

Point of care prehospital ultrasound in Basic Emergency Services in Portugal

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Abstract

Background and Aims: The Point of Care Ultrasound and Point-of-Care Ultrasound in Resource-Limited Settings are differentiated diagnostic methods using ultrasound, essential in urgent patients screening, allowing better guidance in the diagnostic process and therapeutic approach. This study intends to observe the impact of these techniques in two Basic Emergency Services (SUB) in Portugal.

Methods: A longitudinal study was carried out in two remote locations in Portugal (SUB N and SUB S). Data were collected by trained radiographers in each location, and a total of 972 exams were considered. Imaging findings were documented by exam type, the exam normality and the resolution after exam. χ^2 and Cramer's V tests were performed to check significant correlations between the variables.

Results: Regarding the type of echographic findings, 289 (29.7%) were considered normal, 628 (64.6%) were classified as abnormal and 55 (5.7%) were considered inconclusive. As for the type of resolution, 58% had local resolution, 24% were referred to a hospital emergency service and 18% referred to ambulatory care. Regarding the Location versus Resolution after exam versus Findings variables, it was verified a stronger statistically significant association for the exams considered "Abnormal" (Cramer's V = 0.414; $p < 0.001$). In the variables Location versus Findings versus Resolution after exam, it was verified a stronger statistical significance for "Referral to Ambulatory" (Cramer V = 0.443; $p < 0.001$) although Referral for Hospital (Cramer V = 0.252; $p = 0.003$) or Local Resolution (Cramer V = 0.252; $p < 0.001$) also had a moderate association strength.

Conclusion: Ultrasonography is a useful diagnostic tool for patients screening, having an influence on patient management in remote settings. Given the limited literature in Portugal about this matter, further research and literature will be needed to support and complement the results of this study.

KEYWORDS

POCUS, Portugal, PURLS, Radiographer, Remote, Ultrasound

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1 | INTRODUCTION

Ultrasound is a differentiated and multidisciplinary diagnostic tool that is essential in urgent patients screening, which allows better guidance in the diagnostic process and the initial therapeutic approach in a faster and more reliable way.¹

Point of Care Ultrasonography (POCUS) in prehospital setting is a protocol used worldwide.¹⁻³ Major medical specialties and a considerable part of emergency flowcharts include the POCUS or other ultrasound protocols both for physicians and nonmedical professionals.⁴⁻⁸ The Point-of-care Ultrasound in Resource-Limited Settings (PURLS)⁹ is described in Uganda Hospitals by Stolz¹⁰ as well as in remote settings, for instance, in a study of Henwood.¹¹

Portugal, despite being a small country, has a great geographic dispersion, so there was a need to create, in 2008, the so-called Basic Emergency Services (SUB) to tackle the asymmetry between urban and rural areas in health care emergency services delivery. It is in this context that ultrasound implementation as screening tool was essential in remote contexts.¹²⁻¹⁸ Ultrasound proved to be useful for the patient screening, allowing the relief of hospital admissions, keeping geography from being an obstacle to quality care delivery.^{1,3,6,19}

The literature about ultrasound in remote context is extensive, both for medical and nonmedical personnel, and recognizes the extremely important role of its application in extra-hospital and prehospital settings.^{2,6,14,15,20-27} There are remote places (as we will discuss in the study) with a lack of resources, where the use of ultrasound has shown a very positive effects on the patients management, without interference with the work of the other medical specialties. We highlight a study by Biegler⁶ where nurses were trained to perform lung ultrasound and reports, where instructions and guidance were done remotely. Other study by Léger³ also describes that the majority of emergency units in Québec (95%) used POCUS, which was extremely useful in the clinical response, allowing great health outcomes and savings for the public treasury, namely in interhospital transfers, avoiding late diagnoses and promoting an easier access to emergency health care.

As far as Radiographers/Sonographers are concerned, the reality is no different either, their progressive and fast evolution at academic level has enhanced their ability to perform more complex imaging exams, namely ultrasonography.^{28-32,33}

The European Society of Radiology report, corroborated by the European Federation of Radiographer Societies, described that there were often hospitals and clinics in Europe where specialized Radiographers perform ultrasound examinations and pre-reports, releasing radiologists for more specialized tasks.^{30,34}

The main goal of this study is to verify whether the patient management classification (Normal, Abnormal, or Inconclusive) could influence the type of resolution (Local, Ambulatory, or Hospital emergency). This study was not intended to assess the accuracy of the diagnosis.

2 | METHODS

Two remote basic emergency locations in Portugal with ultrasound available were considered, one in the North (SUB N) and the other in the South (SUB S). Both locations had less than 20,000 inhabitants and were approximately 1 h distance from the nearest Hospital. The sampling methodology was random, not probabilistic by convenience, and the type of study was Cross sectional, observational and longitudinal. Data were registered from January 2016 to December 2019 and descriptively analyzed in the Microsoft Office Excel program version 2019. Statistical analysis and the respective correlation tests between variables were performed using the IBM SPSS Statistics version 28 software.

In one of the locations (SUB N) a Voluson ultrasound equipment was used (General Electric, from 2009 SN 7905/0845/0023) with two probes (convex and linear). In SUB S, a Toshiba Némio XG ultrasound was used, with just a convex probe.

In both locations, data collection was carried out by only one Radiographer in each location, because they were the only ones with specific and differentiated ultrasound training.

Data were collected and registered by the main investigator on a common data file built for that purpose. The Radiographers, after performing and analyzing the exams with the prescriber physician, classified the exams as "Normal," "Abnormal," or "Inconclusive" according to the Table 1 criteria and then registered the type of referral given to the patient by the Basic Emergency Center (Local, Ambulatory, or Hospital emergency).

In the first phase of this study, a descriptive analysis (percentages and frequencies) of the data was made and the main differences in

TABLE 1 Differentiation criteria between normal/abnormal/inconclusive exams

Normal	Abnormal	Inconclusive
Echographic findings traducing normal echotexture/ dimensions and/or normal anatomy characteristics of the specific organ, vessel, and soft tissue component.	Echographic findings traducing changes of normal echotexture/dimensions and/or normal anatomy characteristics of the specific organ, vessel, and soft tissue component.	Echographic imagens that do not allow the exclusion of the pathology under clinical suspicion.
The echographic images obtained are considered sufficient to exclude abnormalities of the scanned area.	Images that may match with the physician examination of patient and be related with analytic and clinical suspicions	Doubtful or limited echographic images requiring further examination with other imaging techniques.

the variables between the two places under study (SUB N and SUB S) were verified. In the second phase, χ^2 and Cramer's V tests were performed to check significant correlations between the variables and the relation strenght for a 95% confidence interval, with the aim of evaluating the influence of this technique in the patient's management.

2.1 | Ultrasound protocols covered in the study

The acquisition of echographic images followed specific and systematic protocols to obtain a correct coverage of what is intended to be seen in each exam. The description of these protocols and the respective clinical indications can be seen in Table 2.

3 | RESULTS

The total number of exams considered in this study was 972, 610 (62.8%) from SUB N and 362 (37.2) from SUB S. Of these, 554 (57%) were male and 418 (43%) were female, with an average age of 55.2 years.

Regarding to the type of exams (Figure 1), the most performed was the Musculoskeletal (41%), followed by the Abdominal/Pelvic (23.6%), Urinary Tract (12.3%) and E-FAST (9.2%).

In relation to the ultrasound findings (Figure 2), 289 (29.7%) were considered normal, 628 (64.6%) were classified as abnormal and 55

(5.7%) were considered inconclusive. Looking at each SUB, the distribution's percentage turned out to be very similar between them, since the normal exams in SUB N was 31% and in SUB S was 27.6%. Considering the abnormal exams, in SUB N it was 63.3% and in SUB S it was 66.9%. As for inconclusive, both sites showed very low percentages, with SUB N having 5.7% and SUB S having 5.5%.

Analyzing the echographic findings by type of exam, there was a percentage of abnormalities above 50% in all the exams considered, namely, 74.9% in Musculoskeletal, 80.0% in Neck/Thyroid and Pleuropulmonary, 59.2% in Urinary Tract, 55.6% in Cardiovascular, 50.7% in Abdominal/Pelvic and 50.6% in E-FAST.

Regarding to the type of resolution after the exam (Figure 3), there was a large percentage of exams (58%) that ended up having a local resolution in both SUBs, clearly ahead of the 24% of referrals to Hospital emergency and 18% for Ambulatory care/follow-up.

Analyzing the type of resolution by exam type (Figure 4), in musculoskeletal exams, the large majority had local resolution (69.8%) and ambulatory referral (25.1%), only being considered hospital emergent referral in 5,5% of cases. In the case of Neck/Thyroid exams, 25% had local resolution, 65% were referred to ambulatory and 10% to Hospitals. In the remaining procedures, the exams with the greatest trend for referral to Hospital emergency were E-FAST (51.7%), Cardiovascular (51.1%), Pleuropulmonary (38.6%), Urinary tract (34.5%) and Abdominal/Pelvic (34.5%). Note that, in the cases of E-FAST and Cardiovascular, they represented almost half of the resolutions, with almost no referral to ambulatory care (4.5% and 6.7%, respectively).

TABLE 2 Type of protocols used during the examinations

Type of exam	Indications	Examples
E-Fast	Multisystemic trauma	Bilateral assessment of upper abdominal recesses, cardiac, pelvic, and pulmonary imaging, bilateral search for pleural effusion. Applied to injured patients, patients with generalized cardiac and respiratory conditions with frank weakness, suspicion of pneumothorax, hypotension.
Cardiovascular	Dyspnea of unknown cause, chest pain, DVT signs	Includes summary cardiac assessment by subxiphoid technique, observation of the inferior vena cava/aorta. It was performed mainly on patients with dyspnea, suspected of acute pulmonary edema; In the lower limbs, exclude cases of deep vein thrombosis (DVT) and in the abdominal region great vessels (aorta and cava)
Pleuropulmonary	Dyspnea of unknown cause, fever	Visualization of the right and left pleuro-diaphragmatic transitions and pulmonary parenchymal alterations. Also used to complement doubtful chest X-rays
Abdominal/Pelvic	Abdominal diffuse or concrete pain; Suspected cholecystitis or appendicitis	Summary assessment of the liver, biliary tract, pancreas, spleen, and peritoneal recesses. In the pelvic region, summary observation of the bladder and female and male reproductive system and respective expansive lesions or accumulation of fluid in the Douglas space
Urinary tract	Renal colic, hematuria with no obvious cause	Visualization of both kidneys, summary assessment of dimensions and ecostructure. Search for Pyelocalicial dilation, bladder globe ou nodules
Musculoskeletal	Trauma with sudden functional loss, swelling	Visualization of musculoskeletal structures including muscles, tendons, ligaments, joints, and periosteum from regions such as the shoulder, elbow, hand, wrist, foot, ankle, knee and hip.
Neck/Thyroid	Suspected nodules or vascular changes	Visualization of the thyroid lobes, and structural changes, nodules and regional lymph nodes. Visualization of muscular and vascular structures (carotid and jugular) as well as salivary glands (parotid and submaxillary)

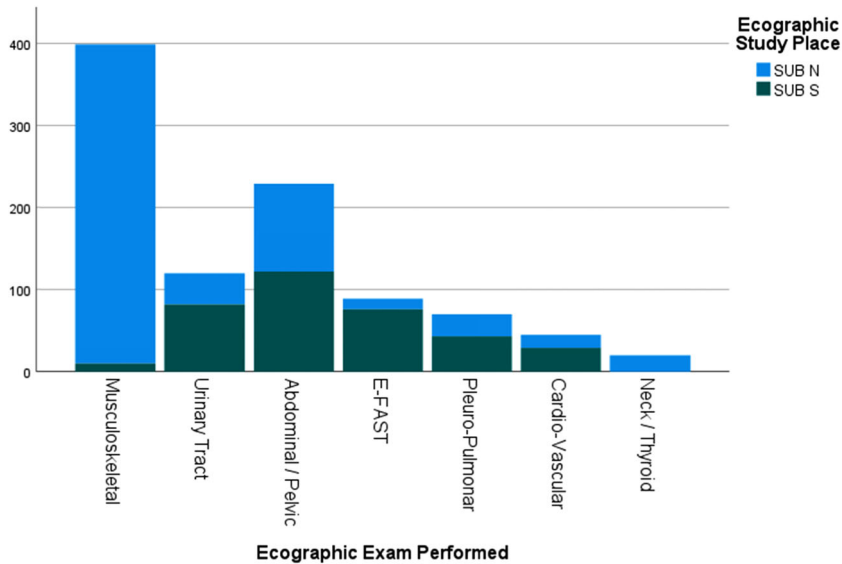


FIGURE 1 Ultrasound examinations performed by place

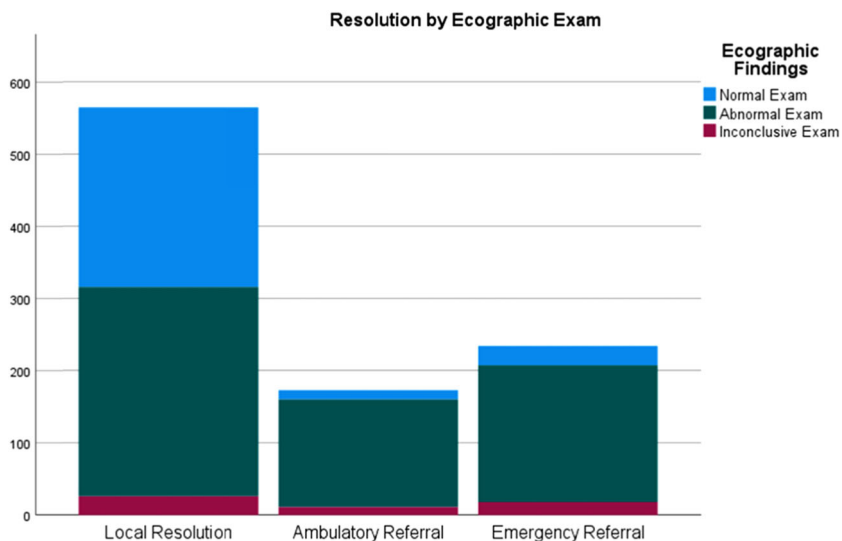


FIGURE 2 Echographic findings by place of exam

To analyze the relationship between variables, χ^2 test was performed. First only two variables were compared at the time. For instance the variable "Type of Exam" was compared with the variable "Type of Resolution after exam," The variable "Location" with "Resolution after exam," the variable "Findings" with "Type of Resolution after exam" and the variable "Study location" with the variable "Findings," also checking the Cramer's V value and its respective significance³⁵ as shown in the Table 3 below.

After this initial analysis between two variables, χ^2 tests were carried out stratifying the variables by Location, Findings and Resolution after exam. Through Table 3, significant statistically relationships for 99% confidence interval, can be verified in most cases, and those that showed greater strength of association (higher Cramer V) were the variables Type of exam versus Type of Resolution after exam (0.317; $p < 0.001$), Type of exam versus Type of Resolution after exam versus SUB M (0.320; $p < 0.001$), Type of exam versus

Findings versus Abnormal (0.414; $p < 0.001$) and the variables Study location versus Findings versus Ambulatory (0.443; $p < 0.001$).

4 | DISCUSSION

Although the services have their own local characteristics, one item seems to stand out, which is the low percentage of inconclusive exams, either for SUB N (5.7%) or for SUB S (5.5%). Despite the literature about this subject is scarce, it can be estimated a usefulness for the diagnostic contribution of 94.3% and 94.5%, respectively, quite similar to the study by Lapostolle²⁵ in which the ultrasound examination increased the diagnostic certainty by 90%. In the remaining literature consulted, the percentage varied between >30% and <87% depending on the type of exam¹² and it proved to be useful in 67.8% of the cases according to Steinmetz and Berger.¹⁶

FIGURE 3 Type of resolution after exam

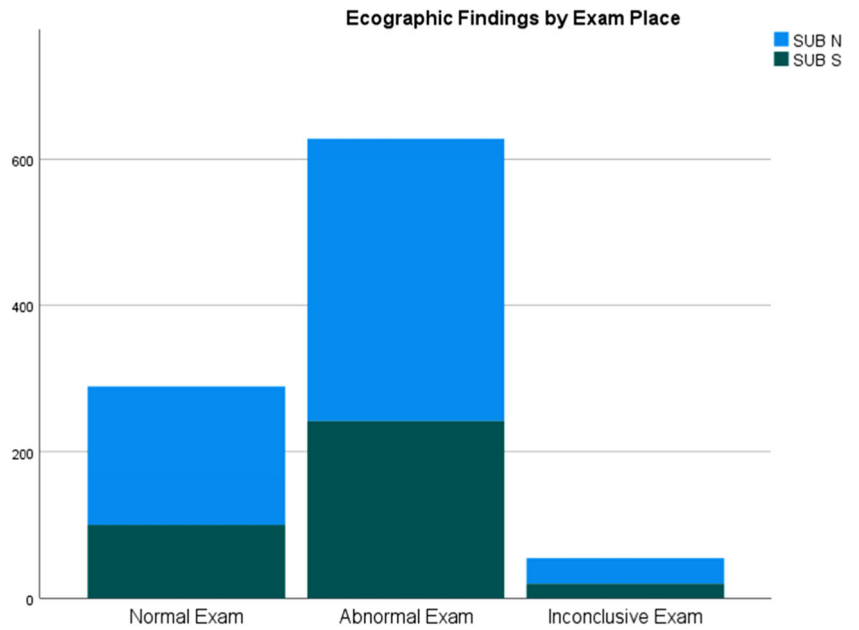
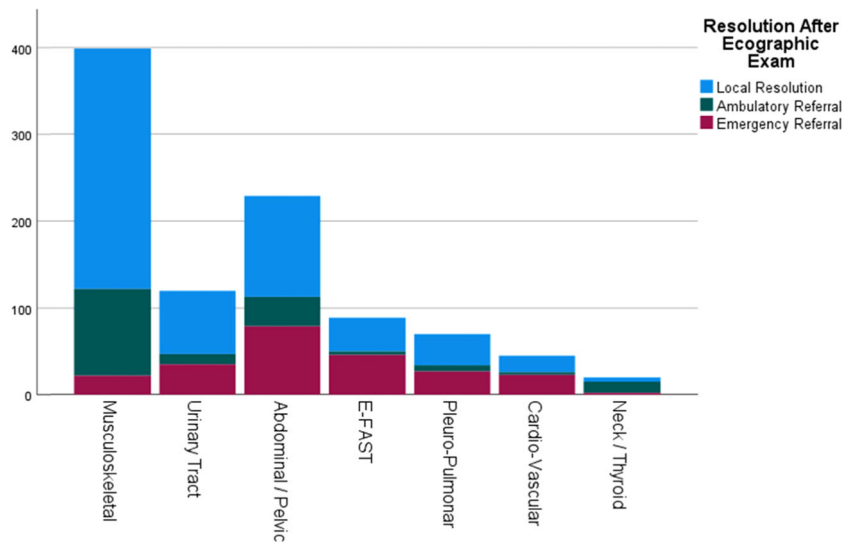


FIGURE 4 Type of resolution by type of exam



The data also showed that the abnormal-to-normal ratio of the SUB N was 2.0:1 and in the SUB S was 2.4:1, quite similar to each other, although the regional differences between them. Comparing with Stainmetz and Berg study the abnormal-to-normal ratio was 4.5:1 but this study was more focused on obstetric and abdominal POCUS.¹⁶

Globally analyzing the total exams that had local and ambulatory resolution and considering what is paid on average in the Transport and Patient Management System, we can estimate savings of approximately 64.823 euros in the considered period (49.581 eur in SUB N, and 15.242 eur in SUB S).

If we add what was saved in orthodox exams (considering that the travel is paid by the user³⁶) it can be estimated in 13.247 euros of savings which gives 78.070 euros in total. We carried out this analysis, with the due reservation that the POCUS and PURLS exam has different purposes and objectives than the orthodox ultrasound

examinations. Nevertheless, this reveals an interesting cost effectiveness in the way that it allowed to pay and maintain the ultrasound equipment in this period. This is an example that in health care, cost-effective measures can be taken in this type of ultrasound projects in remote environments, as described in the literature, although other authors have never estimated monetary values.^{6,11-13}

Regarding descriptive statistics, as mentioned above, it was found a large number of musculoskeletal exams in SUB N, compared to SUB S, which is related to the fact that there is a linear probe available, the characteristics of the local Radiographer and the users who attend the services. It should be noted that precisely because of this, there are fewer cases referred to Hospital emergency in the SUB N, because musculoskeletal problems are rarely *live-saving*, unlike the abdominal, cardiovascular and pleuropulmonary exams.³⁷

Despite all these regional and context differences, regarding to the classification of exams, this reveals a lot of homogeneity, which

TABLE 3 Chi Square, Cramer's V and *p* values for the tested variables

Variables under study	χ^2	Cramer V	<i>p</i> Value
Exam versus resolution after exam	195,309	0.317	<0.001
SUB N	125,003	0.320	<0.001
SUB S	28,709	0.199	<0.01
Location versus resolution after exam	102,515	0.325	<0.001
Normal	8,954	0.176	<0.02
Abnormal	107,714	0.414	<0.001
Inconclusive	4,788	0.295	<0.1
Findings versus resolution after exam	134,100	0.263	<0.001
SUB N	92,848	0.276	<0.001
SUB S	51,857	0.268	<0.001
Study location versus findings	1,329	0.037	<0.6
L. resolution	71,774	0.252	<0.001
Ambulatory	64,872	0.443	<0.001
Hospital	29,818	0.252	<0.01

Note: Bold values indicates 99% confidence interval.

means that there are similar criteria for interpretation and approach to the Radiographers of both places. It was in this aspect that, in the inferential statistics (Study Location versus Findings), there was no statistically significant relationship between the variables ($p < 0.6$), which means that they are independent. In other words, it was indifferent to do a given type of exam in SUB N or SUB S.

Regarding to the inferential statistics between variables (Table 3), there was verified a statistically correlation between the aggregate variables: Exam versus Resolution after exam versus Location, which reinforces that, regardless of the location (radiographer, context limitations, and patient characteristics), there seems to be a homogeneous approach and interpretation of the ultrasound exams.

Reinforcing this thesis, the Cramer's V value was higher in the Exam x Resolution after exam (0.317; $p < 0.001$), followed by the Findings versus Resolution After exam versus SUB N (0.320; $p < 0.001$).

Considering the relationship between the variables Location versus Resolution after exam versus Findings it was verified a stronger statistically significant association for the exams considered "Abnormal" (Cramer's V was 0.414; $p < 0.001$). This may indicate that, regardless the location, the type of resolution is strongly influenced when the findings are considered abnormal. This means that exams considered abnormal seem to have more "weight" for a decision to manage in a certain direction.

Regarding the relationship between the variables Findings versus Resolution after exam versus Location, was verified the influence of the exam findings and the type of resolution after the exam

(0.263; $p < 0.001$). This is also valid, individually, for each of the study locations (0.276; $p < 0.001$ and 0.268; $p < 0.001$ for the SUB N and SUB S, respectively).

This highlights the contribution of the exam findings to a presumption diagnosis and the specific type of referral needed. Although the methodology was different, this trend was already verified in the studies by Groen¹² and Stainmetz and Berg.¹⁶

Observing the relationship between the variables Location versus Findings versus Resolution after exam, it was found that, although there was a statistically significant relationship between variables for all types of resolutions, this was considerably stronger for "Referral to Ambulatory" (0,443; $p < 0.001$) although Referral for Hospital (0.252; $p < 0.01$) and Local Resolution (0.252; $p < 0.001$) also had a moderate association strength.

4.1 | Limitations of the study

There were some limitations on this study that must be considered. The data was gathered by two different Radiographers in two different locations, with different levels of experience. The ultrasound findings results weren't validated by a Radiologist because there were none in both places, and no control group without POCUS was included due to the difficulty of selection of potential elective patients. The Ultrasound machines had some issues, the SUB N had 2 probes (linear and convex) and in the SUB S only the convex probe was available.

5 | CONCLUSION

Ultrasound in rural and prehospital settings with limited resources, as in SUB S and SUB N, has proved to be a very important and differentiated imaging diagnostic tool, allowing for better guidance in the diagnosis process and in the initial approach to the patient management.

In this study, ultrasound proved to be a very resolute tool in remote contexts due to the low percentage of inconclusive exams observed, either from SUB N (5.7%) and from SUB S (5.5%), a fact that allows us to predict a high utility for the diagnostic contribution of 94.3% and 94.5%, respectively. The abnormal-to-normal ratio for the SUB N was 2.0:1 and for the SUB S it was 2.4:1, that is lower than in some available literature, but very similar between each other. The influence of the exam findings and the type of resolution after the exam was verified and confirmed for both locations. The type of resolution after exam is strongly influenced by the findings especially when they are considered abnormal, and the results in the study also seem to indicate greater statistical significance in referring the patients to ambulatory care.

Given the limited literature in Portugal about this matter, further research and literature will be needed to support and complement the results of this study.

AUTHOR CONTRIBUTIONS

Manuel José Cruz Duarte Lobo: Conceptualization; data curation; formal analysis; investigation; methodology; supervision; validation; writing – original draft; writing – review and editing. **Sérgio Carlos Castanheira Nunes Miravent Tavares:** Conceptualization; data curation; formal analysis; investigation; methodology; resources; validation; visualization; writing – original draft; writing – review and editing. **Rui Pedro Pereira de Almeida:** Data curation; formal analysis; methodology; software; validation; writing – original draft; writing – review and editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

TRANSPARENCY STATEMENT

The lead author Manuel José Cruz Duarte Lobo affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.


DATA AVAILABILITY STATEMENT

The anonymized data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHIC STATEMENT

All exams were prescribed by physicians in an emergency context. In this context, some patients were unable to sign the informed consent due to their health status. No patient and institutional data were registered, in accordance with the general data protection law. The main objective was to try to prove the importance and usefulness of this techniques in remote contexts. This study followed the scientific investigation ethical patterns, including the declaration of Helsinki and the general data protection national legislation.

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