


RESEARCH

Open Access



# Pediatric ultrasound practice in Italy: an exploratory survey

Anna Maria Musolino<sup>1</sup>, Monica Tei<sup>2\*</sup> , Cristina De Rose<sup>3</sup>, Danilo Buonsenso<sup>3</sup>, Maria Chiara Supino<sup>1</sup>, Stefania Zampogna<sup>4</sup>, Annamaria Staiano<sup>5</sup>, Massimiliano Raponi<sup>6</sup>, Antonella Amendolea<sup>7</sup>, Vincenzo Colacino<sup>8</sup>, Laura Gori<sup>9</sup>, Alessandro Manganaro<sup>10</sup>, Riccardo Ricci<sup>11</sup>, Victoria D'Inzeo<sup>12</sup>, Salvatore Grosso<sup>2</sup>, Alberto Villani<sup>13</sup> and Rino Agostiniani<sup>14</sup>

## Abstract

**Background** The aim of this exploratory survey is to describe the current state of US (ultrasound) technique across different pediatric settings nationwide.

**Methods** A questionnaire was emailed to all members of the Italian Society of Pediatrics, including pediatric residents. The survey was open from December 2021 to March 2022.

**Results** There were 1098 respondents. Seven hundred and seven pediatricians (84.1%) reported any use of US, while 51 (44.3%) residents denied it. The majority of participants ( $n = 956$ , 87.1%) reported to have a US machine available within the department, mostly cart-based ( $n = 516$ , 66.9%) and provided from 1 to 5 years prior to the survey ( $n = 330$ , 42.8%). Lung and neonatal cerebral regions were the most frequently scanned ( $n = 289$ , 18.7% and  $n = 218$ , 14.1%, respectively). The suspicion of pneumonia or respiratory distress represented the main reasons for performing US in emergency room ( $n = 390$ , 78% and  $n = 330$ , 66%, respectively). The majority of family pediatricians reported to scan lung and kidney/urinary tract regions ( $n = 30$ , 16.9%, and  $n = 23$ , 12.9%, respectively). Regarding US training, the majority of respondents ( $n = 358$ , 34.6%) declared an experience-based education, with a deficient certification enabling the use of US in 71.6% ( $n = 552$ ) of cases. The most common barriers included the lack of a well-defined training program ( $n = 627$ , 57.1%), unavailability of the US machine ( $n = 196$ , 17.9%) and legal responsibility concern ( $n = 175$ , 15.9%).

**Conclusions** Despite the growing interest on pediatric US nationally, significant barriers still limit widespread adoption. These obstacles may be addressed through the dissemination of a specific US education plan and providing additional resources.

**Keywords** Pediatric ultrasound, Education, Training, Pediatric residency, Point-of-care ultrasound, Survey

\*Correspondence:  
Monica Tei  
monicatei24@gmail.com

Full list of author information is available at the end of the article



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

## Introduction

The growing interest toward ultrasound (US) in recent years is basically due to a non-invasive and portable nature of this imaging tool [1]. Being free from ionizing radiation and painless, US is suitable also for neonatal and pediatric age, with a wide range of applications supported by research literature [2]. Pediatric consultants are becoming more and more self-confident in US practice, which is becoming integral to the physical examination and may help physicians for decision-making process, follow up management of acute diseases and therapeutic procedures [3, 4].

Despite a remarkable body of evidence, a routine use of US in pediatrics cannot be recognized yet [5, 6]. Moreover, literature investigating US application almost entirely relies on the emergency and critical medicine experience [7] while deficient data exist for its use in different pediatric settings, such as non-intensive pediatric units or outpatient clinics.

Significant gaps still need to be addressed in order to implement US dissemination. To date, the lack of core infrastructural elements is one of the most perceived barrier in US widespread development. Different practice environments may affect the limitation size even if literature is controversial. Some authors report that divisions with larger units invest more resources for technology, have an adequate number of faculty and a greater possibility of collaborating with specialists (i.e., cardiology, radiology) [8, 9]. Conversely, Conlon et al. found that limited access to US machines is independent of the division size [10]. The lack of or inadequate diagnostic imaging equipment is reported as a major barrier for US implementation also in low- and middle-income countries, as underlined in a recent systematic review [11]. Definitely, the availability of US equipment and machines throughout various clinical settings should be enhanced, also favoring the use of portable and handheld devices with lower cost but good resolution [12, 13].

Nevertheless, the US application is limited by another main factor that is education. Although US has become a powerful tool for treating clinicians, it is dependent on the user's skills and training. A great push towards the importance of training and standardized educational curriculum has been made through national guidelines publications [14, 15]. Despite this, at present, a standardization of training pathways for both pediatric residents and faculty has not been established and US curricula and credentialing processes deeply vary worldwide [10, 16, 17]. Furthermore, even if a brief educational intervention has been demonstrated to be effective in increasing proficiency on US [12], the lack of learning time as well as the paucity of skilled trainers are also reported limitations in literature [16, 18]. As the use of US continues to increase, the need for early training also increases:

numerous pieces of evidence report how starting upstream training from the medical school period would ease US application postgraduating [19–21].

The objective of this national survey is to investigate the use of US among pediatricians and pediatric residents and to describe the characteristics of the US machines, the number of scans carried out, the years of experience of the performers and the main US applications.

across different pediatric settings. Another main purpose of the survey is to identify training needs and possible barriers to US implementation.

## Materials and methods

The present study is a national, cross-sectional, web-based survey. The questionnaire was emailed to all members of the Italian Society of Pediatrics, including pediatric residents and it was distributed for completion from December, 2021 to March, 2022. In order to optimize the return rate of the survey, reminder e-mails were sent 3 times during the period and the subsequent analysis of the results was performed only for surveys which were fully completed one month after the third reminder. Written consent was not required due to the anonymous and voluntary nature of the questionnaire. Ethical consent was not required due to the study design and local regulations. The estimated time to complete the questionnaire was 6 min.

The questionnaire ranged from 24 to 27 items, depending on whether pediatricians or residents answered, respectively. The full version of the survey is reported as annex.

The questions were formulated as multiple-choice response, with some exceptions (four-point Likert scales and open questions). For questions with "other" category, a free-text response was solicited.

Data were extracted from the SurveyMonkey platform and statistics was performed using IBM SPSS for Windows (Version 24.0, IBM Corp).

## Results

The survey was completed by 1098 respondents with an overall response rate of 11%. Descriptive characteristics of survey respondents are reported in Table 1.

Most of participants (87.1%,  $n=956$ ) declared to have an US machine available within the department. The predominant model resulted to be cart-based (66.9%,  $n=516$ ), followed by portable (28.5%,  $n=220$ ) and handheld (4.5%,  $n=35$ ). Linear and convex were the most available probes (33.8%,  $n=551$  and 30.1%,  $n=491$ , respectively). Nearly one third of respondents (42.8%,  $n=330$ ) assessed that US machines had been provided from 1 to 5 years prior to the survey while only 12.2% ( $n=94$ ) from more than 10 years. Lung and neonatal cerebral US were the most frequently performed by participants (18.7%,

**Table 1** Characteristics of Surveyed Participants

| Characteristics of Participants, n (%) |            |            |            |            |            |            |
|--|------------|------------|------------|------------|------------|------------|
| Age in years                           | < 30       | 31–40      | 41–50      | 51–60      | > 60       | To n(%)    |
| <b>Gender</b>                          |            |            |            |            |            |            |
| Female                                 | 107 (9,7)  | 194 (17,6) | 157 (14,3) | 143 (13,0) | 109 (9,9)  | 710 (64,7) |
| Male                                   | 35 (3,2)   | 68 (6,2)   | 58 (5,3)   | 76 (6,9)   | 151 (13,8) | 388 (35,3) |
| <b>Current position</b>                |            |            |            |            |            |            |
| Resident                               | 140 (12,8) | 48 (4,4)   | 2 (0,2)    | 2 (0,2)    | 6 (0,5)    | 198 (18)   |
| Pediatrician                           | 2 (0,2)    | 214 (19,4) | 211 (19,7) | 217 (19,6) | 254 (23,0) | 898 (81,8) |
| Other <sup>s</sup>                     | 0          | 0          | 2 (0,2)    | 0          | 0          | 2 (0,2)    |
| <b>Region of Italy</b>                 |            |            |            |            |            |            |
| North                                  | 17 (1,5)   | 84 (7,6)   | 71 (6,5)   | 44 (4,0)   | 46 (4,2)   | 262 (23,9) |
| Centre                                 | 81 (7,4)   | 93 (8,5)   | 76 (6,9)   | 87 (7,9)   | 102 (9,3)  | 439 (40,0) |
| South                                  | 44 (4,0)   | 85 (7,7)   | 68 (6,2)   | 88 (8,0)   | 112 (10,2) | 397 (36,1) |
| <b>Setting</b>                         |            |            |            |            |            |            |
| University/ teaching Hospital          | 66 (6,0)   | 13 (1,2)   | 10 (0,9)   | 6 (0,5)    | 4 (0,4)    | 99 (9,0)   |
| Private Hospital                       | 1 (0,1)    | 9 (0,8)    | 7 (0,6)    | 14 (1,7)   | 38 (3,5)   | 69 (6,4)   |
| Community/District Hospital            | 75 (6,8)   | 181 (16,5) | 163 (14,8) | 166 (15,1) | 107 (9,7)  | 692 (63,0) |
| Family pediatrician                    | 0          | 40 (3,6)   | 32 (2,9)   | 27 (2,4)   | 87 (7,9)   | 186 (16,9) |
| Private practice                       | 0          | 19 (1,7)   | 3 (0,3)    | 6 (0,5)    | 24 (2,2)   | 52 (4,7)   |
| <b>Department*</b>                     |            |            |            |            |            |            |
| General pediatric unit                 | 60 (5,0)   | 85 (7,0)   | 79 (6,5)   | 76 (6,3)   | 53 (4,4)   | 353 (29,2) |
| Pediatric ED                           | 41 (3,4)   | 81 (6,7)   | 40 (3,3)   | 39 (3,2)   | 13 (1,1)   | 214 (17,7) |
| Neonatology unit                       | 40 (3,3)   | 92 (7,6)   | 73 (6,0)   | 70 (5,8)   | 50 (4,1)   | 325 (26,9) |
| Adult ED                               | 0          | 25 (2,0)   | 13 (1,1)   | 19 (1,5)   | 10 (0,8)   | 67 (5,5)   |
| Outpatient clinic                      | 1 (0,1)    | 44 (3,6)   | 40 (3,3)   | 34 (2,8)   | 26 (2,1)   | 145 (12)   |
| Other <sup>†</sup>                     | 2 (0,2)    | 2 (0,2)    | 35 (2,9)   | 39 (3,2)   | 28 (2,3)   | 104 (8,6)  |

\*Some respondents reported multiple settings

<sup>s</sup>Other: 2 radiologists

<sup>†</sup>Other: 52 private practice, 18 neonatal intensive care unit, 14 pediatric intensive care unit, 14 district outpatients clinic and 6 on retirement

ED: emergency department

$n=289$  and 14.1%,  $n=218$ , respectively). Details of US applications are reported in Figs. 1, 2 and 3.

Regarding US utilization, 707 (84.1%) pediatricians reported any use of US in clinical practice while 51 (44.3%) residents denied it. Among pediatric residents, 71.8% ( $n=46$ ) asserted to use US with less than one year of experience. Moreover, more than half residents (59.4%,  $n=38$ ) declared a frequency of scans less than 10 per month. On the other hand, 36.4% of pediatricians ( $n=257$ ) stated to have more than ten-years experience and 46% ( $n=325$ ) referred to perform more than twenty exams per month.

Personal position and expertise about US utilization and differences between university/not university and public/private settings are summarized in Tables 2, 3 and 4.

There were no statistically significant differences in the use of US by dividing the sample by working department and geographical area (north, central or south).

More than half respondents (55.7%,  $n=430$ ) affirmed to use ultrasounds in the emergency room, for most cases in the suspicion of pneumonia (78%,  $n=390$ ), or for patients with respiratory distress (66%,  $n=330$ ). 44% ( $n=360$ ) of participants used ultrasounds for trauma cases while 38%

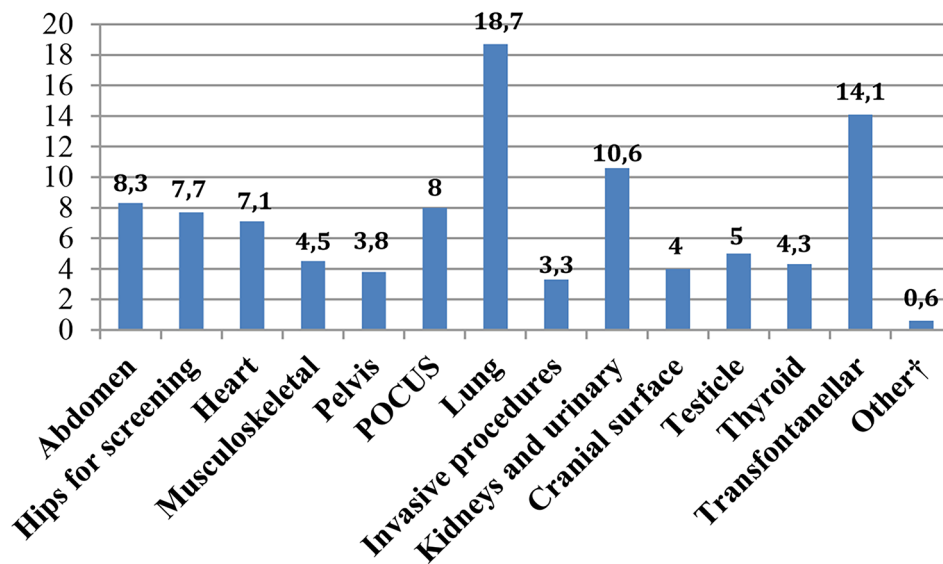
( $n=311$ ) for undifferentiated shock. Among family pediatricians, 177 (95.2%) declared to use US routinely, mainly for lung and kidney/urinary tract regions (16.9%,  $n=30$  and 12.9%,  $n=23$ , respectively).

With regard to US training and certification, data are reported in Table 5.

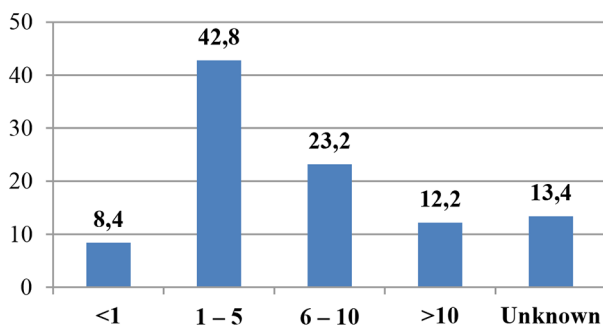
In addition, 59.4% ( $n=38$ ) of residents claimed that US practice was not included in the training program while 94% ( $n=36$ ) of them considered desirable the insertion of a specific course during the residency.

When asked to express about the main difficulties in using US, most participants complained a lack of a well-defined training program (57.1%,  $n=627$ ), 17.9% ( $n=196$ ) unavailability of the US machine, 15.9% ( $n=175$ ) legal responsibility concern, 8.1% ( $n=89$ ) non-collaboration of colleagues. In "other" category (1%,  $n=11$ ) participants listed as possible obstacles also insufficient educational time for learning US, lack of trained faculty to rely on and resistance to pediatric US application from other departments such as radiology or surgery (Fig. 4).

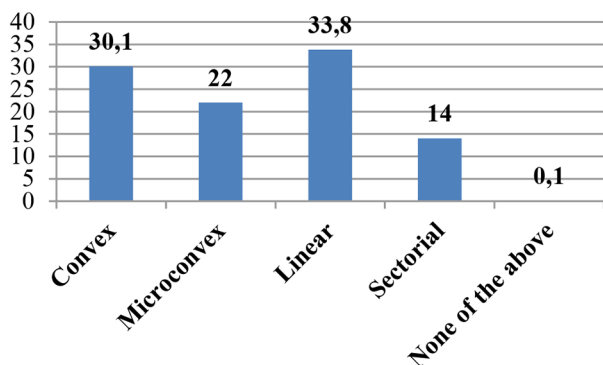
Almost all participants (98%,  $n=1076$ ) considered US a useful tool for clinical practice and they deemed US very or quite relevant in guiding clinical decisions (83.5%,  $n=644$  and 15.7%,  $n=121$ , respectively).



**Fig. 1** US Applications. Legend: Data are expressed as a percentage. †Other: ocular and female reproductive system US



**Fig. 2** When US machine in use at time of the survey was provided (years). Legend: Data are expressed as a percentage



**Fig. 3** Type of probe available. Legend: Data are expressed as a percentage. Respondents reported multiple answers

169 (60.1%) of pediatricians working in ED have increased the use of ultrasound during the SarsCoV2 pandemic compared to 26.4% (216) of those working in other departments ( $p=0.001$ ). 153 (54.4%) of

pediatricians working in ED have increased their knowledge during the COVID period compared to 111 (13.6%) of those working in other departments ( $p=0.001$ ).

## Discussion

Since the use of US has increased exponentially worldwide in the last few decades, also for the pediatric age [1], we aimed to provide data on the current Italian state of pediatric US practice.

### US equipment and applications

The US spread is strictly related to the availability of machines: the majority of participants declared to have a US machine available for use within the department, with percentages in line with the literature [22, 23]. Particularly, convex and linear probes have been found to be the ones most obtainable for US examinations.

US practice seems to be relatively recent tool in pediatrics [4], considering that machines have been provided mostly 1–5 years prior to the survey. Nevertheless, the vast majority of US machines have been found to be conventionally cart-based, at the expense of newer models such as portable and handheld systems [13], which have been demonstrated to improve patient outcomes also in environments with limited resources [24]. These results focus on the urgent need to direct more resources for improving US equipment and advanced scanning technologies in pediatric units.

Concerning the type of examination, lung resulted to be the most common scanned region. We also found that participants working in the emergency room, mostly use US in suspicion of lung pathologies. Similar results were also highlighted for family pediatricians. A possible

**Table 2** Personal position and expertise about US application for pediatricians and residents

| Personal position towards US application | Pediatricians | Residents  | Tot n (%)  |
|--|---------------|------------|------------|
| Use of US                                | Yes           | 707 (84.1) | 771 (80.6) |
|  | No            | 134 (15.9) | 185 (19.4) |
| Experience in US (years)                 | < 1           | 89 (12.6)  | 135 (17.5) |
|  | 2–5           | 243 (34.4) | 255 (33.1) |
|  | 6–10          | 118 (16.7) | 118 (15.3) |
|  | > 10          | 257 (36.4) | 263 (34.1) |
| Number of scans in a month               | < 10          | 202 (28.6) | 240 (13.1) |
|  | 11–20         | 180 (25.5) | 196 (25.4) |
|  | > 20          | 325 (46)   | 335 (43.5) |

**Table 3** Personal position and expertise about US application in university and not university setting

| Personal position towards US application | University | Not University | Tot n (%)  | p  |
|--|------------|----------------|------------|----|
| Use of US                                | Yes        | 87 (82,8)      | 771 (80.6) | Ns |
|  | No         | 18 (17,2)      | 185 (19.4) |    |
| Experience in US(years)                  | < 1        | 10 (11,5)      | 135 (17.5) |    |
|  | 2–5        | 34 (39,1)      | 255 (33.1) | Ns |
|  | 6–10       | 6 (6,9)        | 118 (15.3) |    |
|  | > 10       | 37 (42,5)      | 263 (34.1) |    |
| Number of scans in a month               | < 10       | 13 (14,9)      | 240 (13.1) |    |
|  | 11–20      | 36 (41,4)      | 196 (25.4) | Ns |
|  | > 20       | 38 (43,7)      | 335 (43.5) |    |

**Table 4** Personal position and expertise about US application in public or private setting

| Personal position towards US application | Public | Private    | Tot n (%)  | p  |
|--|--------|------------|------------|----|
| Use of US                                | Yes    | 682 (79,8) | 771 (80,6) | Ns |
|  | No     | 173 (20,2) | 185 (19,4) |    |
| Experience in US (years)                 | < 1    | 129 (18,9) | 135 (17,5) |    |
|  | 2–5    | 247 (36,2) | 255 (33,1) | Ns |
|  | 6–10   | 104 (15,3) | 118 (15,3) |    |
|  | > 10   | 202 (29,6) | 263 (34,1) |    |
| Number of scans in a month               | < 10   | 225 (33)   | 240 (31,1) |    |
|  | 11–20  | 158 (23,2) | 196 (25,4) | Ns |
|  | > 20   | 299 (43,8) | 335 (43,5) |    |

explanation for this finding may be the steep learning curve which also allows novices to be able to perform lung US [25]. It should be also underlined that nearly one third of respondents assessed to use US for cardiac and abdominal application: traditionally, the use of US for these two anatomic regions is a prerogative of cardiologists and radiologists, respectively [5]. This finding may be considered as the beginning of a growth path to be pursued in the future for the entire pediatric personnel [26, 27].

#### US practice among different pediatric settings

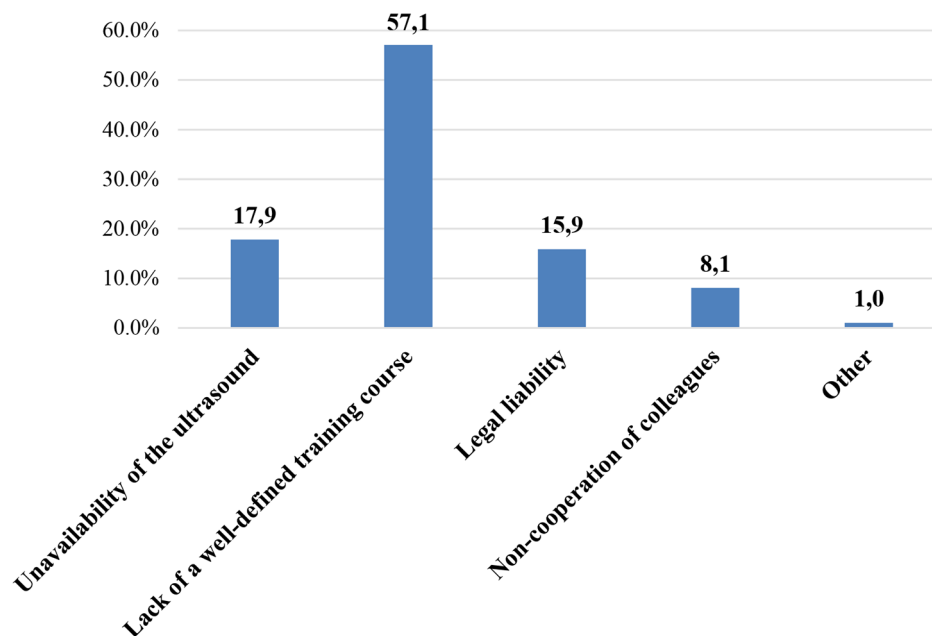
Some differences on US practice between pediatric residents and pediatricians have been found in this survey. Among residents, only half declared to use US, mostly with little experience and low scanning frequency. On the contrary, the majority of attending pediatricians routinely perform US, although less than half of them with experience over ten years and a scanning frequency more than twenty per month. Controversial data are reported in literature about disparity in US application between

**Table 5** US training and certification

| US training and certification                   | Pediatricians | Residents | Tot n (%)   |
|---|---------------|-----------|-------------|
| US training                                     |               |           |             |
| Lectures with practical session                 | 271 (28.6)    | 20 (23)   | 291# (28.1) |
| Advanced training course                        | 203 (21.4)    | 10 (11.5) | 213# (20.6) |
| Online course                                   | 118 (12.4)    | 13 (14.9) | 131# (12.7) |
| On-site experience                              | 320 (33.8)    | 38 (43.7) | 358# (34.6) |
| Other <sup>†</sup>                              | 36 (3.8)      | 6 (6.9)   | 42# (4)     |
| Do you have a certification for echography use? |               |           |             |
| Yes   | 207 (29.3)    | 12 (18.8) | 219 (28.4)  |
| No  | 500 (70.7)    | 52 (81.2) | 552 (71.6)  |

#Respondents reported multiple answers

<sup>†</sup>Other: simulation, integrated conferences, utilization of online resources, radiology unit attendance, fellowship in specialized center (in Italy or abroad)



**Fig. 4** Limitations to pediatric US application. Legend: Data are expressed as a percentage

residents and pediatricians [6]: regarding the Italian situation, we can speculate that, despite the growing interest on US in last decades, the method still needs to be spread and implemented in clinical practice, especially during residency.

The vast majority of the surveyed family pediatricians report to perform US routinely. As far as we know, the present survey is the first study investigating US application in pediatric family care, so we are not able to compare our data with similar findings in literature. Our results even seem to be in contrast with those described by a recent survey which reports a low percentage of US scans performed among family medicine residents and practicing physicians [28]. We hypothesize that the high percentage of US utilization among family pediatricians may reflect a bias selection.

Finally, we did not find statistically significant differences for US practice dividing the sample by geographical

area (north, central or south) or working department. We definitely believe that this last result should be verified on a larger study sample. We were not even able to compare our data with those in literature since, as far as we know, there are no studies comparing the US use in the private, public or university setting nor for different geographical areas of the same nation.

#### US and education

The section of the survey dedicated to training underlined interesting issues. To date, an informal experience-based training or theoretical-practical courses have been found to be the most frequently adopted while a credentialing process was missing in most cases. Similar findings are reported in literature, pointing out the lack of specific training pathways and non-homogeneous programs [29–31]. Learning methods also vary based on different realities. In middle and low-income countries,

e-learning methods have been reported to be the commonest method, related to the high costs of face-to-face training [11]. Nevertheless challenges relating to poor internet connectivity still affects access to study platform and communication with supervisors [11].

The standardization of training plans, starting preferably during residency rather than early under graduation medical period, might allow to create a US curriculum as guarantee of educational pathway and quality assessment [32, 33]. Furthermore medical school/residency directors and their institutions should consider the curriculum as a core requirement for the implementation of US technique [33]. More than half respondents within the pediatric residents subgroup declared that a specific training program has yet to be described; however, almost all of them showed a positive attitude towards US, supporting its endorsement during residency, as previously underlined in literature [5, 34].

#### **Barriers to POCUS applications**

Our survey points out possible barriers to POCUS applications. Among these barriers, the lack of well-defined training plan has been identified as a main obstacle to US expansion by respondents: we strongly believe that an educational US curriculum should be mandatory not only for residents but also for attending physicians, as reported in recent literature [35, 36].

Despite the dramatic rise of US use, it is noteworthy that the unavailability of US machine is still considered as a barrier for daily practice in both our study and literature [8, 9]. Actually, some major reasons for complaints from physicians are the expensiveness of US machines and the subsequent difficulty in affording to purchase them by institutions, the scarce use of low-cost ultraportable devices, the US equipment deficiency and the inaccessibility to US machines for bedside use, often due to resistance from other departments [5, 8, 9, 30, 37]. The lack of technological devices for performing US is reported to be a barrier to the implementation of the method even in middle and low-income countries where clinicians often deal with the high costs of equipments, adverse climatic conditions, power instability, and inadequate maintenance service [11].

If the unavailability of US machines is indeed an absolute requirement for US practice, proper education still remains a main issue to be acknowledged [15]. First of all, sufficient time for training should be given since a number of reports indicates a lack of time to learn [9, 16, 30]. Moreover, a well-structured educational program could implement the small number of trainers within various institutions [8]. Last but not least, an ongoing education should be mandatory for all credentialed US physicians [15] in order to improve and consolidate their sonographic skills.

Regarding the liability concerns, they may be closely related to the lack of credentialing plan and quality assurance program in case of misinterpretation or misdiagnosis leading to malpractice claims [29, 38]. Again, healthcare professionals should be aware that literature provides non-apprehensive data about litigation directly related to US application in the last decade [39]. Furthermore, to improve ultrasound skill and reduce concerns about the sense of responsibility, with the possibility of using US more in daily clinical practice, it is not only necessary to train ultrasound skills but also training to imaging evaluation starting, for example, from the study of CT findings or anatomical information.

From the perspective of survey respondents, US has been highly scored in term of usefulness in order to integrate the patient's clinical evaluation and guide clinical decision, confirming positive attitude toward US application [6, 12, 40, 41].

#### **POCUS during the COVID-19 pandemic**

The last two questions of the survey investigated the perception of US role during the outbreak of the COVID-19 pandemic. Italy has been the first European country to deal with COVID-19, serving a resilient assistance both in emergency departments and outpatient clinics nationwide [42]. Despite the enormous efforts to better understand clinical features of COVID-19 disease [42, 43], participants assumed that the pandemic does not seem to have implemented neither the use nor the knowledge expansion of US in pediatrics. This unexpected issue may be due to possible challenges in logistics of US examination (e.g. lack of portable ultrasound machines, high risk for contracting the COVID-19 infection) [44]. On the other hand, the further analysis for the subgroup of pediatricians working in ED found that both US use and knowledge were improved during the pandemic maybe due to a focused attention on emergency and COVID patients.

#### **Limitations and strengths**

Our study had a number of limitations and strengths. The first limitation is intrinsic to the nature of the survey which is self-reported designed. Another limitation is low response rate, which may reflect a lack of participant involvement and motivation on this topic. Actually, a potential response-bias could be due to the overestimation of US users among respondents, as those more interested in US technique may have been more likely to respond. Regarding possible strengths, this study is one of the few surveys which investigated the US application not only in pediatric emergency department but also in outpatient clinics. Moreover the survey was not targeting to a specific population sample, including pediatric residents, pediatric hospitalists and family pediatricians.

## Conclusions

This survey underlines a striking interest towards pediatric US for both pediatricians and residents nationwide. Pediatric residents support US training within the residency period in order to improve knowledge and confidence on the method. Nevertheless, the technique still needs to be implemented so that everyone can easily access it. Future US development would benefit from addressing more resources for up-to-date equipment as well as standardized education plans.

## Abbreviations

US Ultrasound

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13052-024-01680-3>.

Supplementary Material 1

Supplementary Material 2

## Acknowledgements

The authors would like to thank the Italian Pediatric Society for supporting US implementation.

## Author contributions

AMC.M. and M.T. conceptualized the study design; AMC. M, M.T., C.D.R., A.M., V.C., A.A. and L.G. developed the survey's questionnaire; V.D. and R.R. contributed to survey's distribution, data collection and statistical analysis; M.C.S. and D.B. extracted data from the web-platform and interpreted the results; AMC.M. and M.T. wrote the initial manuscript, and reviewed and revised the manuscript; S.Z., A.S., M.R., S.G. A.V. and R.A. critically reviewed the manuscript for important intellectual content. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

## Funding

Not applicable.

## Data availability

The datasets used and analyzed during the current study is available from the corresponding author upon reasonable request.

## Declarations

### Human Ethics and Consent to Participate declarations

Participants provided consent to participate by accepting the invitation email from the Italian Society of Pediatrics. All methods were performed in accordance with the ethical standards as laid down in the Declaration of Helsinki and its later amendments or comparable ethical standards. The ethic approval was not requested according to national rules for this type of study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

### Author details

<sup>1</sup>Unit of Emergency Pediatrics, Department of Emergency, Admission and General Pediatrics, Bambino Gesù Children's Hospital (IRCCS), Rome, Italy

<sup>2</sup>Clinical Pediatrics, Department of Mother and Child, Siena University Hospital, Viale Bracci 16, Siena 53100, Italy

<sup>3</sup>Department of Woman and Child Health and Public Health, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy

<sup>4</sup>Department Pediatrics, Hospital of Crotona President of SIMEUP (Italian Society of Pediatric Emergency Medicine Urgency), Crotona, Italy

<sup>5</sup>Department of Translational Medical Sciences, Section of Pediatrics, University of Naples "Federico II", President of SIP (Italian Society of Pediatric), Naples, Italy

<sup>6</sup>Management and Diagnostic Innovations and Clinical Pathways Research Area, Medical Directorate, Bambino Gesù Children's Hospital, IRCCS, Rome 00165, Italy

<sup>7</sup>Pediatric Unit, Cecina Civil Hospital, Cecina, Italy

<sup>8</sup>Health District of Central Friuli, Cividale del Friuli, Italy

<sup>9</sup>Department of Maternal and Child Health, Santa Chiara Hospital, University of Pisa, Pisa 56100, Italy

<sup>10</sup>Pathology and Neonatal and Pediatric Intensive Care Unit, University Hospital G. Martino, Messina, Italy

<sup>11</sup>Professional Development, Continuing Education and Research, Bambino Gesù Children's Hospital (IRCCS), Rome, Italy

<sup>12</sup>Department of Cardiac Surgery, Cardiology and Heart and Lung Transplant, Bambino Gesù Children's Hospital (IRCCS), Rome, Italy

<sup>13</sup>Unit of General Pediatrics, Department of Emergency, Admission and General Pediatrics, Bambino Gesù Children's Hospital (IRCCS), Rome, Italy

<sup>14</sup>Department of Pediatrics and Neonatology, San Jacopo Hospital, Via Ciliegiole 97, 51100 Pistoia, Italy

Received: 10 February 2024 / Accepted: 25 May 2024

Published online: 09 June 2024

## References

1. Conlon TW, Nishisaki A, Singh Y, Bhombal S, De Luca D, Kessler DO, et al. Moving beyond the stethoscope: Diagnostic Point-of-care Ultrasound in Pediatric Practice. *Pediatrics*. 2019;144:e20191402.
2. Singh Y, Tissot C, Fraga MV, Yousef N, Cortes RG, Lopez J, et al. International evidence-based guidelines on point of Care Ultrasound (POCUS) for critically ill neonates and children issued by the POCUS Working Group of the European Society of Paediatric and neonatal intensive care (ESPNIC). *Crit Care*. 2020;24:65.
3. Soni NJ, Schnobrich D, Mathews BK, Tierney DM, Jensen TP, Dancel R, et al. Point-of-care Ultrasound for hospitalists: a position Statement of the Society of Hospital Medicine. *J Hosp Med*. 2019;14:E1–6.
4. Hopkins A, Doniger SJ. Point-of-care Ultrasound for the Pediatric Hospitalist's practice. *Hosp Pediatr*. 2019;9:707–18.
5. Jamil SF, Rajendram R. Training pediatric residents in point-of-care ultrasound: an assessment of the needs and barriers to acquire the skill. *Int J Pediatr Adolesc Med*. 2022;9:49–55.
6. McGinness A, Lin-Martore M, Addo N, Shaahinfar A. The unmet demand for point-of-care ultrasound among general pediatricians: a cross-sectional survey. *BMC Med Educ*. 2022;22:7.
7. Burton L, Bhargava V, Kong M. Point-of-care Ultrasound in the Pediatric Intensive Care Unit. *Front Pediatr*. 2022;9:830160.
8. Nguyen J, Amirmovin R, Ramanathan R, Noori S. The state of point-of-care ultrasonography use and training in neonatal-perinatal medicine and pediatric critical care medicine fellowship programs. *J Perinatol*. 2016;36:972–6.
9. Eisen LA, Leung S, Gallagher AE, Kvetan V. Barriers to ultrasound training in critical care medicine fellowships: a survey of program directors. *Crit Care Med*. 2010;38:1978–83.
10. Conlon TW, Kantor DB, Su ER, Basu S, Boyer DL, Haileselassie B, et al. Diagnostic bedside Ultrasound Program Development in Pediatric critical Care Medicine: results of a National Survey. *Pediatr Crit Care Med*. 2018;19:e561–8.
11. Abrokwa SK, Ruby LC, Heuvelings CC, Bédard S. Task shifting for point of care ultrasound in primary healthcare in low- and middle-income countries—a systematic review. *EClinicalMedicine*. 2022;45:101333.
12. Arichai P, Delaney M, Slamowitz A, Rosario R, Gordish-Dressman H, Basu S, et al. Pediatric Residency Point-of-care Ultrasound Training needs Assessment and Educational intervention. *Cureus*. 2022;14:e28696.
13. Nielsen MB, Cantisani V, Sidhu PS, Badea R, Batko T, Carlsen J, et al. The Use of Handheld Ultrasound devices - an EFSUMB position paper. *Ultraschall Med*. 2019;40:30–9.
14. Mayo PH, Beaulieu Y, Doelken P, Feller-Kopman D, Harrod C, Kaplan A, Orpello J, Vieillard-Baron A, Axler O, Lichtenstein D, Maury E, Slama M, Vignon P.



- American College of Chest Physicians/La Société De Réanimation De Langue Française statement on competence in critical care ultrasonography. *Chest*. 2009;135:1050–60.
15. Ultrasound Guidelines. Emergency, point-of-Care, and clinical Ultrasound guidelines in Medicine. [No authors listed]. *Ann Emerg Med*. 2023;82:e115–55.
  16. Parri N, Berant R, Giacalone M, Jones SD, Friedman N. REPEM POCUS collaboration. Dissemination and use of point-of-care Ultrasound by pediatricians in Europe: A Research in European Pediatric Emergency Medicine Network Collaborative Survey. *Pediatr Emerg Care*. 2022;38:e1594–1600.
  17. Bhargava V, Haileselassie B, Rosenblatt S, Baker M, Kuo K, Su E. A point-of-care ultrasound education curriculum for pediatric critical care medicine. *Ultrasound J*. 2022;14:44.
  18. Good RJ, O'Hara KL, Ziniel SI, Orsborn J, Cheetham A, Rosenberg A. Point-of-care Ultrasound Training in Pediatric Residency: A National needs Assessment. *Hosp Pediatr*. 2021;11:1246–52.
  19. Arora S, Cheung AC, Tarique U, Agarwal A, Firdouse M, Ailon J. First-year medical students use of ultrasound or physical examination to diagnose hepatomegaly and ascites: a randomized controlled trial. *J Ultrasound*. 2017;20:199–204.
  20. Sena A, Alerhand S, Lamba S. Milestone Approach to Designing a point-of-care Ultrasound Curriculum for Transition-to-Residency Programs in the United States. *Teach Learn Med*. 2021;33:270–81.
  21. Zawadka M, Graczyńska A, Janiszewska A, Ostrowski A, Michałowski M, Rykowski M, et al. Lessons learned from a study of the integration of a point-of-care Ultrasound Course into the Undergraduate Medical School Curriculum. *Med Sci Monit*. 2019;25:4104–9.
  22. Chamberlain MC, Reid SR, Madhok M. Utilization of emergency ultrasound in pediatric emergency departments. *Pediatr Emerg Care*. 2011;27:628–32.
  23. Mosier JM, Malo J, Stolz LA, Bloom JW, Reyes NA, Snyder LS, et al. Critical care ultrasound training: a survey of US fellowship directors. *J Crit Care*. 2014;29:645–9.
  24. Becker DM, Tafoya CA, Becker SL, Kruger GH, Tafoya MJ, Becker TK. The use of portable ultrasound devices in low- and middle-income countries: a systematic review of the literature. *Trop Med Int Health*. 2016;21:294–311.
  25. Rizvi MB, Rabiner JE. Pediatric Point-of-care lung Ultrasonography: a narrative review. *West J Emerg Med*. 2022;23:497–504.
  26. van Rijn RR, Stafrace S, Arthurs OJ, Rosendahl K. European Society of Paediatric Radiology. Non-radiologist-performed point-of-care ultrasonography in paediatrics - European Society of Paediatric Radiology position paper. *Pediatr Radiol*. 2021;51:161–7.
  27. Andronikou S, Otero HJ, Belard S, Heuvelings CC, Ruby LC, Grobusch MP. Radiologists should support non-radiologist point-of-care ultrasonography in children: a case for involvement and collaboration. *Pediatr Radiol*. 2022;52:604–7.
  28. Ludden-Schlatter A, Kruse RL, Mahan R, Stephens L. Point-of-care Ultrasound attitudes, barriers, and current use among Family Medicine residents and practicing Physicians. *PRiMER*. 2023;7:13.
  29. Marin JR, Zuckerbraun NS, Kahn JM. Use of emergency ultrasound in United States pediatric emergency medicine fellowship programs in 2011. *J Ultrasound Med*. 2012;31:1357–63.
  30. Gold DL, Marin JR, Haritos D, Melissa Skaugset L, Kline JM, Stanley RM, et al. Pediatric Emergency Medicine Physicians' Use of Point-of-care ultrasound and barriers to implementation: a Regional Pilot Study. *AEM Educ Train*. 2017;1:325–33.
  31. Smalley CM, Fertel BS, Broderick E. Standardizing point-of-care Ultrasound Credentialing across a large Health Care System. *Jt Comm J Qual Patient Saf*. 2020;46:471–76.
  32. Marin JR, Lewis RE, American Academy of Pediatrics, Committee on Pediatric Emergency Medicine. Society for Academic Emergency Medicine, Academy of Emergency Ultrasound; American College of Emergency Physicians, Pediatric Emergency Medicine Committee; World Interactive Network focused on critical Ultrasound. Point-of-care ultrasonography by pediatric emergency medicine physicians. *Pediatrics*. 2015;135:e1113–22.
  33. Hoppmann RA, Mladenovic J, Melniker L, Badea R, Blaivas M, Montorfano M et al. International consensus conference recommendations on ultrasound education for undergraduate medical students. *Ultrasound J*. 2022;14:31.
  34. Meggitt A, Way DP, Iyer MS, Mahan JD, Gold D. Residents' perspective on need for point-of-care Ultrasound Education during Pediatric Residency. *Hosp Pediatr*. 2022;12:607–17.
  35. Hoeffe J, Desjardins MP, Fischer J, Carriere B, Gravel J. Emergency point-of-care ultrasound in Canadian pediatric emergency fellowship programs: current integration and future directions. *CJEM*. 2016;18:469–74.
  36. Abo AM, Alade KH, Rempell RG, Kessler D, Fischer JW, Lewis RE, et al. Credentialing Pediatric Emergency Medicine Faculty in Point-of-care Ultrasound: Expert guidelines. *Pediatr Emerg Care*. 2021;37:e1687–94.
  37. Wong J, Montague S, Wallace P, Negishi K, Liteplo A, Ringrose J, Dversdal R, Buchanan B, Desy J, Ma IWY. Barriers to learning and using point-of-care ultrasound: a survey of practicing internists in six north American institutions. *Ultrasound J*. 2020;12:19.
  38. Nguyen J, Cascione M, Noori S. Analysis of lawsuits related to point-of-care ultrasonography in neonatology and pediatric subspecialties. *J Perinatol*. 2016;36:784–6.
  39. Solomon L, Emma M, Gibbons LM, Kusulas MP. Current risk landscape of point-of-care ultrasound in pediatric emergency medicine in medical malpractice litigation. *Am J Emerg Med*. 2022;58:16–21.
  40. Watkins LA, Dial SP, Koenig SJ, Kurepa DN, Mayo PH. The utility of point-of-care Ultrasound in the Pediatric Intensive Care Unit. *J Intensive Care Med*. 2022;37:1029–36.
  41. Raucci U, Musolino AM, Di Lallo D, Piga S, Barbieri MA, Pisani M, et al. Impact of the COVID-19 pandemic on the Emergency Department of a tertiary children's hospital. *Ital J Pediatr*. 2021;47:21.
  42. Parri N, Lenge M, Cantoni B, Arrighini A, Romanengo M, Urbino A, et al. COVID-19 in 17 Italian Pediatric Emergency Departments. *Pediatrics*. 2020;146:e20201235.
  43. Musolino AM, Supino MC, Buonsenso D, Ferro V, Valentini P, Magistrelli A, et al. Lung ultrasound in children with COVID-19: preliminary findings. *Ultrasound Med Biol*. 2020;46:2094–98.
  44. McDermott C, Daly J, Carley S, Combatting. COVID-19: is ultrasound an important piece in the diagnostic puzzle? *Emerg Med J*. 2020;37:644–49.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.