# Oxford COVID-19 Evidence Service

# Are there any evidence-based ways of assessing dyspnoea (breathlessness) by telephone or video?

## Short answer and clinical bottom line:

We found no validated tests for assessing breathlessness in an acute primary care setting. We found no evidence that attempts to measure a patient’s respiratory rate over the phone would give an accurate reading, and experts do not use this test in telephone consultations. Our search identified a potentially promising test (the Roth score), which needs further research.

Pending further research, **the recommendations below are based on expert opinion**. A rapid survey of 50 clinicians who regularly assess patients by phone (on 20.3.20) recommended not using the Roth score (though opinions were mixed) and gave the following advice:

1. Ask the patient to **describe the problem with their breathing in their own words**, and assess the ease and comfort of their speech. Ask open-ended questions and listen to **whether the patient can complete their sentences**.

*“How is your breathing today?”*

1. **Align with NHS111 symptom checker**, which asks three questions (developed through user testing but not evaluated in formal research):

*“Are you so breathless that you are unable to speak more than a few words?”*

*“Are you breathing harder or faster than usual when doing nothing at all?”*

*“Are you so ill that you've stopped doing all of your usual daily activities?”*

1. Focus on change. **A clear story of deterioration** is more important than whether the patient currently feels short of breath. Ask questions like

*“Is your breathing faster, slower or the same as normal?”*

*“What could you do yesterday that you can’t do today?”*

*“What makes you breathless now that didn’t make you breathless yesterday?”*

1. Interpret the breathlessness in the **context of the wider history and physical signs**. For example, a new, audible wheeze and a verbal report of blueness of the lips in a breathless patient are concerning.

The tools and instruments and tools identified were as follows:

1. **Roth Score.** Easy to use and has been validated in one study against pulse oximetry in healthy volunteers and hospital inpatients but has not been validated in primary care. Ask the patient to take a deep breath and count out loud from 1 to 30 in their native language. Count the number of seconds before they take another breath. If the “counting time” is 8 seconds or less, this has a sensitivity of 78% and specificity of 71% for identifying a pulse oximeter reading of <95%. If the counting time is 5 seconds or less, sensitivity is 91%. Of 50 experts, only 6 used the score (most had never heard of it). They were concerned that if used indiscriminately and as a substitute for holistic clinical assessment in the COVID crisis, this score could lead to harm by increasing the number of patients called in for physical examination.
2. **Smartphone apps for oximetry**: Very limited published research, but one small, single-centre study in hospitalised patients reported high (>98%) correlation between the smartphone reading and the reference device. There are many devices and apps; use readings cautiously in the context of a wider clinical assessment.
3. **Oximetry devices supplied to patients**. Commonly used in respiratory medicine clinics but have not yet been evaluated in a primary care setting.

Searches and critical appraisal undertaken by Dr Koot Kotze and Dr Helene-Mari Van Der Westhuizen, and expert survey by Professor Trisha Greenhalgh from University of Oxford

## Background

There is an increased interest in telemedicine solutions in order to meet the challenges posed by the Covid19 pandemic.1,2 A potential limitation of this is the accurate assessment and risk stratification of patients. A key symptom and physical sign in patients with COVID is dyspnoea (breathlessness), which may indicate low blood oxygen levels. Can dyspnoea be accurately assessed remotely?

Dyspnoea is defined as “a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity”3.Our search therefore focused on approaches that might allow objective quantification of dyspnoea as measured against either pulse oximetry, arterial blood gas measurement, or another reliable indicator of severity.

Existing dyspnoea symptom-based scores (see table 3), such as the MRC Scale, are designed and validated for use in monitoring chronic diseases (such as COPD) with the exception of the vertical visual analogue scale that has been validated for treatment response in acute asthma attacks. However, none of the scales have been validated for use in a setting such as telephone or video consultations in primary care.

Scoring systems to quantify respiratory distress in children, especially in bronchiolitis and asthma exacerbations, are widely used, although there are concerns about the validity and reliability of these scores.4,5 One such score (the Respiratory Clinical Score) has been shown to be nearly as accurate through telemedicine as in face-to-face consultation, but it requires a digital stethoscope or microphone for auscultation and was therefore not included in this review.

Options for assessing breathlessness remotely include the Roth Score,6 smartphone based oximetry devices,7,8 and the provision of oximetry devices to remote patients. The latter strategy is standard in telemedicine interventions in chronic pulmonary diseases9, but we did not find studies of oximeter use in the acute setting by patients or carers.

There is much variability in the oximetry measurement technology between, for example, newer Samsung devices (some of which use a dedicated sensor capable of estimating pulse rate and oxygen saturation) and Apple (which uses the built-in camera and light or a separate device).7,8 Some studies have shown poor correlation between smartphone measurements and those from devices used in the clinical setting,10 and the incidence and impact of user error has not been studied. We would not generally recommend using them in clinical assessments. In crisis situations,

The Roth Score is a potentially useful, easy-to-use tool, which combines maximal count reached (starting from 1 to 30 in one’s native language) during a single exhalation and the time taken to reach the maximum count (the second score is called the “counting time”). It has been validated against pulse oximetry.6 However, only one study describing and attempting to validate this tool exists, and was conducted in hospitalized patients and healthy volunteers. If this tool is to be used in the primary care (or other settings), it should continue to be studied and adapted to the setting. Its use is summarized in the table 4.

## Research question

In patients experiencing dyspnoea (population), what are reliable methods for assessing their respiratory complaints through the use of telemedicine ie video/phone (intervention), compared with face-to-face consultations (comparison) in detecting low blood oxygen saturation, or estimating need for hospitalisation or risk death (outcome)?

We searched for primary research studies assessing methods to evaluate dyspnoea remotely through a tool compared to oximeter, arterial blood gas measurement or other reference standard.

* Inclusion criteria: Primary research studies assessing acute dyspnoea through questionnaire or self-examination or other method available via video or telephone.
* Exclusion criteria: Assessment of chronic dyspnoea, studies that use devices not available through telephone or video interview.

## Sources and searches:

We searched EMBASE and PubMed

Embase: We used the Thesaurus search builder with the terms “dyspnea” OR “hypoxia” OR “oximetry” AND “telemedicine” OR “smartphone” OR “telephone”

This yielded 627 results.

Pubmed: We performed the following search string using the relevant MeSH terms:

("Oximetry"[Mesh] OR "Blood Gas Monitoring, Transcutaneous"[Mesh] OR "Dyspnea"[Mesh] OR "hypoxia"[Mesh]) AND ("Telemedicine"[Mesh] OR "Remote Consultation"[Mesh] OR "Smartphone"[Mesh] OR "Telephone"[Mesh])

This yielded 112 results.

We reviewed the titles and abstracts of the results and identified 18 studies for full-text review.

Based on inclusion/exclusion criteria, we identified 3 studies meeting our inclusion criteria, which we summarized in table 1 and critically appraised in table 2. We have also included a summary of other existing dyspnoea symptom-based scores and a brief description of each and assessment of their applicability to the research question.

## Conclusion

The needs of healthcare systems during the Covid19 pandemic are rapidly evolving. Remote consultations may have to rely on incomplete information in order to make appropriate decisions regarding escalation of care, both for patients with suspected Covid19 disease and other patients in primary care. In the absence of oxygen saturation information, the use of the Roth Score “counting time” may assist primary care health workers in identifying patients in need of further assessment and care.

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| **Table 1: Included studies** |
| **Author, Journal, Year, Country**  | **Aims/objectives, Study type** | **Sampling/recruitment method, No of participants** | **Data collection method** | **Main Findings** |
| Chorin E, Padegimas A, Havakuk O, et al. Assessment of Respiratory Distress by the Roth Score. Clin Cardiol 2016;39:636–9. Israel | Validation study for a novel scoring method against pulse oximetry“This study introduces an index called the Roth score as a tool that uses patient counting times to accurately risk-stratify dyspnea severity in terms of hypoxia.” | The study recruited patients admitted to a cardiac care centre in Tel Aviv. “Inclusion criteria included pulse oximetry on room air requiring 2 L to 6 L nasal cannula oxygen to maintain oxygen saturation >92%. Exclusion criteria included hypoxia requiring advanced non-invasive or invasive oxygenation.”“The patient group consists of 93 individuals (53 males and 40 females) with mean age of 76 +/- 13 years.” “[A]dmission diagnoses were congestive heart failure exacerbation (25%), pneumonia (17%), and acute coronary syndrome (15%);”The control group were 103 healthy volunteers (64 males and 39 females) with mean age of 56 +/- 18 years. | “This score is measured by requesting that the patients take a deep breath followed by counting out loud from 1 to 30 in their native language, in a single breath, as rapidly as possible. The time duration was measured on a stopwatch in seconds from number 1 until the highest number reached. The test was repeated after the subject had taken 3 deep breaths. The result of the Roth score includes 2 measurements: (1) the duration of time elapsed between counting from 1 to 30 in 1 breath, or until the patient took another breath; and (2) the highest number reached in 1 breath. The subjects’ respiratory rate and pulse oximetry on room air were recorded as markers of respiratory distress to evaluate for correlation with their Roth scores.”The participants counted in Hebrew, Arabic, Russian and English and it appears that the averages have been recorded. | (See table 4)“There is a positive strong correlation between the pulse oximetry measurement on room air and both the maximal count achieved in 1 breath (r = 0.67; P < 0.001) and the counting time (r = 0.59; P < 0.001). All individuals in the control group counted to at least 15 in 1 breath, and 97 (94%) counted to at least 20”The scores plotted on a receiver operating characteristics (ROC) curve and the AUC was calculated: “Counting time >8 (sic)\* seconds had a sensitivity of 78% and specificity of 71% for identifying a room-air pulse oximetry <95%. For identifying oxygen saturation <90%, the AUC for maximal count number is 0.843 and for count time is 0.812” \*: (The sentence should have read “<8 seconds”)“Maximal counting number <10 or counting time <7 seconds identified patients with a room-air pulse oximetry <95% with sensitivity of 91% and 83%, respectively. Maximal counting number <7 or counting time <5 seconds identified patients with a room-air pulse oximetry <90% with sensitivity of 87% and 82%, respectively.”  |

**Table 1: Included studies (continued)**

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| **Author,Title, Journal, Year, Country**  | **Aims/objectives, Study type** | **Sampling/recruitment method, No of participants** | **Data collection method** | **Main Findings** |
| Sarah Tomlinson, Sydney Behrmann, James Cranford, Marisa Louie, and Andrew Hashikawa. Accuracy of Smartphone-Based Pulse Oximetry Compared with Hospital-Grade Pulse Oximetry in Healthy Children. Telemedicine and e-Health.Jul 2018.527-535, United States of America  | Validation study that compared: “a camera-based app (CBA), which utilizes the phone's own camera lens and flash with no additional device required” and “a probe-based app (PBA), which is an app designed to use an external probe that connects directly to the smartphone. “ | “81 children ages 2–13 years without a respiratory complaint and a triage SpO2 ‡97% seen in a pediatric Emergency Department.” Children were excluded if they were in the ED for a respiratory-related complaint, if they had underlying cardiac, respiratory, hematologic, or metabolic disease, if they were a trauma patient, if capillary refill time in fingers was >3 s, or if they had nail polish on their fingernails.  | Two investigators obtained heart rate and SpO2 using each app. Inter-rater reliability was tested using interclass correlations (ICCs), and Bland– Altman method was used to compare app values to triage measurements. | The Probe Based App (PBA) was equivalent to standard pulse oximetry (in non-hypoxic children), but the Camera Based App (CBA) that uses the phone's camera and flash was unreliable. “ICC for SpO2 for PBA and CBA were 0.73 and -0.24, respectively. The 95% limits of agreement between the PBA SpO2 and triage SpO2 were -2.8 to +2.5 compared with -4.1 to +3.5 for the CBA SpO2 and triage SpO2. Mean differences between triage SpO2 and the PBA SpO2 (-0.17%) and triage SpO2 and CBA SpO2 (-0.33%) were not statistically significant. “ |

**Table 1: Included studies (continued)**

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| **Author,Title, Journal, Year, Country**  | **Aims/objectives, Study type** | **Sampling/recruitment method, No of participants** | **Data collection method** | **Main Findings** |
| Tayfur I, Afacan MA. Reliability of smartphone measurements of vital parameters: A prospective study using a reference method. *Am J Emerg Med* 2019;37:1527–30. Turkey | This was a study “aimed to evaluate the accuracy of HR and SaO2 data obtained using a smartphone compared with the measurements of a vital signs monitor (VSM) and an arterial blood gas (ABG) device, respectively.” | Convenience sample of 114 patients presenting to an emergency unit in Istanbul. 13 results were excluded due to technical reasons. ”The data of a total of 101 patients, 48 male (47.5%) and 53 female (52.5%), were analyzed.”“The mean age of the male and female patients was 68.08 and 72 years, respectively. According to the age distribution of the patients, the highest number of patients were in the 60–69 years group (25.75%, n=26).” 42% had pulmonary disease.It is not noted how many patients were excluded according to pre-defined exclusion criteria, which were: “patients aged under 18 years, those that did not agree or give consent to participate in the study, those requiring urgent intervention (blue code, unstable patients), those not able to adapt to the measurements with a device (unconscious, confused, etc.), those with a high degree of hypothermia that might adversely affect the measurement from the skin, and those wearing nail polish or false nails.  | “This study investigated the SaO2 and HR measurement reliability and efficacy of a Samsung Galaxy S8 (SM- G950F) smartphone… and the VSM (Welch Allyn, Connex Spot Monitor 71 WT) equipped with a Nellcor probe, and an ABG device (Radiometer ABL800, 754R0428N007), both available in the emergency service. The HR data measured by the smartphone were compared with the HR values obtained from the same VSM simultaneously. The triage nurse/paramedic measured the HR and SaO2 values using VSM and noted them in the study form. The smartphone measurements were undertaken by a second emergency service nurse blinded to the HR and SaO2 values determined by VSM and recorded in another form. The real-time ABG analysis was performed by doctors working in the emergency room on the same day and the results were noted in the ABG section of the study form.” | A Bland-Altman analysis of the results comparing VSM to the smartphone for heart rate and oxygen saturation found aMean difference:Smartphone SaO2 vs Arterial blood gas SaO2:−0.67% (95%CI=−0.845 to−0.494). Correlation coefficient: 0.968 for smartphone SaO2 – ABG SaO2 (95% CI = 0.952 to 0.978).The VSM and Smartphone SaO2 mean difference and correlation coefficient are not reported, and this is problematic as it is the most clinically useful parameter, given that this is the likely application of the study – replacing one form of non-invasive oximetry with another. |

## Critical appraisal:

We used the the BMJ Best Practice guidelines for Diagnostic test studies.11

**Table 2: Critical appraisal of included studies.\***

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| **Question** | **Chorin and colleagues****ROTH SCORE** | **Thomlinson and colleagues****SMARTPHONE OXIMETRY** | **Tayfur and Afacan****SMARTPHONE OXIMETRY** |
| *Was there an independent, blind comparison with a reference (gold) standard of diagnosis?*  | Not really. Patients and controls’ Roth scores were compared to pulse oximetry, which is a reference standard but not the gold standard (blood gas). Researchers were not blinded to the measurements. | No. The children’s SaO2 measurements were compared between two smart phone applications and pulse oximeter measurements taken during triage. The researcher was not blinded to the initial triage measurement or result of the different apps. | Yes. Smartphone SaO2 was compared with blood gas analysis but not pulse oximetry, however, the arterial blood gas measurement was not done simultaneously, but on the same day. Researchers were blinded to the results. |
| *Was the diagnostic test evaluated in an appropriate spectrum of patients (like those a clinician would see in practice)?*  | Yes. The participants were inpatients of a cardiac care centre, with a variety of chronic and acute conditions with a mean age of 76. The healthy population had a mean age of 58. | No. “Children were excluded if they were in the ED for a respiratory-related complaint, if they had underlying cardiac, respiratory, hematologic, or metabolic disease, if they were a trauma patient, if capillary refill time in fingers was >3 s, or if they had nail polish on their fingernails.”  | Yes. Mean age of patients was 72 years and 42% suffered from pulmonary disease. |
| *Was the test validated in a second independent group of patients?*  | Yes. A control group of healthy volunteers was also included. | No | No |

\*: The question **“***Was the reference standard applied regardless of the index diagnostic test result?”* was omitted as this was not applicable to these studies.

**Table 3. Selected overview\* of symptom-based measuring scores for dyspnoea:**

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| --- | --- | --- | --- |
| **Scale** | **Structure and Target population** | **Validation** | **Applicable to new onset dyspnoea?** |
| Medical Research Council (MRC) Scale12 | Measures [perceived respiratory disability](https://mrc.ukri.org/research/facilities-and-resources-for-researchers/mrc-scales/mrc-dyspnoea-scale-mrc-breathlessness-scale/#definition) by matching tasks with breathlessness, eg. ‘I only get breathless with strenuous exertion’ (Grade 1) or ‘I am too breathless to leave the house’ (Grade 5). Used in COPD, IPF, Sarcoidosis, pulmonary rehabilitation, chronic heart failure. | Widely used for past 50 years due to simplicity. Validated for COPD.12Is insensitivity to change, for example in COPD it is uncommon for someone to move between grades. 13 | This scale is the simplest to use but has not been validated as a tool for the management of new onset dyspnoea in previously well patients, or matched to oxygen saturation levels. |
| [Oxygen Cost Diagram (OCD)](https://www.resmedjournal.com/article/S0954-6111%2899%2990266-4/pdf)14 | Measures patient’s evaluation of their tolerance to exercise | Used in COPD clinical trials, but does not correlate with other measures (FEV, FVC, PaOz, PaC02,)14 | Not applicable |
| Baseline and Transition Dyspnoea Indices15 | Includes measurement of functional impairment (the degree to which activities of daily living are impaired) and magnitude of effort (the overall effort exerted to perform activities), in addition to magnitude of task | Used for COPD intervention trails. | Not applicableTakes 5 minutes to administer. |
| University of California at San Diego Shortness of Breath Questionnaire (UCSDQ)16 | 24-item questionnaire measuring dyspnea during the past week  | Used for COPD intervention trails. | Not applicable |

**Table 3. Selected overview\* of symptom-based measuring scores for dyspnoea (continued):**

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| Vertical Visual Analogue Scale17 | The anchors on the scale have not been standardized, but “not breathless at all” to “extremely breathless” are frequently used. | Construct validity of the Vertical Visual Analogue Scale as a measure of dyspnoea in both acute and chronic populations - included asthma and COPD.Used as a measure for nurses to assess response to treatment in acute setting. | Construct validity done in acute setting for asthma. Not used as an acute assessment tool, but used to measure treatment response.Difficult to use in telephone consultations without video as health worker needs to show a picture of the scale. |
| Dyspnoeia-12 Scale18 | “Provides a global score of breathlessness severity that incorporates both “physical” and “affective” aspects.” | “The “Dyspnoea-12” had good internal reliability (Cronbach’s alpha = 0.9) and fit to the Rasch model (χ2 p = 0.08). Mean Dyspnoea-12 score was strongly associated with HADS scores (anxiety r = 0.51 and depression r = 0.44, p<0.001). Dyspnoea-12 correlated significantly with FEV1 (r = −0.30, p = 0.03), 6MWD (r = −0.38, p<0.01) and MRC grade (r = 0.48, p<0.001).” | No, targetted towards chronic causes of dyspnoeia that impairs quality of life. |

# \*= Existing systematic reviews on ‘Measurement of breathlessness in advanced disease19 (focussing on progressive disease with limited prognosis) and Studies of the symptom dyspnoea: A systematic review20 (focussing on the frequency and causes of dysnoeia) were identified but deemed not relevant. This is a selection of studies mentioned in these reviews.

**Table 4: Using the Roth Score to assess Dyspnoea in Adults**

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| **Step 1:** Ask the patient to take a deep breath and to count as fast as they can from 1 to 30 in a single breath in their native language. Time them from the count of 1 until they stop to take a breath. |
| **Step 2:** The amount of time it takes for the patient to have to take a breath in is the **counting time**. The highest number they reached while counting with one breath is the **highest number reached**. |
| **Score** | **Interpretation** |
| Counting time is 8 or less  | Will detect 78% of persons with pulse oximetry less than 95% |
| Counting time is 5 or less | Will detect 91% of persons with pulse oximetry of <95% |
| Highest number reached is 10 or less | Will detect 91% of persons with pulse oximetry of <95% |
| Highest number reached is 7 or less | Will detect 100% of persons with pulse oximetry of <95% |
|  | **SaO2 <95% on Room Air** | **SaO2 <90% on Room Air** |
| **Highest number reached** | **Sensitivity, %** | **Specificity, %** | **Sensitivity, %** | **Specificity, %** |
| 7 | 100 | 30 | 87 | 48 |
| 10 | 91 | 43 | 78 | 68 |
| 15 | 83 | 71 | 57 | 100 |
| 20 | 57 | 87 | 32 | 100 |
| **Counting time in seconds (How long they can count with one breath)** | **Sensitivity, %** | **Specificity, %** | **Sensitivity, %** | **Specificity, %** |
| 5 | 91 | 34 | 82 | 56 |
| 6 | 83 | 49 | 71 | 72 |
| 7 | 83 | 63 | 63 | 88 |
| 8 | 78 | 71 | 53 | 92 |
| 9 | 65 | 81 | 41 | 100 |
| 10 | 57 | 87 |  |  |
| 11 | 39 | 89 |  |  |
| 12 | 26 | 90 |  |  |
| 13 | 17 | 96 |  |  |

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