Radiology

Use of Chest Imaging in the Diagnosis and Management of COVID-19: a WHO Rapid Advice Guide

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Key Results:

- The rapid guide includes three diagnosis recommendations and four management recommendations covering patients with suspected or confirmed COVID-19 with different levels of disease severity, throughout the care pathway from outpatient facility or hospital entry, to home discharge.
- The rapid guide offers considerations about implementation, monitoring and evaluation, and identifies research needs.
- The guide will be relevant for clinicians, hospital managers and planners, policy-makers, hospital architects, biomedical engineers, medical physicists, logistics staff, and control officers involved in water/sanitation and infection prevention.

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Summary statement:

The guide includes seven recommendations covering patients with suspected or confirmed COVID-19 with different levels of disease severity, throughout the care pathway from outpatient facility or hospital entry, to home discharge.

Abbreviations:

- WHO: World Health Organization
- SARS-CoV-2: severe acute respiratory syndrome coronavirus-2
- COVID-19: coronavirus disease 2019
- RT-PCR: reverse transcriptase polymerase chain reaction
- GRADE: Grading of Recommendations Assessment, Development and Evaluation
- RIGHT: Reporting Items for practice Guidelines in HealThcare
- GDG: guideline development group
- LMICs: low- and middle-income countries
- PICO: population, intervention, comparison, outcomes
- CT: computed tomography
- IPC: infection prevention and control

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Abstract

The World Health Organization (WHO) undertook the development of a rapid guide on the use of chest imaging in the diagnosis and management of COVID-19. The rapid guide was developed over two months using standard WHO processes, except for the use of 'rapid reviews' and online meetings of the panel. The evidence review was supplemented by a survey of stakeholders regarding their views on the acceptability, feasibility, impact on equity and resource use of the relevant chest imaging modalities (chest radiography, chest CT and lung ultrasound). The guideline development group had broad expertise and country representation. The rapid guide includes three diagnosis recommendations and four management recommendations. The recommendations cover patients with suspected or confirmed COVID-19 with different levels of disease severity, throughout the care pathway from outpatient facility or hospital entry, to home discharge. All recommendations are conditional and are based on low certainty evidence (n=2), very low certainty evidence (n=2), or expert opinion (n=3). The remarks accompanying the recommendations suggest which patients are likely to benefit from chest imaging and what factors should be considered when choosing the specific imaging modality. The guidance also offers considerations about implementation, monitoring and evaluation, and identifies research needs.

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Introduction

A cluster of pneumonia cases in Wuhan, China was first reported to the World Health Organization (WHO) Country Office in China on 31st of December 2019 [1]. Soon thereafter, a novel coronavirus was identified as the causative agent [2-4]. This virus was named severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) and the associated disease was named coronavirus disease 2019 (COVID-19) [5]. Since December 2019, COVID-19 has rapidly spread from Wuhan to other parts of China and throughout the world. On 30 January 2020, WHO declared the outbreak a public health emergency of international concern and on 11 March 2020, WHO characterized the outbreak as a pandemic [6,7].

The diagnosis of COVID-19 is currently confirmed by identification of viral RNA in reverse transcriptase polymerase chain reaction (RT-PCR). Chest imaging has been considered as part of the diagnostic workup of symptomatic subjects with suspected COVID-19 in settings where laboratory testing (RT-PCR) is not available or results are delayed or are initially negative in the presence of symptoms attributable to COVID-19.

COVID-19 manifests with non-respiratory symptoms as well as respiratory symptoms which are non-specific and of variable severity, ranging from mild to life threatening, which may demand advanced respiratory assistance and artificial ventilation. Imaging has been also considered to complement clinical evaluation and laboratory parameters in the management of patients already diagnosed with COVID-19 (1).

A recent international survey conducted by the International Society of Radiology and the European Society of Radiology found important variations in imaging practices related to COVID-19 [8]. Several countries requested WHO's advice on the role of chest imaging in the diagnostic workup of subjects with suspected or probable COVID-19 disease and in the clinical management of patients with confirmed COVID-19. As a consequence, WHO undertook the development of a rapid guide on the use of chest imaging in the diagnosis and management of COVID-19 [9].

Methods

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The development of this rapid advice guide followed the process outlined in the WHO handbook for guideline development [10], which used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology [11]. Given the nature of the emergency, the process was implemented within a time frame of two months. The reporting of this guide followed the Reporting Items for practice Guidelines in HealThcare (RIGHT) checklist [12]. The main target audience of the guidance are health professionals involved in the diagnosis and management of COVID-19.

Group composition

In conformity with the WHO process, the following bodies were established: a core group (coordination role), a steering group (advisory role), a guideline development group (GDG; the expert panel) and an external review group (peer review role). Membership of the GDG and the external review group included experts from 10 high income countries and 14 low- and middle-income countries (LMICs). In addition, a systematic review team was contracted to conduct a rapid systematic review for each of the guidance's questions. Appendix E1 provides the details on group composition and roles and list of contributors.

Management of declaration of interests

All experts declared their interests prior to participation in the guideline development processes and meetings. All declarations were managed following WHO regulations, on a case-by-case basis and communicated to the experts at the start of the first GDG meeting. A summary was included in Appendix E2. All authors have completed the ICMJE uniform disclosure form at ww.icmje.org/coi_disclosure.pdf and declare no conflicts.

Identification of the key questions

The core group reviewed formal consensus statements from professional bodies and/or national health authorities on the use of chest imaging in COVID-19, with the assistance of the GDG and the International Society of Radiology. Informed by these statements [8,13], the core group formulated the key questions using the PICO format (Population, Intervention, Comparator, Outcomes), with the help of the steering group, the GDG and the systematic review team (see Appendix E3). The intended

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populations are those in whom a COVID-19 diagnosis need to be established and those in whom the diagnosis is already established. The questions addressed three chest imaging modalities (chest radiography, chest computed tomography [CT] and lung ultrasound); three questions addressed diagnosis while four questions addressed management. These key questions formed the basis of the systematic reviews and of the development of recommendations.

Identification of the critical outcomes

The core group drafted a list of outcomes relevant for each PICO question which was circulated to the GDG for importance rating [14]. The list included three types of outcomes: diagnostic accuracy, clinical outcomes and health systems outcomes (see Appendix E3).

The outcomes selected for each question and the scores assessing their importance are included in the evidence-to-decision tables presented in Appendix E4.

Evidence identification and retrieval, quality assessment and synthesis of evidence

A systematic review team performed a rapid review (initial search on 15 April 2020, with subsequent literature surveillance through 29 April 2020, and update on 28 May 2020). Refer to the full guideline publication for more information on the systematic review [15]. The systematic review team produced a GRADE evidence profile for each PICO question [16]. According to the GRADE methodology, the certainty of evidence is categorized into “high”, “moderate”, “low” and “very low”, based on study limitations, inconsistency, imprecision, indirectness, and other factors [17,18].

The core group conducted an online cross-sectional survey of stakeholders asking them to rate (i) the importance of the outcomes and (ii) their views on the acceptability, feasibility, impact on equity and resource use of the relevant chest imaging modalities (chest radiography, CT and lung ultrasound) in the different clinical scenarios.

Formulation of the recommendations

The GDG formulated the recommendations using the GRADE framework, with explicit consideration of specific factors that may affect the direction and strength of each recommendation (benefits and

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harms, the certainty of the evidence, values and preferences, resource use, equity, acceptability and feasibility) [11,19]. The direction (whether "in favour of" or "against" an intervention) and strength (whether "conditional" or "strong") of the recommendations reflects the GDG's degree of confidence as to whether the desirable effects of the intervention being considered outweigh the undesirable effects.

The methodologist (EAA) developed an evidence-to-decision table for each PICO question (using the GRADEpro software), [17] and used them to guide online discussions [18]. The GDG voted on each of the evidence-to-decision factors, then on the direction and strength of the recommendation using an online voting tool (menti.com). The voting results served as the starting point for building consensus. None of the GDG members expressed opposition to the final strength or direction of any of the recommendations. The recommendation was termed as "based on expert opinion" when the systematic review identified no relevant evidence.

Peer review and quality assurance

The members of the External Review Group provided peer review on the draft report of the guidance. The core group considered and addressed all comments with detailed documentation of the responses. The WHO COVID-19 Publications Review Committee provided oversight and approved the final version of the report.

Results

The literature review identified 28 studies that met the eligibility criteria. Out of the seven PICO questions, four had no identified evidence (PICO 1, 3, 6, 7), one had low certainty evidence (PICO 2), and two had very low certainty evidence (PICO 4, 5). The summary of the evidence by PICO question is as follows:

PICO 1: The systematic review identified no eligible study evaluating the diagnostic accuracy of imaging in asymptomatic contacts of patients with COVID-19.

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PICO 2: The systematic review identified 23 studies that evaluated the diagnostic accuracy of three imaging modalities in symptomatic patients with suspected COVID-19, against a reference standard, chest radiography (n=3), chest CT (n=19) and lung ultrasound (n=1). None of these studies compared two imaging modalities against each other. The systematic review team judged those studies to be at either high risk of bias (n=17) or moderate risk of bias (n=6). The studies provided limited information regarding clinical presentation (e.g. the severity of symptoms at presentation) and few reported specific criteria for a positive imaging test for COVID-19. Eleven studies did not describe a reference standard to diagnose COVID-19 that included serial RT-PCR or clinical follow-up. The median sensitivity and specificity reported by the included studies were 0.64 and 0.82 for chest radiography; 0.92 and 0.56 for chest CT; and 0.95 and 0.83 for lung ultrasound. The systematic review team judged the certainty of this evidence to be low for chest radiography, chest CT and lung ultrasound. The corresponding evidence-to-decision table available in Appendix E4 provides the counts for true positives, true negatives, false positives and false negatives for four hypothetical prevalence values of COVID-19 infection which were assumed to be 20%, 40%, 60% and 80% among symptomatic patients with suspected COVID-19. The update of the review conducted before the publication of the guide identified five new studies that evaluated the diagnostic accuracy of chest radiography, chest CT and lung ultrasound in symptomatic patients with suspected COVID-19. The synthesized evidence as well as its associated certainty were judged to remain unchanged.

PICO 3: The systematic review identified no eligible study that evaluated any chest imaging modality in patients with suspected or confirmed COVID-19 not yet hospitalized to support decisions on hospital admission versus home discharge on health outcomes.

PICO 4: The systematic review identified no eligible study that evaluated any chest imaging modality in patients with suspected or confirmed COVID-19 not yet hospitalized to support decisions on regular admission versus intensive care unit admission on health outcomes. The update of the review conducted before the publication of the guide identified one new study that evaluated the use of chest imaging in patients with suspected or confirmed COVID-19 not yet hospitalized. The certainty of the evidence was judged as very low.

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PICO 5: The systematic review team identified three studies that evaluated chest imaging in patients currently hospitalized with moderate or severe symptoms and suspected or confirmed COVID-19, for predicting mortality or admission at the intensive care unit. The certainty of evidence was judged to be very low.

PICO 7: The systematic review team identified no study that evaluated any chest imaging modality to support the decision on discharge home.

Refer to the full guideline publication for the citations of studies referred in the summary of evidence [15].

The GDG developed one recommendation for each PICO question with two exceptions: it developed two recommendations for PICO 2 and developed no recommendation for PICO 6 (due to lack of evidence and the rapidly evolving knowledge related to that question). The recommendations for which no evidence meeting inclusion criteria was identified were labelled as based on expert opinion. Table 1 presents a summary of the recommendations. All developed recommendations are conditional, which means that the desirable effects were judged to likely outweigh the undesirable effects under certain conditions. One set of these conditions relates to the characteristics of patients who are likely to benefit from the recommended interventions (listed in Table 1 for each recommendation).

Another set of conditions relates the factors to consider when choosing a specific imaging modality (included in Table 2 for all recommendations). Appendix E5 provides implementation considerations, monitoring and evaluation considerations, and research priorities for the different recommendations. Table 3 lists only those implementation considerations that are common across all recommendations. The evidence-to-decision tables for the different recommendations are included in Appendix E4.

Discussion

The purpose of the guide is to support WHO Member States in their response to the COVID-19 pandemic by providing up-to-date guidance on use of chest imaging in adult patients with suspected or confirmed COVID-19, including chest radiography, computed tomography and lung ultrasound. It covers the care pathway from outpatient facility or hospital entry to home discharge. The guidance is

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provided for patients with different levels of disease severity, from asymptomatic individuals to critically ill patients. Additional guidance on infection prevention and control (IPC) in medical imaging procedures for COVID-19 management is provided in Appendix E6. The IPC guidance addresses both general measures for all imaging procedures and specific precautions for chest radiography, chest CT and lung ultrasound. The guide also promotes quality and safety of radiation use in health facilities, thus enhancing protection and safety of patients and health workers (Appendix E6).

The guide has a number of strengths including its development based on standard methodology [20], the consideration of contextual factors [11], its reporting according the RIGHT statement, and the consideration of stakeholders views [21]. Limitations include that the evidence on which the recommendations are based is either lacking or at best of low certainty, and that scope is relatively narrow (e.g., excluded children, did not address the systemic aspects of the disease). However, the latter was necessary to allow the rapid development of recommendations addressing the most pressing questions.

The recommendations address chest imaging in general, but not specific imaging modalities. While there is accumulating evidence about typical findings with each imaging modality [22], evidence about comparative diagnostic and prognostic value of the different modalities is still lacking. The experience indicates that in most cases chest radiography with portable equipment can provide the information needed at the point of care. In addition to limiting patient transfers it gives the possibility of adapting procedures to reduce staff exposure and increase operational efficiencies (e.g. portable chest radiography obtained through the glass of an isolation room door) [23]. Preliminary studies on lung ultrasound seem promising, in particular for use of portable ultrasound scanners at the point of care, but further evidence still needs to be generated. A CT scan may be the indicated modality for particular patient groups (e.g. those with suspected thrombotic/thromboembolic disease, multi-systemic disease). In health facilities, particularly in LMICs, where CT scans are not available for those patients, policy makers should consider provisions to facilitate patient transfer to reference hospitals where CT scans can be performed. In the long-term, the assessment of clinical, social,

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economic, organizational and ethical issues should inform decision-making about procurement of imaging technology [24,25]. There is wide variability of the contextual factors across settings (e.g., availability and cost of each modality and availability of the required expertise). Along with other technical considerations, the guide refers to the choice of a chest imaging modality in the remarks that apply to all recommendations (see Table 2). Indeed, the GDG gave due consideration to resource use, impact on equity, acceptability and feasibility when drafting the recommendations.

This guide is primarily intended for health professionals working in emergency departments, imaging departments, clinical departments, intensive care units and other health care settings involved in the diagnosis of COVID-19 and in the management of COVID-19 patients. The document can also be useful for hospital managers and planners, policy-makers, hospital architects, biomedical engineers, medical physicists, logistics staff, water/sanitation and infection prevention and control officers. Health authorities and radiation regulators can use the guide to develop specific national standards relevant to COVID-19 outbreak preparedness, readiness and response in different contexts. Finally, it can be useful to funders that wish to donate equipment and devices as well as funding priority research.

We were able to develop the guideline in about 10 weeks, which fits the 3-month timeframe of 'rapid' guidelines [26]. Two main facilitating factors include the existence of a clear and detailed process in place (as described in the WHO handbook for guideline development) [10], and the use of a rapid review process [27]. The latter factor is important considering that conducting the systematic review typically consumes a number of months. In addition, we used a staggered approach when developing the guide: e.g., we started training the GDG members even before the findings of the rapid review were available, and we sent out recommendations for peer review (by the external review group) even before all recommendations were developed. Finally, the most critical factor was probably having a dedicated core group that developed and followed a very strict timeline and worked on keeping a steady momentum. The core group members met almost daily (including weekends) and maintained an intense email communication.

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While the guide was developed within a relatively short timeframe, we do not believe this has affected the quality of the recommendations. Indeed, we followed standard WHO process, including proper development of PICO questions, determination and prioritization of outcomes of interest, conflicts of interest declaration and management, reliance on systematically collected evidence, use of GRADE methodology, and use of Evidence to Decision tables. While the rapid review could have missed relevant studies, it is very unlikely that any impactful studies have been missed. We did have all members of the GDG verify eligible studies, and we continually monitored the literature over the period of the project. The online format of the GDG meetings, due to the travel restrictions during the pandemic, did not impede proper discussions. On the contrary, GDG discussions were lively constructive and allowed all members the opportunity to contribute.

Moreover, we conducted a survey of stakeholders to capture their views on factors that were very important to the development of recommendations, namely resource use, impact on equity, acceptability and feasibility. The panel paid attention to the resource implications for low resource settings.

As growing body of literature is confirming the multi-systemic nature of COVID-19 (including the nervous, vascular and cardiac systems, kidneys) [28], this raises questions on whether/when/how imaging other than that of the chest (e.g., cardiac ultrasound, brain MRI, vascular imaging, abdominal imaging) may contribute to early diagnosis and/or management of patients with COVID-19. Specifically, pulmonary embolism in patients with COVID-19 is gaining attention with its relatively high prevalence and the ongoing discussion about its embolic versus intravascular thrombotic mechanism [29,30]. When addressing this question, the GDG members felt that both the published literature and the collective clinical experience were not adequate to justify any recommendation. We are aiming to address it in the next update of the guide.

In the future, guidance and policies for procurement of imaging equipment are needed. There is also a need for research on diagnostic accuracy, and desirable and undesirable impact of the different modalities on clinical and health systems outcomes. Ideally, the clinical studies should consist of well-designed clinical trials that are registered [31], and reported according to standard guidelines [22].

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Finally, there is a need for studies addressing contextual factors, including cost, cost effectiveness, impact on equity, acceptability and feasibility of the different imaging modalities.

In summary, the guide provides up-to-date guidance on the use of chest imaging in patients with suspected or confirmed COVID-19 for clinicians, and other stakeholders. It also provides research recommendations that can hopefully provide a better evidence base for future updates of the guide.

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Tables

Table 1. Summary of the Recommendations.

Recommendation	Remarks

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R1: For asymptomatic contacts of patients with COVID-19, WHO suggests not using chest imaging for the diagnosis of COVID-19. *Conditional recommendation, based on expert opinion*	RT- PCR should be done for confirming diagnosis
R2.1: For symptomatic patients with suspected COVID-19, WHO suggests not using chest imaging for the diagnostic workup of COVID-19 when RT-PCR testing is available with timely results. *Conditional recommendation based on low certainty evidence*	RT- PCR should be done for confirming diagnosis

In Press

R2.2: For symptomatic patients with suspected COVID-19, WHO suggests using chest imaging for the diagnostic workup of COVID-19 when: (1) RT-PCR testing is not available; (2) RT-PCR testing is available, but results are delayed; and (3) initial RT-PCR testing is negative, but with high clinical of suspicion of COVID-19. *Conditional recommendation based on low certainty evidence*	Imaging should be used as one element of the diagnostic workup that otherwise includes clinical and laboratory data. Patients likely to benefit are those who: ● have presentations that could represent complications of COVID-19, e.g. pneumonia; pulmonary arterial thrombosis or thromboembolism; ● need to be admitted irrespective of diagnosis (e.g. disease is severe or likely to progress), to help with disposition or triaging (e.g. to dedicated COVID-19 ward versus non-COVID-19 ward); ● need to be transferred to another facility; ● live with people at high risk if infected with COVID-19 (e.g. immunocompromised, persons aged over 60 years); ● live in small homes, overcrowded households or densely populated settings, where isolation is very difficult to implement; ● live in communities with people at high-risk such as retirement homes or dormitories.

In Press

R3: For patients with suspected or confirmed COVID-19, not currently hospitalized and with mild symptoms, WHO suggests using chest imaging in addition to clinical and laboratory assessment to decide on hospital admission versus home discharge. *Conditional recommendation, based on expert opinion*	Imaging should be used as one element of the patient evaluation that otherwise includes clinical, laboratory and epidemiological data. Patients likely to benefit are those who: ● have or are at high risk of disease progression; ● represent an increased risk of dissemination within their community due to their occupational, social or other circumstances; ● have associated comorbidities (such as diabetes, hypertension, heart disease, obesity) or other chronic diseases which might decompensate and/or are aged over 60 years; ● live with individuals at high risk of morbidity and mortality associated with COVID-19 (e.g., elderly, immunocompromised), whether at home or retirement home; ● live in small homes, overcrowded households or densely populated settings where isolation is very difficult to implement. ● represent an increased risk of dissemination within their community due to their occupational, social or other circumstances.

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R4: For patients with suspected or confirmed COVID-19, not currently hospitalized and with moderate to severe symptoms, WHO suggests using chest imaging in addition to clinical and laboratory assessment to decide on regular ward admission versus intensive care unit admission. *Conditional recommendation, based on very low certainty evidence*	Imaging should be used as one element of the patient evaluation that otherwise includes clinical and laboratory data. Patients likely to benefit are those who: ● are at higher risk of disease progression (e.g. with comorbidities) ● are not responding to supportive treatment (oxygen supplementation) ● present acute clinical deterioration not elucidated

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R5: For patients with suspected or confirmed COVID-19, currently hospitalized and with moderate to severe symptoms, WHO suggests using chest imaging in addition to clinical and laboratory assessment to inform the therapeutic management *Conditional recommendation, based on very low certainty evidence*	Imaging should be used as one element of patient evaluation that otherwise includes clinical and laboratory data. Patients likely to benefit are those who: ● are at high risk of disease progression ● are not responding to treatment (oxygen supplementation) ● have presentations with clinical suspicion of pulmonary fibrosis, pulmonary artery thrombosis or thromboembolism.
R6: For hospitalized patients with COVID-19 whose symptoms are resolved, WHO suggests not using chest imaging in addition to clinical and/or laboratory assessment to inform the decision regarding discharge. *Conditional recommendation, based on expert opinion*	When imaging is used, it should be one element of the patient evaluation that otherwise includes clinical and laboratory data. Patients likely to benefit from chest imaging are those who: ● have had a severe form of COVID-19 ● have pre-existing chronic lung disease

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Abbreviations: WHO= World Health Organization, COVID-19= coronavirus disease 2019, RT-PCR= reverse transcriptase polymerase chain reaction

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Table 2. Factors to consider when choosing the specific imaging modality (applies to all recommendations).

- Compared to chest CT, chest radiography appears to have a lower sensitivity and might have higher specificity. Chest radiography is less-resource intensive, is associated with lower radiation doses, is easier to repeat sequentially for monitoring disease progression or disease recovery, and can be performed with portable equipment at the point of care (which minimizes the risk of cross-infection related to patient transport).
- Chest CT has the highest sensitivity but relatively lower specificity and can be useful in patients with some pre-existing pulmonary diseases.
- Lung ultrasound has very low-certainty evidence supporting its diagnostic accuracy but might be helpful with the appropriate expertise as a supplemental or alternative modality (e.g. in pregnant women, children, patients with mechanical ventilation). Lung ultrasound can be done at the point of care but requires closer physical proximity of the operator to the patient for a longer period and needs specific infection prevention and control precautions.
- Consider the differential diagnoses and potential complications for each specific case (e.g. CT angiography for pulmonary arterial thrombosis or thromboembolism, ultrasound for pleural effusions and heart conditions) when choosing imaging modality.
- Choice should be made through shared decision-making involving the referring physician, the radiologist and the patient whenever possible. If possible, provide the patient with information regarding the imaging modality and the likelihood of subsequent imaging procedures.

Abbreviations: CT= computed tomography

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Table 3. Implementation considerations that are common across recommendations.

- Implement the recommendations based on your equipment availability. Consider the resources needed (budget, health workforce, personal protective equipment, imaging equipment), the need to adapt the clinical workflow and the need to deprioritize other indications for imaging.
- When performing chest radiography, consider using portable equipment, and if feasible, a unit dedicated to patients with COVID-19.
- When performing chest radiography and chest CT, minimize radiation dose while maintaining diagnostic image quality (e.g. low-dose CT protocols) and use digital imaging rather than film-screen equipment [32].
- Consider the potential harm from exposure to ionizing radiation, in particular for pregnant women and children.
- Ensure proper use of personal protective equipment by health care workers and proper disinfection of equipment and devices (see Appendix E6).
- Provide appropriate training of radiologists and technologists on infection prevention and control practices and ensure efficient management of typical imaging findings of COVID-19 through accepted local protocols.
- Consider the transfer of images for remote reporting (teleradiology) as needed (e.g. settings where radiologists are not available for on-site reporting).
- Set policy/pathway for use of imaging related to COVID-19 illustrated with flow charts or diagrams locally developed and accepted.

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- Whenever is possible, provide information to patients about safety provisions adopted by the facility for infection prevention and control (see Appendix E6) as well as for radiation protection [32].
- Make provisions to ensure that all patients get the imaging services they need without suffering financial hardship.

Abbreviations: CT= computed tomography, COVID-19= coronavirus disease 2019

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Appendix E1: Group Composition and Roles and List of Contributors

Group composition and roles

WHO steering group

The WHO steering group was composed of relevant staff members from WHO headquarters, including from the departments of Environment, Climate Change and Health (ECH), Maternal, Newborn, Child and Adolescent Health and Ageing (MCA), Integrated Health Services (IHS), Health Care Readiness (HCR), Emerging Diseases and Zoonoses (EZD), Health Product Policy and Standards (HPS), Business Relationship Management (BRM), as well as the Regional Advisor on Radiological Health in the WHO Regional Office for the Americas. The WHO steering group helped identify the GDG and external review group members. It contributed to the formulation of the key questions and reviewed the recommendations and the final document.

Guideline development group

The GDG included experts and relevant stakeholders from multiple disciplines: a guideline methodologist, experts in the field of medical imaging, emergency medicine, intensive care, pulmonology and molecular diagnostics, as well as a representative from a patient advocacy organization. The GDG provided input at all stages of the process and played the main role in development of recommendations. The composition of the GDG ensured geographic representation from five of the six WHO regions, gender balance and absence of conflicts of interest.

External review group

The external review group was composed of experts in the field of medical imaging and pulmonary diseases and representatives of patient advocacy groups and civil society. The experts reviewed the recommendations developed by the GDG and the final document, and commented on the technical accuracy, clarity of language, contextual issues and implications for implementation. The group was asked not to modify the recommendations that were formulated by the GDG.

Systematic review team

The systematic review team was composed of experts in the field of systematic reviews with clinical background in internal medicine and content experts in the field of medical imaging. They conducted rapid reviews of the literature and provided a report summarizing the findings and certainty of evidence for each key question. The systematic review report was shared with members of the GDG. Representatives of the systematic review team attended the GDG meetings to provide an overview of the available evidence and to respond to technical queries from the GDG.

Core group

The development of these recommendations under very compressed timelines during the COVID-19 pandemic represented a challenge in the context of unprecedented demands in terms of global and local public health response. Anticipating this challenge, the WHO Secretariat assembled a core group to assist in project management. This group included two methodologists, the chairperson of the GDG and a radiology consultant who worked in close consultation with the WHO Secretariat and participated in daily planning and coordination meetings held virtually. The core group drafted the key questions using the PICO format, supervised the syntheses and retrieval of evidence, convened and facilitated the GDG meetings, liaised with all established groups, and drafted and finalized the rapid advice guide. In addition, the core group facilitated survey implementation and assessment of current imaging practices in different regions of the world.

List of contributors

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Appendix E2: Management of Declaration of Interests

The disclosure and appropriate management of relevant financial and non-financial conflicts of interest of guideline development group members and other external experts and contributors is a critical part of guideline development at WHO. According to WHO regulations, all experts must declare their interests prior to participation in WHO guideline development processes and meetings. All GDG members were therefore required to complete a standard WHO declaration of interests form before engaging in the guideline development process and before participating in guideline-related processes. All declarations were reviewed before finalizing the experts' invitations to participate based on the criteria for assessing the severity of conflict of interests as outlined in the WHO handbook for guideline development (9) to all participating experts. All findings from the declaration of interests forms received were managed in accordance with the WHO declaration of interests guidelines on a case-by-case basis and communicated to the experts at the start of the first GDG meeting. Annex C shows a summary of the declaration of interests and how conflicts of interest declared by invited experts were managed.

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Appendix E3: PICO Questions and Critical Outcomes Identified

PICO questions identified

The following seven key PICO questions were identified:

1. In asymptomatic contacts of patients with COVID-19, and in contexts where laboratory testing (reverse transcription-polymerase chain reaction [RT-PCR]) is not available/results are delayed/results are initially negative, should chest imaging (including chest radiography, CT scan, lung ultrasound) vs no chest imaging be used for the diagnostic workup of COVID-19?
2. In symptomatic patients with suspected COVID-19, and in contexts where laboratory testing (RT-PCR) is not available/results are delayed/results are initially negative, should chest imaging (including chest radiography, CT scan, lung ultrasound) vs no chest imaging be used for the diagnostic workup of COVID-19?
3. In patients with suspected or confirmed COVID-19, not currently hospitalized and with mild symptoms, should chest imaging (including chest radiography, CT scan, lung ultrasound) vs no chest imaging be used to support the decision on hospital admission versus home discharge?
4. In patients with suspected or confirmed COVID-19, not currently hospitalized and exhibiting moderate to severe symptoms, should chest imaging (including chest radiography, CT scan, lung ultrasound) vs no chest imaging be used to support decision on regular ward admission versus ICU admission?
5. In patients with suspected or confirmed COVID-19, currently hospitalized and exhibiting moderate or severe symptoms, should chest imaging (including chest radiography, CT scan, lung ultrasound) vs no chest imaging be used to modify the therapeutic management?
6. In patients with suspected or confirmed COVID-19 and clinical deterioration and/or suspicion of pulmonary embolism, should imaging (including CT pulmonary angiography) vs no imaging be used to diagnose pulmonary embolism?
7. In patients with COVID-19 whose symptoms are resolved, should chest imaging (including chest radiography, CT scan, lung ultrasound) be added to vs not added to laboratory criteria to support decisions on hospital discharge vs no discharge?

Critical outcomes identified

The following critical outcomes were identified:

- diagnostic accuracy measures (rates of true positive, true negative, false positive, false negative);
- clinical outcomes, including the “core outcomes” developed for COVID-19 (mortality, respiratory failure, multi-organ failure, shortness of breath, recovery), adverse effects of imaging (e.g. exposure to radiation), and COVID-19 transmission to health care workers;[1]
- health systems outcomes, including service use (length of emergency department stay, length of hospital stay, length of ICU stay), availability of care, access to care and quality of care.

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Appendix E4: Evidence-to-Decision Tables for Each PICO Question

PICO 1

Should chest imaging vs. no chest imaging be used for asymptomatic contacts of patients with COVID-19; contexts where laboratory testing (RT PCR) is not available/results are delayed/results are initially negative?	
POPULATION:	Asymptomatic contacts of patients with COVID-19
INTERVENTION:	Chest imaging
COMPARISON:	No chest imaging
MAIN OUTCOMES:	1. Accuracy of the diagnostic modality (rates of true positive, true negative, false positive, false negative) 2. Clinical outcomes • Mortality • Respiratory failure • Multiorgan failure • Shortness of breath • Recovery • Adverse effects of imaging (e.g., exposure to radiation) • COVID-19 transmission to health workers 3. Health systems outcomes • Service use, including: ○ Length of stay in Emergency Department ○ Length of hospital stay ○ Length of ICU stay • Availability of care • Access to care • Quality of care
SETTING:	Laboratory testing (RT PCR) is not available/results are delayed/results are initially negative
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

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ASSESSMENT

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	• No study evaluated the accuracy of the diagnostic imaging modality • No study evaluated the effects of chest imaging on clinical outcomes • No study evaluated the effects of chest imaging on health systems outcomes	• Smaller benefit compared to the symptomatic population The voting results are: • Trivial: 5 • Small: 3 • Moderate: 1 • Large: 0 • Varies: 0 • Don't know: 0
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ● Moderate ○ Small ○ Trivial ○ Varies ○ Don't know	• No study evaluated the accuracy of the diagnostic imaging modality • No study evaluated the effects of chest imaging on clinical outcomes • No study evaluated the effects of chest imaging on health systems outcomes	The voting results are: • Large: 1 • Moderate: 6 • Small: 1 • Trivial: 1 • Varies: 0 • Don't know: 0
Certainty of evidence		

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What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies		• Very low for CT scan vs no CT scan • Very low for chest radiography vs no chest radiography • Very low for LUS vs no LUS

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):** **Critical outcomes (GDG, stakeholders n=249):**	The voting results are • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
Multiorgan failure	0	5	19	22	82	75
Shortness of breath	0	6	27	33	74	63
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

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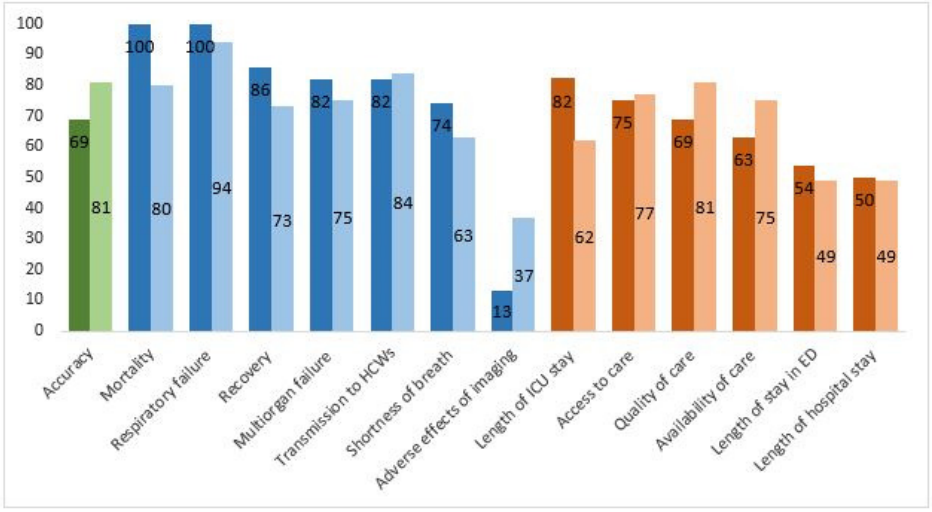

Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes

Dark color: GDG; light color: stakeholders

Stakeholder respondents (n=249) included:

- members of the public (3%)
- patients (2%)
- physicians (22%)
- technicians (53%)
- other health professionals (5%)
- researchers (3%)
- policy-makers (3%)
- other (7%)

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 5 • Probably favors the comparison: 2 • Does not favor either the intervention or the comparison: 0 • Probably favors the intervention: 3 • Favors the intervention : 0 • Varies: 1 • Don't know : 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		The voting results are: • Large costs: 10 • Moderate costs: 1 • Negligible costs and savings: 0 • Moderate savings: 1 • Large savings: 0 • Varies: 0 • Don't know : 0

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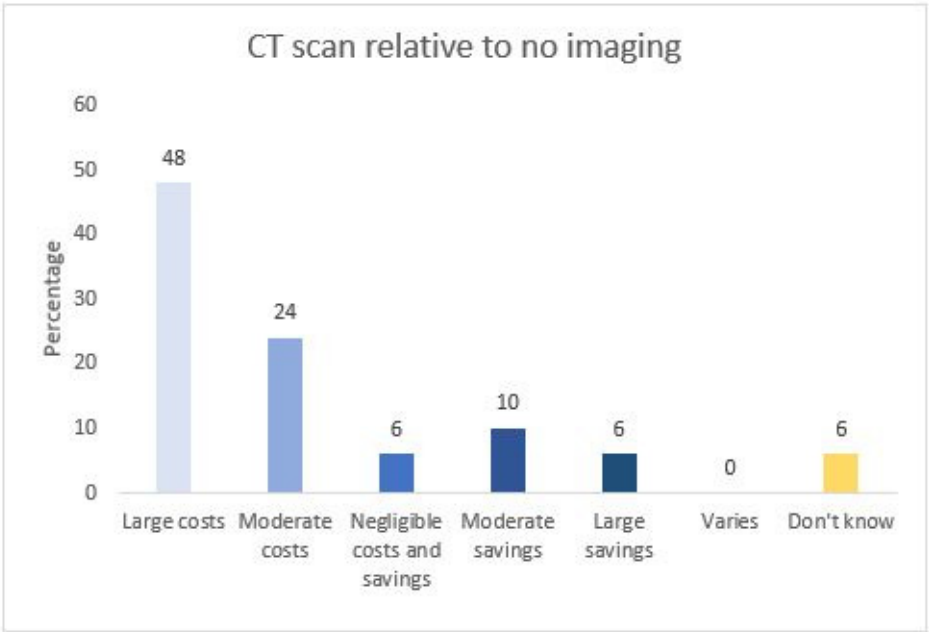
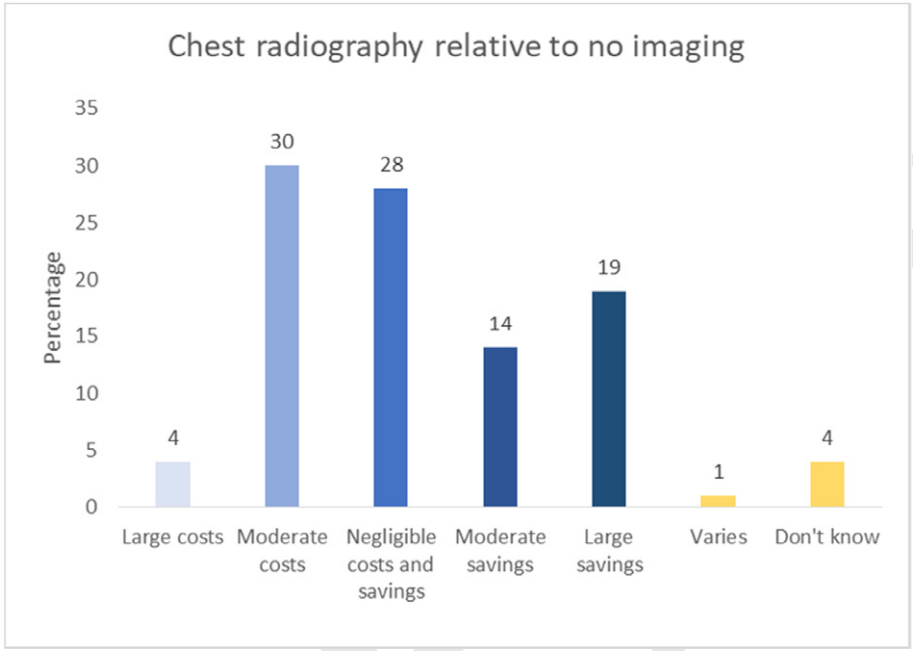
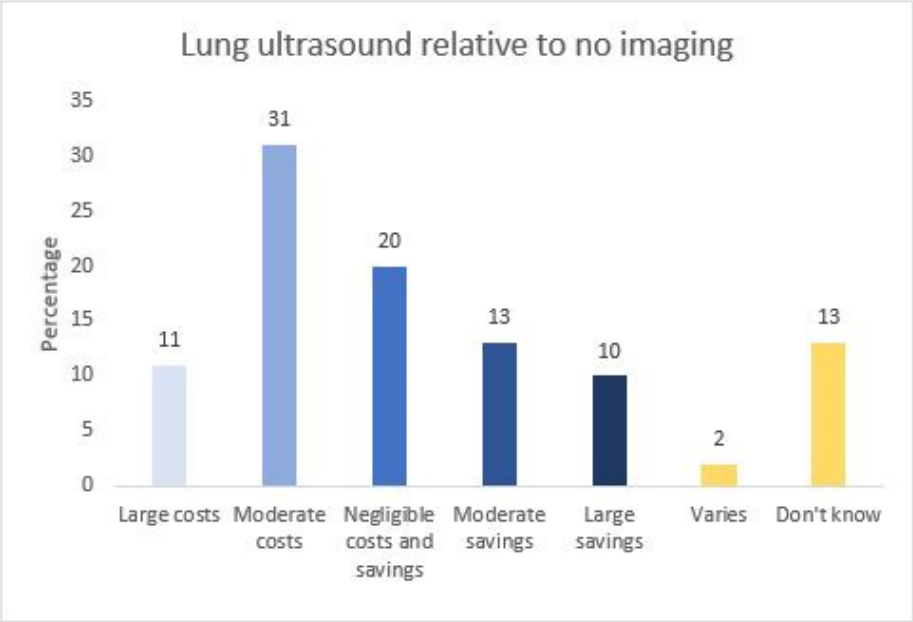

CT scan relative to no imaging
Percentage
60
50
40
30
20
10
0
48
24
6
10
6
0
6
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

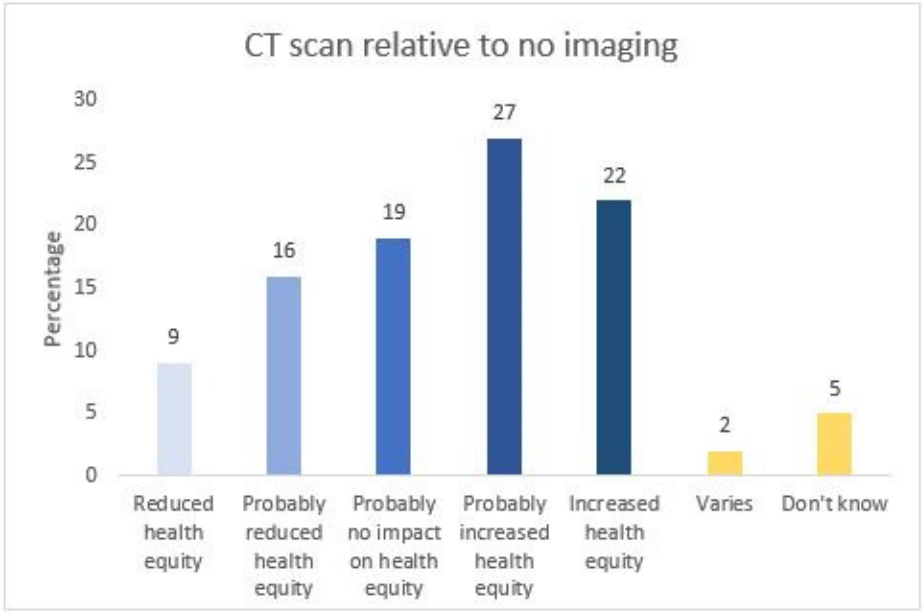

Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
4
30
28
14
19
1
4
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

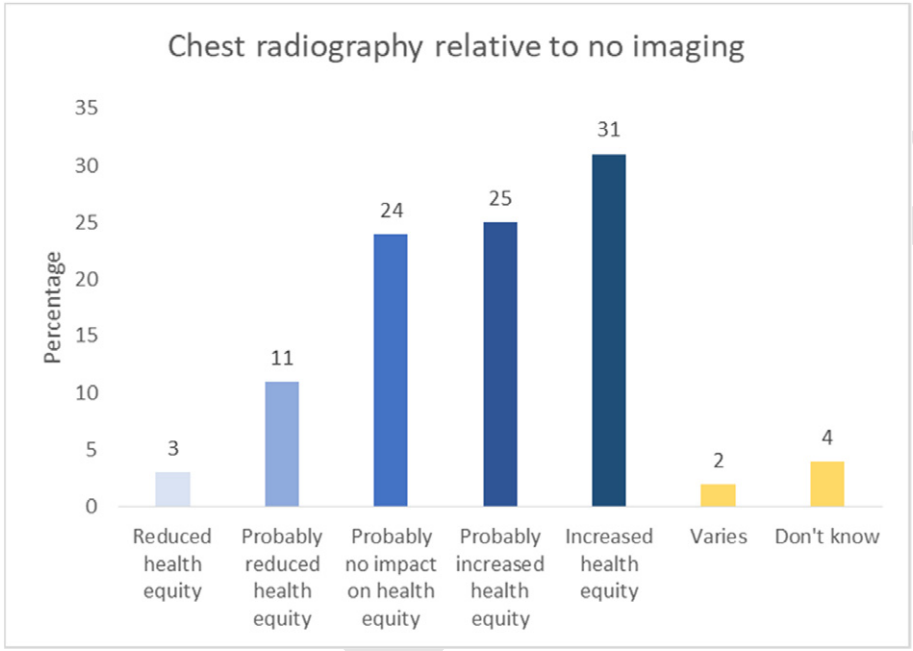


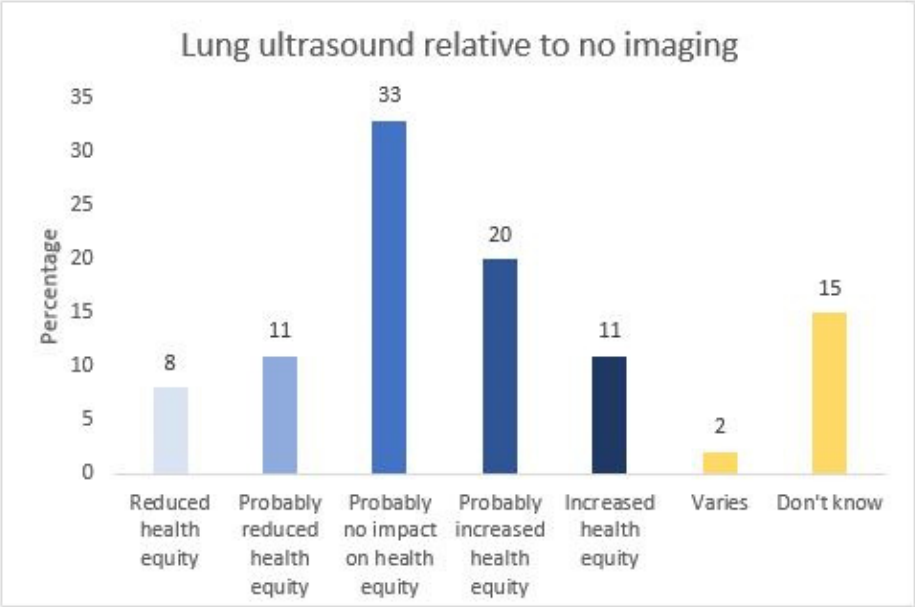
Respondents (n=124) included:

•members of the public (3%)
•patients (2%)
•physicians (16%)
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Equity

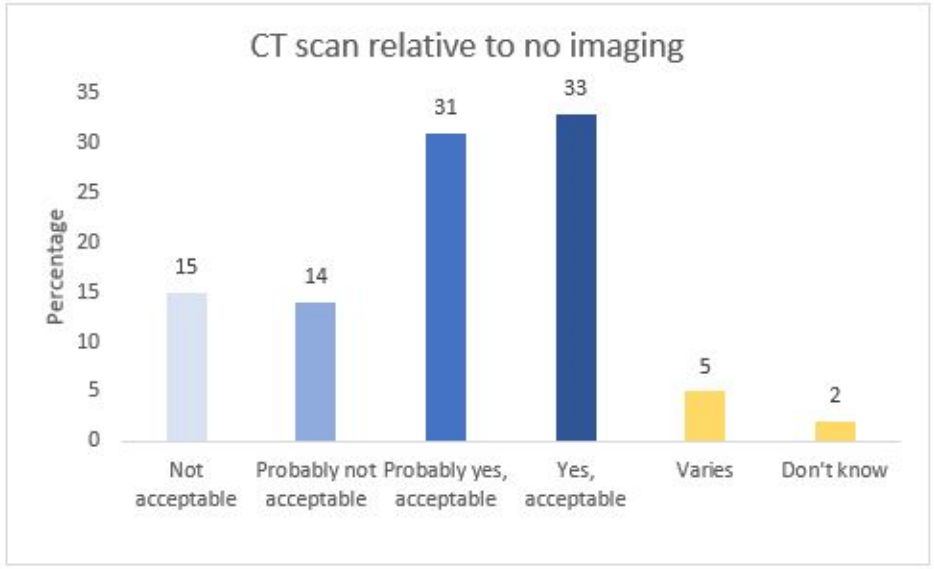
What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		The voting results are: • Reduced: 5 • Probably reduced: 4 • Probably no impact : 2 • Probably increased: 1 • Increased: 2 • Varies: 0 • Don't know : 0

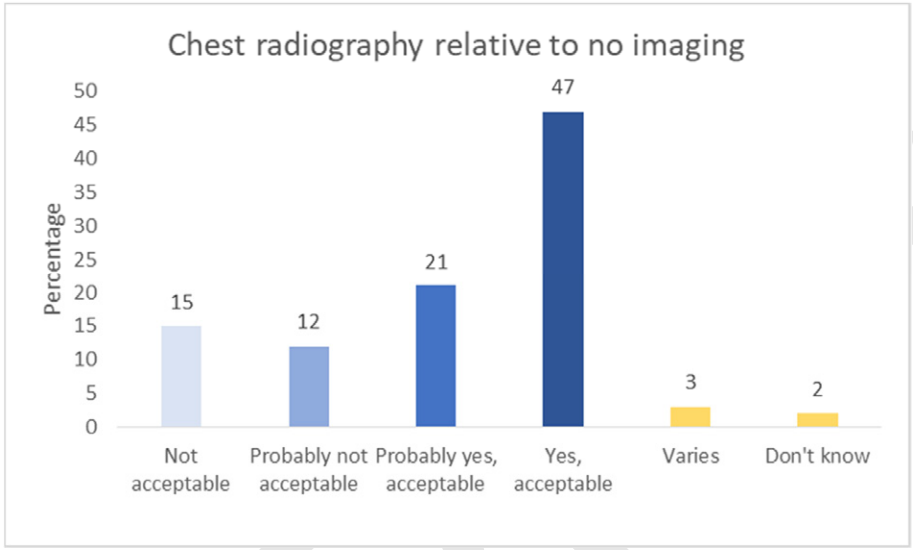

Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
3
11
24
25
31
2
4
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



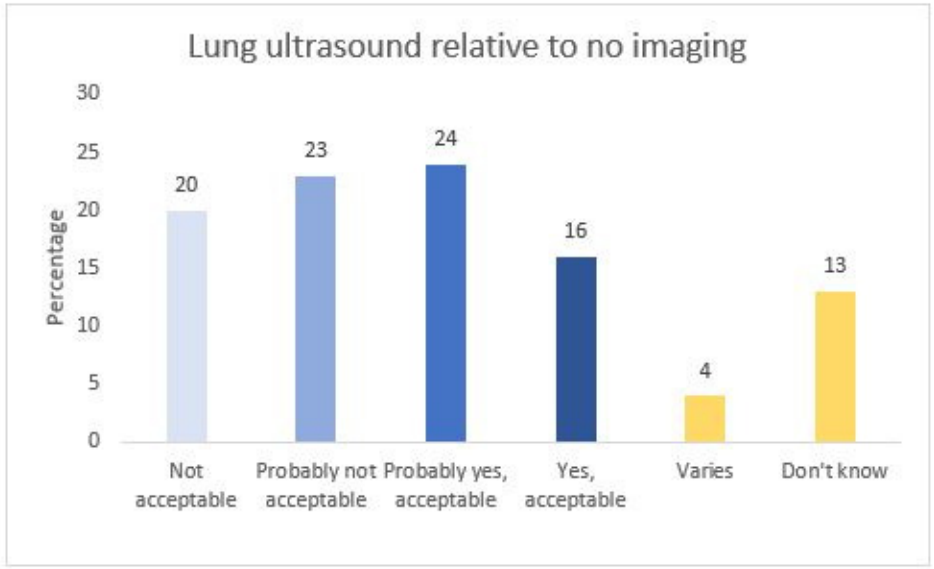
Respondents (n=124) included:
•members of the public (3%)
•patients (2%)
•physicians (16%)
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Acceptability

Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ● Probably no ○ Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 0 • Probably no : 4 • Probably yes: 4 • Yes: 2 • Varies: 2 • Don't know : 0


Chest radiography relative to no imaging
Percentage
50
45
40
35
30
25
20
15
10
5
0
15
12
21
47
3
2
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

In Press



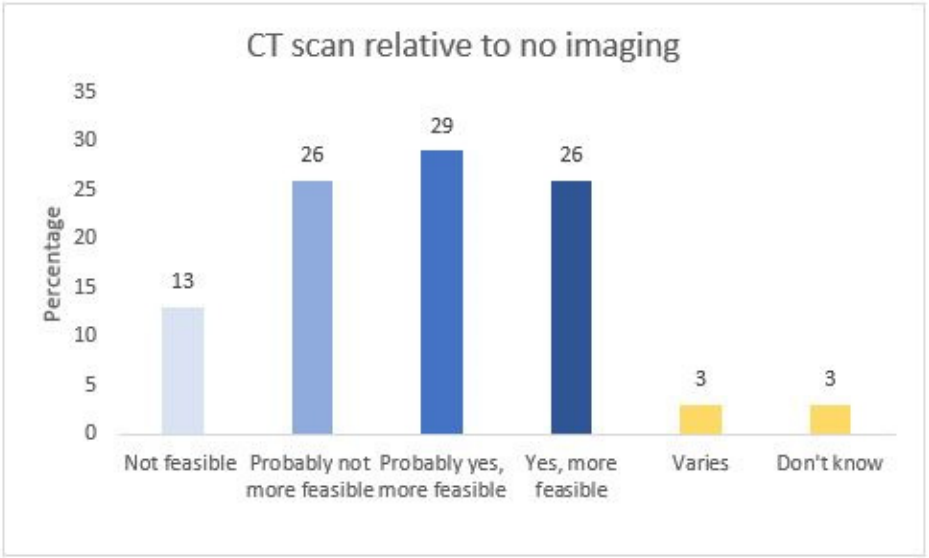
Respondents (n=124) included:

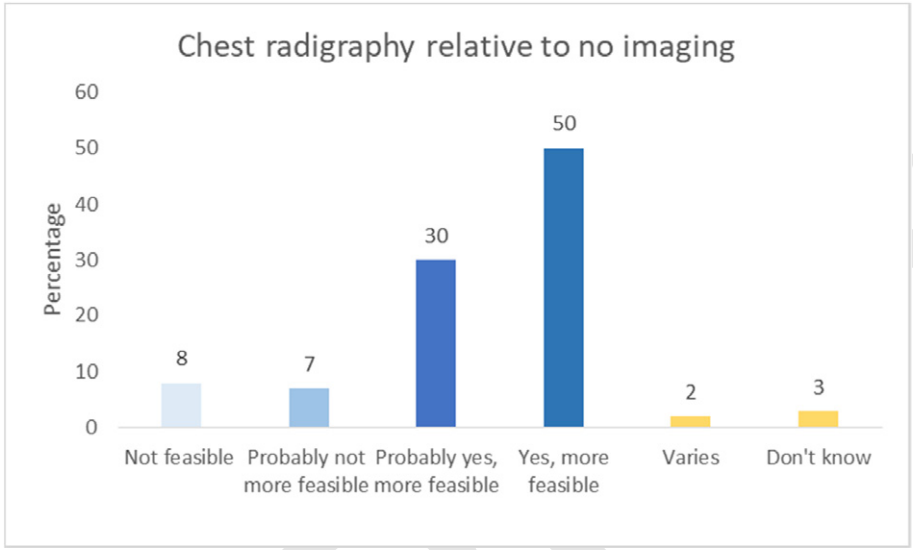
•members of the public (3%)
•patients (2%)
•physicians (16%)
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Feasibility

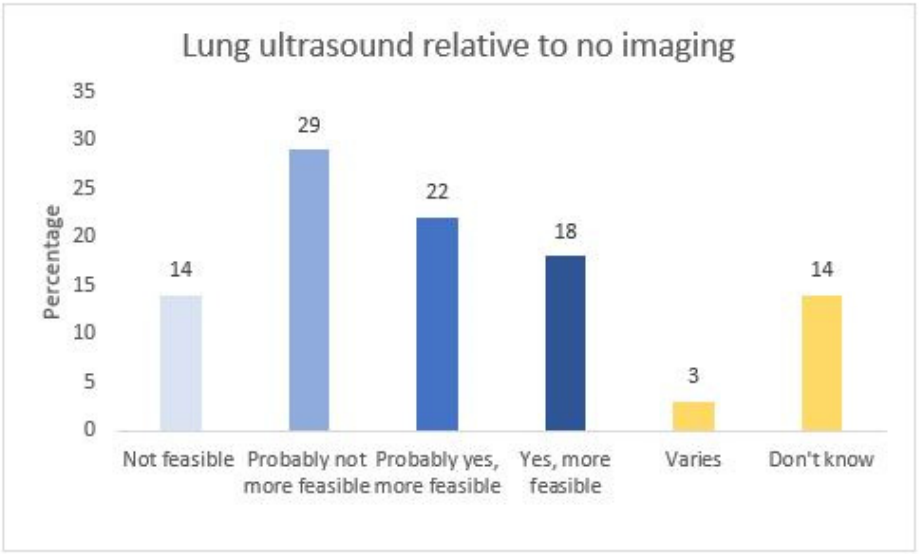
Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 2 • Probably no : 4 • Probably yes: 6 • Yes: 3 • Varies: 0 • Don't know : 0

In Press


CT scan relative to no imaging
Percentage
35
30
25
20
15
10
5
0
13
26
29
26
3
3
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know


Chest radigraphy relative to no imaging
Percentage
60
50
40
30
20
10
0
8
7
30
50
2
3
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



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•other health professionals (4%)
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•policy-makers (4%)
•other (8%)

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	**Moderate**	Small	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	**Favors the comparison**	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	**Large costs**	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	**Reduced**	Probably reduced	Probably no impact	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	**Probably no**	Probably yes	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	**Conditional recommendation against the intervention**	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	●	○	○	○

CONCLUSIONS

Recommendation

For asymptomatic contacts of patients with COVID19, WHO **suggests not** using chest imaging for the diagnosis of COVID-19 (conditional recommendation, based on very low certainty evidence)

Conditions:

- Higher risk of disease progression
- In need of emergency procedures
- implementing public health interventions (e.g., quarantine)

In Press

Remarks:

When choosing the imaging modality, consider the following:

- CT scan has the highest sensitivity and is preferred in patients with pre-existing pulmonary disease;
- Chest radiography has a lower sensitivity but is associated with lower risk of HCW infection transmission; is less resource intensive; is associated with lower radiation doses than CT scan; and is easier to repeat sequentially for monitoring disease progression;
- LUS has limited evidence but is helpful with the appropriate expertise and can be done at the point of care. However, it requires closer physical proximity of the operator to the patient for a longer period of time and requires specific infection prevention and control precautions;
- Choice should consider the differential diagnosis in the specific case (e.g., CT angiography for pulmonary embolism, LUS for pleural effusions)
- Choice should be through a shared decision making involving the patient, the referrer physician and the radiologist;

The voting results are:

- Strong recommendation against the intervention: 7
- Conditional recommendation against the intervention: 3
- Conditional recommendation for either the intervention or the comparison: 1
- Conditional recommendation for the intervention: 3
- Strong recommendation for the intervention: 0

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

In Press

PICO 2

Should chest imaging vs. no chest imaging be used for symptomatic patients with suspected COVID-19; contexts where laboratory testing (RT PCR) is not available/results are delayed/results are initially negative?	
POPULATION:	Symptomatic patients with suspected COVID-19
INTERVENTION:	Chest imaging
COMPARISON:	No chest imaging
MAIN OUTCOMES:	1. Accuracy of the diagnostic modality (rates of true positive, true negative, false positive, false negative) 2. Clinical outcomes • Mortality • Respiratory failure • Multiorgan failure • Shortness of breath • Recovery • Adverse effects of imaging (e.g., exposure to radiation) • COVID-19 transmission to health workers 3. Health systems outcomes • Service use, including: ○ Length of stay in Emergency Department ○ Length of hospital stay ○ Length of ICU stay • Availability of care • Access to care • Quality of care
SETTING:	Laboratory testing (RT PCR) is not available/results are delayed/results are initially negative
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

In Press

ASSESSMENT

Desirable Effects
How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	CT scanning Chest radiography	• Potential benefit of shortening length of stay in ED • In patients who already qualify for admission, the CT would be beneficial in COVID19 unit (based on the presentation) • Using the CT to rule out COVID-19 might be safest in low prevalence setting (lower FNs) • Using the CT to rule in might be safest in high prevalence setting (lower FPs) • Disposition of patients whom the decision to admit is already made • Implementation of public health measures (those who are likely to be discharged, with not a confirmed PCR delayed/unavailable RT-PCR): outpatient guidance [maximized in low prevalence setting] • In patients who have tested negative by PCR but have clinical suspicion, perform a CT scan. The voting results are: • Trivial: 2 • Small: 1 • Moderate: 8 • Large: 4 • Varies: 0 • Don't know: 0

Test result	Number of results per 1,000 patients tested			
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	184	368	552	736
False negatives	16	32	48	64
True negatives	448	336	224	112
False positives	352	264	176	88

Se=0.92; Sp=0.56

Test result	Number of results per 1,000 patients tested			
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	128	256	384	512
False negatives	72	144	216	288
True negatives	656	492	328	164
False positives	144	108	72	36

Se=0.64; Sp=0.82

LUS

Test result	Number of results per 1,000 patients tested			
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	190	380	570	760
False negatives	10	20	30	40
True negatives	664	498	332	166
False positives	136	102	68	34

Se=0.95; Sp=0.83

No study evaluated the effects of chest imaging on health outcomes

No study evaluated the effects of chest imaging on health systems outcomes

Undesirable Effects
How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	## CT scanning 	Test result	Number of results per 1,000 patients tested			
---	---	---	---	---
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	184	368	552	736
False negatives	16	32	48	64
True negatives	448	336	224	112
False positives	352	264	176	88 | Se=0.92; Sp=0.56 ## Chest radiography | Test result	Number of results per 1,000 patients tested			
---	---	---	---	---
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	128	256	384	512
False negatives	72	144	216	288
True negatives	656	492	328	164
False positives	144	108	72	36	 Se=0.64; Sp=0.82	• Exposure of radiation • Use low-dose CT • Transmission to HCWs • Transmission to patients • Pregnant/children: higher risk The voting results are: • Large: 1 • Moderate: 4 • Small: 6 • Trivial: 1 • Varies: 2 • Don't know: 0

LUS

Test result	Number of results per 1,000 patients tested			
	Prevalence 20%	Prevalence 40%	Prevalence 60%	Prevalence 80%
True positives	190	380	570	760
False negatives	10	20	30	40
True negatives	664	498	332	166
False positives	136	102	68	34

Se=0.95; Sp=0.83

No study evaluated the effects of chest imaging on health outcomes

No study evaluated the effects of chest imaging on health systems outcomes

Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies		Low for CT vs. no CT Very low for CXR vs. no CXR Very low for US vs. no US

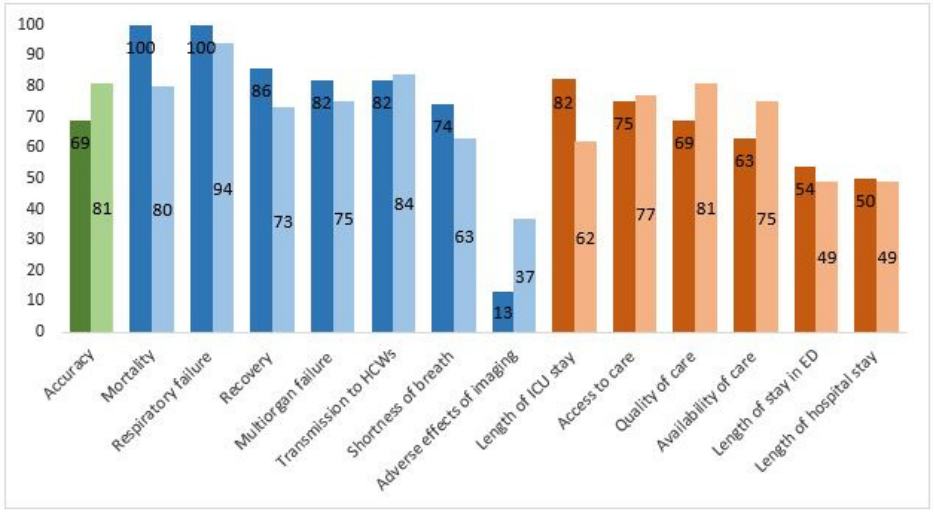
In Press

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):** **Critical outcomes (GDG, stakeholders n=249):**	The voting results are: • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
Multiorgan failure	0	5	19	22	82	75
Shortness of breath	0	6	27	33	74	63
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

In press



Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes

Dark color: GDG; light color: stakeholders

Stakeholder respondents (n=249) included:

•members of the public (3%)
•patients (2%)
•physicians (22%)
•technicians (53%)
•other health professionals (5%)
•researchers (3%)
•policy-makers (3%)
•other (7%)

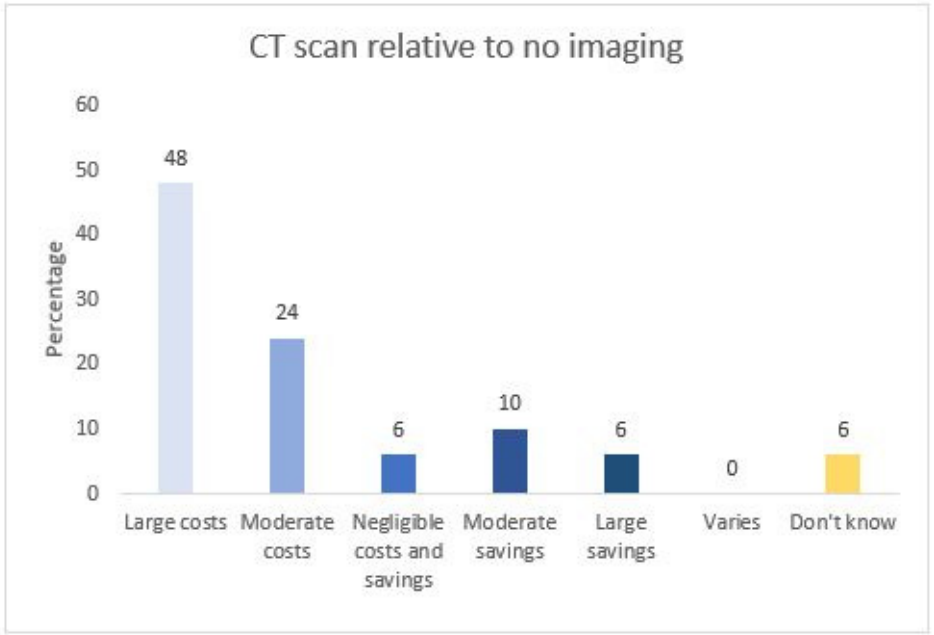
Balance of effects
Does the balance between desirable and undesirable effects favor the intervention or the comparison?

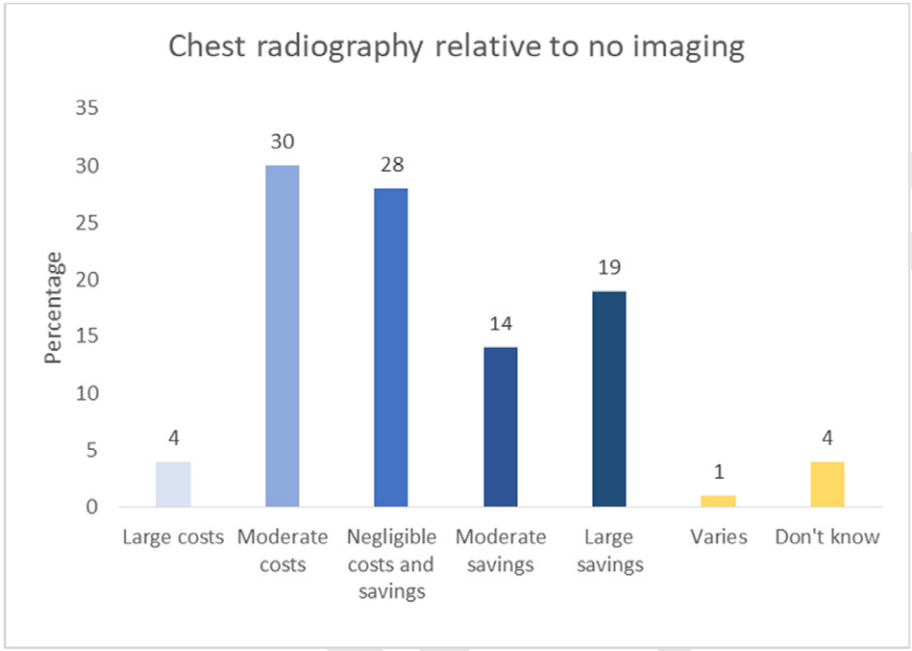
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

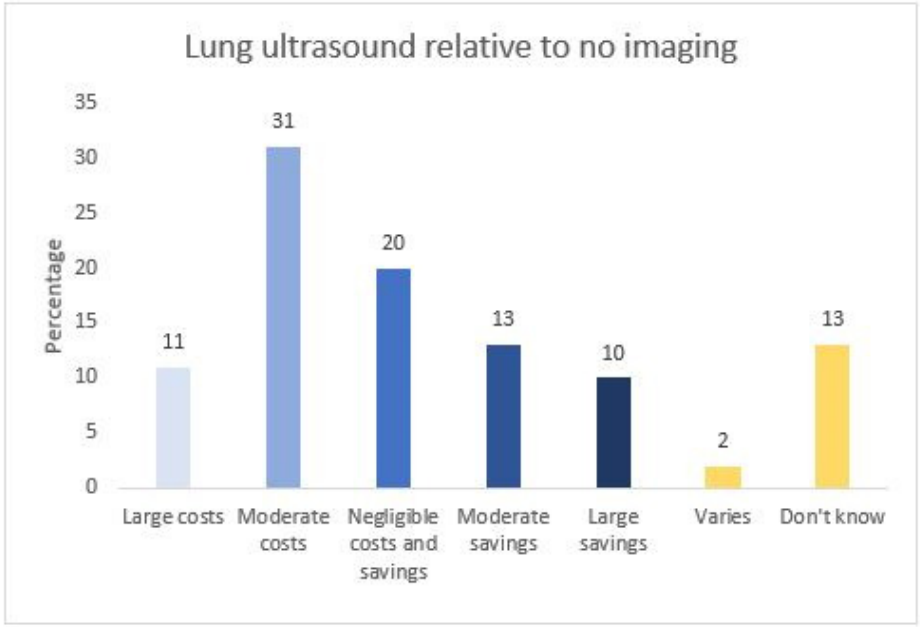
In Press

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 1 • Probably favors the comparison: 1 • Does not favor either the intervention or the comparison: 1 • Probably favors the intervention: 7 • Favors the intervention: 1 • Varies: 2 • Don't know: 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

In Press

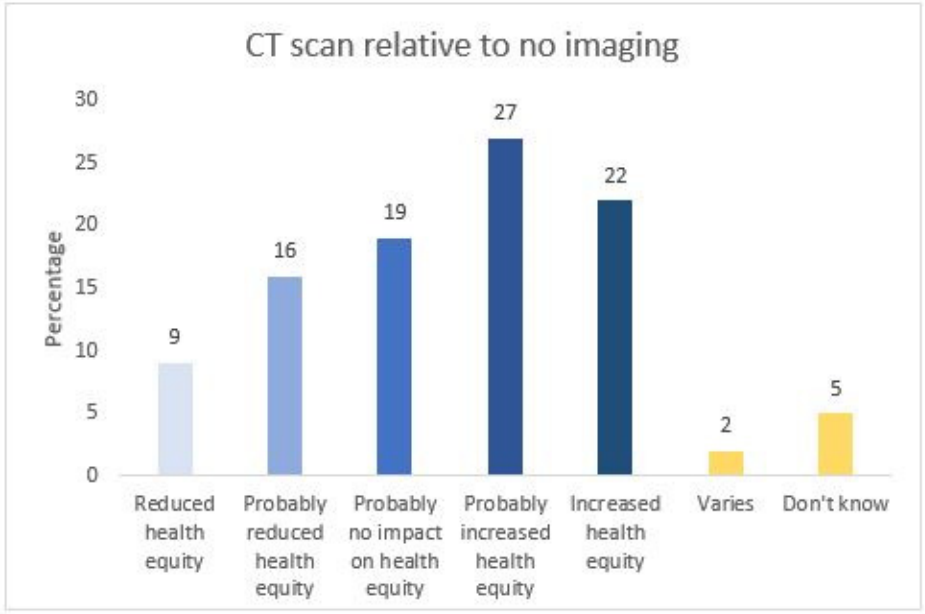
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		• The cost might be high in certain settings i.e. the resources needed to book and conduct the test • The cost includes HCW protection, utilization of the space, transfer of patients and payment for expert reading • Part of the cost might be on patients The voting results are: • Large costs: 5 • Moderate costs: 7 • Negligible costs and savings: 1 • Moderate savings: 1 • Large savings: 0 • Varies: 0 • Don't know : 0

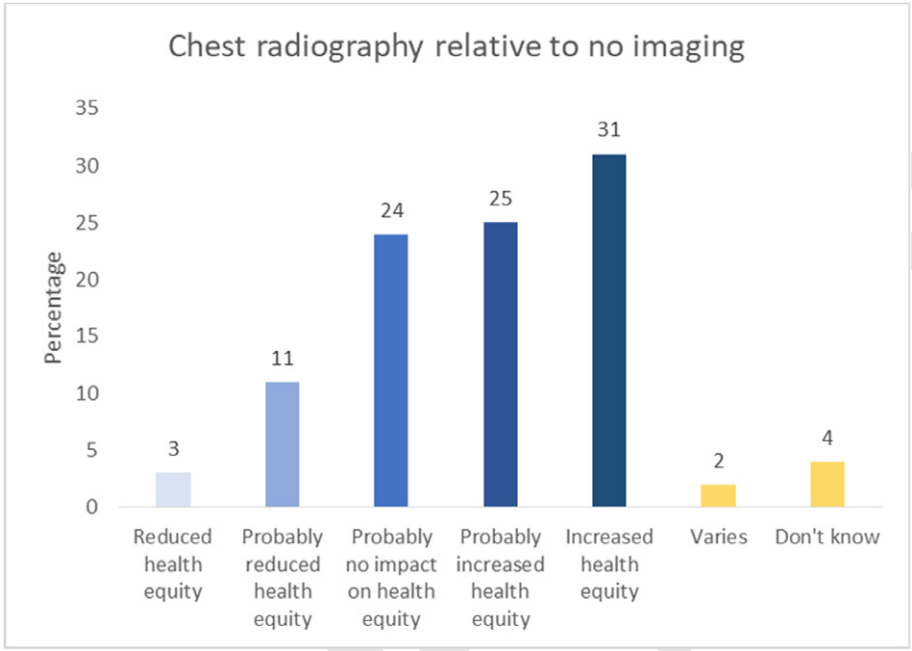

Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
4
30
28
14
19
1
4
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

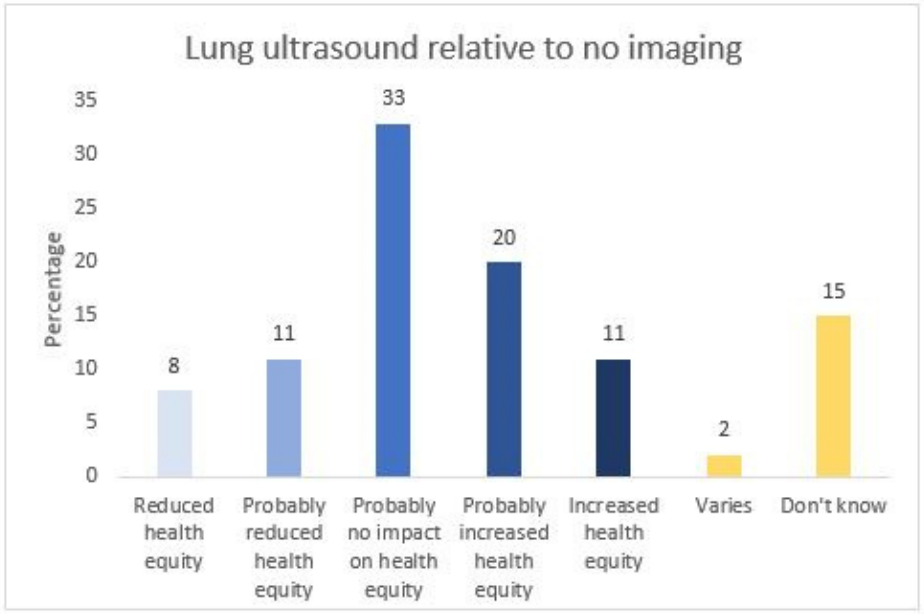


Respondents (n=124) included:

•members of the public (3%)
•patients (2%)
•physicians (16%)
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Equity What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ● Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		• In some settings when patients have to pay out of pocket, those who are disadvantaged might be affected • Accessibility of CT scans in communities with limited health resources • Impact on equity might depend on whether the fees are covered • diversion of resources from non-COVID care The voting results are: • Reduced: 0 • Probably reduced: 8 • Probably no impact : 0 • Probably increased: 4 • Increased: 2 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
3
11
24
25
31
2
4
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



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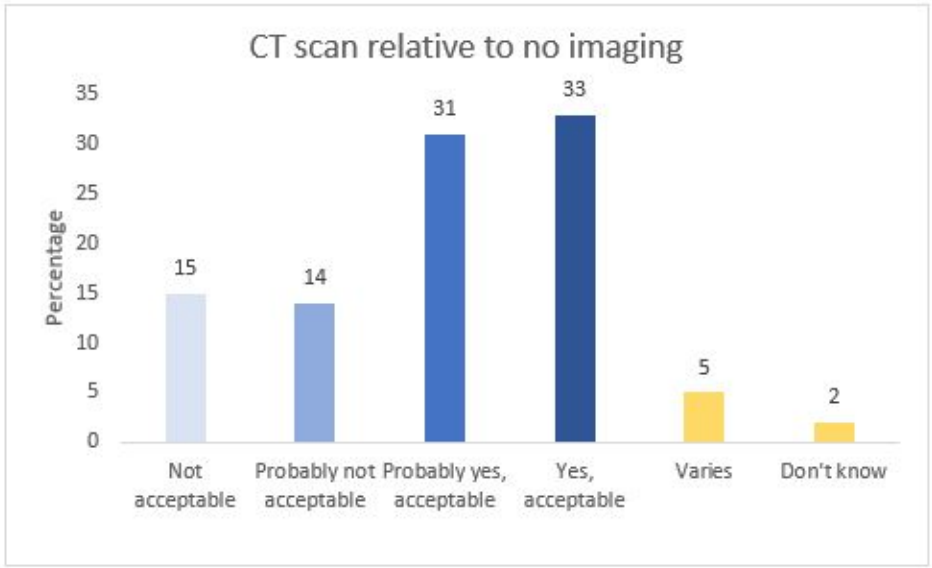
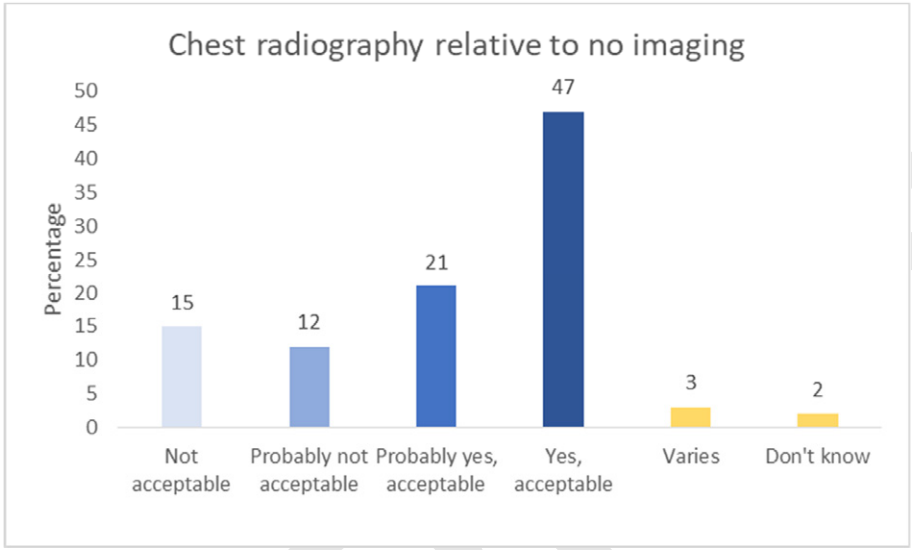
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Acceptability
Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		• Providing information to patients is required • Consent would be ideal, but might not be feasible • Likely to be acceptable for patients, less likely to be acceptable to technicians • Varies by the administrator • Might be less acceptable to payers • Perform low-dose CT whenever possible The voting results are: • No : 0 • Probably no : 1 • Probably yes: 9 • Yes: 5 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
50
45
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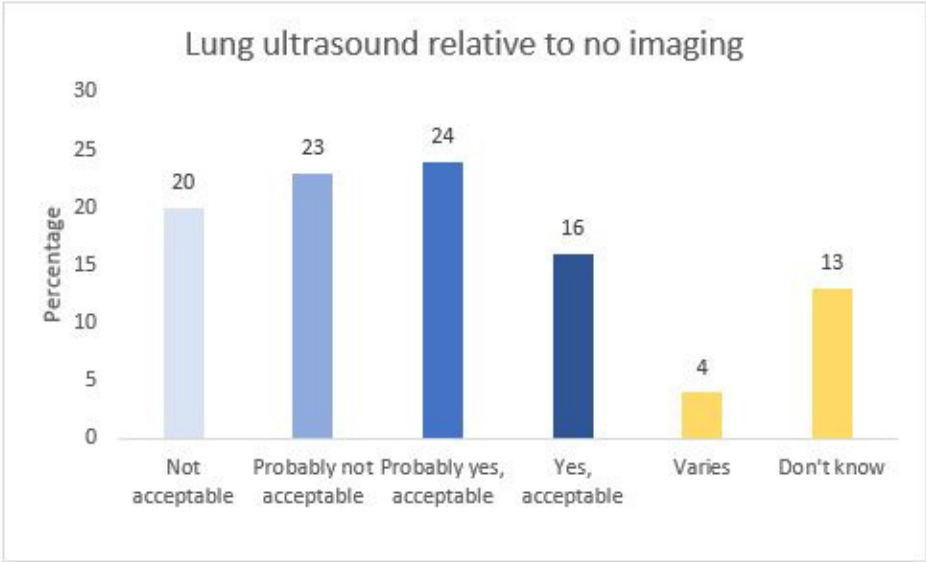
35
30
25
20
15
10
5
0
15
12
21
47
3
2
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

In Press



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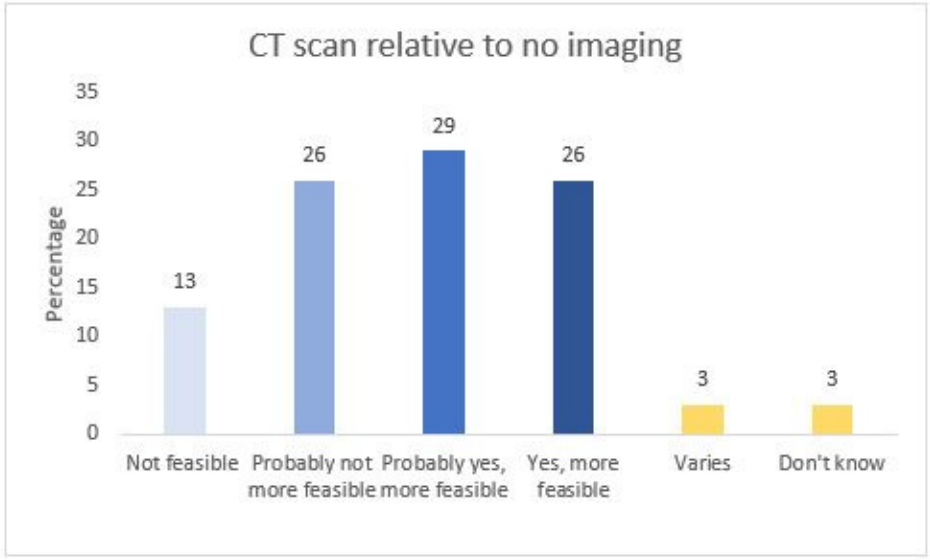
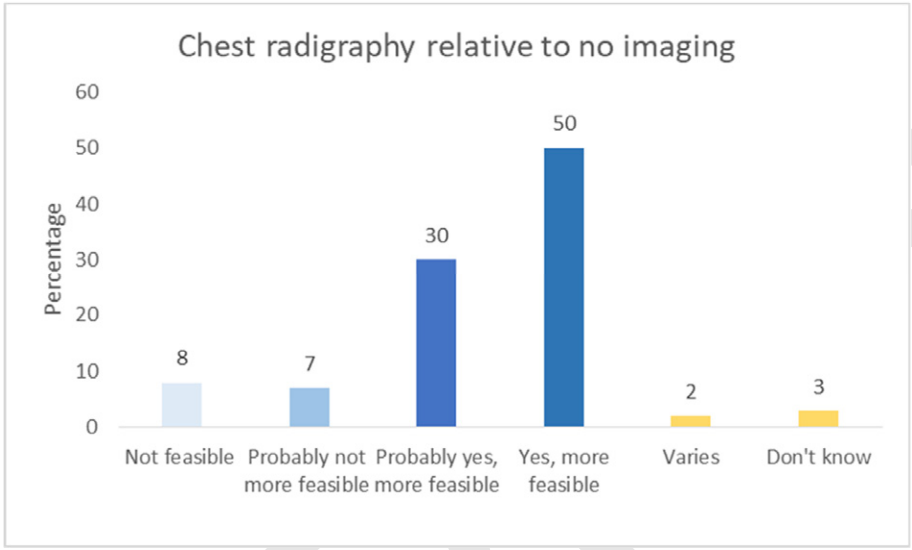
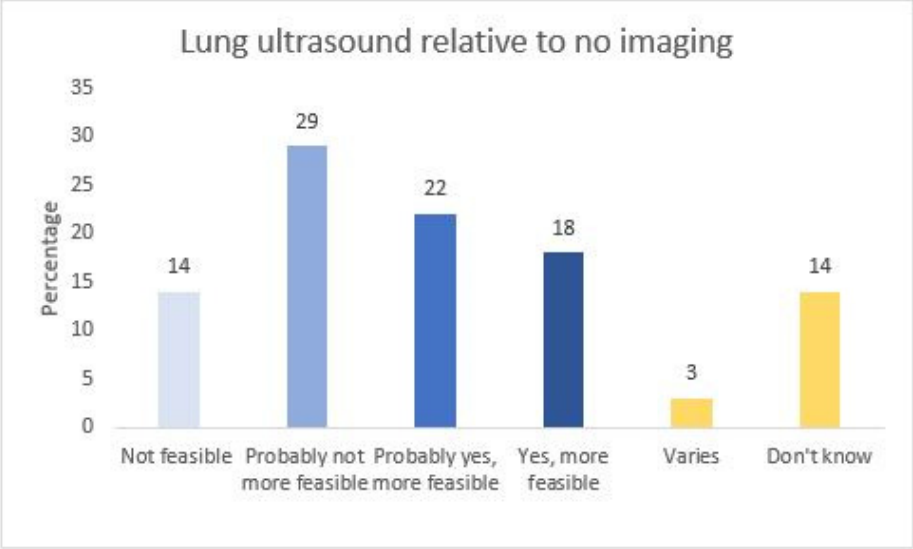
Feasibility

Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		• Need to clean CT unit • Stop the non-urgent use of CT scan (issue of access and availability) • Availability of staff to interpret the scan (24/7) • Adapting the workflow in the CT room The voting results are: • No : 0 • Probably no : 0 • Probably yes: 10 • Yes: 4 • Varies: 0 • Don't know : 0


Chest radigraphy relative to no imaging
Percentage
60
50
40
30
20
10
0
8
7
30
50
2
3
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



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•other (8%)

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	Reduced	**Probably reduced**	Probably no impact	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	○	○	○	○

CONCLUSIONS

Recommendation

1-When PCR testing is available with timely results, using vs. not using CT scan to diagnose COVID 19.

When PCR testing is available with timely results, *conditionally against* using CT scan.

The voting results are:

- Strong recommendation against the intervention: 2
- Conditional recommendation against the intervention: 9
- Conditional recommendation for either the intervention or the comparison: 2
- Conditional recommendation for the intervention: 3

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- Strong recommendation for the intervention: 0

2-When PCR testing is not available, using vs. not using CT scan to diagnose COVID 19

When PCR testing is not available, *conditionally for* using CT scan to diagnose COVID 19

· *the rate of false-negative will be the lowest in low prevalence settings and in patients with low pretest probability (e.g., clinical presentation not consistent with COVID19)*

· In patients who need to be admitted irrespective of diagnosis/likelihood of disease progression, to help with disposition (to dedicated COVID floor vs. non COVID floor)

Consider different alternatives e.g. chest radiography

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 2
- Conditional recommendation for either the intervention or the comparison: 0
- Conditional recommendation for the intervention: 8
- Strong recommendation for the intervention: 6

3-When PCR testing is available, but results are delayed, using vs. not using CT scan to diagnose COVID 19

When PCR testing is available, but results are delayed, *conditionally for* using CT scan to diagnose COVID 19

· In patients requiring emergency procedures or other urgent interventions (e.g., in patients with stroke, requiring hemodialysis)

· In patients who need to be admitted irrespective of diagnosis/likelihood of disease progression, to help with disposition (to dedicated COVID floor vs. non COVID floor)

· In patients who need to be transferred to another facility

The voting results are:

- Strong recommendation against the intervention: 1
- Conditional recommendation against the intervention: 3
- Conditional recommendation for either the intervention or the comparison: 1
- Conditional recommendation for the intervention: 8
- Strong recommendation for the intervention: 1

In Press

4-In patients with negative initial PCR test, but with clinical suspicion of COVID19 (e.g., severe presentation or with co-morbidities), using vs. not using CT scan to diagnose COVID 19

In patients with negative initial PCR test, but with clinical suspicion of COVID19 (e.g., severe presentation or with co-morbidities), *conditionally for* using CT scan to diagnose COVID 19

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 1
- Conditional recommendation for either the intervention or the comparison: 1
- Conditional recommendation for the intervention: 8
- Strong recommendation for the intervention: 4

Conditions (apply to 1 thru 4)

· Those who are discharged based on a negative CT scan result, need to consider a small chance of false-negative results and abide by public health measures (e.g., quarantine) until definitive PCR diagnosis is made

· Resource use

· Feasibility (PPE)

· Acceptability (technicians)

· Special attention to pregnant women and children

· Apply appropriate clinical measures taking into account the possibility of false-negative results.

When choosing the imaging modality, consider the following:

- CT scan has the highest sensitivity and is preferred in patients with pre-existing pulmonary disease;
- Chest radiography has a lower sensitivity but is associated with lower risk of HCW infection transmission; is less resource intensive; is associated with lower radiation doses than CT scan; and is easier to repeat sequentially for monitoring disease progression;
- LUS has limited evidence but is helpful with the appropriate expertise and can be done at the point of care. However, it requires closer physical proximity of the operator to the patient for a longer period of time and requires specific infection prevention and control precautions;
- Choice should consider the differential diagnosis in the specific case (e.g., CT angiography for pulmonary embolism, LUS for pleural effusions)
- Choice should be through a shared decision making involving the patient, the referrer physician and the radiologist;

Remarks:

Patients likely to benefits are those who:

In Press

- require emergency procedures or other urgent interventions (e.g., in patients with stroke, patients requiring hemodialysis);
- need to be admitted irrespective of diagnosis (e.g., disease is severe or likely to progress), to help with disposition (to dedicated COVID19 floor vs. non COVID19 floor);
- need to be transferred to another facility.
- when using chest radiography and CT scan, optimize radiation dose, and use digital imaging rather than film (to decrease contamination).

**The voting was based on using CT scan vs not using CT scan, however the group decided that this applies to imaging vs no imaging.

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

PICO 3

Should chest imaging vs. no chest imaging be used for patients with suspected or confirmed COVID-19 and mild symptoms presenting to the healthcare system (e.g. emergency department); context of a decision on hospital admission versus home discharge?	
POPULATION:	Patients with suspected or confirmed COVID-19 and mild symptoms presenting to the healthcare system (e.g. emergency department)
INTERVENTION:	Chest imaging
COMPARISON:	No chest imaging
MAIN OUTCOMES:	1. Clinical outcomes • Mortality

In Press

	• Respiratory failure
	• Multiorgan failure
	• Shortness of breath
	• Recovery
	• Adverse effects of imaging (e.g., exposure to radiation)
	• COVID-19 transmission to health workers
	
	2. Health systems outcomes
	
	• Service use, including:
	  ○ Length of stay in Emergency Department
	  ○ Length of hospital stay
	  ○ Length of ICU stay
	• Availability of care
	• Access to care
	• Quality of care

SETTING:	Decision on hospital admission versus home discharge
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

ASSESSMENT

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	• Risk stratifying patients • Higher risk for disease progression • Establishing definitive diagnosis • Artificial intelligence (AI) may be used in interpreting the results The voting results are: • Trivial: 0

In Press

		• Small: 5 • Moderate: 6 • Large: 5 • Varies: 0 • Don't know : 0
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	• Risk of radiation • Exposure of HCWs • The undesirable effects vary based on modality, might be less in chest radiography • If portable chest radiography available, harms would be lower in chest radiography The voting results are: • Large: 2 • Moderate: 1 • Small: 9 • Trivial: 0 • Varies: 3 • Don't know : 0
Certainty of evidence What is the overall certainty of the evidence of effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

In Press

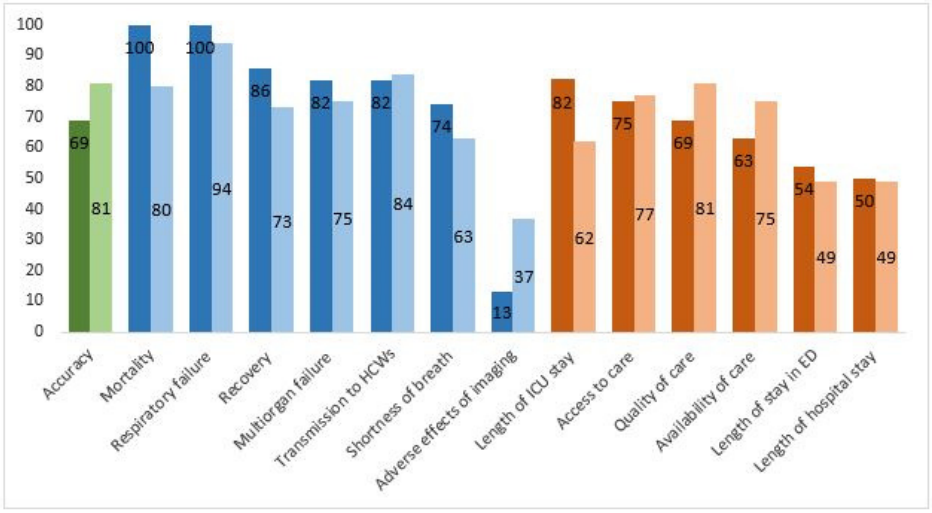
● Very low ○ Low ○ Moderate ○ High ○ No included studies		• Very low for CT vs. no CT • Very low for CXR vs. no CXR • Very low for US vs. no US

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):** **Critical outcomes (GDG, stakeholders n=249):**	The voting results are: • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
Multiorgan failure	0	5	19	22	82	75
Shortness of breath	0	6	27	33	74	63
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

In press



Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes

Dark color: GDG; light color: stakeholders

Stakeholder respondents (n=249) included:

•members of the public (3%)
•patients (2%)
•physicians (22%)
•technicians (53%)
•other health professionals (5%)
•researchers (3%)
•policy-makers (3%)
•other (7%)

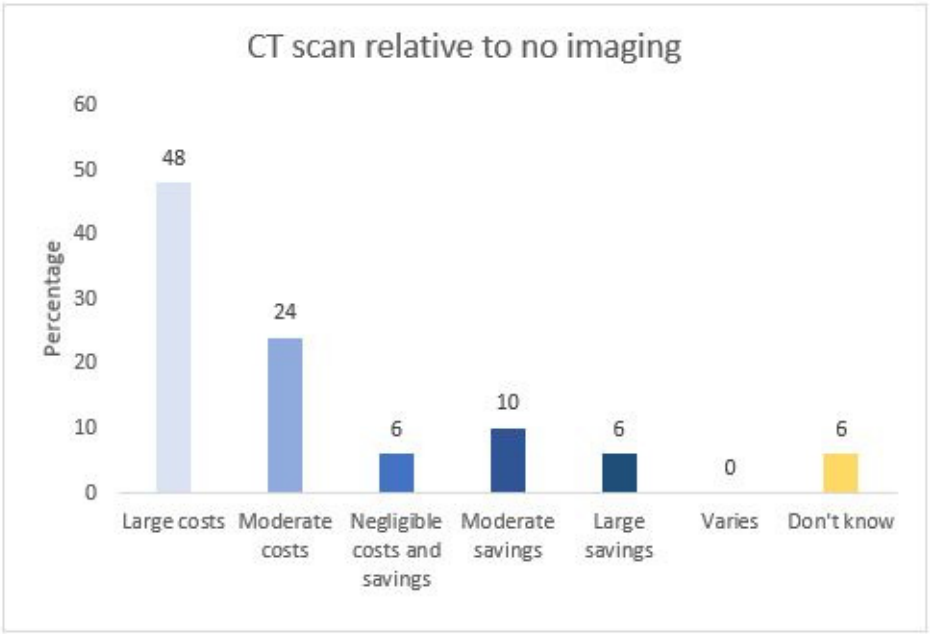
Balance of effects
Does the balance between desirable and undesirable effects favor the intervention or the comparison?

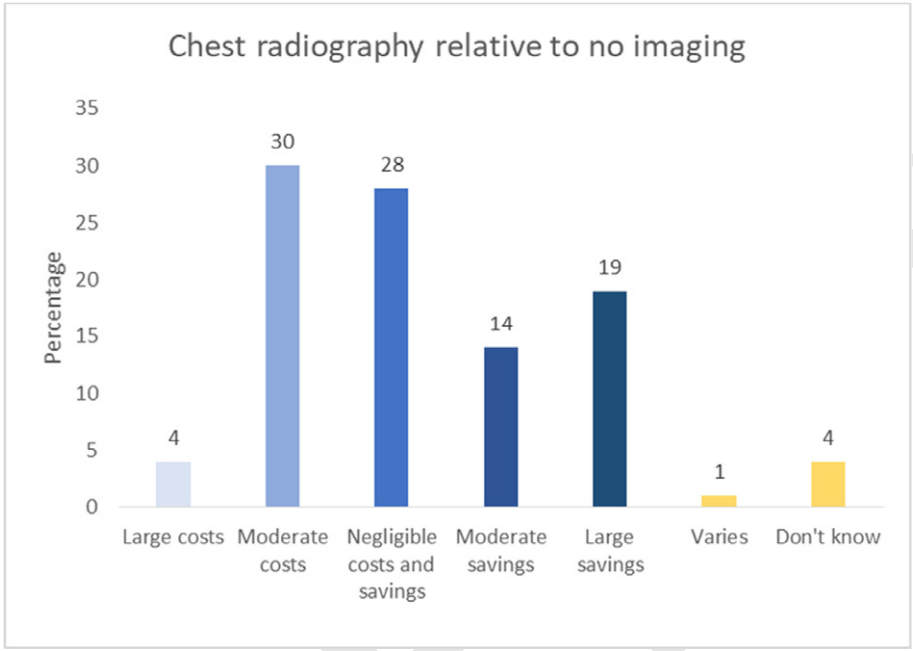
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

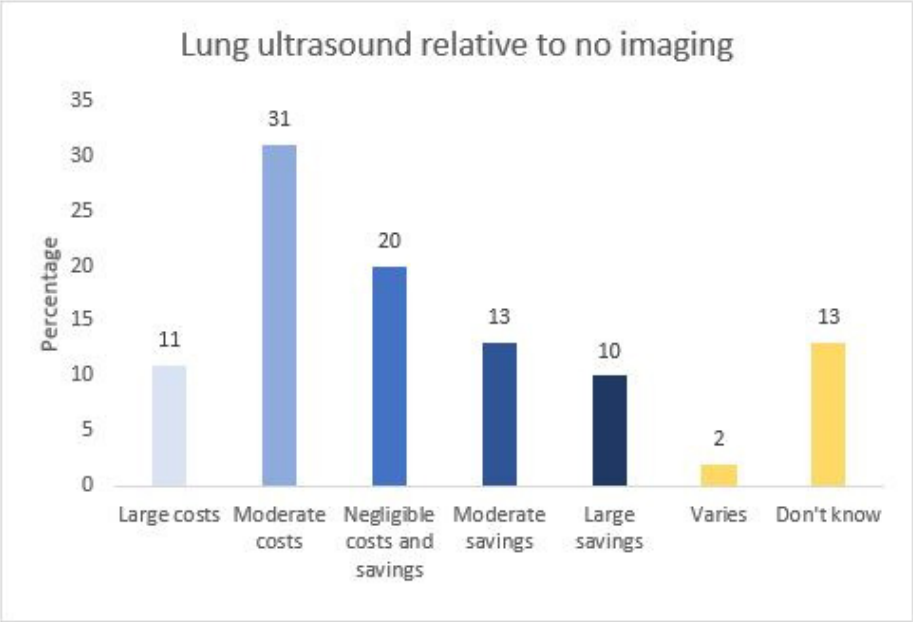
In Press

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 1 • Probably favors the comparison: 0 • Does not favor either the intervention or the comparison: 0 • Probably favors the intervention: 11 • Favors the intervention : 2 • Varies: 0 • Don't know : 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

In Press

○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		• Chest radiography may be more feasible • opportunity cost diverting resources from evidence-based interventions • The cost might be high in certain settings i.e. the resources needed to book and conduct the test • The cost includes HCW protection, utilization of the space, transfer of patients and payment for expert reading • Part of the cost might be on patients The voting results are: • Large costs: 2 • Moderate costs: 10 • Negligible costs and savings: 0 • Moderate savings: 0 • Large savings: 0 • Varies: 2 • Don't know : 0


Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
4
30
28
14
19
1
4
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

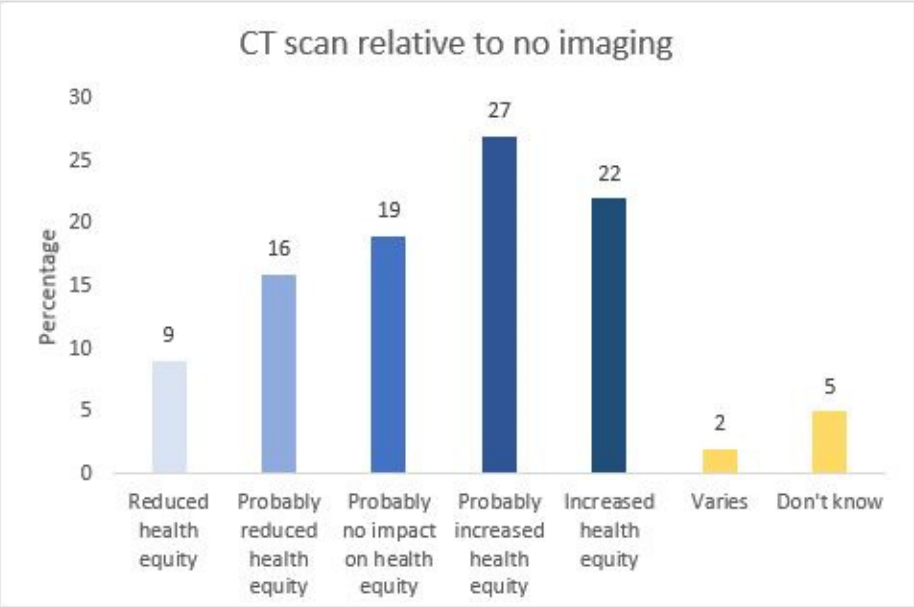


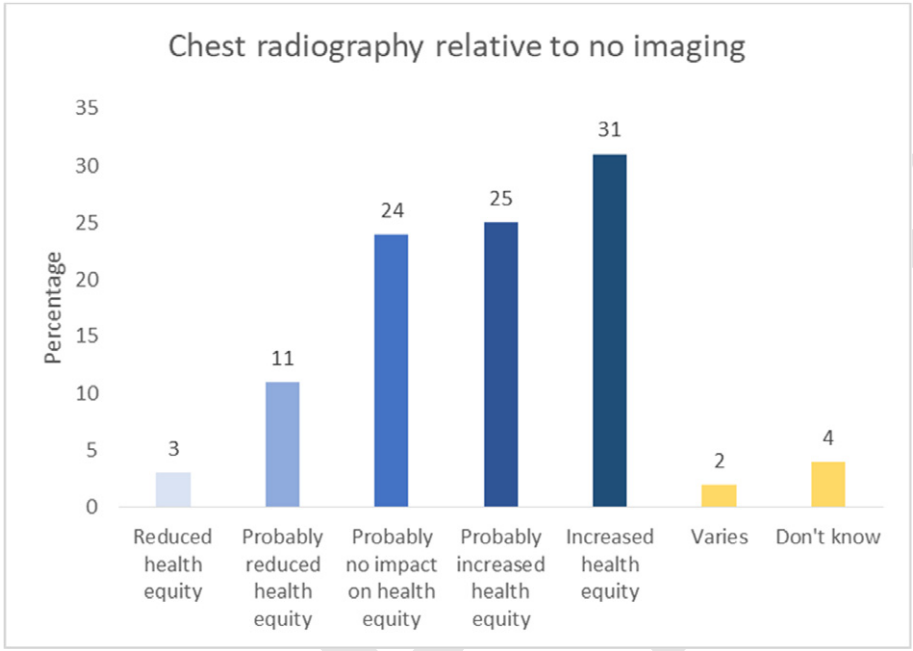
Respondents (n=124) included:

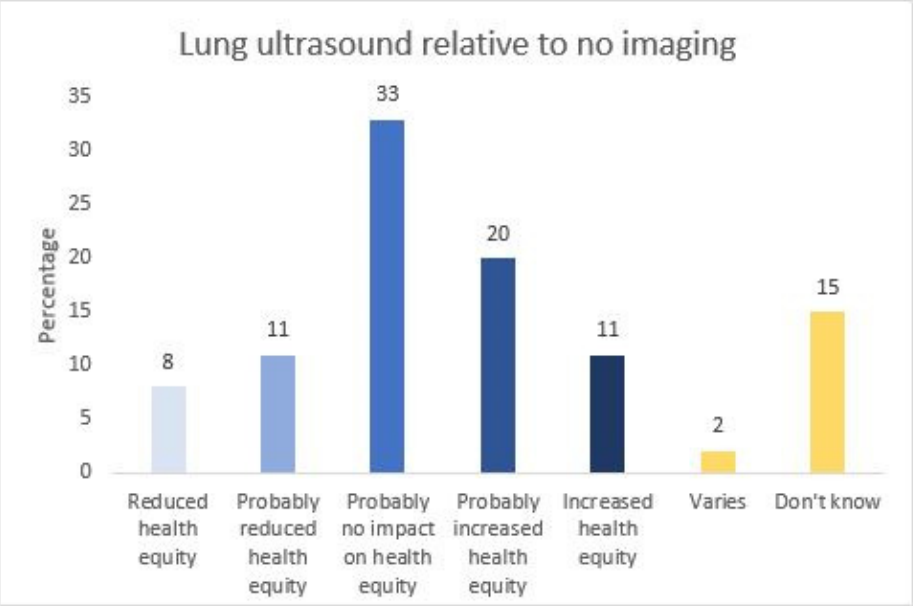
•members of the public (3%)
•patients (2%)
•physicians (16%)
•technicians (59%)
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Equity
What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ● Probably reduced ○ Probably no impact		• diversion of resources • Consider setting i.e. cities vs rural areas

○ Probably increased ○ Increased ○ Varies ○ Don't know		• people having to pay out of pocket The voting results are: • Reduced: 2 • Probably reduced: 8 • Probably no impact : 1 • Probably increased: 0 • Increased: 1 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
35
30
25
20
15
10
5
0
3
11
24
25
31
2
4
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



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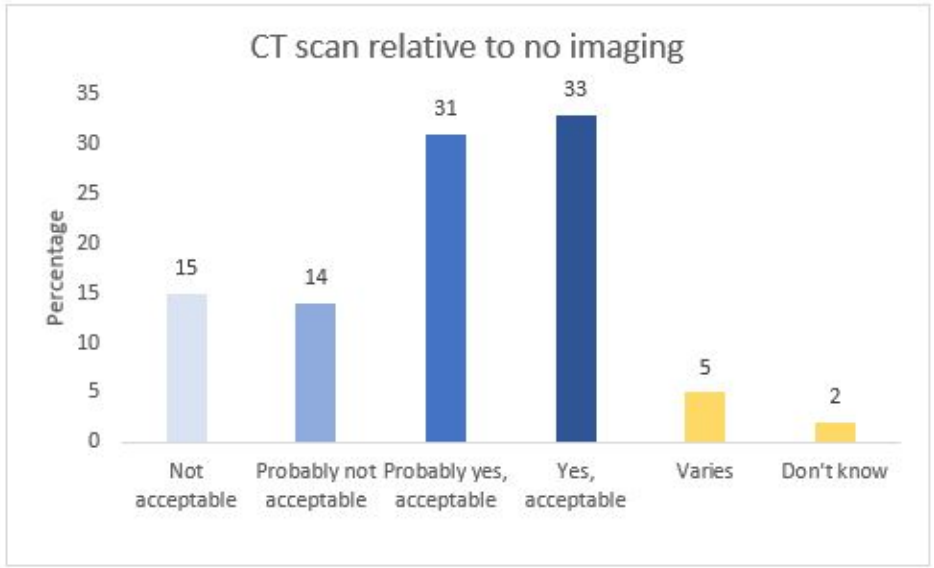
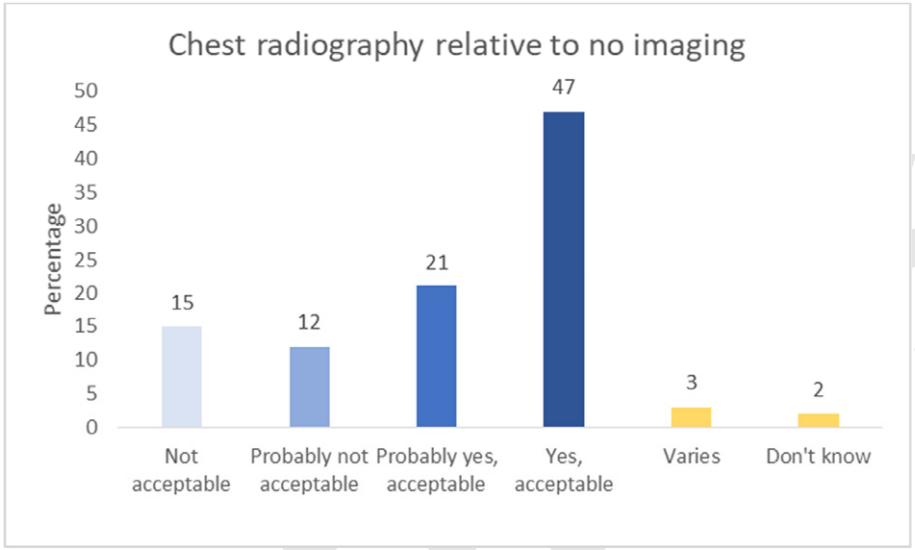
•researchers (4%)
•policy-makers (4%)
•other (8%)

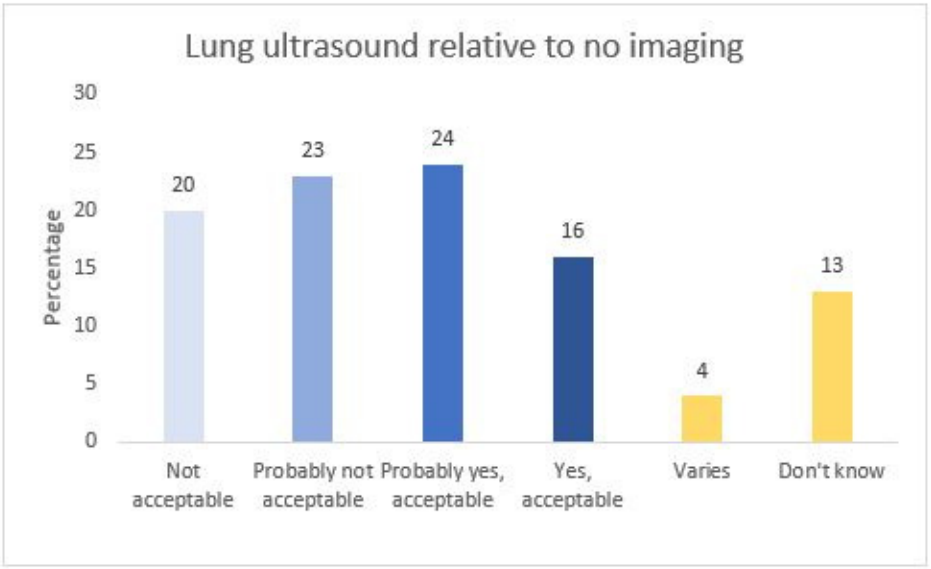
Acceptability
Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		• Providing information to patients is required • Consent would be ideal, but might not be feasible • Likely to be acceptable for patients, less likely to be acceptable to technicians • Varies by the administrator • Might be less acceptable to payers • Perform low-dose CT whenever possible The voting results are: • No : 0 • Probably no : 0 • Probably yes: 7 • Yes: 3 • Varies: 1 • Don't know : 0


Chest radiography relative to no imaging
Percentage
50
45
40
35
30
25
20
15
10
5
0
15
12
21
47
3
2
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

In Press



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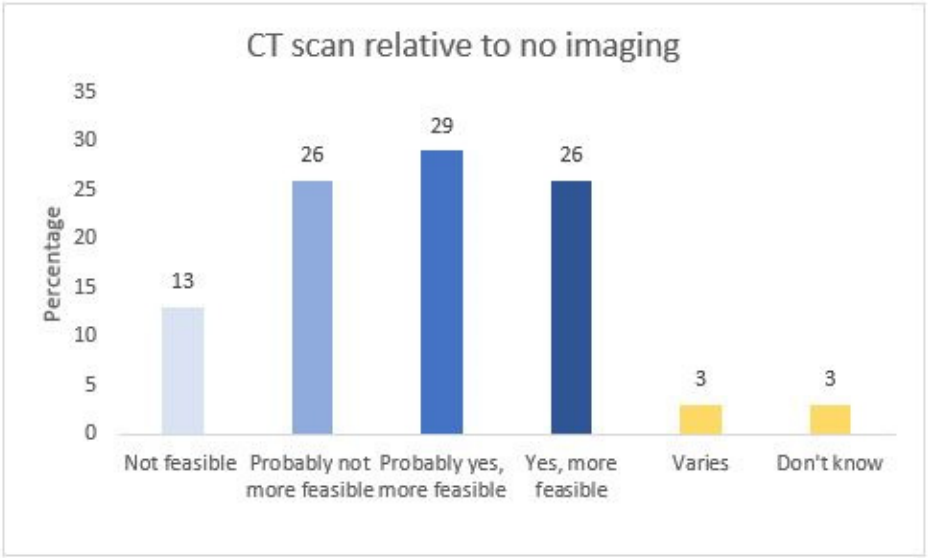
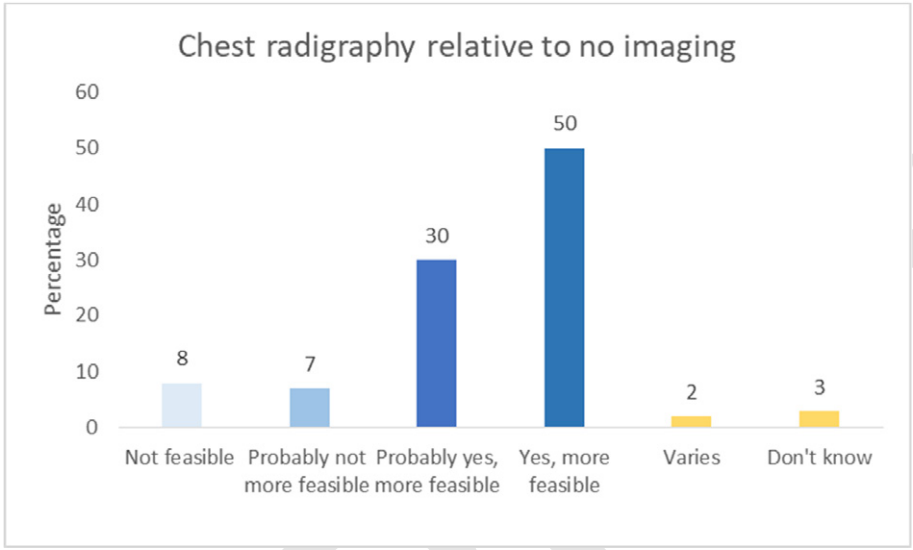
•other health professionals (4%)
•researchers (4%)
•policy-makers (4%)
•other (8%)

Feasibility
Is the intervention feasible to implement?

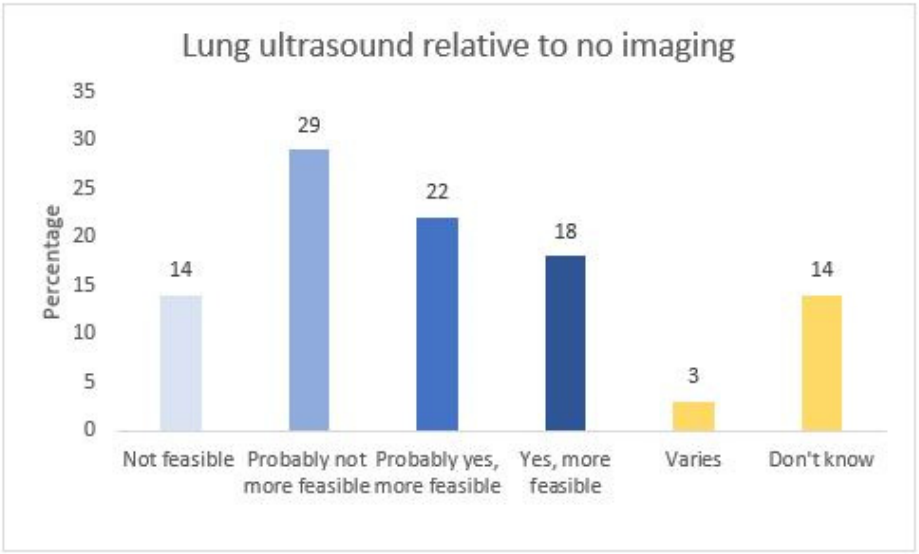
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies		• Need to clean CT unit • Stop the non-urgent use of CT scan (issue of access and availability) • Availability of staff to interpret the scan (24/7)

○ Don't know		• Adapting the workflow in the CT room The voting results are: • No : 0 • Probably no : 0 • Probably yes: 6 • Yes: 3 • Varies: 0 • Don't know : 0

In Press


Chest radigraphy relative to no imaging
Percentage
60
50
40
30
20
10
0
8
7
30
50
2
3
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



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•other (8%)

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	Reduced	**Probably reduced**	Probably no impact	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

For patients with suspected or confirmed COVID-19, not currently hospitalized and with mild symptoms, WHO **suggests using** chest imaging to support the decision on hospital admission versus home discharge (conditional recommendation, based on very low certainty evidence)

Remarks:

Patients likely to benefits are those who:

- are at high risk of disease progression
- are not responding to treatment

When choosing the imaging modality, consider the following:

- CT scan has the highest sensitivity and is preferred in patients with pre-existing pulmonary disease;

In Press

- Chest radiography has a lower sensitivity but is associated with lower risk of HCW infection transmission; is less resource intensive; is associated with lower radiation doses than CT scan; and is easier to repeat sequentially for monitoring disease progression;
- LUS has limited evidence but is helpful with the appropriate expertise and can be done at the point of care. However, it requires closer physical proximity of the operator to the patient for a longer period of time and requires specific infection prevention and control precautions;
- Choice should consider the differential diagnosis in the specific case (e.g., CT angiography for pulmonary embolism, LUS for pleural effusions)
- Choice should be through a shared decision making involving the patient, the referrer physician and the radiologist;

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 1
- Conditional recommendation for either the intervention or the comparison: 0
- Conditional recommendation for the intervention: 9
- Strong recommendation for the intervention: 2

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

PICO 4

Should chest imaging vs. no chest imaging be used for patients with suspected or confirmed COVID-19 and moderate to severe symptoms; context of a decision to choose between admission to regular ward vs. ICU?	
POPULATION:	Patients with suspected or confirmed COVID-19 and moderate to severe symptoms

In Press

INTERVENTION:	Chest imaging
COMPARISON:	No chest imaging
MAIN OUTCOMES:	1. Clinical outcomes • Mortality • Respiratory failure • Multiorgan failure • Shortness of breath • Recovery • Adverse effects of imaging (e.g., exposure to radiation) • COVID-19 transmission to health workers 2. Health systems outcomes • Service use, including: ○ Length of stay in Emergency Department ○ Length of hospital stay ○ Length of ICU stay • Availability of care • Access to care • Quality of care
SETTING:	Decision to choose between admission to regular ward vs. ICU
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

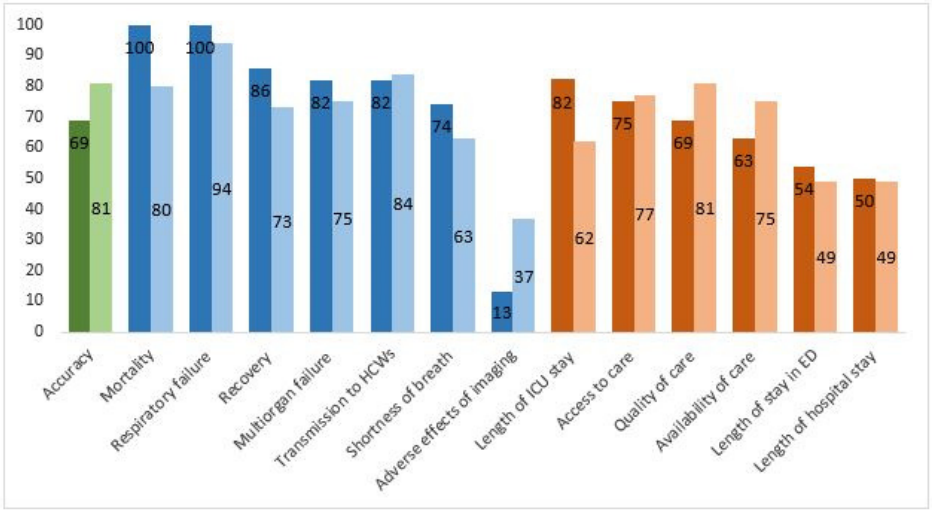
ASSESSMENT

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	The voting results are: • Trivial: 0 • Small: 0 • Moderate: 6

In Press

		• Large: 4 • Varies: 0 • Don't know : 0
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	The voting results are: • Large: 0 • Moderate: 2 • Small: 6 • Trivial: 1 • Varies: 0 • Don't know : 0
Certainty of evidence What is the overall certainty of the evidence of effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Very low ○ Low ○ Moderate ○ High ○ No included studies		• Very low for CT vs. no CT • Very low for CXR vs. no CXR • Very low for US vs. no US
Values Is there important uncertainty about or variability in how much people value the main outcomes?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

In Press

○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):** **Critical outcomes (GDG, stakeholders n=249):** 	The voting results are: • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
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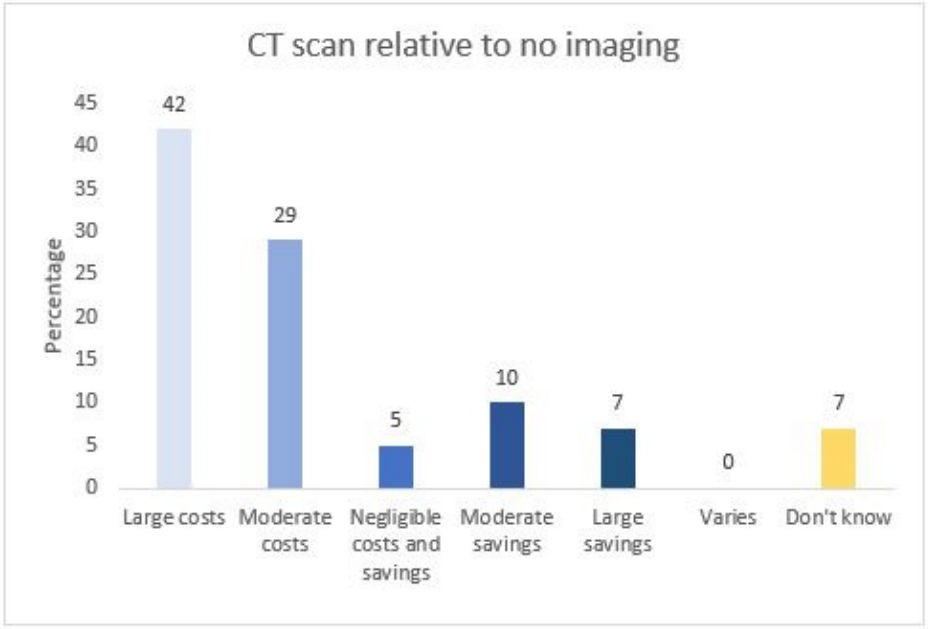
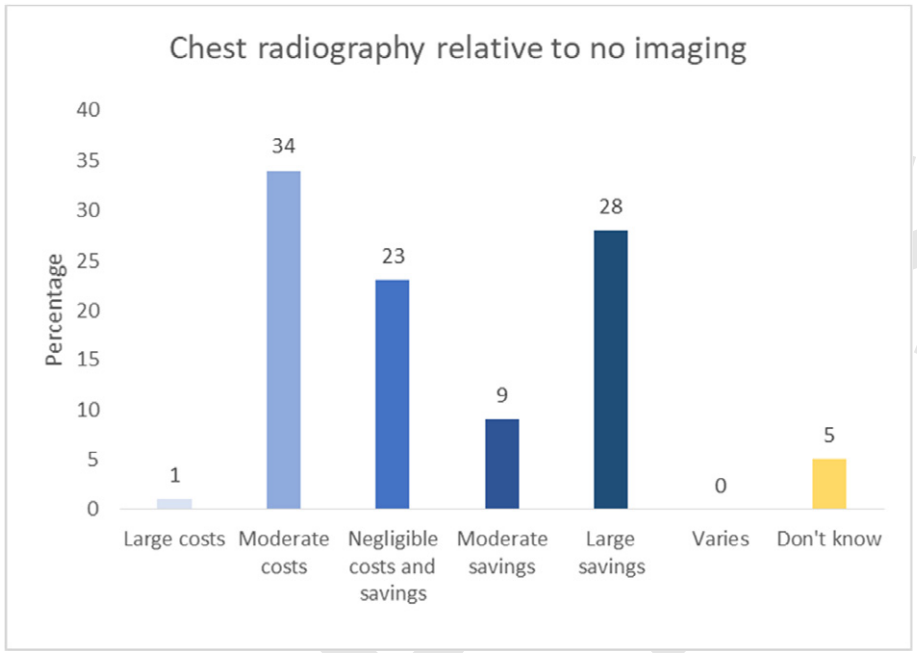
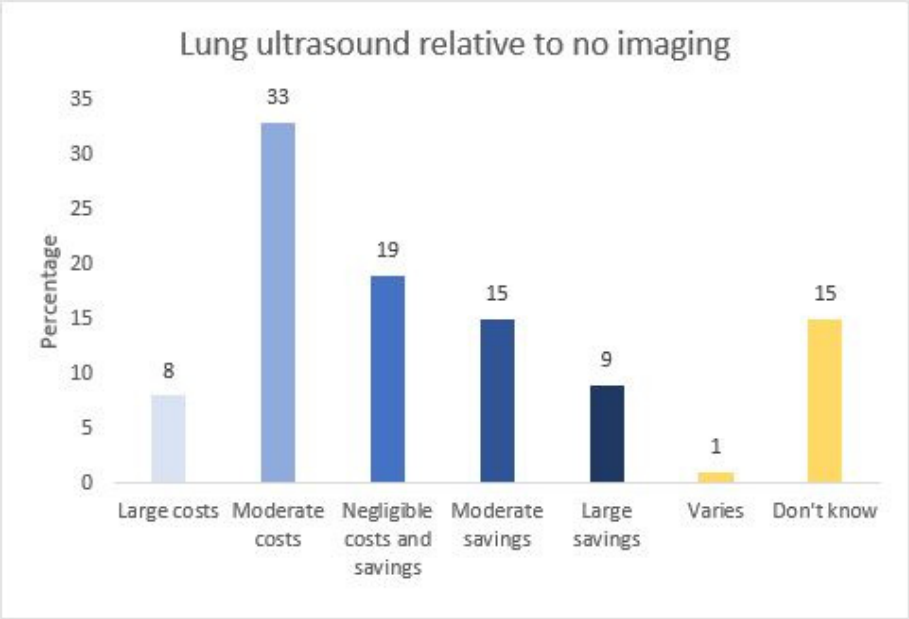
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

	Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes Dark color: GDG; light color: stakeholders Stakeholder respondents (n=249) included: •members of the public (3%) •patients (2%) •physicians (22%) •technicians (53%) •other health professionals (5%) •researchers (3%) •policy-makers (3%) •other (7%)	
Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 0 • Probably favors the comparison: 0 • Does not favor either the intervention or the comparison: 1 • Probably favors the intervention: 6 • Favors the intervention : 4 • Varies: 0 • Don't know: 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

In Press

○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		The voting results are: • Large costs: 2 • Moderate costs: 8 • Negligible costs and savings: 0 • Moderate savings: 1 • Large savings: 0 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
40
35
30
25
20
15
10
5
0
1
34
23
9
28
0
5
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

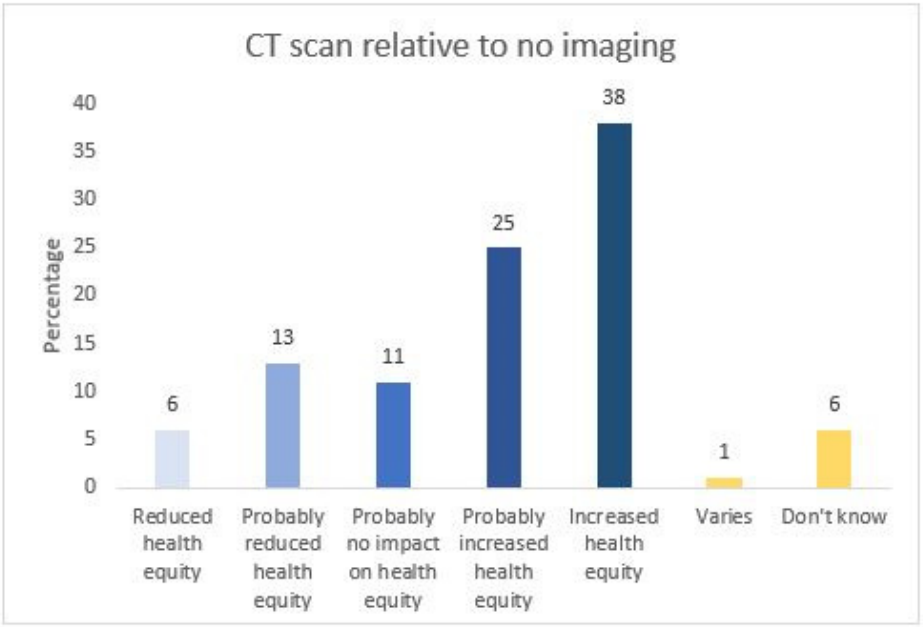


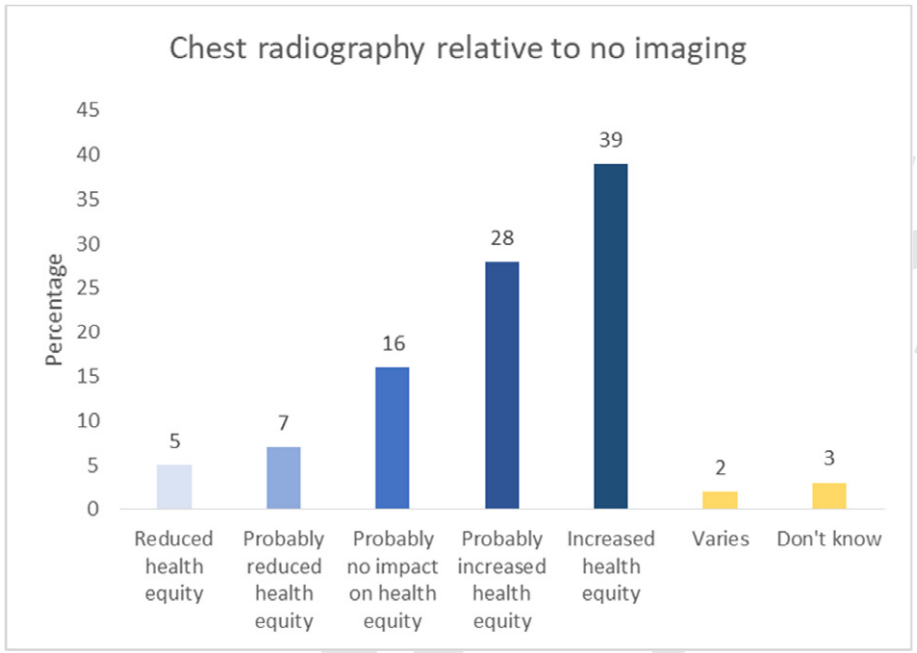
Respondents (n=93) included:

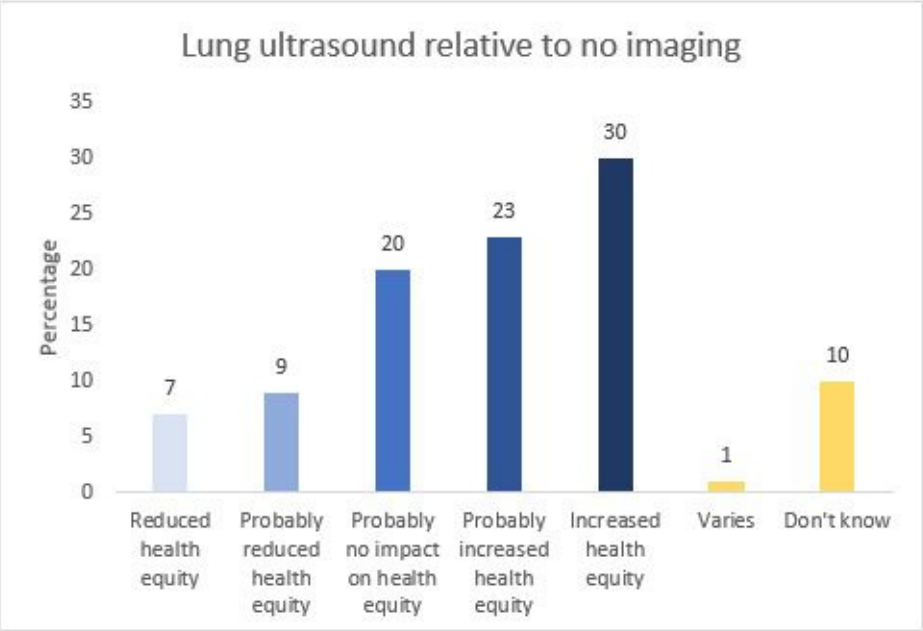
•members of the public (2%)
•patients (3%)
•physicians (14%)
•technicians (61%)
•other health professionals (4%)
•researchers (5%)
•policy-makers (3%)
•other (8%)

Equity
What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Reduced ● Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		The voting results are: • Reduced: 0 • Probably reduced: 8 • Probably no impact : 3 • Probably increased: 0 • Increased: 0 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
45
40
35
30
25
20
15
10
5
0
5
7
16
28
39
2
3
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



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•other health professionals (4%)
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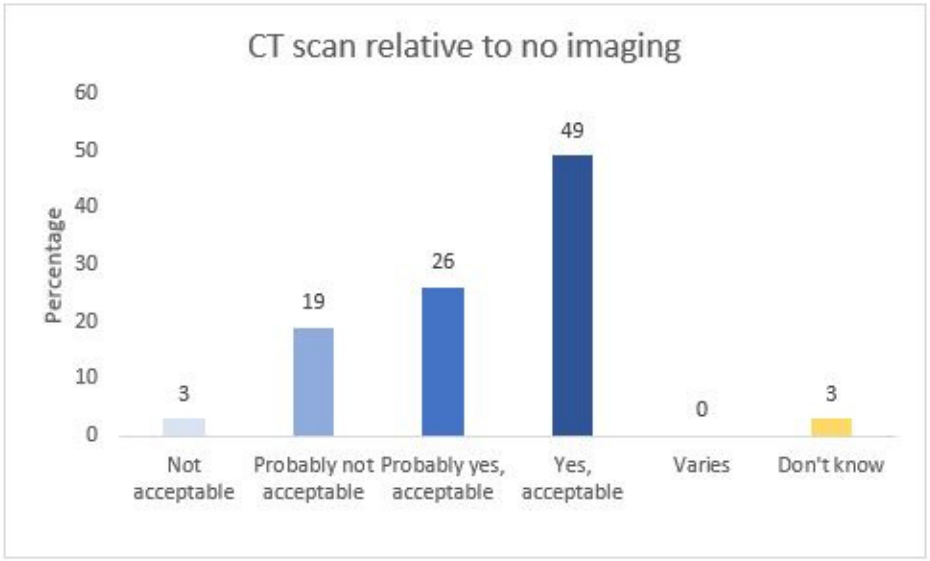
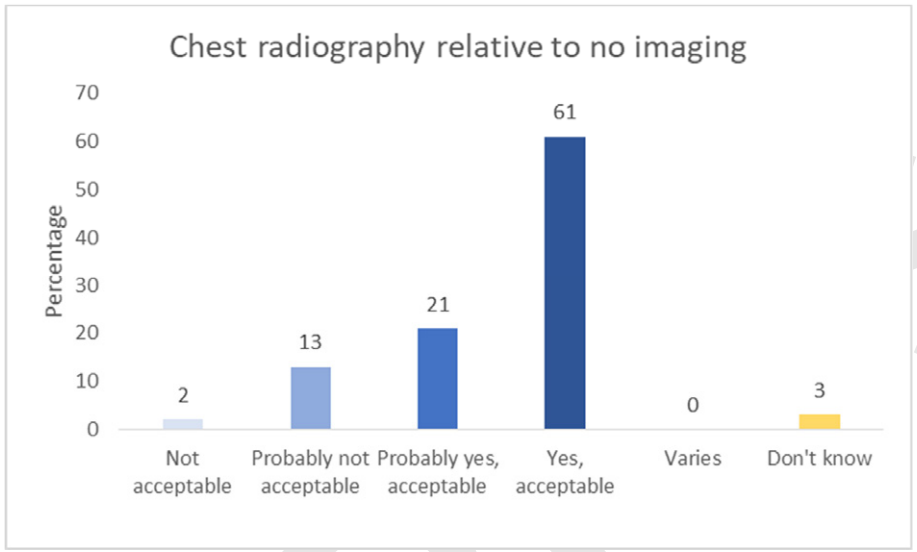
•policy-makers (3%)
•other (8%)

Acceptability
Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes		The voting results are:

○ Yes ○ Varies ○ Don't know		• No : 0 • Probably no : 1 • Probably yes: 7 • Yes: 2 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
70
60
50
40
30
20
10
0
2
13
21
61
0
3
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

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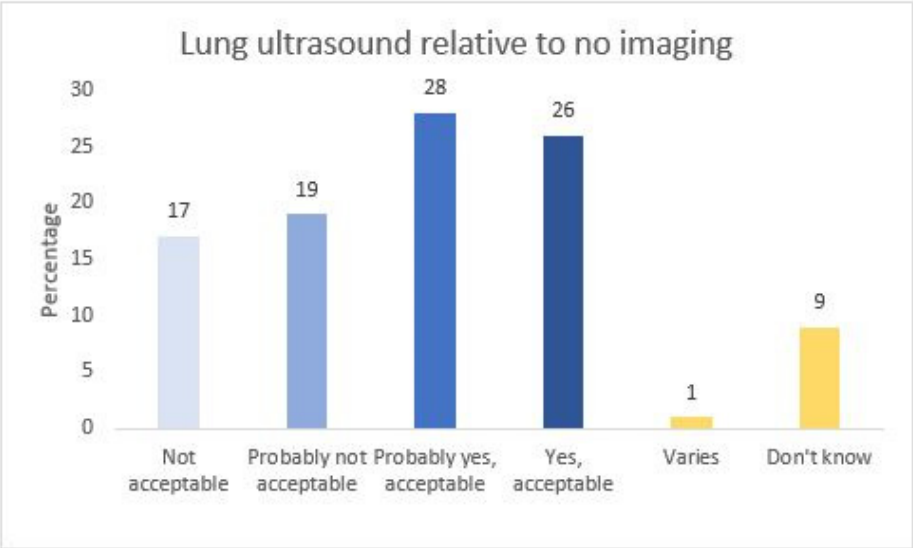
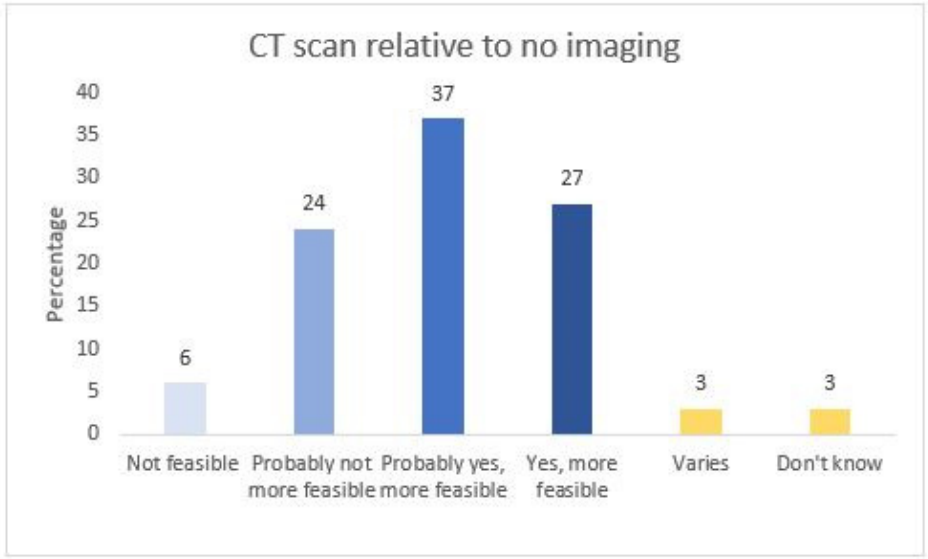
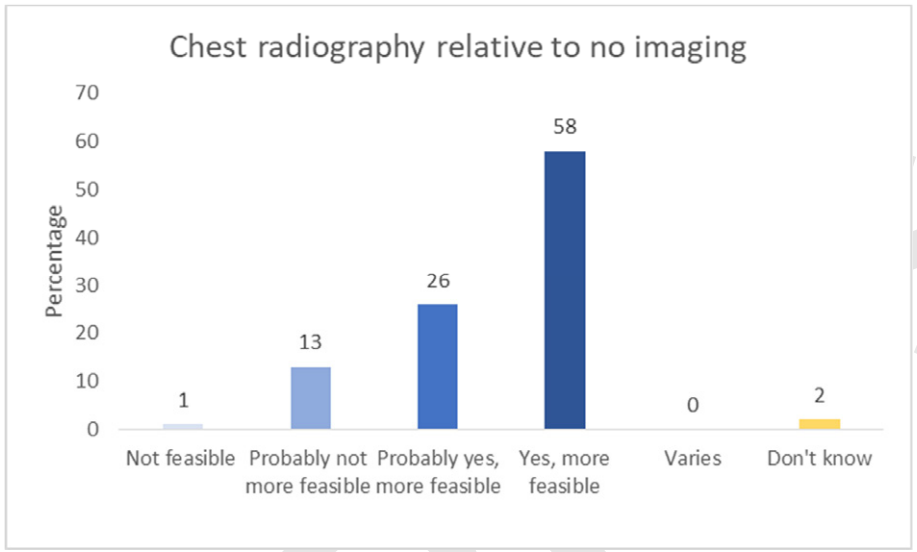
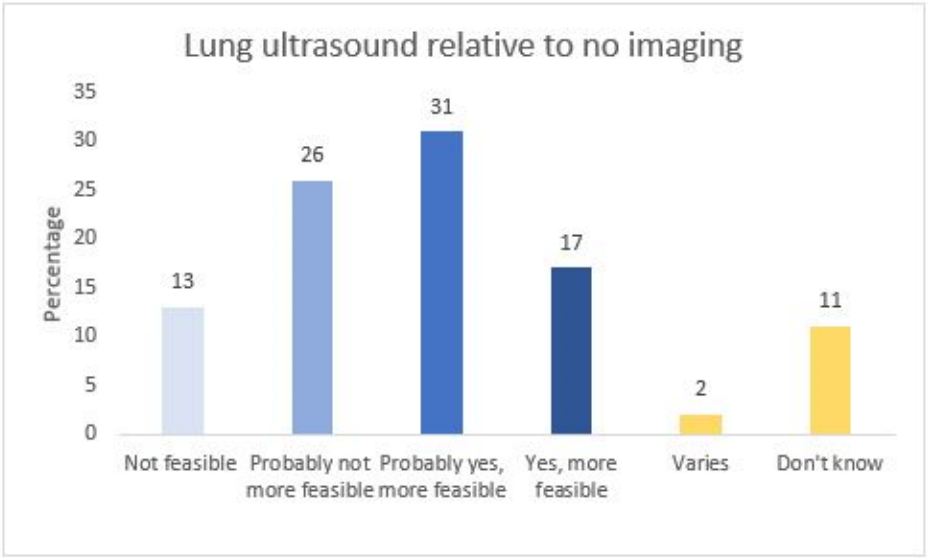
	 Respondents (n=93) included: •members of the public (2%) •patients (3%) •physicians (14%) •technicians (61%) •other health professionals (4%) •researchers (5%) •policy-makers (3%) •other (8%)	
Feasibility Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 0 • Probably no : 1 • Probably yes: 9 • Yes: 2 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
70
60
50
40
30
20
10
0
1
13
26
58
0
2
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



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•other (8%)

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	Reduced	**Probably reduced**	Probably no impact	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

For patients with suspected or confirmed COVID-19, not currently hospitalized and with moderate to severe symptoms, WHO **suggests using** chest imaging to support the decision on regular ward admission versus intensive care unit admission (conditional recommendation, based on very low certainty evidence)

Remarks:

Patients likely to benefits are those who:

- are at high risk of disease progression
- are not responding to treatment

When choosing the imaging modality, consider the following:

- CT scan has the highest sensitivity and is preferred in patients with pre-existing pulmonary disease;

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- Chest radiography has a lower sensitivity but is associated with lower risk of HCW infection transmission; is less resource intensive; is associated with lower radiation doses than CT scan; and is easier to repeat sequentially for monitoring disease progression;
- LUS has limited evidence but is helpful with the appropriate expertise and can be done at the point of care. However, it requires closer physical proximity of the operator to the patient for a longer period of time and requires specific infection prevention and control precautions;
- Choice should consider the differential diagnosis in the specific case (e.g., CT angiography for pulmonary embolism, LUS for pleural effusions)
- Choice should be through a shared decision making involving the patient, the referrer physician and the radiologist;

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 0
- Conditional recommendation for either the intervention or the comparison: 0
- Conditional recommendation for the intervention: 8
- Strong recommendation for the intervention: 3

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

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PICO 5

Should chest imaging vs. no chest imaging be used for patients with suspected or confirmed COVID-19, currently hospitalized and moderate or severe symptoms; context of a decision to choose whether to escalate respiratory support?	
POPULATION:	Patients with suspected or confirmed COVID-19, currently hospitalized and moderate or severe symptoms
INTERVENTION:	Chest imaging
COMPARISON:	No chest imaging
MAIN OUTCOMES:	1. Clinical outcomes • Mortality • Respiratory failure • Multiorgan failure • Shortness of breath • Recovery • Adverse effects of imaging (e.g., exposure to radiation) • COVID-19 transmission to health workers 2. Health systems outcomes • Service use, including: o Length of stay in Emergency Department o Length of hospital stay o Length of ICU stay • Availability of care • Access to care • Quality of care
SETTING:	Decision to choose whether to escalate respiratory support
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

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ASSESSMENT

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	The voting results are: • Trivial: 0 • Small: 1 • Moderate: 5 • Large: 3 • Varies: 1 • Don't know : 0
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	The voting results are: • Large: 0 • Moderate: 2 • Small: 7 • Trivial: 2 • Varies: 0 • Don't know : 0

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Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies		• Very low for CT vs. no CT • Very low for CXR vs. no CXR • Very low for US vs. no US

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):** **Critical outcomes (GDG, stakeholders n=249):**	The voting results are: • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
Multiorgan failure	0	5	19	22	82	75
Shortness of breath	0	6	27	33	74	63
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

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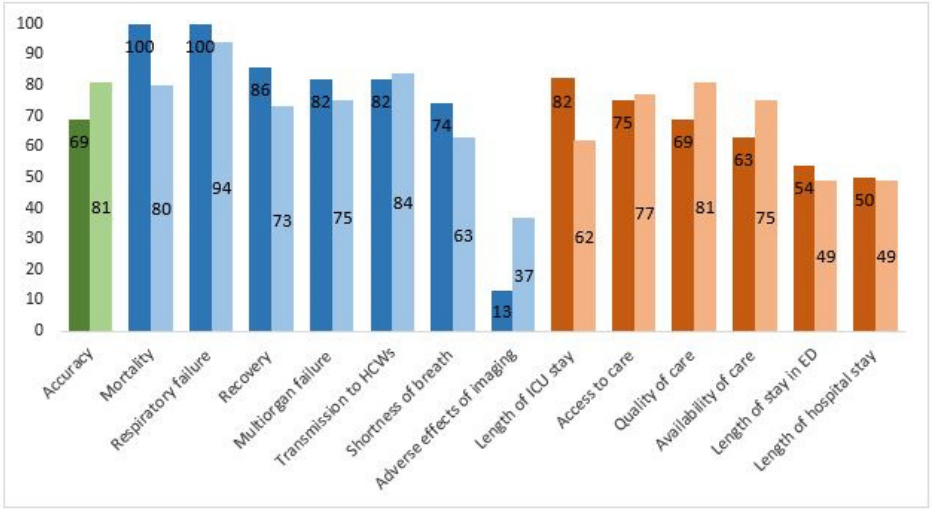

Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes
Dark color: GDG; light color: stakeholders
Stakeholder respondents (n=249) included:
•members of the public (3%)
•patients (2%)
•physicians (22%)
•technicians (53%)
•other health professionals (5%)
•researchers (3%)
•policy-makers (3%)
•other (7%)

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Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 0 • Probably favors the comparison: 1 • Does not favor either the intervention or the comparison: 1 • Probably favors the intervention: 8 • Favors the intervention : 1 • Varies: 0 • Don't know : 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		The voting results are: • Large costs: 1 • Moderate costs: 8 • Negligible costs and savings: 0 • Moderate savings: 1 • Large savings: 0 • Varies: 1 • Don't know : 0

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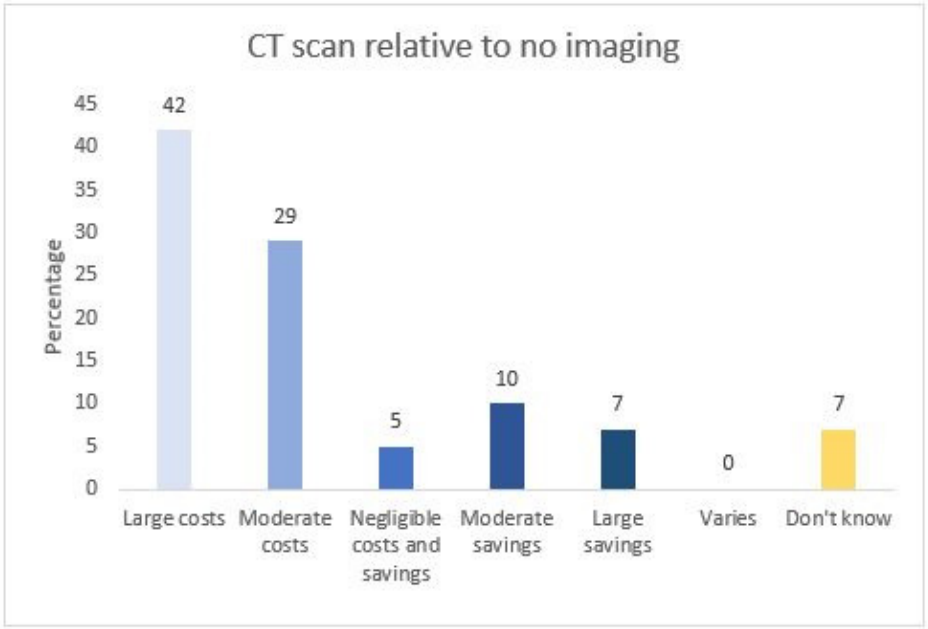
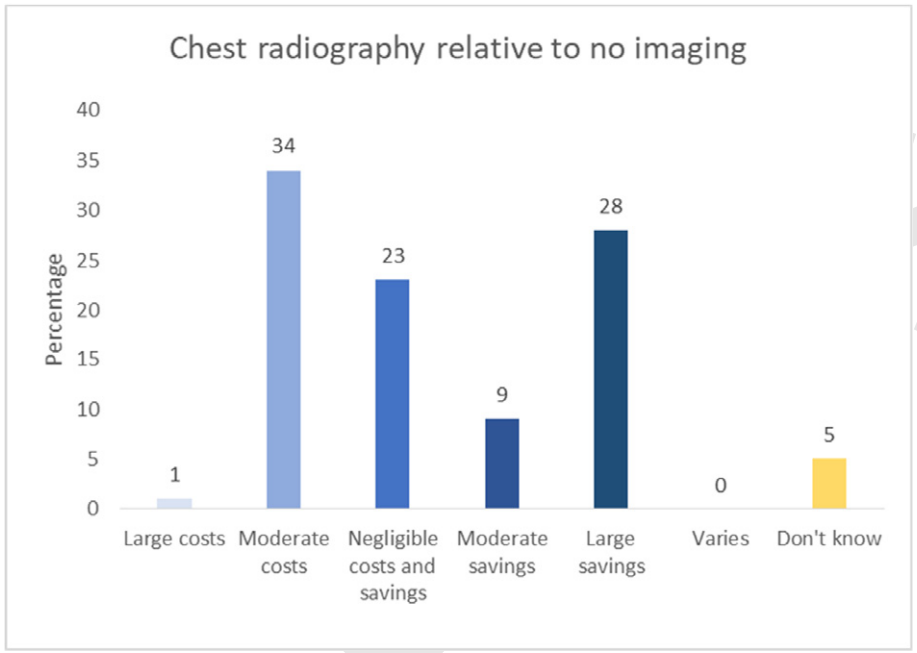
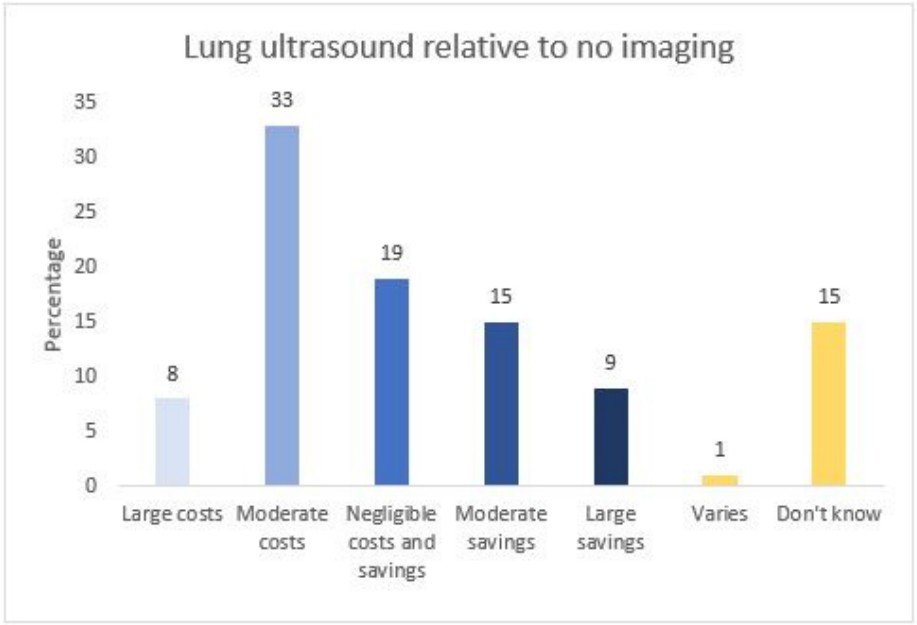

CT scan relative to no imaging
Percentage
45
40
35
30
25
20
15
10
5
0
42
29
5
10
7
0
7
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know


Chest radiography relative to no imaging
Percentage
40
35
30
25
20
15
10
5
0
1
34
23
9
28
0
5
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know



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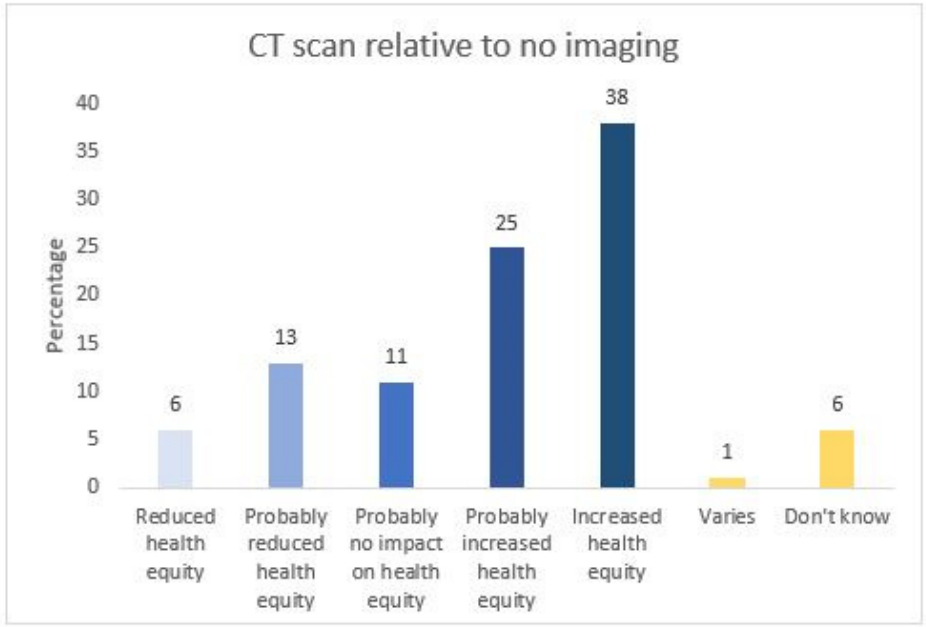
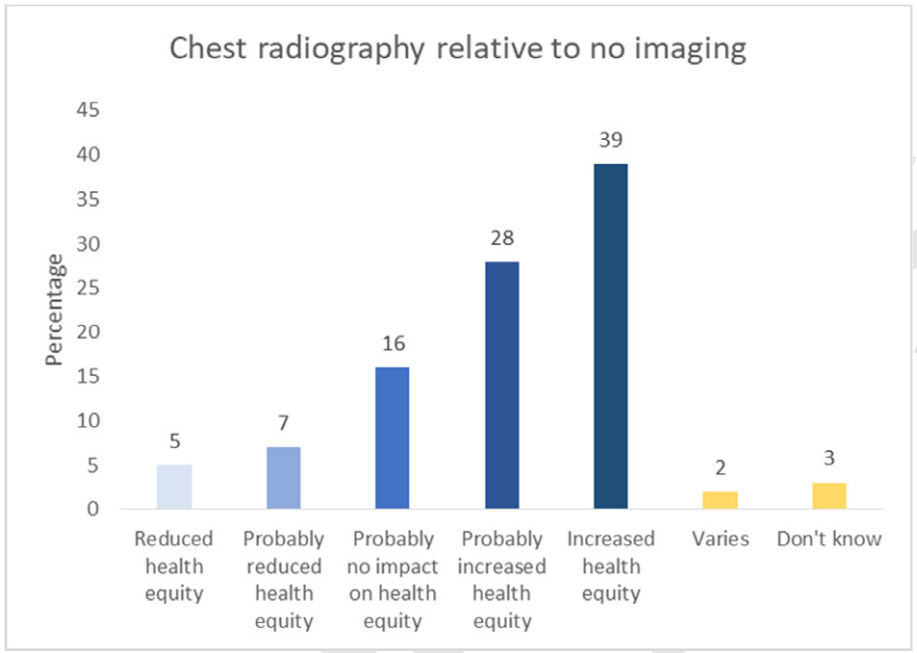
•other (8%)

Equity
What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		The voting results are: • Reduced: 0 • Probably reduced: 4 • Probably no impact : 4 • Probably increased: 2 • Increased: 1 • Varies: 0 • Don't know : 0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Percentage
45
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10
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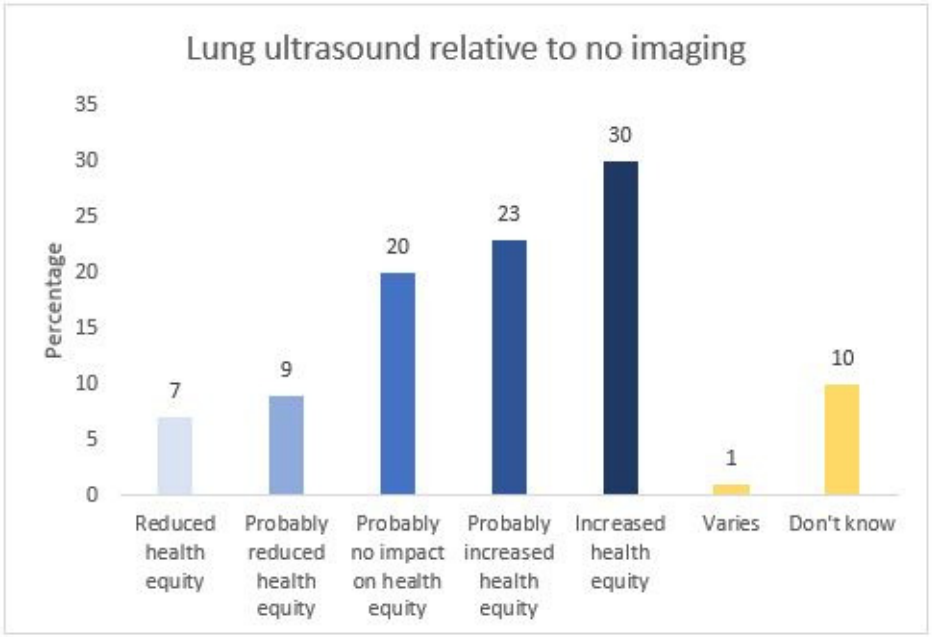
0
5
7
16
28
39
2
3
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



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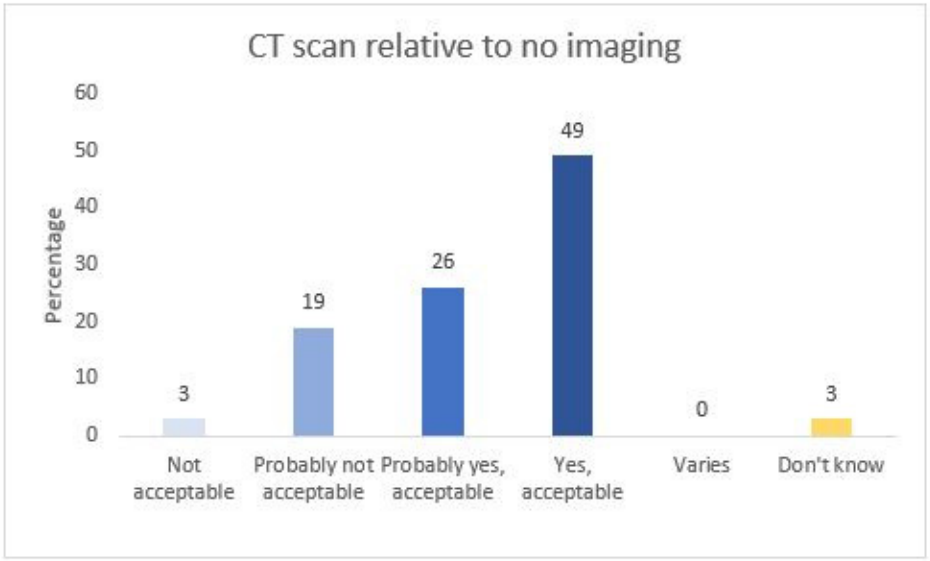
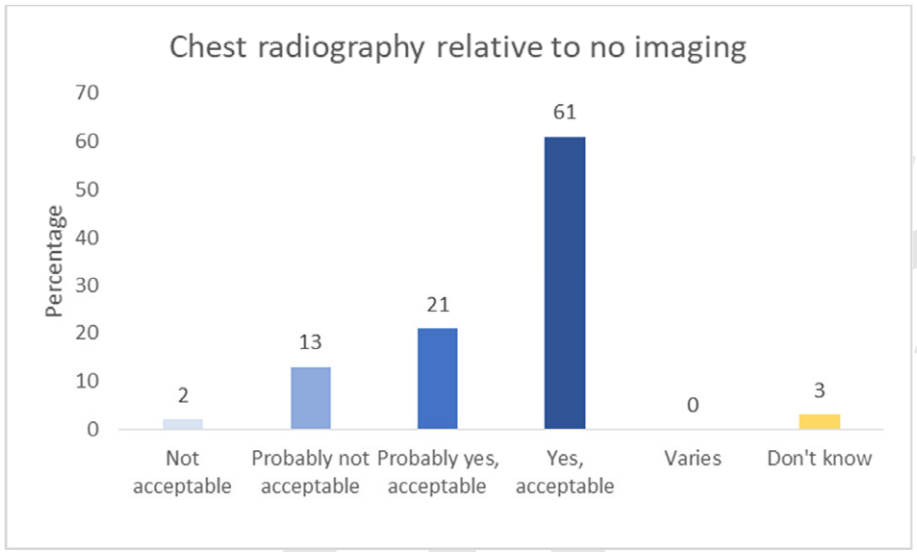
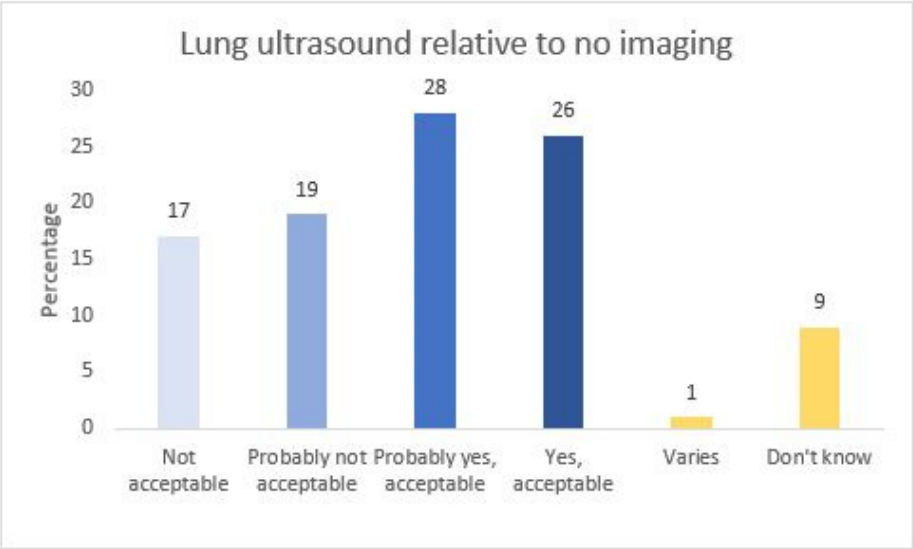
Acceptability Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 0 • Probably no : 0 • Probably yes: 7 • Yes: 4 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
70
60
50
40
30
20
10
0
2
13
21
61
0
3
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

In Press



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•other (8%)

Feasibility

Is the intervention feasible to implement?		
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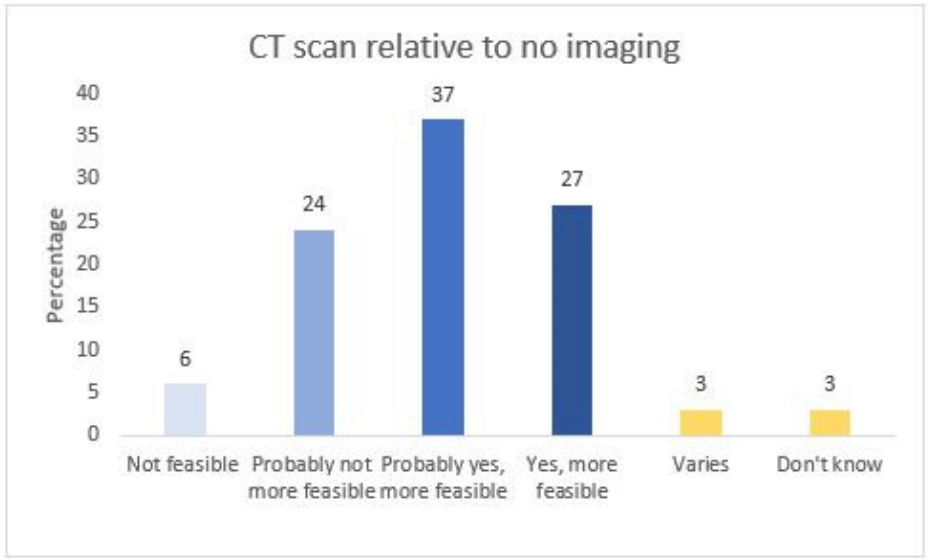
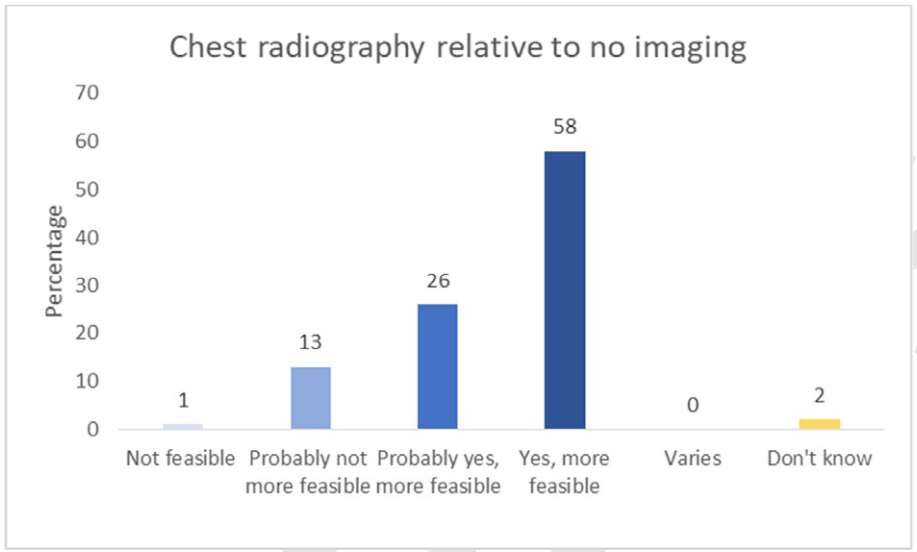
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 0 • Probably no : 0 • Probably yes: 8 • Yes: 2 • Varies: 0 • Don't know : 0


Chest radiography relative to no imaging
Percentage
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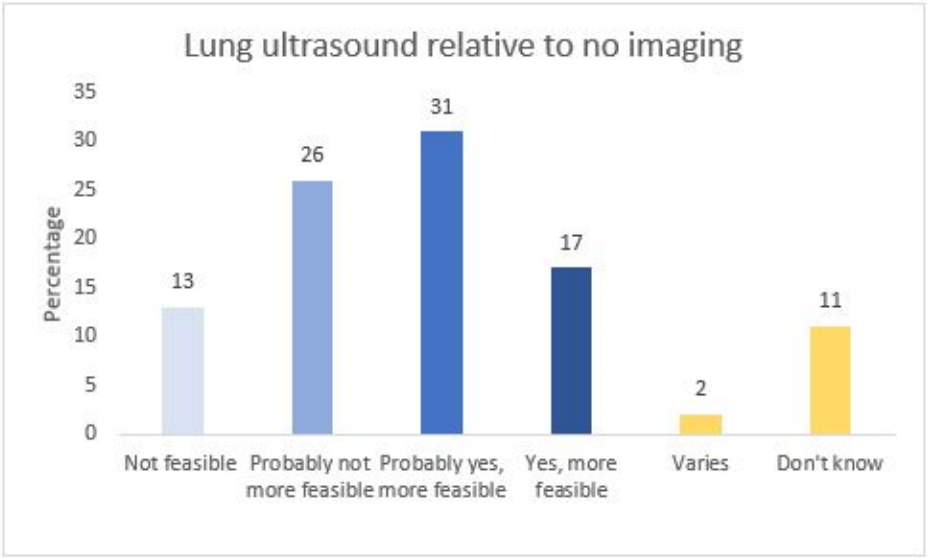
1
13
26
58
0
2
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



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SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
ERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	Reduced	Probably reduced	**Probably no impact**	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

For patients with suspected or confirmed COVID-19, currently hospitalized and with moderate to severe symptoms, WHO **suggests using** chest imaging to inform the therapeutic management (conditional recommendation, based on very low certainty evidence)

Remarks:

Patients likely to benefits are those who:

- are at high risk of disease progression
- are not responding to treatment

When choosing an imaging modality, consider the following

In Press

- Chest radiography is associated with lower risk of HCW infection transmission; is less resource intensive (adequate for low resource settings); is associated with radiation doses lower than for CT scans, and would help in monitoring disease progression, which may require multiple/sequential imaging procedures
- CT scan is preferred in patients with pre-existing pulmonary disease;
- LUS is helpful with the appropriate expertise and can be done at the point of care. However, it requires closer physical proximity of the operator to the patient for a longer period of time and would require specific infection prevention and control precautions.
- Choice should consider the differential diagnosis in the specific case (e.g., CT angiography for pulmonary embolism, LUS for pleural effusions)
- Choice should be through a shared decision making involving the patient, the referrer physician and the radiologist;

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 0
- Conditional recommendation for either the intervention or the comparison: 0
- Conditional recommendation for the intervention: 9
- Strong recommendation for the intervention: 0

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

PICO 7

Should chest imaging be added to standard of care vs. not added be used for patients with COVID-19 whose symptoms resolved; context of a decision to choose between discharge home vs. no discharge home?	
POPULATION:	Patients with COVID-19 whose symptoms resolved
INTERVENTION:	Chest imaging added to standard of care

In Press

COMPARISON:	Chest imaging not added to standard of care
MAIN OUTCOMES:	1. Clinical outcomes • Mortality • Respiratory failure • Multiorgan failure • Shortness of breath • Recovery • Adverse effects of imaging (e.g., exposure to radiation) • COVID-19 transmission to health workers 2. Health systems outcomes • Service use, including: ○ Length of stay in Emergency Department ○ Length of hospital stay ○ Length of ICU stay • Availability of care • Access to care • Quality of care
SETTING:	Decision to choose between discharge home vs. no discharge home
PERSPECTIVE:	Societal perspective
BACKGROUND:	
CONFLICT OF INTERESTS:	

ASSESSMENT

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	• Any benefit is reduced by the fact that the radiologic improvement lags behind the clinical improvement • Potential benefit is to assess for post COVID-19 sequelae • Might be used to assess the progression or regression of the radiologic findings

In Press

		• Lack of data for the association between radiological findings and rate of readmission The voting results are: • Trivial: 4 • Small: 7 • Moderate: 4 • Large: 1 • Varies: 0 • Don't know : 0
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	• **No study evaluated the effects of chest imaging on clinical outcomes** • **No study evaluated the effects of chest imaging on health systems outcomes**	• Identification of incidental findings • HCWs exposure • Harm of radiation The voting results are: • Large: 2 • Moderate: 6 • Small: 7 • Trivial: 1 • Varies: 0 • Don't know : 0

In Press

Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies		• Very low for CT vs. no CT • Very low for CXR vs. no CXR • Very low for US vs. no US

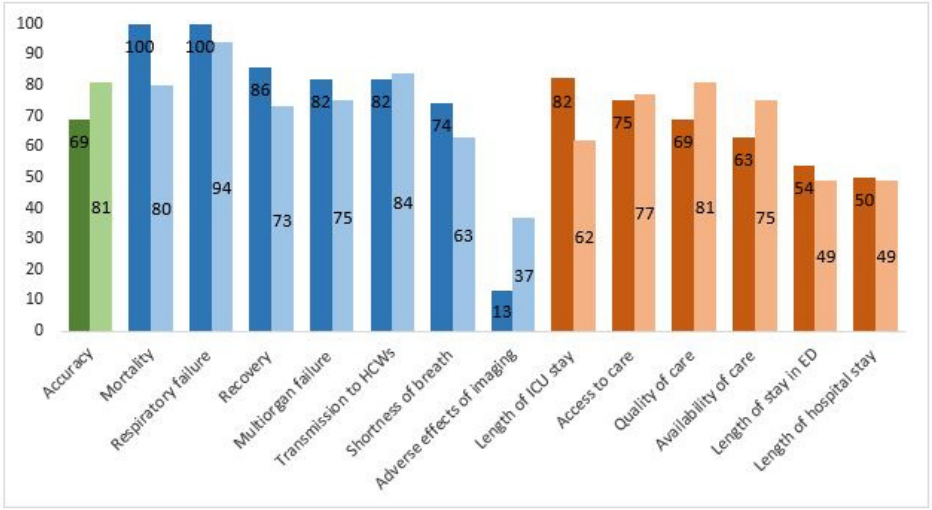
Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	**Outcomes valuation (stakeholders n=249):**	The voting results are: • Important uncertainty or variability: 2 • Possibly important uncertainty or variability: 7 • Probably no important uncertainty or variability: 4 • No important uncertainty or variability: 1

Outcomes	Not important (%)		Important (%)		Critical (%)	
	GDG	Stakeholders	GDG	Stakeholders	GDG	Stakeholders
Accuracy	0	1	32	19	69	81
Mortality	0	6	0	16	100	80
Respiratory failure	0	4	0	4	100	94
Multiorgan failure	0	5	19	22	82	75
Shortness of breath	0	6	27	33	74	63
Recovery	0	4	15	25	86	73
Adverse effects of imaging	44	24	44	40	13	37
Transmission to HCWs	7	3	13	14	82	84
Length of stay in ED	14	12	34	40	54	49
Length of hospital stay	13	8	38	44	50	49
Length of ICU stay	0	4	19	36	82	62
Availability of care	0	4	38	23	63	75
Access to care	0	4	25	21	75	77
Quality of care	7	3	25	18	69	81

Critical outcomes (GDG, stakeholders n=249):

In press



Green: accuracy of the diagnostic modality; blue: clinical outcomes; orange: health systems outcomes

Dark color: GDG; light color: stakeholders

Stakeholder respondents (n=249) included:

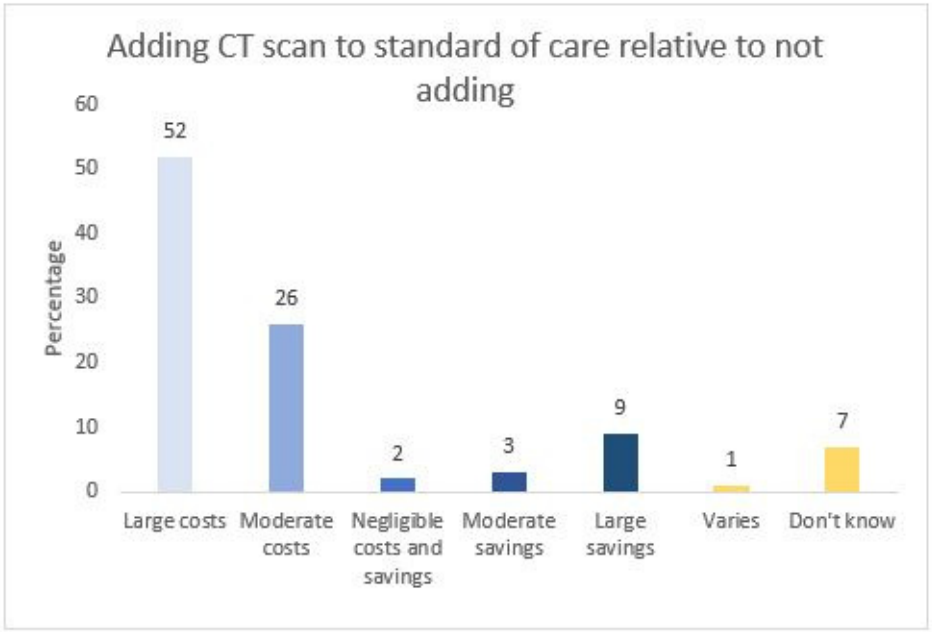
•members of the public (3%)
•patients (2%)
•physicians (22%)
•technicians (53%)
•other health professionals (5%)
•researchers (3%)
•policy-makers (3%)
•other (7%)

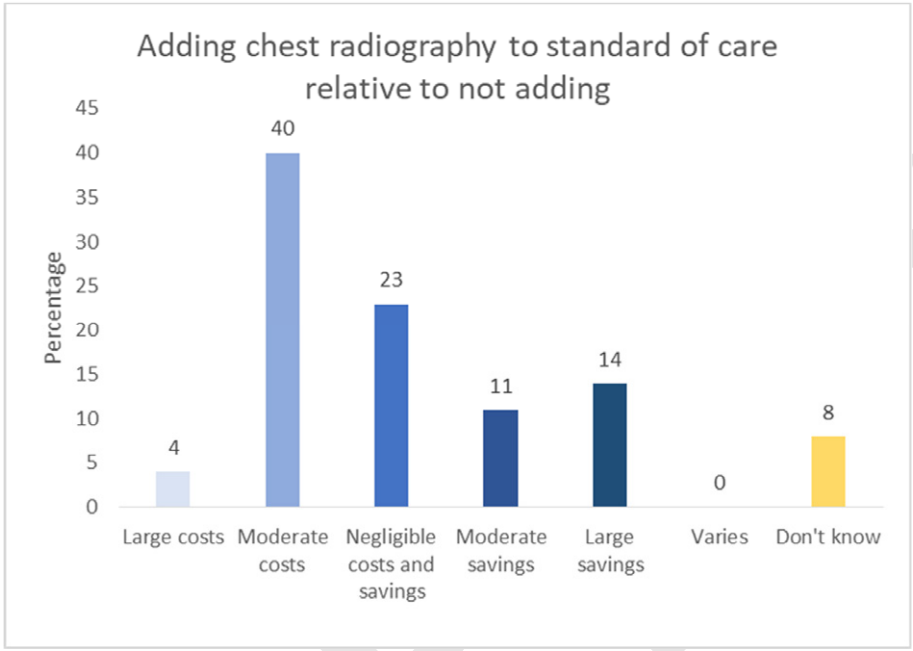
Balance of effects

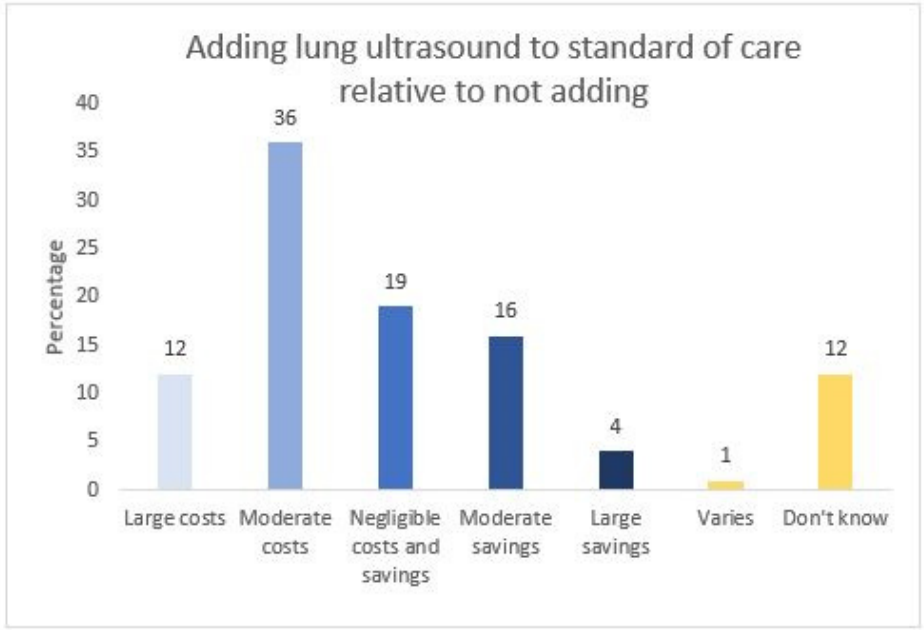
In Press

Does the balance between desirable and undesirable effects favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ● Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		The voting results are: • Favors the comparison: 4 • Probably favors the comparison: 8 • Does not favor either the intervention or the comparison: 0 • Probably favors the intervention: 2 • Favors the intervention : 1 • Varies: 0 • Don't know : 0
Resources required How large are the resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		The voting results are: • Large costs: 2 • Moderate costs: 10 • Negligible costs and savings: 0 • Moderate savings: 0 • Large savings: 0 • Varies: 1 • Don't know : 0

In Press


Adding CT scan to standard of care relative to not adding
Percentage
60
50
40
30
20
10
0
52
26
2
3
9
1
7
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know


Adding chest radiography to standard of care relative to not adding
Percentage
45
40
35
30
25
20
15
10
5
0
4
40
23
11
14
0
8
Large costs
Moderate costs
Negligible costs and savings
Moderate savings
Large savings
Varies
Don't know

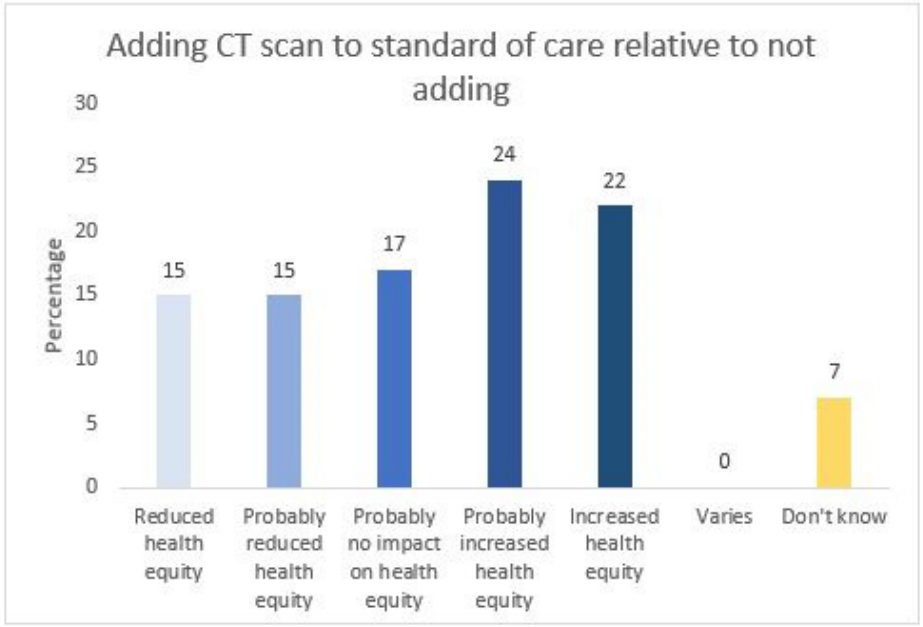


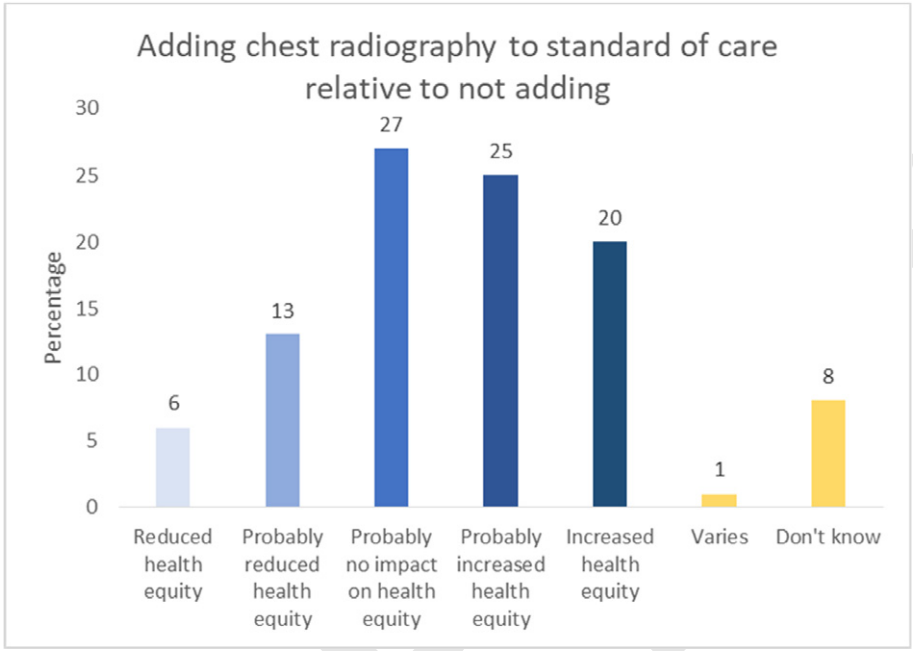
Respondents (n=90) included:

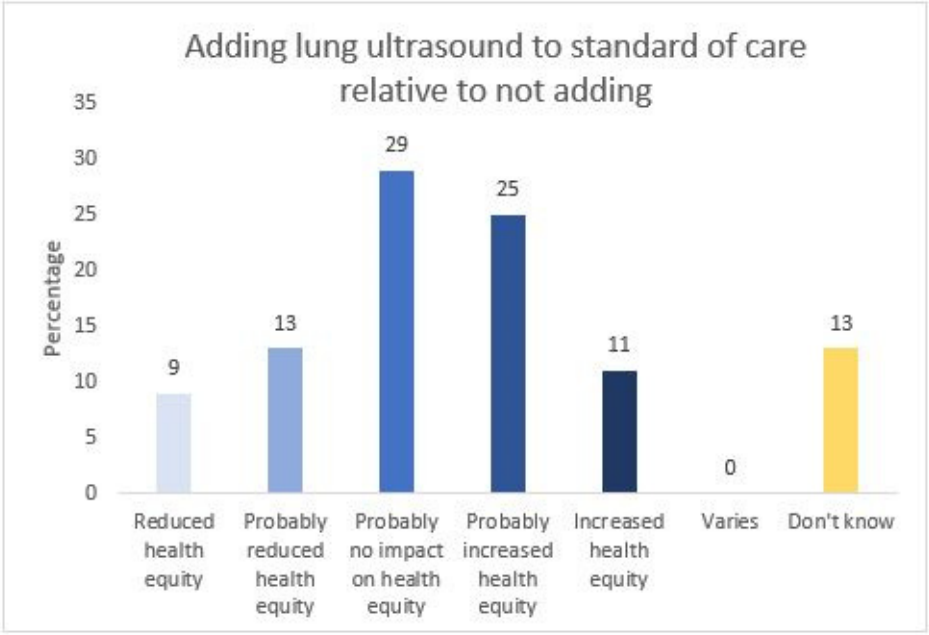
•members of the public (2%)
•patients (3%)
•physicians (18%)
•technicians (56%)
•other health professionals (4%)
•researchers (6%)
•policy-makers (3%)
•other (8%)

Equity
What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ● Probably reduced		The voting results are:

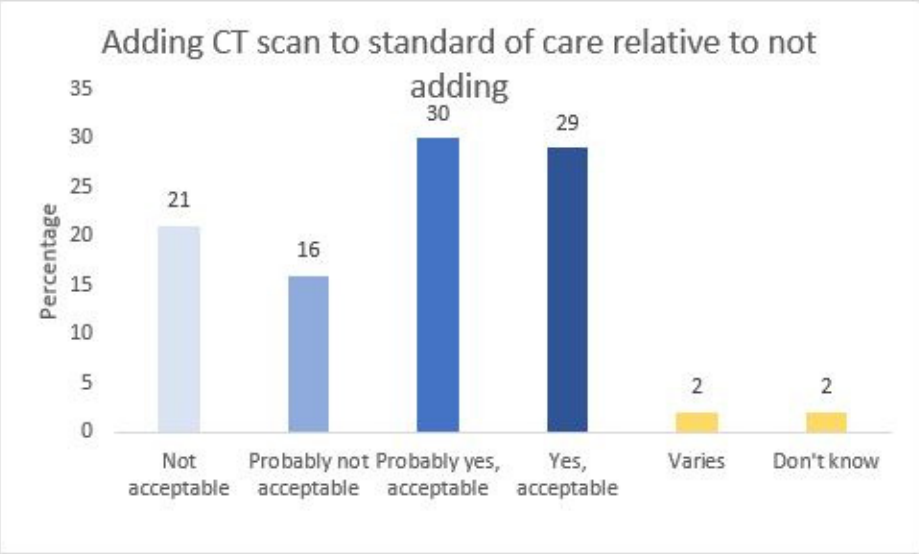
○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		• Reduced: 0 • Probably reduced: 9 • Probably no impact : 2 • Probably increased: 2 • Increased: 0 • Varies: 1 • Don't know : 0

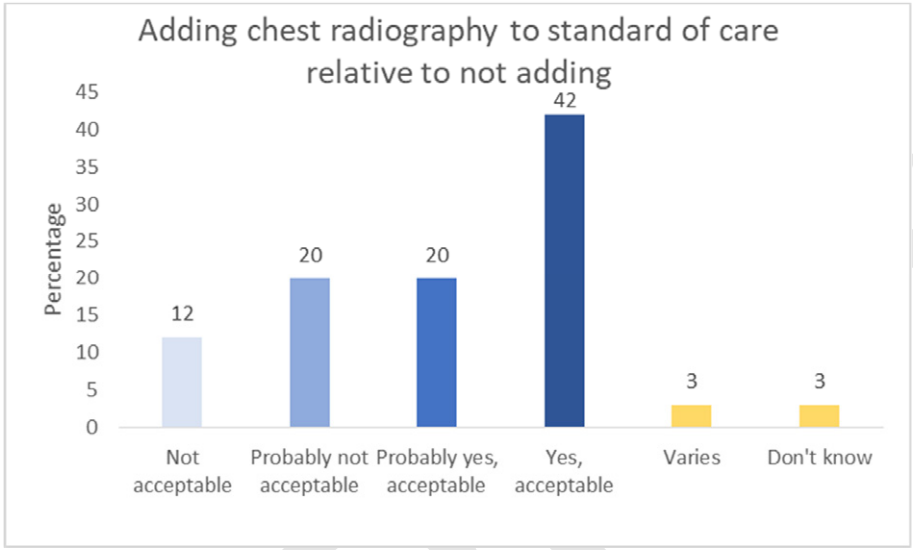

Adding chest radiography to standard of care relative to not adding
Percentage
30
25
20
15
10
5
0
6
13
27
25
20
1
8
Reduced health equity
Probably reduced health equity
Probably no impact on health equity
Probably increased health equity
Increased health equity
Varies
Don't know



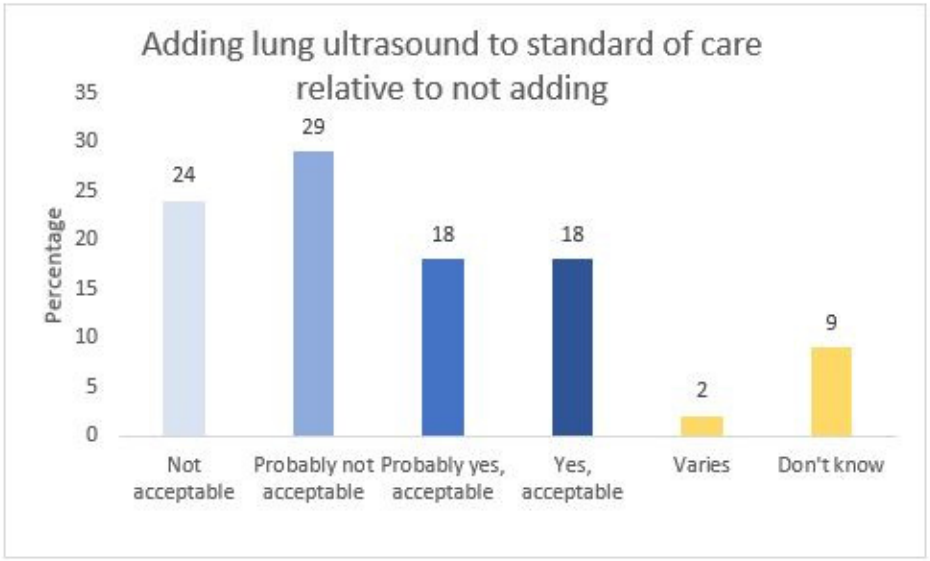
Respondents (n=90) included:

•members of the public (2%)
•patients (3%)
•physicians (18%)
•technicians (56%)
•other health professionals (4%)
•researchers (6%)
•policy-makers (3%)
•other (8%)

Acceptability Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No: 0 • Probably no : 6 • Probably yes: 7 • Yes: 1 • Varies: 0 • Don't know : 0


Adding chest radiography to standard of care relative to not adding
Percentage
45
40
35
30
25
20
15
10
5
0
12
20
20
42
3
3
Not acceptable
Probably not acceptable
Probably yes, acceptable
Yes, acceptable
Varies
Don't know

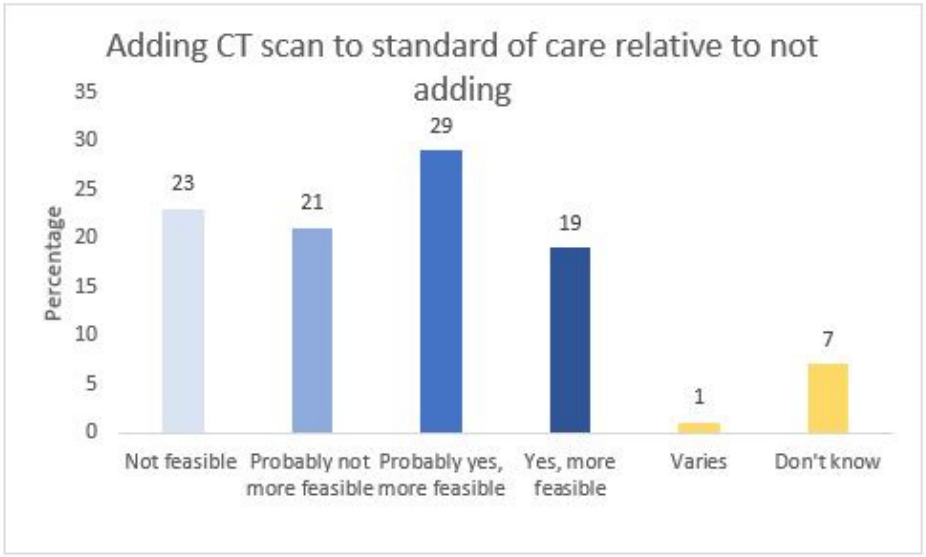
In Press

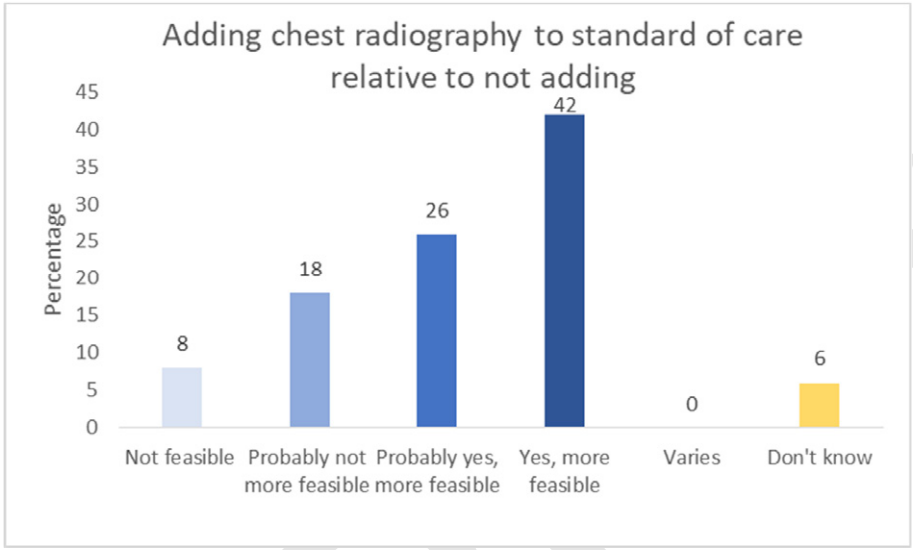


Respondents (n=90) included:

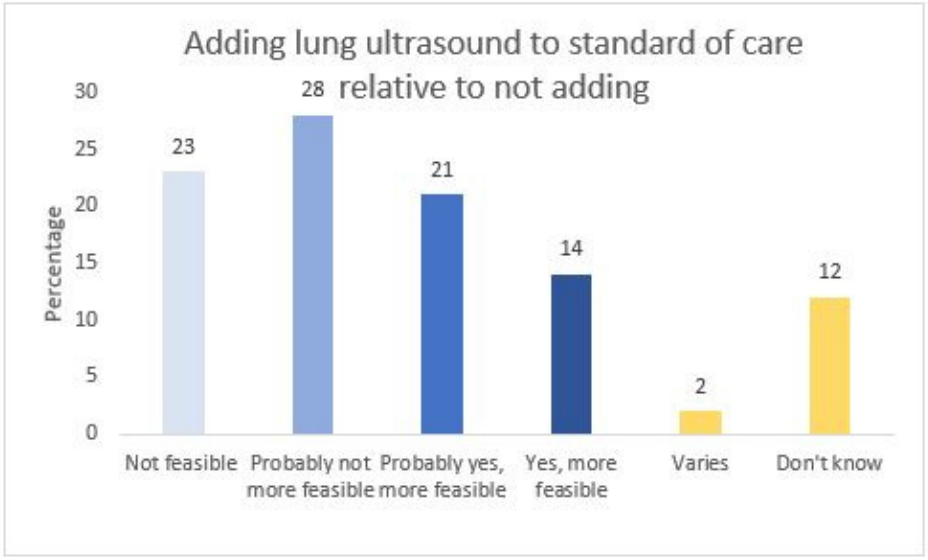
•members of the public (2%)
•patients (3%)
•physicians (18%)
•technicians (56%)
•other health professionals (4%)
•researchers (6%)
•policy-makers (3%)
•other (8%)

Feasibility

Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		The voting results are: • No : 0 • Probably no : 4 • Probably yes: 8 • Yes: 3 • Varies: 0 • Don't know : 0


Adding chest radiography to standard of care relative to not adding
Percentage
45
40
35
30
25
20
15
10
5
0
8
18
26
42
0
6
Not feasible
Probably not more feasible
Probably yes, more feasible
Yes, more feasible
Varies
Don't know

In Press



Respondents (n=90) included:

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•physicians (18%)
•technicians (56%)
•other health professionals (4%)
•researchers (6%)
•policy-makers (3%)
•other (8%)

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	Trivial		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	**Probably favors the comparison**	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
EQUITY	Reduced	**Probably reduced**	Probably no impact	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	**Conditional recommendation against the intervention**	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	●	○	○	○

CONCLUSIONS

Recommendation

For hospitalized patients with COVID-19 whose symptoms resolved, WHO **suggests not adding** chest imaging to clinical and/or laboratory assessment to inform the decision regarding discharge (conditional recommendation, based on very low certainty evidence)

Remarks:

- Standard of care varies based on context (and the community)
- Different criteria for discharge based on resources and stage of the outbreak

The voting results are:

- Strong recommendation against the intervention: 0
- Conditional recommendation against the intervention: 9
- Conditional recommendation for either the intervention or the comparison: 1
- Conditional recommendation for the intervention: 4

In Press

- Strong recommendation for the intervention: 0

Justification

Subgroup considerations

Implementation considerations

Monitoring and evaluation

Research priorities

In Press

Appendix E5. Implementation Considerations, Monitoring and Evaluation Considerations and Research Priorities for the Different PICO Questions

Implementation considerations for each recommendation

Recommendation 1

1. Consider whether RT-PCR is available and, if the test is performed, whether the results are positive or negative.
2. Consider the use of chest imaging in asymptomatic contacts who progress to develop respiratory symptoms (body temperature monitoring).
3. Consider assessing incidental pulmonary findings suspicious of COVID-19 on imaging performed for other reasons (e.g. thoracic spine radiography, cardiac CT) in countries/regions with previous or current high COVID-19 prevalence.

Recommendation 2

1. Consider the resources needed (budget, health workforce, personal protective equipment, imaging equipment), the need to adapt the clinical workflow, and the need to deprioritize other indications for imaging.
2. Consider the use of locally-developed flow charts, infographics and other decision support tools to facilitate implementation.
3. Recommendations for imaging depend on severity on symptoms. Chest imaging is an essential investigation in those who develop respiratory symptoms or hypoxia.
4. Monitor respiratory symptoms and physical exam findings to guide timing of chest imaging.
5. Consider the use of portable equipment for performing chest radiography at the point of care. In the case of home health care, combine chest radiography and/or lung ultrasound by portable equipment with RT-PCR testing.
6. Beware of the risk of infection transmission to health care workers associated with patient transport to the imaging department. This entails careful planning to mitigate risk of potential infection of health care workers and other patients (e.g. use of point of care imaging such as portable equipment) (see infection prevention and control precautions in Appendix E6).
7. Consider the possibility of false negative imaging results in patients for whom chest imaging indicates no findings suspicious of COVID-19 (particularly during the first 2 days after symptom onset).
8. If discharged from the emergency department or other outpatient assessment setting, patients need to abide by the local public health measures (e.g. quarantine, social distancing) until definitive RT-PCR diagnosis is made.
9. If the patient is admitted, health care workers need to consider appropriate clinical precautions until definitive RT-PCR diagnosis is made.
10. When using chest radiography and chest CT, minimize radiation dose while maintaining diagnostic image quality (e.g. low-dose scanning protocols) and use digital imaging rather than film-screen equipment.[2]
11. Consider the potential harms from exposure to ionizing radiation, in particular for pregnant women and children.
12. Ensure proper use of personal protective equipment by health care workers and proper disinfection of equipment and devices (see Appendix E6).
13. Provide appropriate training of radiologists and technologists in COVID-19 for safe practices relating to infection transmission and self-protection and ensure that imaging findings suggestive of COVID-19 are managed through accepted local protocols.
14. Consider the transfer of images for remote reporting (teleradiology) as needed (e.g. settings where radiologists are not available for on-site reporting).
15. Provide patient information about safety provisions for infection prevention and control (see Appendix E6) as well as for radiation protection.[2]
16. Make provisions to ensure that all patients get the imaging services they need without them suffering financial hardship.

In Press

Recommnedation 3

1. Consider the resources needed (budget, health workforce, personal protective equipment, imaging equipment), the need to adapt the clinical workflow and the need to deprioritize other indications for imaging.
2. Consider performing RT-PCR tests of suspected cases within 24 hours and implement precautions until results are available.
3. Consider that home isolation may not be feasible in certain settings (e.g. overcrowded households, densely populated cities).
4. If available, low-dose CT can be performed on adult patients. For paediatric patients, chest radiography would be favoured. Consider the potential harms from exposure to ionizing radiation, in particular for pregnant women and children.
5. Favour the use of portable equipment for performing chest radiography in isolated rooms in the emergency department.
6. Consider the possibility of false negative imaging results in patients for whom chest imaging indicates no findings suspicious of COVID-19 (particularly during the first two days after symptom onset).
    a. If discharged from the emergency department or other outpatient assessment setting, patients need to abide by the local public health measures (e.g. quarantine, social distancing) until definitive RT-PCR diagnosis is made.
    b. If the patient is admitted, health care workers need to consider appropriate clinical precautions until a definitive RT-PCR diagnosis is made.
7. When using chest radiography and chest CT, minimize radiation dose while maintaining diagnostic image quality (e.g. low-dose scanning protocols), and use digital imaging rather than film-screen equipment.[2]
8. When using chest radiography, a dedicated portable unit (if possible) is preferable.
9. Ensure proper use of personal protective equipment by health care workers and proper disinfection of equipment and devices (see Appendix E6).
10. Provide appropriate training of radiologists and technologists in COVID-19 for safe practices relating to infection transmission and self-protection and ensure an efficient management of typical imaging findings of COVID-19 through accepted local protocols.
11. Consider the transfer of images for remote reporting (teleradiology) as needed (e.g. settings where radiologists are not available for on-site reporting).
12. Set policy/pathway for use of imaging related to COVID-19 illustrated with flow charts, infographics and/or other decision support tools locally developed and accepted.
13. Inform the patient about safety provisions for infection prevention and control (see Appendix E6) as well as for radiation protection.[2]
14. Make provisions to ensure that all patients get the imaging services they need without them suffering financial hardship.

Recommendation 4

1. Implement the recommendations based on your equipment availability. Consider the resources needed (budget, health workforce, personal protective equipment, imaging equipment), the need to adapt the clinical workflow, and the need to deprioritize other indications for imaging.
2. If available, low-dose chest CT can support the decision on regular ward admission versus ICU admission. Chest radiographs are preferred for follow-up in regular ward admission. Patients with rapid progression of COVID-19 pneumonia or diffuse lung damage need ICU admission.
3. Consider the possibility of false negative imaging results in patients for whom chest imaging indicates no findings suspicious of COVID-19 (particularly during the first 2 days after symptom onset).
4. Health care workers need to consider appropriate clinical precautions until the definitive RT-PCR diagnosis is made. Ensure proper use of personal protective equipment and proper disinfection of equipment and devices (see Appendix E6).
5. When using chest radiography and chest CT, minimize radiation dose while maintaining diagnostic image quality (e.g. low-dose CT protocols) and use digital imaging rather than film-screen equipment.[2]
6. Consider the potential harm from exposure to ionizing radiation, in particular for pregnant women and children.
7. When performing chest radiography, using a portable device is preferable.

In Press

8. Provide appropriate training of radiologists and technologists in COVID-19 for safe practices relating to infection transmission and self-protection and ensure an efficient management of typical imaging findings of COVID-19 through accepted local protocols.
9. Consider the transfer of images for remote reporting (teleradiology) as needed (e.g. settings where radiologists are not available for on-site reporting).
10. Set policy/pathway for use of imaging related to COVID-19 illustrated with flow charts or diagrams locally developed and accepted.
11. If clinical condition permits, inform the patient about safety provisions for infection prevention and control (see Appendix E6) as well as for radiation protection.[2]
12. Make provisions to ensure that all patients get the imaging services they need without them suffering financial hardship.

Recommendation 5

1. Bedside lung ultrasound can be helpful to explain respiratory gas exchange deterioration and detecting pleural complication in ICU patients.
2. Portable equipment is preferred for follow-up of ICU patients. Bedside chest radiography can be helpful for dynamic evaluation of COVID-19 pneumonia and its complications. Resolve or progress in lung consolidation on bedside chest radiography can inform the therapeutic management. Chest imaging can inform management of pneumothorax or pneumomediastinum.
3. Daily chest radiographs in stable patients are not necessary and may increase the risk of viral transmission to health care workers.
4. When complications are suspected, in particular pulmonary arterial thrombosis or thromboembolism, contrast-enhanced CT may be considered, after weighing the potential risks and benefits.

Recommendation 6

1. Consider radiological findings along with clinical and laboratory data.
2. Implement the recommendations based on your equipment availability. Consider the resources needed (budget, health workforce, personal protective equipment, imaging equipment), the need to adapt the clinical workflow, and the need to deprioritize other indications for imaging.
3. Decision to discharge should be based more on clinical stability and two negative RT-PCR tests at least 24 hours apart.
4. Implement re-evaluation for patients who had severe form of the disease, to depict fibrotic changes.
5. Keep a record of the explorations carried out.
6. When using chest radiography and chest CT, minimize radiation dose while maintaining diagnostic image quality (e.g. low-dose scanning protocols) and use digital imaging rather than film-screen equipment.[2] Portable chest radiography equipment is preferable.
7. Consider the potential harm from exposure to ionizing radiation, in particular for pregnant women and children.
8. Ensure proper use of personal protective equipment by health care workers and proper disinfection of equipment and devices (see Appendix E6).
9. Provide appropriate training of radiologists and technologists in COVID-19 for safe practices relating to infection transmission and self-protection and ensure an efficient management of typical imaging findings of COVID-19 through accepted local protocols.
10. Consider the transfer of images for remote reporting (teleradiology) as needed (e.g. settings where radiologists are not available for on-site reporting).
11. Set policy/pathway for use of imaging related to COVID-19 illustrated with flow charts, infographics and/or other decisions support tools locally developed and accepted.
12. Provide patient information about safety provisions for infection prevention and control (see Appendix E6) as well as for radiation protection.[2]
13. Make provisions to ensure that all patients get the imaging services they need without them suffering financial hardship.

Monitoring and evaluation

We identified outcome and performance measures that can be used to measure the impact of the recommendations provided in this guide. They could help set up baselines against which to assess changes resulting from the implementation of this guide and provide a framework to facilitate the generation of comparable information in a standardized manner. The measures that are relevant to both diagnostic and management recommendations include: monitoring the number of requested chest imaging investigations related

to COVID-19 and judge their adequacy; monitoring the impact of COVID-19-related chest imaging in different clinical scenarios on institutional and national resources (human and financial); monitoring the appropriate implementation of workflow and infection prevention and control measures (e.g. personal protective equipment); and monitoring the number of cases of COVID-19 infections among hospital staff attributable to COVID-19-related chest imaging. The measures that are relevant to only the diagnostic recommendations include: comparing the results of COVID-19-related chest imaging with the results of RT-PCR (once available); and monitoring the impact of chest imaging on patient stratification into different COVID-19 related risk profiles. Finally, the measures relevant to management recommendations include: monitoring the use of portable radiography equipment; and monitoring the request of CT pulmonary angiography in suspected and confirmed COVID-19 patients.

Research priorities

We identified some research priorities in areas where the certainty of the available evidence is low or very low, or where evidence is lacking. Those relevant to both diagnostic and management recommendations are:

- Conduct randomized controlled trials to compare the effects of using the different imaging modalities and using no imaging (in addition to clinical judgement) on clinical and health services outcomes of interest, for the questions addressed in this guidance.
- Evaluate access and health insurance coverage of chest imaging services related to COVID-19 in different settings.
- Study the role of artificial intelligence in chest imaging in different settings.
- Assess the incidence of COVID-19 infections among hospital staff attributable to chest imaging of patients with COVID-19 (e.g. in radiologists and radiographers).
- Evaluate the implementation of workflow developed for COVID-19-related chest imaging.
- Evaluate the safety and effectiveness of performing portable chest radiography, with and without RT-PCR testing, at home.
- Evaluate the impact of COVID-19-related imaging on institutional and national resources (human and financial).
- Evaluate the impact of COVID-19-related imaging on equity.
- Assess the values and preferences of different stakeholders for relevant chest imaging modalities in different settings.

Research priorities relevant to diagnostic recommendations include:

- Conduct well designed studies to assess the diagnostic accuracy measures of the different imaging modalities. These studies should ideally be cohort studies of patients with suspected or confirmed COVID-19 that clearly describe the disease severity and use adequate reference standard (serial RT-PCR and/or clinical follow-up) and clearly defined criteria for positive imaging.
- Study the characteristics of the chest imaging findings in suspected COVID-19 cases who eventually turn out to be positive.
- Study the diagnostic value of chest imaging in asymptomatic contacts who eventually become symptomatic.
- Assess the frequency of radiological findings of COVID-19 in asymptomatic contacts who are scheduled for urgent or non-urgent interventions (e.g. cardiac catheterization, surgery, endoscopy).
- Study the findings of CT pulmonary angiography in patients with COVID-19, particularly those with severe and moderate symptoms.

Finally, those relevant to management recommendations are:

- Evaluate the prognostic value of chest imaging findings during hospital admission regarding inpatient clinical outcomes (risk stratification), and duration of hospital stay.
- Evaluate the prognostic value of chest imaging findings upon discharge regarding post-discharge clinical outcomes (risk stratification) and readmission rates.
- Evaluate the correlation between radiological improvement and clinical improvement in patients with COVID-19.
- Assess the proportion of patients with COVID-19 infection who have pulmonary sequelae on follow-up imaging.
- Assess the value of different imaging modalities in assessing the short- and long-term complications of COVID-19.
- Evaluate the COVID-19 community transmission attributed to patients who are discharged based on negative findings in chest imaging.

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Appendix E6. Infection prevention and control for chest imaging in patients with suspected or confirmed COVID-19

Introduction

Modifying working practices and training staff in the proper use of personal protective equipment and in the application of safe clinical imaging techniques, combined with environmental control and equipment disinfection are essential during the COVID-19 pandemic to reduce the risk of infection transmission to patients and staff. This focuses on the imaging modalities referred in the guide recommendations. Building upon WHO guidance on COVID-19 infection prevention and control in health care settings, [3-5] this addresses good practices for infection prevention and control for front-line staff performing imaging procedures during the COVID-19 pandemic. Additionally, it describes specific infection prevention and control measures necessary while undertaking chest radiography both in the general imaging department and with portable radiography equipment, as well as when undertaking chest CT and lung ultrasound scans.

General considerations

A checklist is provided on infection prevention and control when performing chest imaging in patients with suspected or confirmed COVID-19. Information in Table E1 is applicable to all imaging modalities addressed.

In addition, it is important to remember that those undertaking imaging procedures are at the front line of the healthcare service, so they must follow existing local guidance/protocols. In general, the chest imaging procedures recommended in this guide require following droplet and contact precautions. Airborne precautions are reserved for aerosol-generating procedures (e.g. bronchoscopy, tracheotomy, cardiopulmonary resuscitation, non-invasive ventilation, intubation, nebulization, open suction).[6] Below is a list of additional infection prevention and control considerations and best practices.[3,7,8]

General environment

- Schedule appointments to reduce numbers of patients in the waiting room. Designate a waiting area, which should be set up to adopt international guidelines for social distancing of at least 1 metre minimally or whenever possible adapt to local or national guidelines (e.g. 2 metres is adopted in some settings).
- Screen all patients and visitors using standardized checklists for symptoms of acute respiratory infection, significant travel history, occupation, contacts, etc.
- Triage patients to perform imaging in only urgent cases.
- Extend times between scans to allow for cleaning and disinfecting.
- When possible, schedule suspected or confirmed COVID-19 patients at end of clinic day.
- Inform superiors/other healthcare professionals/colleagues which patients are suspected or confirmed prior to imaging.

Image acquisition and reporting

- Apply radiation protection principles (justification and optimization) and radiation safety standards where relevant. [2]
- Adjust protocols to reduce exposure and speed up throughput while maintaining quality.
- Always ensure the image quality is diagnostic before leaving the patient.
- In settings where a picture archiving and communication system (PACS) is available, ensure the image is received and available in PACS ready for reporting.
- Images should be reported, and the report communicated to the requesting physician immediately.

Personal protective equipment and hand hygiene

- Ensure that appropriate personal protective equipment is available for staff, that all staff are trained in infection prevention and control measures including hand hygiene, donning and doffing of personal protective equipment3, and that they know how to use it based on local risk assessment and according to national/international guidance.
- Ensure staff have the resources, training and ability to practice the WHO 5 moments for hand hygiene. All practitioners should perform hand hygiene before and after all patient contact, contact with potentially infectious material (e.g. linen from patient room), and before putting on and after removing personal protective equipment including gloves.
- Personal eye glasses do not provide adequate eye protection. If necessary, a face shield or goggles should be worn over personal eyeglasses. If staff wears eyeglasses, be careful not to touch them

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throughout the procedure, or during doffing of personal protective equipment. Personal eyeglasses can be cleaned and disinfected after personal protective equipment has been removed if soiling has occurred or there has been potential contamination during the doffing process.

- Wear a medical mask and follow droplet-contact precautions when interacting with a patient with suspected or confirmed COVID-19, unless performing an aerosol generating procedure (AGP), whereby additional protection, such as an N95 respirator, is required.

Staff considerations

- Split staffing into multiple shifts to limit exposure of the entire team, ensuring appropriate skill and experience whenever possible. Encourage staff to maintain >1meter distance between one another when working and during breaks.
- Do not allow staff who are potentially ill to work.
- For certain imaging procedures, such as CT, when a patient is suspected or confirmed to have COVID-19, use infection control acquisition techniques in pairs as required. This can be also applied in procedures performed with portable equipment. This is implemented by having one staff who will operate the equipment, who would not need personal protective equipment if only operates the console in a separate area (this may not apply in bedside imaging with portable equipment) while the other, having contact with the patient should wear appropriate personal protective equipment.
- In addition to self-monitoring and reporting for COVID-19 symptoms, the unit supervisor should keep records of on-site imaging staff health status when they arrive at work. Encourage staff to stay home if respiratory symptoms or fever.

Equipment decontamination

- Separate cold/blue/clean from hot/red/contaminated designated areas.
- Clean and disinfect all high touch surfaces including patient couches, chairs, door handles in the waiting room and imaging room, following local protocols.
- Ensure protocols for cleaning and disinfection of all medical equipment are in place according to manufacturer's instructions for use.
- Ensure adequate ventilation of the premises. Vacuum/negative air pressures would not be required in routine chest imagine procedures. Where necessary, there may be a room for imaging procedures that may generate aerosols, and this room should be adequately ventilated (i.e. natural ventilation with air flow of at least 160 L/s per patient or in negative- pressure rooms with at least 12 air changes per hour (and controlled direction of air flow when using mechanical ventilation)
- There is no need to wait for air exchanges unless there was an aerosol generating procedure
- Keep all surfaces free of unnecessary paper, and non-essential material to allow for rapid and effective disinfection-decontamination of areas and equipment.

Training and education

- Always work within the scope of practice and job role.
- Remove students/trainees from high risk scenarios.
- Activate retired/vacationing radiographers/technologists when possible, ensuring appropriate risk assessment, access to supervision and refresher training is available.
- Ensure that all staff are trained in donning and doffing of personal protective equipment, hand hygiene and local infection prevention and control protocols [5]

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Table E1. Infection prevention and control when performing chest imaging in patients with suspected or confirmed COVID-19

	Imaging personnel tasks	Patient considerations	Equipment considerations (fixed and portable)	Environmental considerations of imaging room
Preparation	• Explore whether the imaging procedure would change patient management, and/or assess if the procedure could be delayed. • Assess whether portable imaging is an option for suspected and confirmed COVID-19 cases. • Evaluate risk factors (age>60 years, comorbidities, serious underlying medical conditions, immunosuppressive condition, pregnancy, mental health concerns, etc.). • Perform hand hygiene and don personal protective equipment with all appropriate steps. • Use personal protective equipment during transfer to department when portable imaging equipment unavailable. • Ensure that the imaging protocol and patient identification procedures are followed.	• Verify imaging request and check whether imaging is required urgently. • Determine whether patient will come to imaging department or whether portable imaging is possible/ necessary. • Inform all patients of the need for hand hygiene, and the use of tissues or elbow when coughing or sneezing. Upon arrival for chest imaging, supply masks to patients (and caregivers, if present) upon arrival, if available and if patient able to tolerate.	• Ensure infection prevention and control measures are employed when managing the imaging equipment. • The imaging equipment must be subject to regular cleaning and disinfection, consistent with local infection prevention and control guidance and cleaning schedules completed, signed and dated. • Remove unnecessary equipment from imaging room. • Determine whether the examination can be performed with portable imaging equipment. • Cover equipment that cannot be moved with plastic or other suitable material.	• Ensure infection prevention and control measures are employed when managing the imaging room. • The imaging room must be subject to regular cleaning and disinfection, consistent with local infection prevention and control guidance and cleaning schedules completed, signed and dated. • Verify that terminal cleaning and disinfection of the imaging room occurred at end of day the previous day. If not done (or not verifiable) ensure that terminal cleaning and disinfection of the imaging room is performed before starting.
During	• Ensure appropriate personal protective equipment worn. • Employ " contact and non-contact radiographer/technologist" scenario of chest radiography, CT and ultrasound. • Ensure single patient attendance to the imaging department wherever possible to enable further imaging, if this is required.	• Provide medical mask to the patient (if feasible), as well as comfort and reassurance.	• Ensure standard operating procedures for infection prevention and control according to local guidance, contact minimization and barrier precautions in place (e.g. suitable covers whenever possible).	• Control access to imaging room or patient area during the portable radiography procedure. • Consider appropriate signage/visual alerts in front of imaging room (e.g. patient inside/arriving, ongoing cleaning/disinfection, time of last cleaning/disinfection).
Post procedure	• Ensure imaging review is made appropriately and apply local protocols to follow up clinical and infection prevention and control actions, if/as required. • If the chest imaging procedure was performed at the imaging department, staff should wear personal protective equipment during patient transfer. • Ensure personal protective equipment is taken off appropriately, if used.	• Ensure rapid delivery of the imaging results to guide management.	• Ensure appropriate decontamination of medical equipment between patients (applicable to both fixed and portable equipment).	• Ensure appropriate environmental cleaning and disinfection (focus on high touch surfaces) between patients. Staff performing this task will be trained on cleaning and disinfection and should wear appropriate PPE. • If bedside imaging was performed using portable equipment, room cleaning and disinfection should occur following the protocols applicable for the specific setting (e.g. emergency room, regular ward, intensive care unit)

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Specific considerations

Chest radiography:

- Where possible, designate a portable imaging unit for investigation of suspected or confirmed COVID-19 cases and leave this within the patient care area to reduce transmission risk.
- Use direct digital radiography (DDR) imaging whenever possible to reduce transmission risk and minimize radiographer workload.
- Designate one or two image receptors specific for patients with COVID-19 if computed digital radiography (CDR) or film/screen technology is to be used.
- Adjust radiography technique in accordance with the patient's condition e.g. anteroposterior with the patient supine or posteroanterior with the patient prone on intensive care unit wards.
- Cover X-ray detector/cassettes with plastic cover or disposable cellophane wrapper and make sure to clean X-ray cassette in between each patient.
- Ensure positioning sponges of X-ray table or vertical Bucky stand and immobilization straps are covered with plastic protection.
- Remove all radiopaque objects in the region of interest from the patient.
- Preferably work in pairs with one radiographer to facilitate contact/non-contact technique.
- Ensure the radiographer undertaking the radiography with the portable imaging equipment stands outside the controlled area, without physical contact with the team or any object.
- Image acquisition/exposure should be made by the non-contact radiographer, ensuring the radiation protection principles (i.e. justification of procedures, optimization of protection and safety, radiation dose limitation for workers and public), as well as the radiographer/radiological technologist ethical code and professional rights at all times.[2,9]
- If working alone (i.e. not in pairs) use gloves and consider the X-ray equipment and mobile control screen keys as contaminated. Ensure hand hygiene after removal of gloves.
- Check image for optimum quality before sending it to the picture archiving and communication system.
- Clean and disinfect all imaging equipment, including the portable X-ray machine, X-ray couch and vertical Bucky stand between each patient.
- When performing imaging, both within the department and when using portable equipment, wherever possible, one radiographer positions the X-ray tube and makes the exposure, and the second radiographer positions the patient and the covered detector and applies the anatomical marker.

Computed tomography (CT):

- Consider implementing a containment zipper (a room isolation tarp barrier with a zipper for room access) to separate the control area from the CT scanner room. Practice infection control in accordance with national public health guidelines, relevant department policies and instructions from the committees responsible for hospital infectious diseases control and hospital waste management.
- Avoid crowding and maintain the safety distance of at least 1 meter or where possible 2 meters.
- Remove any metallic objects in the region of interest from the patient very carefully (especially when it comes to artificial dentures where there is a risk of getting infected).
- Perform examination (i.e. scanning and intravenous contrast media injection) in consideration of the diagnostic requirements and the principles of justification, optimization, radiation dose limitation as well as the radiographer/radiological technologist ethical code and professional rights at all times.
- Note which personnel are involved in and present during the procedure.
- Single use CT couch paper cover is removed and disposed of into the corresponding bin according to hospital policy.
- CT gantry controls and contrast media injector control screen keys are considered contaminated and must be used with gloves.
- The CT console keyboard, mouse and exposure pad as well as the contrast media injector remote control panel are considered clean and may be used without gloves.
- Contrast media injector control panel may be covered with a disposable plastic cover.
- Separate clean console area from contaminated CT room area where the radiographer/radiological technologist must remove gloves and wash hands before entering the console area.

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- When performing CT on patients confirmed with COVID-19, radiographers/radiological technologists must follow the instructions and guidance of the hospital committee responsible for infectious disease control.
- However asymptomatic patients pose a latent threat for medical imaging and therapy departments and hence radiographers/radiological technologists in CT are advised to follow the instructions divided in three stages (i.e. preparation, during and post procedure; see table 1).

Ultrasound:

- Lung ultrasound presents specific challenges. The first is physical proximity to the patient: this is usually within1 m and may be as little as 30–50cm; ultrasound rooms are typically small, ventilation may be restricted and seldom are there windows; examination time may last between 10 and 60 minutes; patients may be asked to inhale/exhale deeply and hold their breath.
- If possible, designate a specific ultrasound room and machine and probes for use on patients with COVID-19.
- Adjust schedule (appointment times) to avoid crowding in the waiting room and to allow time between appointments for decontamination of the ultrasound system and room.
- Best practice is to have patient attend examination alone.
- The ultrasound health care workers should follow droplet and contact precautions (airborne precautions required only for aerosol-generating procedures). They should use surgical/medical facemask. For any aerosol-generating procedures, an N95/FFP2/FFP3 medical protective mask or PAPR Powered Air Purifying respirators or respirators that offer a higher level of protection should be used.
- The ultrasound health care workers should don personal protective equipment (including long sleeved gowns and gloves) when the patient is suspected or confirmed for COVID-19.
- Shorten duration of examination by arranging for the most experienced professional available to perform the examination. Single use ultrasound gel sachets should be considered for patients suspected or having COVID-19.
- Reduce the number of probes connected to the ultrasound machine to a minimum and remove all other probes from unit or store in closed cabinet to avoid the necessity of high-level disinfection in the event the patient coughs or sneezes during the procedure.
- Separate inpatients on the ward from outpatients.
- Cover the equipment such as the ultrasound scanner console to contribute to infection prevention and control and in this way enhance workflow.
- Follow manufacturer's recommendation for decontamination of ultrasound system.
- Follow local protocols for appropriate decontamination of ultrasound probes between patients.
- Cleaning of probes includes three disinfection levels: non-critical, semi-critical and critical.[10] Probes used for lung ultrasound would typically be in the first category, since they are usually in contact with intact skin (i.e. noncritical devices). However, all three levels are described below to cover any other possible scenario that would deserve a higher-level disinfection.
    - Noncritical devices: ultrasound probes that come in contact with intact skin can be cleaned and disinfected using low- or intermediate-level disinfection.
    - Semi-critical devices: ultrasound probes that come in contact with non-intact skin, blood, body fluids and/or mucous membranes should be cleaned and disinfected using the high level disinfection method. A single use probe cover is mandatory.
    - Critical devices: ultrasound probes must undergo sterilization if compatible or, if not available, high-level disinfection as per medical facility guidelines. Use of sterile transducer cover if mandatory.
- In the context of COVID-19, the normal practices of high-level disinfection are not changed. The only change in the context of COVID-19 is that all external probes must undergo cleaning followed by low-level disinfection to denature any presence of SARS-CoV-2.

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