Mapping remote telementored ultrasound deployments (RTMUS) for use in austere environments: a scoping review

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Background

What is remote telementored ultrasound (RTMUS)?

A novice operator is remotely guided step-by-step by an expert to perform an ultrasound scan. The expert gives verbal instructions while overlooking a live ultrasound video feed.[1]

Why is RTMUS important?

Independent ultrasound scanning requires 3-6 months training,[2] which limits its use in remote medical outposts, the wilderness and in space, where availability of adequately trained staff is poor.[3,4]

What is the knowledge gap?

Previous reviews have identified a number of studies describing RTMUS,[5,6] however our understanding of where and how this was demonstrated is poor. The evidence base has not yet been mapped.

Aims

To highlight the **key features** and **knowledge gaps** of the evidence base behind RTMUS deployments, including the **population** performing the ultrasound, **concept** (scan types performed), **context** (environments where they took place) and the **technical setup** of the studies.

Methods

This scoping review was designed and reported using **JBI methodology.** We identified published literature describing RTMUS within Embase, Medline, CINAHL and Scopus. Inclusion was guided by:

Population – novice operators

Concept – remote telementored ultrasound

Context – with application to austere environments

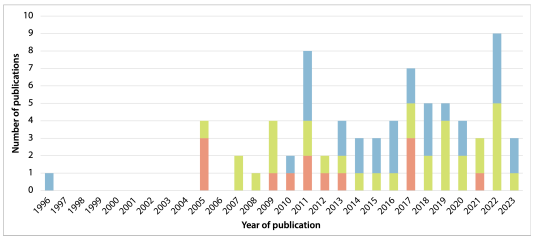
We excluded studies describing RTMUS used for doctors asking other doctors for a second opinion, mentored only with software and asynchronous (not real-time) mentoring.

We extracted and analysed data using a 20-parameter form, covering 5 key categories (general data, population, concept, context, technical parameters). We presented an evidence map of where and how RTMUS has been deployed.

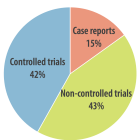
Evidence sources we found

The literature search yielded 3521 papers, of which 1460 were duplicates and 1865 were excluded by title and abstract. 196 full-text papers were assessed for eligibility, of which **86 papers were included in the review**.

Distribution of studies by publication year, according to study design



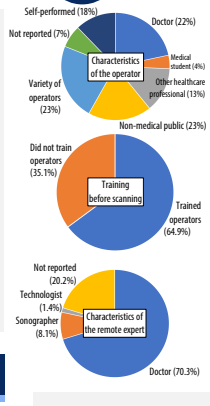
Many studies were exploratory in nature. We recorded 13 case reports, 37 other non-controlled studies and 36 controlled trials.



86 studies were published between 1996 and 2023 in 19 countries, mostly the United States (n=40), Canada (n=18), Scotland (n=5) and Italy (n=4).

86.5% studies measured at least one outcome, e.g. clinical usefulness of the collected images (59.5%), time to completion of scan (32.4%) or confirming a pre-existing diagnosis (10.8%) or that of an expert (17.6%).

Key features of RTMUS deployments



Population: novice ultrasound operators

We found that doctors (21.6%), but also medical students (4.1%), other health professionals (13.5%) and non-medical members of the public (18.9%) could be guided to perform RTMUS. The clinical effectiveness of these groups has not yet been compared.

Training novice operators before the scan

Most studies (64.9%) reported training their novices before scanning. This included a demonstration (52.7%), lecture (5.4%), course (5.4%), video (6.8%) or computer programme (9.5%), which lasted a median of 1 hour. However, these were not validated.

Population: remote experts

Most studies used a doctor as their expert (70.3%), alternatively a sonographer (8.1%) or technologist (1.4%). Most doctors were radiologists (20.3%), emergency medicine doctors (14.9%) or intensivists (10.8%).

Concept: scan types performed

Scans applicable to life-threatening emergencies were explored most (e.g. FAST, cardiac or lung ultrasound).

Spinal, kidney and eye ultrasound were least explored.

Contexts

The **rural, pre-hospital and wilderness context** was the best explored (44.6%) with many controlled trials, however particularly extreme settings were described in case reports.

Studies in the **developing world context** (9.5%) were minimalistic, cost-effective and many explored more than one scan type.

Studies in the **space context** (18.9%) were mostly single demonstrations of each scan type described in case reports due to small crew sizes. Unique problems included microgravity.

Studies in the **unspecified context** (27%) trialled RTMUS with new groups of operators (e.g. nurses) and for procedural scans (e.g. nerve block).

Evidence map of RTMUS scans performed (rows) across various contexts (columns)

	Rural, pre-hospital, wilderness context	Developing world context	Space context	Unspecified context
FAST / eFAST	14		2	1
Cardiac ultrasound	8	1	3	7
Lung ultrasound	11	1		3
Abdominal ultrasound	3	3	2	1
Vascular ultrasound	3	1	1	2
Musculoskeletal ultrasound	2	1	2	
Breast ultrasound		2	1	
Bladder ultrasound	1	1		1
Obstetric ultrasound	1	4		
Cranial ultrasound	2			
Pelvic ultrasound	1	2	1	
Spinal ultrasound			1	
Kidney ultrasound			1	1
Eye ultrasound			1	
Prostate ultrasound		2		
US-guided nerve block		1		4
US-guided lumbar puncture			1	

Colours represent the highest quality study design (case report, non-controlled trial, controlled trial) available for a given scan within a context.

Numbers indicate the number of studies investigating each scan type within a context.

Technical parameters of the telementoring setup

There was no single "standard" setup. The ultrasound video feed was sent directly (70.3%), or was captured using screensharing (8.1%), or a camera (8.1%). Experts guided novices by voice (16.2%) or voice and video (74.3%). Older and low-budget studies have used modular telementoring components, while recently all-in-one solutions have emerged. Some studies trialled navigation aids, e.g. cue cards (14%), positioning aids (5.4%) or posters (2.3%).

Conclusions and limitations

RTMUS has been demonstrated with a wide range of populations and included experts of various specialties and novice operators of medical and non-medical background.

The rural, pre-hospital and wilderness context is best explored. Study designs in other contexts are defined by their inherent characteristics of cost-effectiveness (developing world) or few operators available / microgravity (space).

RTMUS is viable with technical approaches ranging from basic/modular to comprehensive all-in-one solutions.

As highlighted in previous research, current studies are exploratory in nature. Significant variation in study design and technical protocol is contributing to a lack of systematic reviews and established use in policy and practice.

Limitations: We did not register the study protocol or consider unpublished and non-English literarature sources.

Knowledge gaps for future research

Is there a difference in clinical effectiveness of medical versus non-medical operators, or of experts of various specialties?

A number of scan types have not yet been demonstrated within every context.

What telementoring setup is cost-friendly and delivers optimal clinical effectiveness?

References

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