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The Impact of COVID-19 Pandemic on Spine Surgeons Worldwide: A One Year Prospective Comparative Study

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Abstract

Study Design: Survey

Objective: In March of 2020, an original study by Louie et al investigated the impact of COVID-19 on 902 spine surgeons internationally. Since then, due to varying government responses and public health initiatives to the pandemic, individual countries and regions of the world have been affected differently. Therefore, this follow-up study aimed to assess how the COVID-19 impact on spine surgeons has changed 1 year later.

Methods: A repeat, multi-dimensional, 90-item survey written in English was distributed to spine surgeons worldwide via email to the AO Spine membership who agreed to receive surveys. Questions were categorized into the following domains: demographics, COVID-19 observations, preparedness, personal impact, patient care, and future perceptions.

Results: Basic respondent demographics, such as gender, age, home demographics, medical comorbidities, practice type, and years since training completion, were similar to those of the original 2020 survey. Significant differences between groups included reasons for COVID testing, opinions of media coverage, hospital unemployment, likelihood to be performing elective surgery, percentage of cases cancelled, percentage of personal income, sick leave, personal time allocation, stress coping mechanisms, and the belief that future guidelines were needed (P<.05).

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Conclusion: Compared to baseline results collected at the beginning of the COVID-19 pandemic in 2020, significant differences in various domains related to COVID-19 perceptions, hospital preparedness, practice impact, personal impact, and future perceptions have developed. Follow-up assessment of spine surgeons has further indicated that telemedicine and virtual education are mainstays. Such findings may help to inform and manage expectations and responses to any future outbreaks.

Keywords
COVID-19, coronavirus, spine surgeons, global, worldwide, impact

Introduction

In 2020, the COVID-19 virus swept throughout the globe, drastically changing the way of life for billions of people. By March of 2020, almost all countries around the world enacted self-imposed quarantines on their citizens. As of January 2022, there have been over 300 million recorded cases and over 5.4 million reported COVID-19-related deaths worldwide.[1] Several systematic reviews have shown negative impacts on the health-related quality of life for those patients that were infected by the virus.[2,3]

In addition to patients, healthcare workers have been greatly affected by the COVID-19 pandemic. Approximately 3607 healthcare workers in the USA died within the first year of the pandemic.[4] In a systematic review examining the psychological and mental impacts of COVID-19, Luo et al[5] found anxiety, depression, stress, insomnia, and posttraumatic stress symptoms/disorder to be present in both healthcare workers and the general population. Despite having a better understanding of the global impact of the pandemic, little is known about how individual subspecialties were and continue to be affected.

In March/April of 2020, during the early stages of the COVID-19 pandemic, Louie et al[6] distributed the multidimensional AO Spine COVID-19 and Spine Surgeon Global Impact Survey to investigate the impact of COVID-19 on spine surgeons globally. This AO Spine-initiated study consisted of over 900 spine surgeons from 91 different countries and was 1 of the first to report upon the global variations of COVID-19 among healthcare workers, in this case spine surgeons.[6-13] This initiative noted that the pandemic significantly impacted the health, personal life, and professional life of spine surgeons worldwide. Since the original survey was distributed, individual countries and regions of the world have been affected differently, and therefore have responded differently throughout the pandemic. However, little is known as to how this pandemic has impacted spine surgeons prospectively. As such, the current study addressed the 1-year follow-up of the Louie et al[6] study, assessing the impact of COVID-19 on spine surgeons worldwide and its evolution over time.

Methods

Survey Design and Content

Following institutional review board approval (#21012505), a survey comparable to the original AO Spine COVID-19 and Spine Surgeon Global Impact Survey that was distributed in March/April of 2020[6] was constructed and redistributed in March/April of 2021. Question selection involved input from a survey panel composed of 5 regional Research Chairs of AO Spine representing seven global regions (i.e., Africa, Asia, Australia, Europe, Middle East, North America, and South America/Latin America). A Delphi-style approach was used to establish consensus after several rounds of review before finalization of the survey. Domains included in the survey consisted of demographics, COVID-19 observations, preparedness, personal impact, patient care, and future perceptions.

Survey Distribution

The 90-item survey, written in English, was distributed via email to the AO Spine membership who agreed to receive surveys (approximately 4700 spine surgeons at time of follow-up survey). The survey was created with SurveyMonkey Inc (San Mateo, CA, USA) and allowed the recipients 12 days to complete (26 March 2021 to 6 April 2021). Respondent participation was voluntary and anonymous.

Statistical Analyses

All statistical analyses were performed with JASP version .15. Percentages and means (± standard deviation) were reported for count data and rank-order questions, respectively. Statistical analyses were performed to assess significant differences in count data using a combination of Fisher's exact and χ^2 tests where applicable, depending on sample size. Differences in continuous variables between groups were assessed using analysis of variance (ANOVA). We compared our findings to the results based on the Louie et al[6] study. Unlike the original survey, this follow-up did not compare geographic regions

because the sample size on the follow-up survey was smaller. *P*-values were 2-tailed, and a $P < .05$ was considered statistically significant.

Results

Demographics

Similar to the 2020 survey, the majority of the 275 respondents in the 2021 survey were male (89.1%), practicing in academic centers (41.5%), and between the ages of 35 and 44 years (32.7%) ($P = .208$, P$P = .314$, and P$P = .104$, respectively). Moreover, survey groups did not differ by home demographics (e.g., spouse at home, number of children at home, etc.), medical comorbidities, or years since training completion (Tables 1 and 2). There was no difference in the geographic distribution of the respondents from Africa (2020 = 5.0% vs 2021 = 5.1%), Asia (2020 = 24.2% vs 2021 = 26.9%), Australia (2020=.9% vs 2021 = .7%), Europe (2020 = 27.5% vs 2021=27.3%), and South America/Latin America (2020 = 16.5% vs 2021=17.8%) ($P = .816$, $P = .265$, $P = .801$, $P = .885$, $P = .495$, respectively). However, there were statistically more respondents from the Middle East (2020 = 8.7% vs 2021 = 13.1%; $P = .025$) and fewer from North America (2020 = 17.3% vs 2021=9.1%; $P < .002$) in the 2021 follow up. More respondents reported themselves as orthopedic spine surgeons (2020= 70.6% vs 2021=62.5%; $P = .011$) compared to neurosurgery spine surgeons (2020= 27.3% vs 2021=33.8%; $P < .05$) in the follow-up. Fewer respondents were fellowship [trained (2020= 71.5% vs 2021=65.1%; $P < .02$) in the follow-up (Table 2). Notably, there were more respondents in the 2020 cohort compared to the 2021 cohort who reported greater percent of practice devoted to clinical duties (P=.038); however, there were no differences in other practice strata (i.e., research or teaching; $P = .760$ and $P = .220$) respectively; Table 2).

COVID-19 Perceptions

Compared to 6.7% in the original survey, 71.3% of 2021 respondents had undergone testing for COVID-19, of which 18.0% tested positive ($P < .001$). Moreover, 84.4% of participants indicated that they personally knew someone diagnosed with COVID-19 compared to 46.6% in 2020 ($P < .001$). Reasons for testing also differed significantly between groups ($P < .001$). In the 2020 survey, the most likely reason for getting tested was showing symptoms (49.3%), in contrast to having direct contact with a COVID-19 positive patient in 2021 (24.4%). Likewise, opinions of media coverage also significantly differed in that fewer respendats form the 2021 survery (36.7%) thought that the media was accurately covering the pandemic compared to the 2020 survey (48.5%), $P = .013$) and more respondents from the 2021 survey (21.8%) thought the media wasn't providing enough coverage compared to the 2020 survey (16.1%; $P = .007$). There was no difference in media source utilized by respondents between cohorts (i.e., international vs national, internet vs television, etc.; P>.05) except respondants from the 2020 cohort were more likely to use social media (2020= 9.9% vs 2021=4.4%; $P = .028$) (Table 3).

Hospital Preparedness

Respondents of the 2021 survey were significantly more likely to have undergone mandatory or self-imposed quarantine compared to the 2020 respondents (2020= 22.9% vs 2021=32.4%; $P < .001$). Moreover, the interventions employed by the hospital (e.g., quarantine after travel, cancellation of in-person meetings, etc.) differed significantly between the two cohorts ($P \leq .049$). Similarly, respondents from the 2021 survey noted greater hospital unemployment than those in 2020 (2020=8.8% vs 2021=19.6%; $P < .001$); however, furlough rates decreased from 2020 to 2021 (40.5% vs 25.8%; $P = .01$). Frequency of updates from the hospital also differed between groups ($P \leq .031$). More specifically, in 2020, respondents were receiving updates more frequently from the hospital compared to a year later (Table 4).

Practice Impact

Compared to 2020, respondents of the 2021 survey were significantly more likely to be performing elective surgeries (2020= 18.5% vs 2021=67.6%; $P < .001$). Additionally, the percentage of cases cancelled secondary to COVID-19 also decreased from 2020 to 2021 (2020=67.1% vs 2021=12.0%; $P < .001$). Responses regarding impact on resident and fellow training differed significantly between surveys because training residents and fellows returned in 2021 ($P < .001$); however, on further analysis, the only significant changes were that respondents were more likely to return to training residents and fellows and that the COVID-19 impact had decreased in 2021 ($P = .001$ and $P = .001$, respectively). Interestingly, the likelihood of a surgeon to warn patients if he/she is COVID-19 positive also differed between surveys ($P \leq .001$), with a significant decrease in the proportion of respondents who would "absolutely report" (2020 = 74.2% vs 2021 = 53.5%; $P < .001$) and an increase in the proportion responding "less likely to report" (2020 = 5.4% vs 2021 = 8.7%; $P = .013$). Percentage of personal income as well as hospital income also differed between surveys ($P < .001$ and $P < .001$, respectively). In 2021, both personal and hospital income were affected to a lesser extent than in 2020 (Table 5).

Personal Impact and Future Perceptions

Rates of sick leave significantly decreased between 2020 to 2021 (2020=50.0% vs 2021=13.1%; $P < .001$). Regarding personal time allocation (where 1 equaled most time and 8 equaled least time), there were significant changes in time allocated to resting (2020= 4.3 ± 2.0 vs

2021=4.7±1.8; $P = .003$), future planning (2020=4.6 ± 1.8 vs 2021=5.0 ± 1.8; $P = .001$), and practice/medical work (2020=4.1 ± 2.5 vs 2021=3.1 ± 2.4; $P < .001$). Moreover, there were significant differences in reported stress coping mechanisms between surveys ($P = .002$), specifically in decreased reading (2020=62.2% vs 2021=33.1%; $P < .001$), television (2020=53.5% vs 2021=30.5%; $P < .001$) and telecommunication with friends (2020=43.8% vs 2021=22.9%; $P < .001$; Table 6). With regards to future perceptions, specifically belief that future guidelines were needed, significant differences existed between the 2020 and 2021 cohorts ($P < .001$). Respondents from the 2021 (64%) survey were less likely to think that future guidelines are needed than those from the 2020 (94.7%) survey. Interestingly, no differences were reported from the perceived impact of COVID-19 between the two time points ($P > .05$). Interest in online spine education differed between groups ($P < .001$), with a statistically significant decrease in "very interested in online spine education" (2020=42.5% vs 2021=21.1%; $P < .001$); however, no significant differences were noted for the answer choices "Interested and "Not interested" although more respondents from the 2021 follow up reported being "Somewhat Interested" (20.4% vs 17.5%; P=.021) regarding online education (Table 7)**.** Furthermore, there were significant differences in percentage of telecommunication visits between cohorts ($P < .001$), as the majority of respondents (64.4%) indicated that 25% or less of their visits were via telemedicine in 2021 compared to 50% in 2020 (Table 7).

Discussion

Since the initial AO Spine COVID-19 and Spine Surgeon Global Impact Survey was distributed in 2020, different parts of the world have responded to the pandemic in unique ways. With multiple waves of new COVID-19 variants and recent controversial guidelines released by governing public heathcare bodies (e.g. United States Center for Disease Control, World Heath Organization), it is certain that the COVID-19 pandemic remains a global headline whose end remains uncertain. The goal of this follow-up survey was to elucidate how the reactions and perceptions to this global crisis have evolved, noting distinct changes in various practice and personal domains, presenting a quantifiable 1-year follow-up metric of pandemic impact upon the spine surgeon community.

COVID-19 Survey

The original survey was the first to assess the multidimensional impact of COVID-19 on spine surgeons worldwide.[6] Since then, numerous other groups conducted their own assessment of the impact of the pandemic across other physician populations. Jain et al[14] examined the impact of the COVID-19 lockdown on 611 orthopedic surgeons in India and highlighted the lockdown's psychological impact. Chan et al[15] surveyed 222 spine surgeons from 19 different Pacific Asian countries concerning the pandemic's effects on clinical and surgical practice. These surveys, in addition to numerous others published over the past year, provide valuable insight into the knowledge and opinions of surgeons. Nevertheless, the original survey by Louie et al[6] and its current follow-up survey remain the only comprehensive and multidimensional assessments of the impact of COVID-19 on spine surgeons on a global scale.

Resources, Testing, and Vaccinations

At the time of the original survey, the COVID-19 pandemic remained in early stages, and testing and other resources were very scarce. Widespread active COVID-19 viral and antibody testing had not yet been employed, and infections were being inconsistently tracked and counted. Since then, there have been massive global efforts to provide affordable and accessible forms of testing, evidenced by the results of this follow-up survey. Not only did rates of testing amongst surgeons increase, but a much higher percentage of the respondents had tested positive or knew someone who had tested positive by the time of this follow-up survey. Direct contact with a COVID-19 positive patient was the most likely reason for the getting tested in the follow-up survey, further illustrating the personal and professional impact the pandemic has had globally.

The original 2020 survey also preceded the development of COVID-19 vaccines. By 2021, vaccines had become widely available, and the vast majority (95%) of respondents had received at least 1 dose by the time of this follow-up survey. However, vaccination rates and overall perception of vaccine efficacy have varied across the world. Governmental and employer vaccination mandates have generated substantial controversy. Even throughout the pandemic, the perception on proper vaccine protocols has changed. Half of the respondents at the time of survey completion said they were required to be vaccinated against COVID-19, and even more said they would require the members of their team to be vaccinated. As we have learned more about the virus, government and private policies have adjusted accordingly.

Surgeon Well-Being

A goal of the survey was to assess how the surgeons' health status has evolved throughout the pandemic and what factors play a role. In 2020, most of the world was in lockdown and respondents were quarantining at home, with less than 1% having been hospitalized for COVID-19. By the time of the 2021 survey, over 13.1% had taken sick leave for COVID, 2.5% had been hospitalized for COVID, and .4% had required ICU treatment. The pandemic has had a profound impact not only on the physical health of those that have

Table 1. Personal Demographics.

2020 Survey	#	%	2021 Survey	#	%	*P*-value
Age (Years)			Age (Years)			
25-34	130	14.5	25-34	33	12	.311
35-44	344	38.4	35-44	90	32.7	.104
45-54	245	27.4	45-54	87	31.6	.149
55-64	150	16.8	55-64	51	18.5	.460
65+	26	2.9	65+	11	4.0	.353
Sex			Sex			
Female	55	6.2	Female	24	8.7	.127
Male	826	93.8	Male	245	89.1	.208
Home demographics			Home demographics			
Spouse at home	773	86.5	Spouse at home	231	84.0	.486
Children at home			Children at home			
0	250	28.2	0	77	28.0	.927
1	221	24.9	1	52	18.9	.054
2	266	30.0	2	82	29.8	.917
3	109	12.3	3	39	14.2	.358
4+	41	4.6	4+	19	6.9	.119
Estimated home city population			Estimated home city population			
<100,000	46	5.2	<100,000	15	5.5	.816
100,000-500,000	185	20.7	100,000-500,000	45	16.4	.129
500,000-1,000,000	136	15.2	500,000-1,000,000	42	15.3	.937
1,000,000-2,000,000	144	16.1	1,000,000-2,000,000	51	18.5	.314
>2,000,000	382	42.8	>2,000,000	117	42.5	.954
Geographic region			Geographic region			
Africa	44	5.0	Africa	14	5.1	.886
Asia	213	24.2	Asia	74	26.9	.265
Australia	8	0.9	Australia	2	0.7	.801
Europe	242	27.5	Europe	75	27.3	.885
Middle east	77	8.7	Middle east	36	13.1	**.025**
North America	152	17.3	North America	25	9.1	**<.002**
South America/Latin America	145	16.5	South America/Latin America	49	17.8	.495
Medical comorbidities			Medical comorbidities			
Obesity	103	11.4	Obesity	35	12.7	.555
Hypertension	156	17.3	Hypertension	46	16.7	.827
Tobacco use	77	8.5	Tobacco use	14	5.1	.061
Diabetes	45	5.0	Diabetes	16	5.8	.587
Respiratory illness	35	3.9	Respiratory illness	12	4.4	.687
Renal failure	5	0.6	Renal failure	4	1.5	.269
Cancer	4	0.4	Cancer	2	0.7	.924
Cardiac disease	25	2.8	Cardiac disease	7	2.5	.992
No comorbidities	570	63.2	No comorbidities	186	67.6	.178
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

become infected with the virus, but also the psychological and social health of everyone else.[16,17] Although waves of new variants have come and gone, the heightened sense of anxiety and stress throughout the world has remained. Healthcare professionals, specifically surgeons, have been no exception. A look into the state of mental health of clinicians in China found the prevalence of stress and anxiety disorders were 27% and 23%, respectively.[18] In a cohort of UK surgeons, over 56% were classified at high risk of developing psychological comorbidity from the stress and disruption caused by COVID-19, with a greater likelihood of developing burnout in the future.[19,20] As the pandemic has continued to evolve, so has the way surgeons have decided to allocate their time. Specifically increasing their time resting

Table 2. Practice Demographics.

2020 Survey	#	%	2021 Survey	#	%	P-Value
Specialty			Specialty			
Orthopaedics	637	70.6	Orthopaedics	172	62.5	**.011**
Neurosurgery	246	27.3	Neurosurgery	93	33.8	**<.05**
Trauma	104	11.5	Trauma	30	10.9	.777
Pediatric surgery	17	1.9	Pediatric surgery	2	0.7	.289
Other	35	3.9	Other	4	1.5	.076
Fellowship trained			Fellowship trained			
Yes	645	71.5	Yes	179	65.1	**<.02**
No	257	28.5	No	93	33.8	.091
Years since training completion			Years since training completion			
Less than 5 Years	161	25.3	Less than 5 Years	43	15.6	.396
5 to 10 Years	141	22.2	5 to 10 Years	46	16.7	.664
10 to 15 Years	104	16.4	10 to 15 Years	31	11.3	.907
15 to 20 Years	117	18.4	15 to 20 Years	27	9.8	.162
Over 20 Years	113	17.8	Over 20 Years	38	13.8	.575
Practice type			Practice type			
Academic/Private combined	204	22.9	Academic/Private combined	71	25.8	.272
Academic	405	45.4	Academic	114	41.5	.314
Private	144	16.1	Private	37	13.5	.312
Public/Local hospital	139	15.6	Public/Local hospital	49	17.8	.255
Practice breakdown (%)			Practice breakdown (%)			
Research			Research			
0-25	731	81.9	0-25	221	80.4	.802
26-50	129	14.5	26-50	36	13.1	.613
51-75	21	2.4	51-75	9	3.3	.515
76-100	12	1.3	76-100	5	1.8	.760
Clinical			Clinical			
0-25	22	2.5	0-25	17	6.2	**<.003**
26-50	87	9.7	26-50	37	13.5	.072
51-75	194	21.7	51-75	56	20.4	.685
76-100	590	66.1	76-100	161	58.5	**.038**
Teaching			Teaching			
0-25	668	74.9	0-25	187	68.0	.05
26-50	152	17.0	26-50	57	20.7	.141
51-75	50	5.6	51-75	15	5.5	.925
76-100	22	2.5	76-100	13	4.7	.220
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

and planning for the future, and decreasing time on practice and medical work. The global crisis has caused many people to re-evaluate many aspects of life, and spine surgeons are no different. Similar to free time, the stress coping mechanisms of the respondents changed over the year. The most common coping strategies employed here by the respondents in order include spending time with family, exercising, reading, listening to music, and watching TV. Although it has always been important, the impact of the pandemic has really highlighted the importance of finding an appropriate coping strategy for every spine surgeon to help deal with the stresses of everyday life and prevent burnout.

Patient Care

Hospitals and healthcare facilities worldwide implemented interventions to protect their employees and prioritize the health of their patients.[21-25] In the beginning stages of the pandemic when the original survey was distributed, outpatient centers had begun transitioning to a virtual platform and most elective procedures were put on pause. The most frequent intervention was the cancellation of elective surgeries (86%), largely to allocate limited materials, such as hospital beds and medical staff, to provide perioperative care and support for patients

Table 3. COVID-19 Perceptions.

	Overall			Overall		
2020 Survey	#/Mean	%	2021 Survey	#/Mean	%	*P*-Value
COVID-19 diagnosis			COVID-19 diagnosis			
Know someone diagnosed	392	46.6	Know someone diagnosed	232	84.4	**<.001**
Personally diagnosed	9	1.1	Personally diagnosed	46	16.7	**<.001**
COVID-19 testing			COVID-19 testing			
Know how to get tested	701	82.9	Know how to get tested		0.0	
Personally tested	57	6.7	Personally tested	196	71.3	**<.001**
Reason for testing			Reason for testing			
Direct with COVID-19 positive patient	49	35.5	Direct with COVID-19 positive patient	67	24.4	**<.001**
Prophylactic	12	8.7	Prophylactic	28	10.2	**<.001**
Demonstrated symptoms	68	49.3	Demonstrated symptoms	47	17.1	**<.001**
Ask to be tested	9	6.5	Ask to be tested	30	10.9	**<.001**
Mean worry about COVID-19 (1- Not worried to 5- very worried)	3.7	±1.2	Mean worry about COVID-19 (1- Not worried to 5- very worried)	3.5	±1.1	
Current stressors			Current stressors			
Personal health	358	42.5	Personal health	97	35.3	.188
Family health	640	76.0	Family health	191	69.5	.6329
Community health	370	43.9	Community health	91	33.1	**.0183**
Hospital capacity	352	41.8	Hospital capacity	69	25.1	**<.001**
Timeline to resume clinical practice	378	44.9	Timeline to resume clinical practice	104	37.8	.227
Government/Leadership	154	18.3	Government/Leadership	74	26.9	**<.001**
Return to non-essential activities	116	13.8	Return to non-essential activities	67	24.4	**<.001**
Economic issues	385	45.7	Economic issues	103	37.5	.123
Other	11	1.3	Other	2	0.7	.494
Media perceptions			Media perceptions			
Accurate coverage	407	48.5	Accurate coverage	101	36.7	**.013**
Excessive coverage	298	35.5	Excessive coverage	92	33.5	.897
Not enough coverage	135	16.1	Not enough coverage	60	21.8	**.007**
Current media sources			Current media sources			
International News- internet	202	26.0	International News- internet	59	21.5	.896
International News- television	72	9.3	International News- television	24	8.7	.692
National/Local News- internet	224	28.8	National/Local News- internet	62	22.5	.438
National/Local News- television	177	22.8	National/Local News- television	56	20.4	.787
Newspaper	28	3.6	Newspaper	12	4.4	.312
Social media	75	9.6	Social media	12	4.4	**.028**
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

requiring an emergent operation. In the present follow-up survey, the number of elective surgery cancellations dropped to 61%. Other common hospital interventions included cancellations of hospital meetings (66%) and cancellations of educational/academic activities (62%). Our results also indicated that many individuals felt adequate PPE was provided in their institutions. Less than half of respondents reported adequate PPE in the original survey, which likely indicates a vast improvement in the response to the global health crisis by the medical community. When evaluating the perceptions of effectiveness of responses to the pandemic by hospitals, the respondents in the 2021 survey were more likely to believe that acceptable actions were being taken compared to their 2020 conterparts, suggesting an overall improvement in responses made by the healthcare systems.

Despite many spine procedures being considered non-emergent and thus delayed, numerous patients may experience prolonged pain and debilitations by postponing their treatment. Studies have already reported psychological and economic impacts that result from a decrease in physical function and the inability to work.[11] Further studies will be required to evaluate the full impact of treatment delay caused by the COVID-19 pandemic on overall patient well-being.

Table 4. Hospital Preparedness.

2020 Survey	#	%	2021 Survey	#	%	*P*-value
Quarantined	193	22.9	Quarantine	89	32.4	**<.001**
Institution			Institution			
Formal guidelines in place	452	60.4	Formal guidelines in place	170	61.8	**<.001**
Adequate PPE provided	415	49.6	Adequate PPE provided	186	67.6	**<.001**
N95	451	54.0	N95	0	0.0	
Surgical mask	738	88.4	Surgical mask	0	0.0	
Face shield	415	49.7	Face shield	0	0.0	
Gown	491	58.8	Gown	0	0.0	
Full face respirator	95	11.4	Full face respirator	0	0.0	
Ventilators	343	41.0	Ventilators	0	0.0	
Other	55	6.6	Other	0	0.0	
None	33	4.0	None	0	0.0	
Hospital interventions			Hospital interventions			
Quarantine after international travel	507	60.9	Quarantine after international travel	136	49.5	.05
Limitations on domestic travel	483	58.0	Limitations on domestic travel	106	38.5	**<.001**
Non-essential employees work from home	558	67.0	Non-essential employees work from home	127	46.2	**<.001**
Cancellation of all educational/Academic activities	689	82.7	Cancellation of all educational/Academic activities	169	61.5	**<.001**
Cancellation of hospital meetings	674	80.9	Cancellation of hospital meetings	182	66.2	**<.001**
Cancellation of elective surgeries	714	85.7	Cancellation of elective surgeries	167	60.7	**<.001**
None of the above	17	2.0	None of the above	21	7.6	**<.001**
Medical staff furlough			Medical staff furlough			
Yes	307	40.5	Yes	71	25.8	**.011**
Potentially	165	21.8	Potentially	49	17.8	.858
No	286	37.8	No	102	37.1	.096
Medical staff unemployment			Medical staff unemployment			
Yes	67	8.8	Yes	54	19.6	**<.001**
Potentially	108	14.2	Potentially	14	5.1	**.002**
No	586	77.0	No	154	56.0	**.007**
Perception of hospital effectiveness			Perception of hospital effectiveness			
Acceptable/Appropriate	477	61.4	Acceptable/Appropriate	141	51.3	.639
Excessive/Unnecessary	17	2.2	Excessive/Unnecessary	6	2.2	.949
Disarray/Disorganized	68	8.8	Disarray/Disorganized	16	5.8	.402
Not enough action	215	27.7	Not enough action	62	22.5	.658
Frequency of updates from hospital			Frequency of updates from hospital			
Multiple times/Day	160	20.7	Multiple times/Day	15	5.5	**<.001**
Once/Day	366	47.3	Once/Day	63	22.9	**<.001**
2-3 times/Week	106	13.7	2-3 times/Week	46	16.7	**.031**
Once/Week	44	5.7	Once/Week	42	15.3	**<.001**
Less than once/Week	10	1.3	Less than once/Week	21	7.6	**<.001**
Not at all	142	18.4	Not at all	49	17.8	.413
Government			Government			
Cancel elective surgery	646	77.2	Cancel elective surgery	152	55.3	**<.001**
Shelter/Self-protection	570	68.1	Shelter/Self-protection	117	42.5	**<.001**
No gatherings >50 people	365	43.6	No gatherings >50 people	112	40.7	.938
No gatherings >100 people	458	58.3	No gatherings >100 people	139	50.5	.946
No gatherings > household	371	44.3	No gatherings > household	97	35.3	.082
Closure of non-essential business	727	86.9	Closure of non-essential business	186	67.6	**<.001**
Closure of schools/Universities	795	95.0	Closure of schools/Universities	204	74.2	**<.001**
Closure of dine-in restaurants	711	85.0	Closure of dine-in restaurants	183	66.5	**<.001**
Closure of public transportation	239	28.6	Closure of public transportation	52	18.9	**.011**
Restrict elderly to home	426	50.9	Restrict elderly to home	97	35.3	**<.001**

(continued)

Table 4. (continued)

2020 Survey	#	%	2021 Survey	#	%	*P*-value
Perception of government effectiveness			Perception of government effectiveness			
Acceptable/Appropriate	456	58.5	Acceptable/Appropriate	80	29.1	**<.001**
Excessive/Unnecessary	20	2.6	Excessive/Unnecessary	8	2.9	.665
Disarray/Disorganized	88	11.3	Disarray/Disorganized	62	22.5	**<.001**
Not enough action	215	27.6	Not enough action	76	27.6	.201
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

Government, Media, and Future Guidelines

From the onset of the pandemic to now, governments have instituted numerous public health policies to curb the spread of the virus. The most common interventions included closures of schools/universities (81%), closure of non-essential businesses (74%), closure of dine-in restaurants (72%), and the cancellation of elective surgeries (60.3%). Responses from the governments were consistent between surveys. Although the effectiveness of these interventions are still uncertain, overall sentiment on effectiveness of governmental policies may be approximated by using survey responses that probe perceptions on how governments have responded to the pandemic, media portrayal and coverage of the pandemic, and current stressors individuals deal with because of the pandemic. Perceptions of government handling of the pandemic changed drastically over the span of a year between surveys. Nearly 60% of the respondents of the original survey thought the government's efforts were effective while just 35% shared the same belief a year later in the follow-up. Similarly, there was an increase in the percentage of people that belief that futher guidelines are needed, suggesting more than just a year is needed for changes to take effect. It is evident that the outbreak has not only impacted surgeons in their private lives but also professionally, as our results indicate decreases in elective surgeries, clinical time, research productivity, and training experiences overall since the start of the pandemic yet increases in each domain from the 2020 survey to the 2021 follow-up. To continue professional growth and provide quality patient care, continued utilization of technological resources is evident. Most respondents reported interest in online spine education and have already incorporated recommended alternatives for clinical visits, such as telecommunication,[12] into their practice. However, proper infrastructure must first be implemented to allow general access to these resources to hospitals and patients.

Telemedicine and Virtual Education

After government/public health agencies urged that all outpatient clincs, hospitals, and ambulatory surgical centers limit non-essentail activity in April of 2020, some healthcare centers experienced a decrease of more than 80% of in-person visits.[26,27] This caused healthcare providers to adjust the way they traditionally delivered services to their patients and implement new strategies to keep up with the evolving landscape. Telemedicine rapidly became a tool that allowed providers to manage patients' healthcare from a distance while maintaining social distance and minimizing spread.[28] Although there were geographical differences in the rate of telemedicine adoption and utilization, Riew et al[24] reported a significant increase in the use of telemedice globally by spine surgeons in the early stages of the pandemic. Similar to these findings and the global trend, the spine surgeons in the original Louie et al[6] survey experienced a rapid rise in telehealth visits in the initial wave of the COVID-19 pandemic.[10] However, in our follow-up survey, spine surgeons reported a significant decrease in the amount of percent of clinical visits they conducted over telecommunication per week. Drastically, in 2020 over 25% of the spine surgeons reported that 76-100% of their clinical visits occurred using telecommunication where as only 2.5% of the respondents from the 2021 follow-up attested to more than 76% of their clinical visits occurred using telecommunication. Depite the drop in total percentage of cases occurring over telehealth, 64% of spine surgeons still reported that 0-25% of their weekly clinical visits occurred over telecommunicationin during this period. Our results support those of a Delphi study examining telemedicine utilization in spine surgery by Iyer et al[21] that telemedicine was initially introduced out of necessity but because of patient satisfaction and cost savings, it is a mainstay. According to Mann et al,[29] telehealth has transformed the clinical practices of providers across multiple specialties globally. Patients have become accustomed to sharing biometric data and communicating with their provider over electronic platforms with consistently high patient satisfaction levels.[29,30] Initially, hesistant to adopt telehealth because of the challenges of conducting a proper neurological exam without direct surgeon-to-physician contact, spine surgeons are confident in the ability of telemedicine to communicate with patients as concluded by Lovecchio et al[22] Based on a global study of

Table 5. Practice Impact.

2020 Survey	#	%	2021 Survey	#	%	*P*-value
Still performing elective surgery	149	18.5	Still performing elective surgery	186	67.6	**<.001**
Essential/Emergency spine surgery	700	87.3	Essential/Emergency spine surgery		0.0	**<.001**
% Cancelled surgical cases/Week			% Cancelled surgical Cases/Week			
0-25	69	8.6	0-25	106	38.5	**<.001**
26-50	123	15.3	26-50	58	21.1	**.003**
51-75	72	9.0	51-75	35	12.7	**.017**
76-100	539	67.1	76-100	33	12.0	**<.001**
Impact on clinical time spent			Impact on clinical time spent			
Increased	46	5.7	Increased	31	11.3	**<.001**
Decreased	675	84.0	Decreased	127	46.2	**<.001**
Stayed the same	83	10.3	Stayed the same	72	26.2	**<.001**
Perceived impact on resident/Fellow training			Perceived impact on resident/Fellow training			
Not currently training residents/Fellows	268	33.7	Not currently training residents/Fellows	54	19.6	**<.001**
Hurts training experience	450	56.5	Hurts training experience	143	52.0	.539
Improves training experience	30	3.8	Improves training experience	4	1.5	.104
No overall impact	48	6.0	No overall impact	30	10.9	**.001**
Medical duties outside specialty	183	22.8	Medical duties outside specialty	72	26.2	**.038**
Warning patients if the surgeon is COVID-19 positive			Warning patients if the surgeon is COVID-19 positive			
Absolutely	595	74.2	Absolutely	147	53.5	**<.001**
Likely	106	13.2	Likely	35	12.7	.663
Less likely	43	5.4	Less likely	24	8.7	**.013**
Not at all	58	7.2	Not at all	26	9.5	.088
Research activities impacted			Research activities impacted			
No research engagement	206	27.0	No research engagement	47	17.1	**.042**
Complete stop	122	16.0	Complete stop	27	9.8	.105
Decrease in productivity	247	32.4	Decrease in productivity	82	29.8	.431
No change	108	14.2	No change	38	13.8	.416
Increase in productivity	80	10.5	Increase in productivity	28	10.2	.509
Surgery impact			Surgery impact			
Advise against	561	70.4	Advise against	185	67.3	.126
Proceed with standard precautions	138	17.3	Proceed with standard precautions	43	15.6	.892
Absent during intubation/Extubation	322	40.4	Absent during intubation/Extubation	35	12.7	**<.001**
Additional PPE during surgery	428	43.7	Additional PPE during surgery	57	20.7	**<.001**
Income impact			Income impact			
Losing income	308	40.5	Losing income	77	28.0	.057
No impact, salary	244	32.1	No impact, salary	88	32.0	.111
No impact, compensation-based	7	0.9	No impact, compensation-based	7	2.5	**.017**
Planned reduction, salary	138	18.1	Planned reduction, salary	35	12.7	.291
Planned reduction, compensation-based	64	8.4	Planned reduction, compensation-based	14	5.1	.368
% personal income affected			% Personal Income Affected			
0-25	219	28.9	0-25	119	43.3	**<.001**
26-50	226	29.9	26-50	73	26.5	.619
51-75	142	18.8	51-75	18	6.5	**<.001**
76-100	170	22.5	76-100	10	3.6	**<.001**
% hospital income affected			% Hospital income affected			
0-25	169	22.3	0-25	98	35.6	**<.001**
26-50	199	26.3	26-50	89	32.4	**<.001**
51-75	207	27.3	51-75	22	8.0	**<.001**
76-100	182	24.0	76-100	11	4.0	**<.001**
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

Table 6. Personal Impact.

2020 Survey	#/Mean	%/± SD	2021 Survey	#/Mean	%/± SD	*P*-Value
Sick leave for COVID-19	4	50.0	Sick leave for COVID-19	36	13.1	**<.001**
Hospitalization for COVID-19	1	12.5	Hospitalization for COVID-19	7	2.5	**<.001**
Intensive care unit (ICU) treatment	1	12.5	Intensive care unit (ICU) treatment	1	0.4	.373
Mean personal allocation of time (1- most time, 8- least time)			Mean personal allocation of time (1- most time, 8- least time)			
Spending time with family	2.7	±2.2	Spending time with family	2.8	±1.9	.496
Personal wellness	3.8	±1.9	Personal wellness	4	±2.0	.131
Resting	4.3	±2.0	Resting	4.7	±1.8	**.003**
Future planning	4.6	±1.8	Future planning	5	±1.8	**.001**
Hobbies	5.2	±1.9	Hobbies	5.3	±1.8	.439
Academic projects/Research	4.6	±2.1	Academic projects/Research	4.6	±2.1	1.00
Community outreach	6.3	±2.0	Community outreach	6.3	±2.2	1.00
Spine practice/Medical center work	4.1	±2.5	Spine practice/Medical center work	3.1	±2.4	**<.001**
Current stress coping mechanisms			Current stress coping mechanisms			
Exercise	463	62.9	Exercise	144	52.4	.764
Music	330	44.8	Music	86	31.3	.106
Meditation/Mindfulness	118	16.0	Meditation/Mindfulness	29	10.5	.265
Tobacco	29	3.9	Tobacco	14	5.1	.146
Alcohol	89	12.1	Alcohol	34	12.4	.236
Research projects	244	33.2	Research projects	52	18.9	**.006**
Family	578	78.5	Family	166	60.4	.263
Spiritual/Religious activities	116	15.8	Spiritual/Religious activities	35	12.7	.954
Reading	458	62.2	Reading	91	33.1	**<.001**
Television	394	53.5	Television	84	30.5	**<.001**
Telecommunication with friends	322	43.8	Telecommunication with friends	63	22.9	**<.001**
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

spine surgeons by Riew et al,[24] imaging review, initial visits, and follow-up visits were considered feasible to conduct over telemedice, and, interestingly, the vast majority of surgeons still preferred at least on in-person pre-operative visit. Although limitations exist, telehealth appears to be part of the management options of the spine specialist because of the way it has transformed how providers can offer care to their patients.

Similar to telemedicine, virtual education has transformed due to the COVID-19 pandemic. A consequence of the social distancing and quarantine mandates imposed by public and private governing bodies, essentially all major spine educational confrences were suspended for most of 2020 and into 2021. Originally reported by Louie et al,[6] spine surgeons' initial interest in online spine education increased in the early stages of the pandemic. In response to increased demand and decreased supply of spine education, virtual or hybrid spine conferences by various societies as well as webinars were developed.[31] Participants of such initiatives have in large part viewed the content as highly valuable to their practice and would continue participating post COVID-19. In a worldwide study by Swiatek et al[10] found that dedicating more than 25% of their practice to teaching was a predictor for increased interest in online education amoung spine surgeons. Because most conferences and lectures have returned to being in-person, our follow-up study found that interest in online spine education decreased in 2021. However, clinicians want to see "virtual" education continue post COVID-19,[31] as virtual options would help offset costs of travel to locations, decrease time away from work, and provide more flexible learning options.

Strengths and Limitations

As with any survey study, this follow-up study is not without limitation. The survey was distributed to the current AO Spine surgeon members' network and received a 7% response rate, a reduction from 23.7% in the original survey. However, there were no significant differences in the respondents' demographics between the two surveys. Due to the anonymous nature of the surveys, it was impossible to know if any of the same respondents from the original Louie et al[6] survey also responded to this follow-up; however, demographic findings were promising because it allowed us to compare between the two different time points. Selection bias could be a possible limitation and explanation for the

Table 7. Future Perceptions.

2020 Survey	Overall #	Overall %	2021 Survey	Overall #	Overall %	*P*-Value
Belief that future guidelines are needed			Belief that future guidelines are needed			
Yes	710	94.7	Yes	176	64.0	**<.001**
No	8	1.1	No	19	6.9	**<.001**
Unsure	32	4.3	Unsure	23	8.4	**<.001**
Most effective method for hospital updates			Most effective method for hospital updates			
internet webinar	379	48.8	internet webinar	90	32.7	**.006**
Email	486	62.6	Email	125	45.5	.143
Text message	223	28.7	Text message	69	25.1	.902
Flyers	49	6.3	Flyers	11	4.0	.344
Automated phone calls	43	5.5	Automated phone calls	14	5.1	.826
Social media outlets	218	28.1	Social media outlets	46	16.7	**.001**
Perceived impact in 1 Year			Perceived impact in 1 Year			
No change	133	17.7	No change	43	15.6	.716
Heighted awareness of hygiene	435	57.9	Heighted awareness of hygiene	121	44.0	.219
Increase use of PPE	344	45.8	Increase use of PPE	113	41.1	.378
Ask patients to reschedule if sick	285	38.0	Ask patients to reschedule if sick	115	41.8	**.002**
Increase non-operative measures prior to surgery	150	20.0	Increase non-operative measures prior to surgery	58	21.1	.089
Increase digital options for communication	314	41.8	Increase digital options for communication	92	33.5	.678
How likely to attend a conference in 1 year			How likely to attend a conference in 1 Year			
Likely	496	66.3	Likely	145	52.7	.509
Not likely	55	7.4	Not likely	21	7.6	.363
Unsure	197	26.3	Unsure	52	18.9	.297
% telecommunication clinical visits/Week			% Telecommunication clinical Visits/Week			
0-25	398	50.0	0-25	177	64.4	**<.001**
26-50	118	14.7	26-50	37	13.5	.872
51-75	77	9.6	51-75	11	4.0	**.017**
76-100	208	26.0	76-100	7	2.5	**<.001**
Interest in online spine education			Interest in online spine education			
Very interested	318	42.5	Very interested	58	21.1	**<.001**
Interested	300	40.1	Interested	101	36.7	.288
Somewhat interested	131	17.5	Somewhat interested	56	20.4	**.021**
Not interested	23	3.1	Not interested	9	3.3	.665
Total respondents	902	100	Total respondents	275	100	

Calculation of *P*-values was performed using chi-square, Fisher's exact test, and ANOVA.
Bolded values indicate statistical significance at $P < .05$.
= number of respondents/votes, % = percent, ± SD = standard deviation.

low response rate. Because of the smaller number of respondents in this follow-up, we did not statistically analyze the geographical differences withing this second survey. Ultimately, a possible explanation for the difference in response rate is the fact that when the original survey was distributed, a large majority of the respondents had paused their clinical and surgical responsibilities and were quarantined at home, and therefore more likely to take the time to respond. Another limitation is the size of the survey itself. In the follow-up survey, we included 90 questions, up from 73 in the original, which may contribute to survey fatique and lead to fewer responders. In the original Louie et al[6] survey there was a completion rate of 24% whereas in this follow up there was a completion rate of approximately 6%. We attribute this disparity to surgeons not being in quarantine and returning to their clinical duties by the time this follow-up survey was distributed, as well as an increased number of AO Spine members by almost 1000 more member for this follow-up. Although the responses in resource allocation has changed, various countries were still experiencing waves of COVID-19 and its variants; hence, the level of restrictions and lockdowns may be variable. In addition, the current study presents a univariate analytical approach to the data analyses; however, future efforts will consist of more multivariate approaches to identify unique determinants to impact outcomes. Despite its limitations, this follow-up survey still provides invaluable information on the changing prospective impact the COVID-19 pandemic has had on spine

surgeons worldwide, providing quantifiable metrices and documented testament of what the community has sustained throughout a public health ordeal.

Conclusion

The original survey by Louie et al[6] was the first international study to assess the COVID-19 impact among spine surgeons and in fact among any healthcare professionals worldwide. Since that time, there have been many laws and regulations implemented worldwide as a response to minimize mortality and morbidity from the virus. Our follow-up, prospective survey, the first of its kind, highlights distinct personal and practice-based platforms that spine surgeons have responded to or been impacted upon by the pandemic throughout 1 year. Our study also discusses the evolving impact the pandemic has had on telemedice and virtual education for spine surgeons, which appears to be a mainstay moving forward. Our study provides documented and evolving metrices that may help mitigate and direct handling or expectations of future pandemics among spine surgeons.

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