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Level of Diffusion and Training of Lung Ultrasound during the COVID-19 Pandemic – A National Online Italian Survey (ITALUS) from the Lung Ultrasound Working Group of the Italian Society of Anesthesia, Analgesia, Resuscitation, and Intensive Care (SIAARTI)

Grad der Verbreitung und der Schulung von Lungenultraschall während der COVID-19-Pandemie – eine nationale italienische Online-Umfrage (ITALUS) der Arbeitsgruppe Lungenultraschall der Italienischen Gesellschaft für Anästhesie, Analgesie, Reanimation und Intensivmedizin (SIAARTI)

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ABSTRACT

Purpose The goal of this survey was to describe the use and diffusion of lung ultrasound (LUS), the level of training received before and during the COVID-19 pandemic, and the clinical impact LUS has had on COVID-19 cases in intensive care units (ICU) from February 2020 to May 2020.

Materials and Methods The Italian Lung Ultrasound Survey (ITALUS) was a nationwide online survey proposed to Italian anesthesiologists and intensive care physicians carried out after the first wave of the COVID-19 pandemic. It consisted of 27 questions, both quantitative and qualitative.

Results 807 responded to the survey. The median previous LUS experience was 3 years (IQR 1.0–6.0). 473 (60.9 %) reported having attended at least one training course on LUS before the COVID-19 pandemic. 519 (73.9 %) reported knowing how to use the LUS score. 404 (52 %) reported being able to use LUS without any supervision. 479 (68.2 %) said that LUS influenced their clinical decision-making, mostly with respect to patient monitoring. During the pandemic, the median of patients daily evaluated with LUS increased 3-fold ($p < 0.001$), daily use of general LUS increased from 10.4 % to 28.9 % ($p < 0.001$), and the daily use of LUS score in particular increased from 1.6 % to 9.0 % ($p < 0.001$).

Conclusion This survey showed that LUS was already extensively used during the first wave of the COVID-19 pandemic by anesthesiologists and intensive care physicians in Italy, and then its adoption increased further. Residency programs are already progressively implementing LUS teaching. However, 76.7 % of the sample did not undertake any LUS certification.

ZUSAMMENFASSUNG

Ziel Das Ziel dieser Umfrage war es, den Einsatz und die Verbreitung von Lungenultraschall (LUS), den Ausbildungstand vor und während der COVID-19-Pandemie sowie die klinische Bedeutung des LUS auf COVID-19-Fälle auf Intensivstationen (ICU) von Februar 2020 bis Mai 2020 zu beschreiben.

Material und Methoden Die „Italian Lung Ultrasound Survey“ (ITALUS) war eine landesweite Online-Umfrage, die italienischen Anästhesisten und Intensivmedizinern nach der ersten Welle der COVID-19-Pandemie unterbreitet wurde. Sie bestand aus 27 quantitativen und qualitativen Fragen.

Ergebnisse 807 Ärzte nahmen an der Umfrage teil. Die Vorerfahrung im LUS lag bei median 3 Jahren (IQR 1,0–6,0). 473 (60,9 %) gaben an, vor der COVID-19-Pandemie mindestens eine Schulung zu LUS besucht zu haben. 519 (73,9 %) gaben an, mit dem LUS-Score vertraut zu sein. 404 (52 %) gaben an, LUS ohne Aufsicht nutzen zu können. 479 (68,2 %) gaben an, dass LUS ihre klinische Entscheidungsfindung beeinflusst, vor allem in Bezug auf die Patientenüberwachung. Während der Pandemie stieg der Median der Patienten, die täglich mit LUS untersucht wurden, um das 3-Fache ($p < 0{,}001$), der tägliche Einsatz des allgemeinen LUS erhöhte sich von 10,4 % auf 28,9 % ($p < 0{,}001$), und insbesondere der tägliche Einsatz des LUS-Scores stieg von 1,6 % auf 9,0 % ($p < 0{,}001$).

Schlussfolgerung Diese Umfrage zeigte, dass LUS bereits während der ersten Welle der COVID-19-Pandemie von Anästhesisten und Intensivmedizinern in Italien in großem Umfang eingesetzt wurde und dann weiter zugenommen hat. In der Facharztausbildung wird LUS bereits zunehmend eingeführt. Allerdings hatten in der Stichprobe 76,7 % keine LUS-Zertifizierung.

Introduction

The COVID-19 epidemic has been characterized by a high number of pneumonia cases leading to severe acute respiratory distress syndrome (ARDS) and requiring prolonged mechanical ventilation (MV) [1]. This has emphasized the demand for an easy-to-use, repeatable, bedside chest imaging modality [2]. Aside from these features, lung ultrasound (LUS) has already demonstrated higher accuracy than chest X-ray (CXR) in diagnosing several respiratory conditions, such as pneumonia, pleural effusion, and pneumothorax [3]. Thus, LUS has been implemented worldwide in both critically and non-critically ill COVID-19 patients [4–6], becoming a pivotal tool in managing COVID-19 cases, both for diagnosis and prognosis, as supported by the wealth of literature published over the last year [7–10]. Nevertheless, its role in the diagnosis, prognostication, monitoring, and follow-up of COVID-19 patients has yet to be officially acknowledged by any international scientific society. Multiple studies show a close correlation between LUS

and CT scan findings, making them the two main imaging modalities being used during the COVID-19 pandemic [11–13]. Furthermore, while the research has produced convincing evidence on LUS adoption and usefulness in the emergency department, data from intensive care units (ICU) and perioperative settings are still scarce, especially in relation to COVID-19 patients [14, 15].

The present survey aimed to describe the extent of LUS diffusion, the level of LUS training, and the perceived clinical impact of its use on decision-making, before and after the COVID-19 pandemic, among Italian anesthesiologists and intensive care physicians.

Materials and Methods

Study design and participants

This research comprised a nationwide online survey on the use of LUS during the first wave of COVID-19. Ethical approval was not required, but consent to use the collected data was obtained (European General Data Protection Regulation, 2016/679). An e-mail invitation was sent on 24/10/2020 to 7,972 anesthesia and intensive care medicine specialists or specialty trainees who are affiliated members of SIAARTI, and by newsletter to 8070 SIAARTI affiliated and 3355 non-affiliate recipients. Personal identification codes were used to prevent multiple registrations. Data collection closed on 16/11/2020.

Content and data collection

General data about the respondents' gender, age, level of experience, and workplace were collected, followed by a series of questions on: i) the level of LUS training and experience, including residency training, number of accredited courses attended (i. e., registered courses giving continuing medical education [CME] credits) and years of practice and self-evaluated ability; ii) the clinical use of LUS, prior to and during the COVID-19 pandemic, including frequency of use, average number of patients evaluated per work shift, knowledge of the lung ultrasound score (LUS score) [16] and frequency of its application; iii) the clinical impact of LUS on decision-making, both on the extent of LUS influence on clinical decisions and opinion about the future use of LUS in diagnosis and monitoring of ARDS; iv) details about whether the respondents had undertaken a certification course and whether they completed it. Training resources used during the pandemic event were also evaluated. Wherever possible, the survey question responses were quantified using a 5-point Likert scale. The complete survey consisted of 27 questions and was conducted with the SurveyMonkey online application **(Supplementary File 3)**.

Sample size calculation and statistical analysis

After estimating a target population of 15,000 physicians, we calculated a minimum sample size required to obtain relevant statistical power, with a 4 % error margin and 95 % confidence level, of 632 respondents. Details about sample size calculation are provided as **Supplementary File 4**.

▶ **Table 1** Summary of respondent's characteristics.

	n	all (N = 807)
gender	807	
female		426 (52.8)
male		378 (46.8)
not declared		3 (0.4)
age	807	
median (interquartile range)		39.0 (32.0–49.0)
range		26.0–72.0
year of specialty training conclusion	807	
before 2000		127 (15.7)
2000–2004		116 (14.4)
2005–2009		107 (13.3)
2010–2014		78 (9.7)
2015–2019		144 (17.8)
resident, 5th year		98 (12.1)
resident, 4th year		22 (2.7)
resident, 3rd year		67 (8.3)
resident, 2nd year		23 (2.9)
resident, 1st year		25 (3.1)

Continuous variables were reported as medians plus interquartile range (IQR); binary and categorical variables were reported as numbers and percentages. Sample characteristics were summarized, and the absolute and relative response frequencies are presented in tables. The Wilcoxon test was used for paired data and the McNemar test for non-parametric distributions. Significance was set at 5 %. All analyses were carried out using R 4.0.0 software.

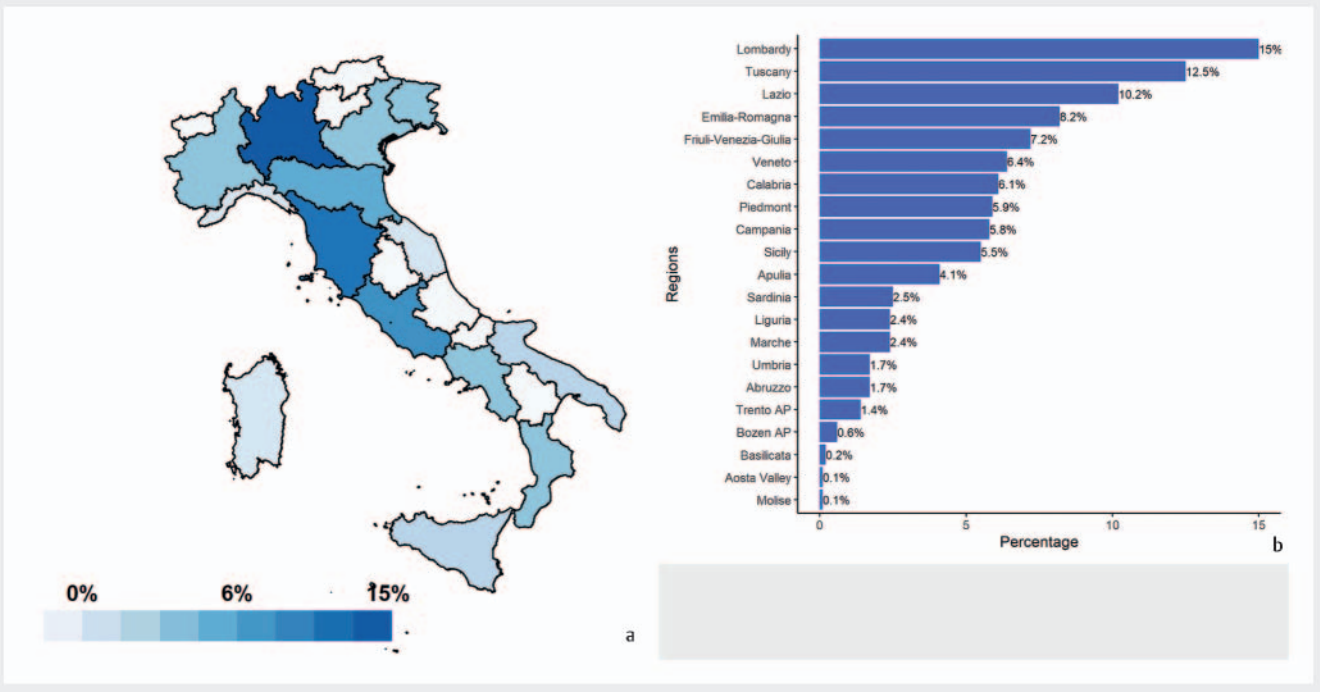
Results

General characteristics

In the period from October 24 to November 5, 2020, 807 Italian anesthesiologists and intensive care physicians responded to the survey, questions 1 to 7, with a response rate of 5.4 %. The respondents' characteristics are shown in ▶ **Table 1**, and their geographical distribution is shown as a percentage in ▶ **Fig. 1A** and detailed as a bar chart in ▶ **Fig. 1B**.

LUS training and use prior to the COVID-19 pandemic

Questions on pre-pandemic LUS training and use (questions 8 to 13) were answered by 777 people. 473 (60.9 %) reported having attended at least one LUS training course, and 357 (45.9 %) respondents said they had received LUS teaching during their residency period. A trend of increasing use of LUS training in anesthesia and intensive care schools emerged by comparing current trainees to junior and senior specialists (respectively, who completed



▶ **Fig. 1** **a** Distribution of the respondents by geographic area. Legend: The blue gradation from 0 % to 15 % represents lung ultrasound utilization for each area. **b** Boxplot of the % of Italian regions.

▶ **Table 2** Descriptive table of lung ultrasound education and technical use.

	n	all
have you ever had a lung ultrasound course before the pandemic?	777	
no		304 (39.1)
yes, one		255 (32.8)
yes, more than one		218 (28.1)
have you ever received any lung ultrasound training during specialist training?	777	
yes		357 (45.9)
▪ number of consultants (N, % of the total)		174 (31.6)
▪ number of trainees (N, % of the total)		183 (81.0)
how would you define your level of knowledge of lung ultrasound?	777	
1. nonexistent or minimal		39 (5.0)
2. mediocre, I have basic knowledge		168 (21.6)
3. sufficient, I am able to perform with supervision		166 (21.4)
4. good, I am able to perform without supervision		347 (44.7)
5. excellent, I am proficient enough to teach		57 (7.3)
how many years have you been practicing lung ultrasound?	777	
median (interquartile range)		3.0 (1.0—6.0)
do you know the lung ultrasound score?		
yes	702	519 (73.9)

▶ **Table 3** Comparison of lung ultrasound use before and during the pandemic.

	before pandemic	during pandemic	p-value
number of patients evaluated with lung ultrasound	N = 777	N = 702	< 0.001[1]
median (IQR)	1 (1, 3)[a]	3 (1, 5)[b]	
how often did you use lung ultrasound?	N = 777	N = 702	< 0.001[2]
1. never	100 (12.9 %)	92 (13.1 %)	
2. rarely (less than once a month)	149 (19.2 %)	76 (10.8 %)	
3. sometimes (less than once a week)	170 (21.9 %)	99 (14.1 %)	
4. often (more than once a week)	277 (35.6 %)	232 (33.0 %)	
5. on a daily basis (every working day)	81 (10.4 %)	203 (28.9 %)	
how often did you use the LUS score?	N = 702	N = 702	< 0.001[2]
1. never	340 (48.4 %)	241 (34.3 %)	
2. rarely (less than once a month)	162 (23.1 %)	103 (14.7 %)	
3. sometimes (less than once a week)	120 (17.1 %)	130 (18.5 %)	
4. often (more than once a week)	69 (9.8 %)	165 (23.5 %)	
5. on a daily basis (every working day)	11 (1.6 %)	63 (9.0 %)	

[1] Wilcoxon test per dati appaiati.
[a] N = 777.
[b] N = 702.
[2] McNemar test.

the specialist training in the last 5 years or before, p < 0.00001). Regarding the self-evaluated LUS skill level, more than half declared to be an independent provider, with 347 (44.7 %) reporting to be able to perform LUS without supervision, and 57 (7.3 %) to be able to mentor other colleagues. Only 39 (5 %) respondents said they were unable to perform LUS. The median reported length of LUS experience was 3 years (IQR 1.0–6.0). When asked if they knew what the LUS score was, 519 (73.9 %) respondents answered affirmatively (▶ **Table 2**).

A total of 100 (12.9 %) respondents stated they never used LUS in clinical practice prior to the onset of the pandemic, whereas 596 (76.7 %) reported to have used it "rarely", "sometimes", or "often". Only 81 (10.4 %) reported daily use of LUS (▶ **Table 3**).

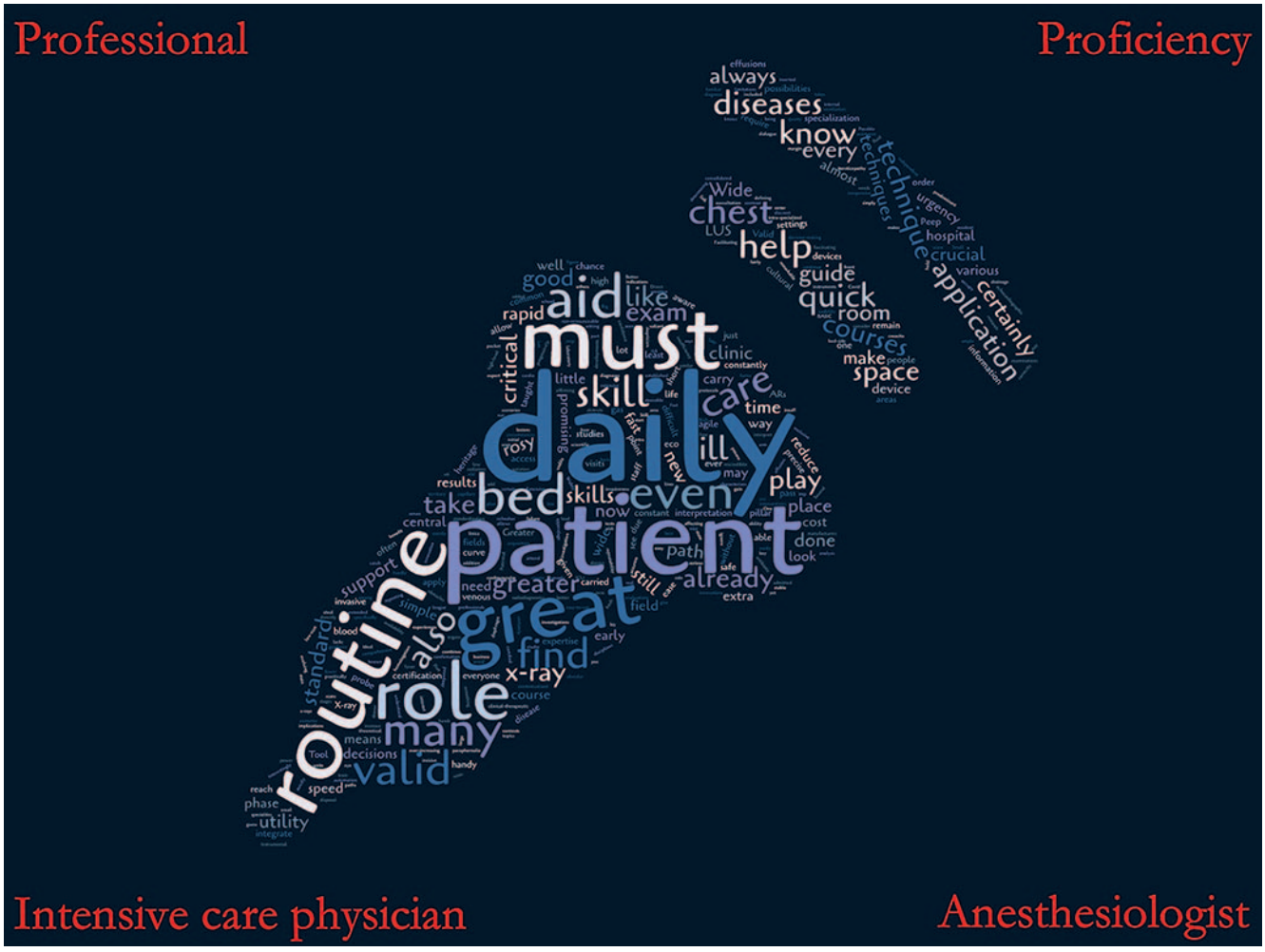
Finally, 76.7 % of the sample reported having never undertaken or completed a certification course in LUS **(Table 5 Supplementary File)**.

LUS training and use during and after the COVID-19 pandemic

Questions regarding peri-pandemic use of LUS (questions 14 to 23) were answered by 702 colleagues. The survey data revealed a 3-fold increase in the average number of patients evaluated on each shift (pre-COVID-19 median 1 [IQR 1–3] vs. COVID-19 median 3 [IQR 1–5], p < 0.001). The change in frequency of use varied according to the different basal degrees: non-users remained unchanged prior to and during the pandemic period (12.9 % vs. 13.1 %, respectively), whereas frequency of use among 86.8 % of respondents increased following the pandemic's onset. In particular, the number of respondents employing LUS on a daily basis increased from 10.4 % to 28.9 % (p < 0.001). Moreover, the LUS score entered the clinical practice of many non-users, reducing their number from 340 (48.4 %) to 241 (34.3 %), and the number of daily users of the LUS score increased from 11 (1.6 %) to 63 (9 %) (p < 0.001) (▶ **Table 3**). With respect to LUS training, respondents reported having used different sources. Published articles were indicated by 487 (69.4 %), followed by webinars (56.1 %), and tutorials (41.5 %), while 39.7 % indicated short local courses or mentoring by local experts. Only 37 (5.3 %) respondents did not refer to any training resources at all **(Table 6 Supplementary data)**.

Perceived clinical impact of LUS

When asked about the extent to which LUS influenced clinical decision-making during the pandemic, 78 (11.1 %) respondents reported no influence, whereas 479 (68.2 %) reported that LUS influenced clinical decision-making "enough", "a lot", or "extremely". Most respondents (79.3 %) stated that LUS had influenced patient monitoring the most. 94 % of the respondents agreed that LUS could be used in the future for the diagnosis and monitoring of ARDS in non-COVID-19 patients (▶ **Table 4**). The qualitative aspects of the survey are provided as Supplementary File 2, and the word cloud generated using the sentences provided in the answers is shown in ▶ **Fig. 2**.



▶ **Fig. 2** Ultrasound probe with word cloud using the words provided in the survey answers.

▶ **Table 4** Lung Ultrasound perceived clinical impact.

	N	
how much the use of pulmonary ultrasound has affected your clinical decisions during the pandemic?	702	
1. nothing		78 (11.1)
2. low		145 (20.7)
3. enough		300 (42.7)
4. A lot		161 (22.9)
5. extremely		18 (2.6)
what do you think the lung ultrasound had the most influence on?	702	
monitoring		557 (79.3)
diagnosis		262 (37.3)
changes in therapy		215 (30.6)
do you think that in the future, lung ultrasound could be used for the diagnosis and monitoring of ARDS not due to COVID-19	702	
yes		658 (93.7)

Discussion

The first main finding of this survey is that LUS use has increased among Italian anesthesiologists and intensive care physicians since the onset of the pandemic. It happened in terms of the frequency of use, number of patients scanned each work shift, and adoption of a structured scoring system, i. e., the LUS score. A second main finding is that there is an increasing trend in LUS teaching among anesthesia and intensive care schools across the country. Moreover, these professionals were able to refer to classic sources, such as current literature and experts, as well as new ones, like webinars and online tutorials. As a third point, this survey's results on the perceived clinical impact of LUS show us that the vast majority of respondents take into account LUS findings when making clinical decisions, influencing mainly patient monitoring. Curiously, although the diagnosis of COVID-19 was considered to be the most influenced aspect by only one-third of the sample, most of the respondents deemed the use of LUS plausible for the diagnosis of non-COVID-19 ARDS. This discrepancy may be explained by the general low specificity of LUS findings. In fact, lung sonography is likely able to detect the newly developed bilateral infiltrates necessary to diagnose the acute respiratory distress syndrome [17], but less accurate in addressing the specific diagnosis of COVID-19, even though some evidence shows a high correlation between LUS and RT-PCR test results [6].

Summarizing the strengths of the present survey, this is the first to evaluate exclusively Italian anesthesiologists and intensive care practitioners' knowledge and use and the clinical impact that the COVID-19 outbreak in Italy had on LUS diffusion and on clinical decision-making. Furthermore, our investigation is the first to incorporate qualitative data about LUS use with quantitative data. Finally, the described results are based on a sample greater than the minimum required to be representative of the general population of Italian intensivists and thus they may actually reflect the real scenario.

Another recent survey by the Italian discussion group, "Academy of Thoracic Ultrasound", was proposed via social media to a population of about 4000 people, obtaining a sample of 123 participants (34 % working in COVID-19 wards, 26 % in COVID-free wards, 20 % in the emergency department, and 31 % in ICUs, as reported by the authors) [18]. Compared to our sample, their respondents had longer LUS experience (a median of 5.3 years vs. 3 years). They reported 34.9 % of the sample having learned LUS recently, while adoption by never-users in our sample was minimal. Their respondents learned mostly from online materials (i. e., video tutorials and webinars, 81.4 %) and 18.6 % from local courses and mentors, while in our sample published articles were the most frequent source, and we registered a greater use of local experts. However, in the Academy's sample, an average increase of 250 % of daily performed exams was reported, consistently with our registered 3-fold increase. Monitoring of patients was reported by our respondents to be the most influenced clinical aspect (79.3 %), similar to the Academy's reported data (63 %). These findings are quite consistent with those collected in our survey, suggesting the application of LUS in the intensive care environment in Italy as a recent and spreading phenomenon.

Comparing our data with another previous survey on LUS adoption in ICUs conducted by the GiViTI (Italian group for the evaluation on interventions in ICU) in 2017 [19], we can note again an increase in LUS popularity and use. We hypothesize three reasons that may explain this difference: a general trend in LUS adoption by consultants, trainees entering workplaces bringing already obtained LUS skills, and the enhancing effect of the COVID-19 pandemic, which brought a large number of patients, increasing the need for diagnostic means.

Finally, in 2013, Xirouchaki et al. reported that LUS determined changes in patient management in 119 out of 253 cases (47 %) [20]. These changes comprised a large variety of invasive interventions: chest tube placement or removal, bronchoscopy, diagnostic thoracentesis, and more. Even though this outcome is less objective and was differently assessed, these results seem to be quite consistent with ours.

An interesting finding is that up to 76.7 % of the sample did not attempt to obtain any LUS certification, in contrast to the fact that 44.7 % reported to be sufficiently skilled to do it alone. Other studies have highlighted physicians limits to self-assess their abilities accurately [21, 22]. In their responses to the open question about the future of LUS in anesthesia and intensive care practice, respondents frequently referred to it as a "fundamental" and "useful" tool, the use of which should be applied "daily" for "diagnosis" and "monitoring" purposes. Keeping in mind that qualitative data are more subjective and must be interpreted considering the context, we agree with these considerations and recognize that the utility of ultrasound means that LUS in particular is influenced by the correct acquisition of practical technical skills, which are difficult to acquire only by watching video tutorials and online webinars [23]. Thus, the need exists to implement professional development strategies with particular regard to LUS.

Clinical implications

Up to February 2021, SARS-CoV-2 has infected at least 2 583 790 individuals in Italy and 2,145 patients are still admitted to ICU [24]. ICU patients with ARDS and prolonged MV require frequent thoracic imaging and LUS reduces the number of chest X-rays and CT scans that patients receive [10, 25]. Our investigation shows that Italian anesthesiologists and intensivists integrate the information gathered from LUS into the clinical evaluation process and into clinical decision-making. Use of LUS to estimate the extent of lung involvement (e. g., after intubation or before the weaning process) seems to be considered plausible by Italian anesthesiologist and intensivists, and comparative studies between LUS and CT have confirmed the strong agreement of these two means [26, 27]. Furthermore, Yang et al. argued that LUS should be the imaging technique of choice for assessing COVID-19 patients due to its sensitivity, portability, and safety [27]. Consistent with our results, ICU physicians seems to be particularly open to the use of LUS in the clinical management of critically ill COVID-19 patients [28, 29]. Thus, the time seems to have now come to consider the full integration of LUS into the teaching programs of the anesthesia and intensive care schools, as is already the case for other medical fields, such as emergency medicine [30].

Limitations

The question used to calculate the sample size was chosen to ensure the largest required sample, but voluntary participation in the survey may have introduced some selection bias. Our survey was formally proposed to SIAARTI members by means of e-mail and newsletter and then eventually disseminated by word of mouth. Thus, colleagues who are not society members, as well as those less keen on informatics, may have suffered from an undercoverage bias. Furthermore, a sample self-selection is likely, since the object of this survey may have been more appealing to an ultrasound-friendly audience. All of the above-mentioned reasons may have resulted in a response rate of 5.4 %. Moreover, a certain amount of attrition bias (13.3 %) has been registered within the different steps of the survey. With regard to subjective outcomes, the answers to certain questions may have been over- or underestimated. Finally, the veracity of the answers is not verifiable.

Conclusion

This survey showed that LUS was extensively used and adopted during the COVID-19 pandemic by anesthesiologists and intensive care physicians in Italy and that these professionals have a strong subjective feeling regarding the clinical utility of this method. However, the data collected show a diffuse lack of in-depth knowledge of the method. Of consequence, better and more diffused training and guidance on LUS use need to be put into place within our discipline. Reassessment of our discipline's ability to establish courses, seminars, and a certification pathway should not be postponed. One part of the solution could be a consensus conference of experts to standardize LUS methods in the specific setting of intensive care, which would also require the concomitant setting up of standardized training programs. This would ensure that LUS will be used in the right way, providing the necessary support to patients in ICUs.

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Conflict of interest

Francesco Mojoli, fee for lectures (Hamilton Medical, GE Healthcare, SEDA Spa). Consultancy agreement between University of Pavia and Hamilton Medical.
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