also launched spine-specific pathology focused international research registries on degenerative disc disease, metastatic spine disease, and primary spine tumors. These are targeted research registries, aiming to answer specific research questions. They are in the early stages and restricted to 15–20 centers due to limited resources. However, if they prove to be fruitful, the goal is to expand them and perhaps even onboard and support under-developed countries that are eager and willing to participate. While costly and faced with legal and ethical issues, there is also a need for establishing international repositories for biospecimens, as there are very few who currently engage in this activity. Such data repositories could provide unique and meaningful data for predictive analytic modeling methods and could contribute to personalized medicine approaches.

The results indicated that there is a demand for more research training and education. This is especially the case for the Middle East/Northern Africa and Asia Pacific,

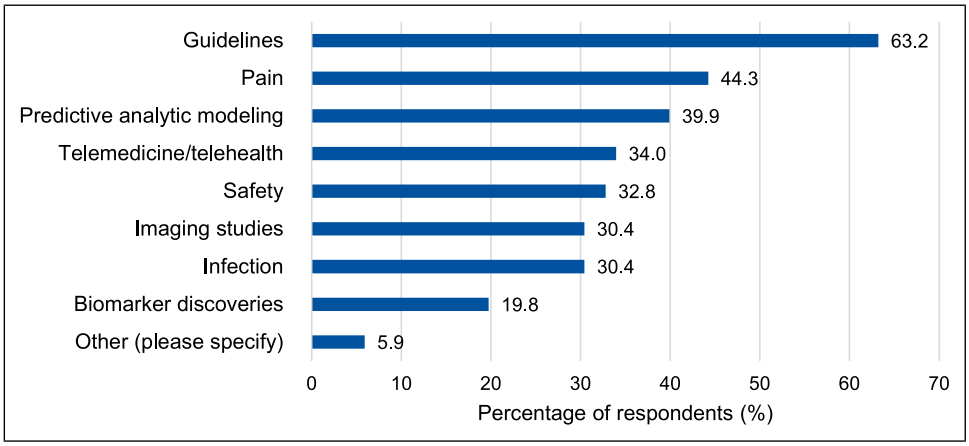

Figure 3. Respondent prioritization of areas for a global research initiative.

followed by Latin America and Europe/Southern Africa. It was felt that one way to stimulate more research in these regions would be by teaching spine surgeons about research. There was especially strong support in Latin America and the Middle East/Northern Africa to have more in-person research education course offerings. Online research education material should be made available in the local language. Another strongly supported research training and educational activity by all regions included providing research fellowship opportunities in either preclinical or clinical research.

Most felt that a research mentorship program would be beneficial but when ranked against other research activities, it was less favored. Nevertheless, this is a research area that could be further developed because less than 50% of respondents currently have/had a research mentor or are a research mentor. In addition, those that were mentored indicated that their mentor was instrumental in motivating them to pursue research. Of the 5 regions, Latin America had this research activity ranked the highest.

There was strong support from all regions to receive more research grants. However, when ranked against other research activities, it was primarily North America and Europe/Southern Africa that favored this activity. These regions were also more likely to apply for research funding, and this comes as no surprise, as there are more opportunities to obtain research funding, especially in North America because of the National Institutes of Health (NIH) in the United States, one of the leading granting agencies in the world.[13] In addition, there are more individual specialized spine societies (e.g., Cervical Spine Research Society, Scoliosis Research Society), funding agencies, and philanthropic foundations in the United States. Providing research grants and financial support is a popular and common research activity performed by several societies but may not be appropriate for building research in regions that are less established in conducting research. Nevertheless, awarding seed funding for new research initiatives and innovation to young investigators is encouraged. Farrokhyar et al.[14] evaluated the effect of awarding seed funding on the research productivity of junior investigators and found that awardees were more likely to publish and had greater success in securing future funding.

This study is not without limitations. The survey received a 7% response rate, and although low, this is consistent with past surveys that have been conducted and published using the AO Spine community.[15,16] In addition, we believe the data are representative as not all AO Spine members are researchers, and the proportion of respondents from each region is similar to that of the AO Spine community. While there was a respectable number of respondents that participated in the survey, not all participants completed all questions. We attribute this to the survey having optional questions and being too long, with 84 questions and taking an average of 22 min to complete. To make the survey simpler for the respondent, we applied branching logic to some of the questions, and this could be perceived as introducing bias to these topics as only some respondents were targeted to answer these questions. In addition, a small portion of the respondents (6.3%, 21/333) did not perform research, so their interest in the survey may have diminished over time. Furthermore, over 50% of respondents represented academic/university hospitals, and in North America this represented 80% of respondents, which could have biased results, and may not be representative of the spine surgeon population. Nevertheless, we believe that those that completed the survey are passionate and interested in research. We also have confidence in the data because when comparing the demographic data to other recently conducted AO Spine surveys, the findings are similar.[15,16] In addition, the current study reports on the overall crude metrics between global regions. We hope that in time we can further elaborate

analytically as to the determinants of various domains, taking into account more multivariate approaches for future reports and evaluating the cost versus utility of the proposed solutions in promoting research in under-developed areas.

Conclusion

Our study is the first, to our knowledge, to assess the research needs and practices of spine surgeons worldwide. Due to the heterogeneity in spine surgeon research practices worldwide, it is advised to tailor local/regional programs according to the needs specific to the region. Further research performed at the regional levels is recommended. Global research initiatives should include establishing research registries and data collection systems as well as research training and education. Therefore, we should promote big data, artificial intelligence and algorithm testing in large datasets and cohorts. To address such platforms, research training and education will be imperative foundational pillars among spine surgeons in years to come. To advance spine care worldwide, spine societies should focus on establishing clinical practice guidelines, conducting studies centered around pain management, and supporting predictive analytic modeling. We hope these findings may be useful to the broader spine community and other relevant professional and academic health societies. Moving forward, a multidisciplinary approach to spine research is needed if the field is to advance.

Acknowledgments

We would like to thank the AO Spine Community Development staff as well as the regional managers and staff for helping to distribute and bring awareness to the survey.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Niccole Germscheid https://orcid.org/0000-0002-8516-2951
Jason P. Y. Cheung https://orcid.org/0000-0002-7052-0875
Daniel M. Sciubba https://orcid.org/0000-0001-7604-434X
Stephen J. Lewis https://orcid.org/0000-0002-9173-8443
Dino Samartzis https://orcid.org/0000-0002-7473-1311

Supplementary Material

Supplementary material for this article is available online.

References

1. Merchan N, Bernstein DN, Maqsoodi N, Ikpeze T, Mesfin A. What is the return on investment of spine society research grants? *Spine (Phila Pa)*. 1976;46(23):2021.
2. Samartzis D, Germscheid NM, Fehlings MG, et al. AO Spine Knowledge Forums: research in motion. *Global Spine J*. 2019; 9(1 suppl l):5S-7S.
3. Schroeder GD, Canseco JA, Patel PD, et al. Establishing the injury severity of subaxial cervical spine trauma: validating the hierarchical nature of the AO Spine subaxial cervical spine injury classification system. *Spine (Phila Pa)*. 2021;46(10):649-657.
4. Versteeg AL, Sahgal A, Rhines LD, et al. Health related quality of life outcomes following surgery and/or radiation for patients with potentially unstable spinal metastases. *Spine J*. 2021;21(3):492-499.
5. Wang JC, Yoon ST, Brodke DS, et al. Development of AO Spine BOnE (bone osteobiologics and evidence) classification. *Global Spine J*. 2020;10(7):871-874.
6. Zuckerman SL, Cerpa M, Lenke LG, et al. Patient-reported outcomes after complex adult spinal deformity surgery: 5-year results of the Scoli-Risk-1 study. *Global Spine J*. 2021; 2192568220988276.
7. Fehlings MG, Tetreault LA, Wilson JR, et al. A clinical practice guideline for the management of patients with acute spinal cord injury and central cord syndrome: recommendations on the timing (≤24 hours versus >24 hours) of decompressive surgery. *Global Spine J*. 2017;7(3 suppl l):195S-202S.
8. Brown NJ. Developing physician-scientists. *Circ Res*. 2018; 123(6):645-647.
9. Ntekim A, Ibraheem A, Adeniyi-Sofoluwe A, et al. Implementing oncology clinical trials in Nigeria: a model for capacity building. *BMC Health Serv Res*. 2020;20(1):713.
10. Benedetti V, Echeverria G, Riquelme I. Biomedical research in Latin America: we can do more. *Lancet*. 2016;387(10022):941.
11. Aebi M, Grob D. SSE Spine Tango: a European spine registry promoted by the Spine Society of Europe (SSE). *Eur Spine J*. 2004;13(8):661-662.
12. Strömqvist B, Fritzell P, Hägg O, Jönsson B, Swedish Society of Spinal Surgeons. The Swedish Spine register: development, design and utility. *Eur Spine J*. 2009;18(suppl 3):294-304.
13. Ralaidovy AH, Adam T, Boucher P. Resource allocation for biomedical research: analysis of investments by major funders. *Health Res Pol Syst*. 2020;18(1):20.
14. Farrokhyar F, Bianco D, Dao D, et al. Impact of research investment on scientific productivity of junior researchers. *Transl Behav Med*. 2016;6(4):659-668.
15. Louie P, Harada G, Harrop J, et al. Perioperative anticoagulation management in Spine surgery: initial findings from the AO Spine anticoagulation global survey. *Global Spine J*. 2020; 10(5):512-527.
16. Riew GJ, Lovecchio F, Samartzis D, et al. Telemedicine in spine surgery: global perspectives and practices. *Global Spine J*. 2021; 21925682211022311.