EVIDENCE SUMMARY

Should pulse oximetry be used for at-home monitoring of COVID-19 patients?

Evidence Reviewers: Mica Olivine Bastillo-Casillan MD, Howell Henrian G. Bayona MSc, Michelle Cristine B. Miranda MD

RECOMMENDATION

We suggest pulse oximetry with close clinical monitoring by qualified medical personnel in suspected and confirmed COVID-19 patients especially those who are at high risk for deterioration. *(Very low certainty of evidence; Weak recommendation)*

Consensus issues
A weak recommendation was made due to the limitations and risk of inaccuracy of pulse oximeters. The panel emphasized (1) ensuring the quality of the device by purchasing from reliable sources and (2) taking measures to get the best reading (e.g., following manufacturer instructions and ensuring adequate battery supply).

Considering the risk of inaccurate measurements that may result in unrecognized low oxygen saturation levels, the role of qualified medical personnel in pulse oximetry monitoring was highlighted by the panelists. Medical personnel should be available to provide instructions, respond to caregiver and/or patient concerns, and monitor signs and symptoms of deterioration.

Key Findings

- A total of 20 observational studies on pulse oximetry monitoring for suspected and confirmed COVID-19 patients were included in this review.
- Effect estimates could not be pooled due to serious heterogeneity across studies. Lowered percentages of admissions, readmissions, and mortalities with pulse oximetry monitoring compared to no monitoring suggest feasibility and safety of remote monitoring using pulse oximetry but the certainty of evidence was very low.
- A single study on device accuracy showed that medical and consumer-grade pulse oximeters, particularly *Oxywatch* (Sn 92.2%, 95% CI 87.3-97.1; Sp 60%, 95% CI 49.59-70.41), *SM* (Sn 90.7%, 95% CI 85.7-95.7; Sp 67.6%, 95% CI 56.7-78.5), and *Onyx* (Sn 92.1%, 95% CI 87.3-96.8; Sp 67.6%, 95% CI 56.9-78.2), were comparable to standard emergency department (ED) monitor units.
- Another study reported that certain levels of oxygen saturation (SpO_2) have high sensitivity and specificity for risk of mortality and intensive care unit (ICU) admission. However, the overall certainty of evidence for this outcome was very low because of non-blinding, imprecision, and significant heterogeneity.

Introduction

While most patients with COVID-19 eventually recover after an initial five to seven days of viral syndrome, around 10-20% would likely deteriorate.[1] Furthermore, there have been reports of patients with no overt signs of respiratory distress but present to the hospital with lower than expected oxygen saturation levels or hypoxemia. Hypoxemia is defined as measured oxygen

saturation of 94-98% or below (or below 88% for those with chronic lung disease).[4] The presence of hypoxemia is common in severe COVID-19 related pneumonia, sepsis, myocardial dysfunction, or embolic disease.[5] This phenomenon, informally called, “silent hypoxemia” or “happy hypoxemia,” describes patients with clinically significant hypoxemia (SpO_2<90%) in the absence of dyspnea and often appear clinically well. Many of these patients were reported to have radiographic findings similar to ARDS and eventually required intubation.[1]

Determining oxygen saturation therefore helps in triaging patients between who will need hospitalization and further management, and those who can be managed and monitored at home. This method may allow early detection of signs of possible clinical deterioration, which may consequently help decongest hospitals. Healthcare systems all over the world have employed remote pulse oximetry along with other methods (e.g., monitoring vital signs, symptoms, teleconsultation) to reduce unnecessary ED visits, exposures, and PPE use.[6-9] Pulse oximetry may be a cost-effective method due to its relatively low cost, portability, non-invasiveness, and ease of use.[2,10]

This review aimed to determine whether pulse oximetry, with or without other parameters, is useful, accurate, and safe in monitoring patients with COVID-19 for the detection of clinical deterioration and, consequently, appropriate triaging of patients.

Review Methods

Systematic literature search until 04 October 2021 was performed in the following electronic databases: PMC, MEDLINE, Cochrane CENTRAL, Google Scholar, CoAP Living Evidence on COVID-19. For the search strategy, keywords searched were MeSH terms and those in study titles. The following keywords were used: "coronavirus infections" [MeSH Terms], novel coronavirus, nCOV, covid-19, SARS COV2; Pulse Oximetry [MeSH Terms] oximeter, oximetry; monitoring; home, outpatient, pre-hospital.

Inclusion criteria for this review were as follows: (a) population - individuals with suspected or confirmed COVID-19, (b) setting - in-home monitoring and care, (c) index test/intervention - pulse oximetry monitoring (using portable, fingertip, or commercially-available pulse oximeters) with or without other measures (e.g., monitoring symptoms, vital signs, breathlessness, perceived deterioration), (d) outcomes - diagnostic accuracy for identifying COVID-19 pneumonia (compared to RT-PCR with or without thoracic imaging as reference standard), impact on other clinical outcomes, and associated adverse effects, and (e) design - randomized controlled trials, observational studies, systematic reviews of RCTs or observational studies. References of guidelines and practice pointers obtained from literature search were also checked and included if it reported pulse oximetry accuracy, use, feasibility, validity, benefits, or harms.

Studies were excluded if oxygen saturation levels were not monitored for all participants, if a study used smartphones or other devices to measure oxygen saturations, or if it did not report the desired outcomes. QUADAS-2 was used to assess the risk of bias. From the studies obtained during literature search, references for focused reviews and practice pointers were checked for eligible studies. Among them was a systematic review on remote monitoring for COVID-19 (suspected and confirmed) patients.[11] Studies that employed portable pulse oximetry home monitoring for all patients in this review were included in the analysis.

Results

Summary of characteristics of included studies

A total of 20 studies were included in this review, among which were one cross-sectional or cohort type accuracy, four case-control, and 15 cohort studies. One study evaluated the diagnostic accuracy of three different pulse oximeter brands (consumer-grade, medical-grade pulse as compared to standard oximeter monitor in the ED).[12] Another study reported the correlation of pulse oximetry monitoring to mortality or ICU admission.[13] Majority of the studies (n=18) described a program or model of remote patient monitoring (RPM) for patients referred from the community, seen at outpatient department (OPD), at ED, or from hospital discharge, or all sources, all of which included oxygen saturations as one of the parameters monitored. These studies reported on one or more of the following clinical outcomes: escalation/referral rates, ED attendance/ reattendance, hospitalization, length of hospital stay, ICU admission or complications and mortality. Three studies [10,14,15] presented measures of patient satisfaction while two studies [16,17] reported cost of monitoring.

Diagnostic accuracy of pulse oximeter

Schrading et al. [12] showed that both medical-grade (Nonin Onyx II 9550*, Onyx*) and consumer-grade pulse oximeters (Walgreen's OxyWatch C20*, OxyWatch* and Santa Medical SM-1665*, SM*) demonstrated high sensitivity in detecting true hypoxia ($SpO_2 \leq 94\%$ on standard ED oximetry monitoring unit) as compared to TRAM 451 pulse oximeter (wall-mounted hospital control unit). Sensitivities for each brand were 92.2% (95% CI 87.3-97.1) for *OxyWatch*, 90.7% (95% CI 85.7-95.7) for *SM,* and 92.1% (95% CI 87.3-96.8) for *Onyx*. Specificity for each brand were 60% (95% CI 49.59-70.41) for *OxyWatch*, 67.6% (95% CI 56.7-78.5) for *SM*, and 67.6% (95% CI 56.9-78.2) for *Onyx*.[12] This was a retrospective study that employed convenience sampling, hence the risk for selection bias. Furthermore, it only reported the accuracy of the pulse oximeter device itself, making it inconsistent with the intended intervention for this current review (i.e., pulse oximetry monitoring). Therefore, this outcome was rated to have a low certainty of evidence.

Accuracy of home oxygen monitoring for predicting deterioration

In terms of predicting mortality and ICU admission, a retrospective cohort study by Inada-Kim et al. [13] found that for confirmed COVID-19 patients that were brought by ambulance to the hospital during the the period of March 1 to July 30, 2021, initial oxygen saturations correlated with short-term patient mortality or ICU admission. Death and ICU admission was confirmed through hospital clinical records and linked with ambulance records. Some cutoffs for initial oxygen saturations showed moderate discriminative ability for predicting 30-day mortality with an AUROC of 0.772 (95% CI 0.712-0.833). For example, an SpO2 $\leq$94% measured using emergency medical service-issued pulse oximeter (unspecified type) among ambulance conveyances showed a sensitivity of 0.71 (95% CI 0.69 to 0.74) and specificity of 0.72 (95% CI 0.71 to 0.74). Meanwhile, an SpO2 $\leq$92% of the above patients had a sensitivity of 0.62 and specificity of 0.84.[13]

The overall certainty of evidence for this outcome was rated low due to risk of bias and indirectness. The included patients depended on subjective tagging of patients as 'COVID'. Those that did not have a pre-hospital reading were also excluded in the analysis. Furthermore, the study only presented pre-hospital oxygen saturations and did not employ pulse oximetry monitoring, which is different from our PICO question. The study has also not been peer-reviewed.

Clinical outcomes

A. Length of stay

Length of hospital stay among those admitted after baseline oxygen saturation measurements or pulse oximetry monitoring was reported in only two studies. Lancet et al. reported that the median length of stay for survivors with baseline O2 saturations ≤90% was five days (2-10) while to those who died was 6 days (3-12).[5] Dirikgil et al. reported length of stay in terms of bed occupancy days per 100 patients. Bed occupancy days per 100 patients was 20 days in the pulse oximetry monitoring group and 47 days in the matched control (no monitoring) group.[20]

B. Care escalation, ED attendance/re-attendance and hospitalization
The estimated incidence of each outcome was reported. Care escalation was used as a measure of detection of hypoxia or of clinical deterioration. Results showed that 21.5% of patients were referred for hypoxia or other concern as specified in the patient safety netting of remote monitoring. Among the participants, 32.2% were brought to ED for assessment or reassessment, while 25.2% were hospitalized or re-admitted. Data from Shah et al. 2020 showed that resting home SpO_2<92% was associated with an increased likelihood of hospitalization compared to SpO2≥92% (RR 7.0, 95% CI 3.4-14.5; p<0.0001).[18]

On follow up after 30 days, decreasing out-of-hospital SpO_2 in 1% increments (subdistribution hazard ratio [SHR] 0.95, 95% CI, 0.94-0.96; *P*<0.001) and increasing age in 10-year increments (SHR 0.82, 95% CI, 0.79-0.86; *P*< 0.001) were associated with a decrease in the subdistribution hazard of being discharged from the hospital on a given day, given that the patient was still in the hospital or had already died on that day. No other risk factors were identified as significant. Lancet et al submits that these data inform triage decisions while also asserting that patients not admitted remain at risk and should be provided with close outpatient monitoring.[5]

C. ICU admission, other complications, and mortality
About 0.9% were admitted or transferred to the ICU or developed other complications. Shah et al. 2020 reported that resting home SpO_2<92% was associated with increased risk of ICU admission (RR 9.8, 95% CI 2.2-44.6, p<0.002), ARDS (RR 8.2, 95% CI 1.7-38.7; p<0.007), and septic shock (RR 6.6, 95%CI 1.3-32.9, p=0.02). This study asserts that pulse oximetry helps detect these risks and facilitates more timely intervention; however, because there was no comparator group it could not be directly stated that the timely interventions did actually improve clinical outcomes.[18]

Of the total number of participants who were detected to have hypoxemia, whether or not eventually admitted, 9.2% died. Results from Lancet et al. [5] showed that increasing age in 10-year increments was also strongly associated with in-hospital mortality (OR 1.45; 95% CI, 1.33-1.58; *P*<0.001). After controlling for the competing risk of death, an out-of-hospital measured SpO2 level ≤90% was associated with over a 50% decreased likelihood of being discharged alive (HR 0.48; 95% CI 0.43-0.54; *P*<0.001), regardless of age. Both age and out-of-hospital SpO_2 were independent predictors of in-hospital mortality and length of stay, after controlling for the competing risk of death.[5] Comparing mortalities among patient sources, Clark et al. 2020 showed that all-cause mortality was significantly higher in patients enrolled from hospital discharge (OR 8.70, 95% CI 2.53-29.89), compared to patients enrolled from primary care.[8] Inada-Kim et al. found that lower initial oxygen saturations were associated with higher mortality rate. Oxygen saturations were the most predictive of mortality or ICU admission (AUROC 0.772, 95 % CI 0.712-0.833).[13]

Certainty of evidence

Overall certainty of evidence for these outcomes was very low due to serious risk for bias, inconsistency, indirectness, and imprecision. There was significant heterogeneity and no blinding or randomization. Many studies did not use a comparator and were simply descriptions of the remote monitoring or virtual hospital program implemented in their setting.

Cost

Two studies indicated the cost of remote monitoring. Gaeta et al. [16] reported cumulative home monitoring costs of $621,800 (including charges incurred due to admissions) and projected cumulative mitigated hospital charges of about $6,718,296 (IQR $4,767,344, $9,902,496), while Vindrola-Padros et al. [17] reported the mean cost per monitored patient at £400 to £553.[17]

Department of Health (DOH) suggests that retail prices of portable or finger pulse oximeter devices as of May 6, 2021 range from Php499.75 to Php 1,785 for pediatric and adult fingertip pulse oximeters.[21] Online shopping sites list the cost to range from Php 499 (HEALMED Pulse Oximeter, Watsons) to Php 1,580 (Inmed Pulse Oximeter Model A310, Watsons).[22-26]

Other Considerations

For home monitoring models in the UK, mean cost per patient monitored is about £400 to £553. In the US, cumulative home monitoring costs $621,800 (including charges incurred due to hospitalization), while projected cumulative mitigated hospital charges were about US$6,718,296 (IQR $4,767,344, $9,902,496). The use of pulse oximeter devices is relatively affordable. Pulse oximeters in the country cost from Php 499 to Php1,785 and are readily available in drugstores, and medical supply and online stores. Studies have shown that pulse oximetry monitoring received positive feedback from patient satisfaction surveys and indicated a lessening of anxiety for patients while on pulse oximetry monitoring. The pulse oximeter is easy to use, although studies emphasize to ensure training on proper use, measurement, and reporting of pulse oximetry readings. Studies have also shown its correlation with risk of mortality and/or ICU admission or other complications.

Recommendations from Other Groups

There are currently no existing local guidelines for pulse oximetry. Table 2 lists the recommendations from other groups.

Research Gaps

There are no randomized trials comparing pulse oximetry monitoring with no pulse oximetry monitoring. Other studies would argue that this might not be ethical and implemented the program in a pandemic. At present, there is one randomized trial with ongoing patient inclusion that focused on pulse oximetry monitoring in addition to primary care as opposed to primary care only. There are also no studies validating the impact of monitoring oxygen saturations on other patient outcomes.

Table 2. Recommendations from other groups

Group	Recommendation
WHO COVID-19 Clinical management Living Guidance [27] (2021 Jan 25)	"A conditional recommendation for use of pulse oximetry monitoring at home as part of a package of care, including patient and provider education and appropriate follow-up, in symptomatic patients with COVID-19 and risk factors for progression to severe disease who are not hospitalized (very low certainty)." "For suggested use of pulse oximetry monitoring at home… potential benefits would outweigh the potential harms, especially if used in patients that were symptomatic and at risk for severe disease; but only as part of a larger package of care including education and follow-up."
NHS UK Guide to Pulse Oximetry [28] (2021 Jan 12)	Cohorts that will benefit most are those with a diagnosis of COVID-19 (either clinically or positive test result), and are also symptomatic and are either aged 65 years or older or under 65 years and clinically extremely vulnerable (CEV) to COVID-19.
NICE guidelines [29]	To assess the severity of illness and detect early deterioration for primary and community care settings with available pulse oximetry, use NHS England's guide to pulse oximetry in people 18 years and over with COVID-19 and for oxygen saturation levels below 91% in room air at rest in children and young people (17 years and under) with COVID-19. Caveat on difference in pulse oximeters different specifications. Under- or over-estimation can occur in borderline saturation levels; or overestimation with people with dark skin.
African CDC [30]	Instructions specified to ensure accurate readings, such as removal of nail polish or false nails, warming cold hands, measuring O2 saturations at rest, using the middle or index finger keeping the device steady on the chest at heart level, recording the highest result once reading stabilizes for five seconds. Reminders are also given to correctly distinguish the heart rate from the oxygen level readings.

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Appendix 1. Evidence to Decision

Table 1. Summary of initial judgements prior to the panel discussion (N = 9)

FACTORS	JUDGEMENT					RESEARCH EVIDENCE/ADDITIONAL CONSIDERATIONS
Problem	No	Yes (6)				Presence of hypoxemia has been observed to be a predictor for mortality and might be the only indicator of clinical deterioration in patients with no overt symptoms of respiratory distress.
Benefits	Large (4)	Moderate (2)	Small	Uncertain		Pulse oximetry monitoring may help decrease unnecessary hospitalizations, unnecessary HCW exposure, and PPE use.
Harms	Large	Moderate (4)	Small (1)	Uncertain (1)		Harms include the risk of patient not opting to go to the hospital because of normal oxygen saturations despite other signs of clinical deterioration.
Balance of Benefits and Harms	Favors pulse oximetry monitoring (2)	Probably favors pulse oximetry monitoring (4)	Does not favor pulse oximetry monitoring			Benefits include: (1) low cost, (2) ease of use, (3) allows detection of clinical deterioration associated with low oxygen saturation. Harms include: (1) interchanging readings with pulse rate may cause confusion or delay in management due to erroneous reading, and (2) opting against admission despite other clinical indications of deterioration. One study suggests not to leave the decision of presenting to the hospital to the patient alone.
Certainty of Evidence	High	Moderate (1)	Low (2)	Very low (3)		Very low overall certainty of evidence
Accuracy	Very Accurate	Accurate (6)	Inaccurate	Very Inaccurate	Uncertain	Consumer-grade (OxyWatch, SM) and medical-grade (Onyx) were comparable in detecting hypoxia as compared to ED hospital control units.
Values	Important uncertainty or variability	Possibly important uncertainty or variability (5)	Possibly NO important uncertainty or variability (1)	No important uncertainty or variability		Despite ease of use, there is still a need to ensure training on proper use, measurement and reporting of pulse oximetry readings. Spot-check device prior to use by those with peripheral artery disease.

FACTORS	JUDGEMENT						RESEARCH EVIDENCE/ADDITIONAL CONSIDERATIONS
Resources Required	Uncertain	Large cost (1)	Moderate Cost (3)	Negligible cost	Moderate savings (2)	Large savings	Pulse oximeters range from Php 499 to Php1,785. Costs may be incurred if a program for remote patient monitoring (including pulse oximetry as one of the parameters monitored). Mean cost per monitored patient: £400 - £553. Cumulative costs for home monitoring: $621,800 (including charges attributed to admissions). Projected cumulative mitigated hospitalization charges: $6,718,296 (IQR: $4,767,344, $9,902,496).
Certainty of evidence of required resources	No included studies	Very low (1)	Low (3)	Moderate (2)	High		Studies that mentioned cost were from retrospective studies, and may have risk for bias in reporting values.
Cost effectiveness	No included studies (3)	Favors comparator	Does not favor either pulse oximetry monitoring or the comparator	Favors pulse oximetry monitoring (3)			No mention of cost of standard Emergency Department wall-mount pulse oximeter monitoring
Equity	Uncertain	Reduced (4)	Probably no impact	Increased (2)			Patients who cannot afford to buy a pulse oximeter will not be able to do pulse oximetry monitoring at home. Various brands may need to be checked for accuracy or validated prior to use. RPM models usually provide the pulse oximeter during the study, to be returned afterwards.
Acceptability	Uncertain	No	Yes (6)				Patients with chronic lung or heart conditions may already have an existing pulse oximeter, so monitoring will be at no cost to them.
Feasibility	Uncertain	No	Yes (6)				Success of pulse oximetry monitoring or a program of remote monitoring is attributed to 1) proper instruction of patient/caregiver on proper use and recording of readings, 2) a safety net for timely intervention in place for patients who actually have episodes of true hypoxia.

Appendix 2. Search Strategy, Yield and Results

Database (Yield)	Date of search	Search Strategy
PMC (8 studies)	Sept 23, 2021	Search (((((((("coronavirus infections"[MeSH Terms]) OR novel coronavirus[Title]) OR nCOV[Title]) OR covid-19[Title]) OR SARS COV2[Title])) AND (((PULSE OXIMETRY[MeSH Terms]) OR oximeter[Title]) OR oximetry[Title])) AND monitoring[Title]) AND (((home[Title]) OR outpatient[Title]) OR pre-hospital[Title])
Pubmed	Sept 23, 2021	("coronavirus infections"[MeSH Terms] OR "nCOV"[Title] OR "covid-19"[Title] OR "sars cov 2"[Title]) AND ("oximetry"[MeSH Terms] OR "oximeter"[Title] OR "oximetry"[Title]) AND ("monitoring"[Title] OR "screening"[Title]) AND ("home"[Title] OR "outpatient"[Title] OR "pre-hospital"[Title])
CoAP Living Evidence on COVID-19*	Sept 26, 2021	((pulse oximetry) OR (oximeter) OR (oximetry)) AND ((home) OR (outpatient) OR (pre-hospital)) AND ((monitoring) OR (screening) OR (surveillance)) Title only
Google scholar	Oct 1, 2021	allintitle: oximetry AND covid

*https://zika.ispm.unibe.ch/assets/data/pub/search_beta/

**Review of references -- 2 studies, including 1 systematic review on remote patient monitoring. Included studies that monitored oxygen saturations. -- yield: 9 studies

Appendix 3. Table of Included Studies

Table 1. Characteristics of included studies

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
Gootenberg 2021	USA	Prospective observational	Presumed or confirmed COVID 19 adult pts assessed for discharge from ED but at risk for deterioration	ED	81	51.7	Patient self-monitoring (d/c & pulse ox instructions); MD follow up	7	Resting: <92%	30 (37%)	No data	Rate of ED return, hospitalization and hypoxia (assess feasibility, describe protocol)
Galbraith 2021	USA	Prospective observational	Vermont resident with positive RT PCR, who are not inmates or inpatients	C	599	No data	Daily pt pulse ox monitoring via email/ SMS/ daily calls	No data	90%	all pts	No data	None specified (described program implementation only)
Shah 2020	USA	Prospective observational	18+y/o, suspected COVID-19; discharged from ED or OPD; SpO2 > 92% on ED discharge; not pregnant; not on O2 support	ED or OPD	77	44	Thrice daily pt pulse ox monitoring via daily calls to pt	7	92%	77	Normoxemic pts (SpO2 ≥92%)	1) Hospitalization rate in resting home SpO2<92% 2) SpO2 trend, dec subsequent ED visits, hospital outcomes (LOS, TOS to ICU, Time to drop)
Kyriakides 2021	UK	Prospectiveobservational	Suspected or confirmed COVID, resting or rm air SaO2 90-94%, can use pulse ox	C	20		Patient home SpO2 monitoring 3x daily Telephone ff-up by MD on days 2, 5, 7	7	SaO2 < 90% at rest on ≥2 occasions w/n 24hrs; Standard safety net info		NS	Rate of avoidance of hospitalization, ED reassessment, discharge from pathway

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
			correctly, non-admissible									
Banzi 2020	Italy	Prospective observational	Symptomatic suspected or confirmed COVID patients not for ED visit or hospitalization; no permanent motor or mental disabilities or temporary conditions	C	37	53.9	Daily visit with resting and post rapid walking test SpO2 recording	8.2	90% at rest or desaturations of ≥5% points after rapid walk test	No data	No data	Percentage of patients referred for escalation of care that were actually transferred within 24 hours of reporting; SpO2 at ED presentation
Hutchings 2020 [Pre print]	Australia	Prospective observational	Patient deemed safe and able to self-isolate	C	62	median: 38	VS rec on app + standardized early warning system. 3x daily phone call & video-consult 2x daily.	8 (1-17 days)	No data	No data	No data	Care escalation rates (ED presentation and hospital admission)
Vindrola - Padros 2021	UK	Multi-site mixed methods study	Triaged as eligible for home monitoring either in a pre-hospital model or from early discharge from the hospital	PC	1737	No data	App or paper diary patient recording; regular monitoring calls from PC or SC staff	14 days or until symptoms resolve	No data	No data	no control group identified	Hospital and ICU admissions or readmissions, ED attendances, mortality rates, patient satisfaction measures
				HD	347	No data						

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
O'Carroll 2020	Ireland	Prospective observational	Discharged from hospital with pulmonary infiltrates on xray & non-O2 requiring	HD	18	48	Daily SpO2 check 4x daily. Mobile app recording check & alert for breathlessness	Median 12 days	≤94%	No data	No data	Resting SpO2, rate of self-reported breathlessness in patients with COVID-19
Gaeta 2020	USA	Retro-spective	Presumptive or confirmed COVID discharged home (exertional SpO2>90% AND RR<22), with consent to early telehealth follow up	HD	488	No data	Retrospective chart review of patients enrolled in the remote patient monitoring program (monitored: s/sx, SpO2, HR, RR)	7	90% (implied)	No data	No data	ED revisit; disease course, hospital LOS, ICU requirements, respiratory support, mortality and loss to follow up
Clarke 2021	UK	Retrospective	Suspected or confirmed COVID-19 in England during Summer 2020	ALL	908	54 (med)	Analyze patient data from 4 pilot sites enrolled from primary care, ED visit or following hospital discharge. Monitoring of HR, SpO2, HR over time, symptoms	No data	≥95%	NS	Compare bet pt source (PC vs ED vs hosp d/c); Compare among age groups, (+/-) comorbidities, SpO2 on enrolment	rates of escalation, ED reattendances (planned or unplanned), hospitalization, death
				OPD	302	55 (med)		No data	No data	No data		
				ED	342	50		No data	No data	No data		
				HD	259	63		No data	No data	No data		

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
							and overall well-being					
Lancet 2021	USA	Prospective observational	Alive on ED arrival, RT PCR+, documented pre-hospital SpO2 measurement on room air	Pre- ED	1673	66	Review of FDNY EMR (adult pts transported by FDNY-EMS to any NYC hospital ED March 5 - April 30, 2020)	No monitoring	<90%	No data	No data	In-hospital mortality and LOS (determine if SpO2 was an independent predictor of COVID 19 in -hospital mortality and LOS)
Grutters 2020	Netherlands	Retrospective	COVID-19 pts discharged (with O2 support (max 3L/min) to rm air) (fr ICU 21%, ICU LOS 8d, on O2 on discharge 61%)	HD	33	57	Daily monitoring of SpO2, temp, COVID resp symptoms rating scale via an mobile app	13.4	NS	31 (94%)	No data	Reduced length of hospitalization, safety, patient satisfaction
Gordon 2020	USA	Prospectiveobservational	Discharged presumed or confirmed COVID 19, no severe symptoms	HD	225	54	MyChart Care Companion (pulse ox, thermometer, instructional packet) Portal-based RPM program	2-3wks at patient discretion median 12days		No data	Patients not referred to the program	ED or hospital readmission rate within 30 days of the initial discharge

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
Kodama 2020	USA	Prospectiveobservational	Stable patients identified for discharge (>18yo, SpO2 >92% prior to and on discharge, with reliability on use of pulse oximeter and gave consent	HD	50	No data	RPM via app-based monitoring (VS at rest and 20s after exercise) by assigned nurse algorithm for monitoring and escalation	14 days	SaO2 <90% or >5% dec on exertion+ 20s HR >115 at rest, >125 exertion inc >10 b/w rest & exertion RR>22, or RR>30 exertion/ inc >8 b/w rest & exertion	No data	No data	ED visits, readmission rate
Silven 2020	Netherlands	Prospective observational	ED pt for suspected COVID or after admission	ED/ HD	55	No data	Remote monitoring package (COVID Box); video consults, app-based monitoring, EMR	No data	Personalized thresholds or general feeling of unwellness	No data	No data	Admission rate
Francis 2020 [pre print]	UK	Prospective observational study	Clinically diagnosed COVID 19 patients	ED OPD	455	48.9	Virtual hospital remote assessment (resp. MD calls on days 2-5,7,10,14 & beyond for high risk patients); pseudonymized EMR	Median 21 days	No data	31.40%	No data	Adverse outcome: Death or re-admission to inpatient hospital care over 28 days
				HD	445	61			No data	60.90%	No data	
Wilcock 2021	UK	Prospective,	RT PCR positive adult	OPD	41	45.9	2x daily self-recording of	14 days since	94% and 92%	No data	No data	Proportion of people SpO2 ≤94% and ≤92%, ave. max

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
[pre print]		observational	pts with symptoms in the past 7 days, self-isolating at home				SpO2 & symptoms (cough, loss of smell, +/- breathlessness)	COVID19 RT PCR (+)				reduction in SpO2, hospitalization rate
Dirikgil 2021	Netherlands	Retrospective case control	all ED visits from 3/1-6/15, 2020 suspected COVID with moderate s/sx or underlying co-morbidities	HD	55	61	home monitoring via COVID-box (3x daily home monitoring; teleconsultations by a HCP	28	personalized thresholds	13	Discharged patients without home monitoring	Total hospital admissions w/in 28 days of ff up; number of patients completing ff up without ED reassessment, bed occupancy rate
			Matched control group		110	59				7	ref	
Schrading 2020	USA	Prospective observational	adults presenting at ED with 1) hypoxia (SpO2 <94%), 2) an acute COPD exacerbation or 3) chest pain or dyspnea; no peripheral artery disease, anemia	ED patients convenience sample	198	median 58	measurement of oxygen saturation using (consumer-grade) Walgreen's OxyWatch C20 (OxyWatch) pulse oximeter brand	N/A	≤94%	No data	TRAM 451 pulse oximeter (wall-mounted hospital control unit)	Sensitivity and Specificity, Positive Predictive and Negative Predictive Values
					200		measurement of oxygen saturation using (consumer-	N/A	≤94%	No data	TRAM 451 pulse oximeter (wall-mounted	

Study ID	Setting	Study design	P				I			C		O
			Patient population	Pt source[1]	n	Mean/ median age	Methodology/ Model	Monitor-ing duration	def for hypoxia/ cutoff criterion/ criteria for escalation	RT PCR positive	Compa-rator/ Control	Target outcomes
							grade) Santa Medical SM-1665 (SM)				hospital control unit)	
					200		measurement of oxygen saturation using (medical-grade) Nonin Onyx II 9550 (Onyx)	N/A	≤94%	No data	TRAM 451 pulse oximeter (wall-mounted hospital control unit)	
Inada-Kim	UK	Retrospective cohort	adult pts initially assessed and conveyed from ambulance service to the ED between March 1, 2020 to July 31, 2020, tagged as 'COVID-Respiratory Distress,' 'Suspected COVID,' 'COVID'	EMR from ambulance service	1080	Not Specified (only age groups reported)	Review of EMR of pts conveyed to hospital by ambulance during specified study period	N/A	Not specified	No data	None Specified	short-term (30-day) mortality or ICU admission

[1] C – Community; OPD/ PC – OutPatient Dept or Primary Care; ED – Emergency Department/ Accident & Emergency; HD – Hospital Discharge
[2] ex -sm – ex- smoker, MH – mental health
[3] Mild: SpO2≥95%; Mod: SpO2 93-94%; Severe: SpO2 ≤92%

Table 2. Outcomes of included studies

Study ID	Patient source [1]	Escalation of care (hypoxia or other concern)	ED attendance/ reattendance	Pneumonia/ abnormal CXR	Admission/ readmission	ICU Admission	Other complications	Length of hospital stay	Mortality	Cost vs savings	Patient satisfaction
Gootenberg 2021	ED	No data	23 (28%); 7 O2-requiring (15 self-presented) RT PCR+: 10	No data	Overall: 10 (12%); RT PCR pos: 5/30 (17%)	Overall: 1 (1.2%); 1 of 30 (17%)	No data	No data	0	No data	No data
Galbraith 2021	C	17	No data	No data	1	No data	No data	No data	0	No data	No data
Shah 2020	ED or OPD	19 (25%)	17	No data	16 (8 of whom came due to incidentally low SpO2) RR hospitalization (resting SpO2<92%): 7.0 (95% CI 3.4 – 14.5), p-value <0.0001	8	Resting home SpO2 < 92% associated with inc risk of ICU admission (RR=9.8, 95% CI=2.2 to 44.6, *p* <0.002) ARDS (RR = 8.2, 95%CI= 1.7 to 38.7, p<0.007); septic shock (RR=6.6, 95% CI = 1.3 to 32.9, p= 0.02)	No data	2	No data	No data
Kyriakides 2021	C	7 (35%)	35% (≥1 clinical comorbidity)	Classic CXR findings: for reassessment: 71% no reassessment: 54% || CTPA as necessary	3 (15%) (Mean age 65)	No data	No data	No data	0	No data	No data
Banzi 2020	C	1	No data	No data	1	No data	1 (abdl hemorrhage, acute toxic hepatitis & acute heart failure)	No data	0	No data	No data

Study ID	Patient source [1]	Escalation of care (hypoxia or other concern)	ED attendance/ reattendance	Pneumonia/ abnormal CXR	Admission/ readmission	ICU Admission	Other complications	Length of hospital stay	Mortality	Cost vs savings	Patient satisfaction
Hutchings 2020 [Preprint]	C	5 (3%)	4 (2.5%)	No data	3 (1.9%)	No data	No data	No data	0	No data	No data
Vindrola-Padros 2021	PC	PH: 174 (10%)	PH: 133 (76.7%)	No data	PH: 92 (52.7%)	PH: 3 (2.0%)	No data	No data	PH: 20 (1.1%)	Mean cost per monitored patient: £400 - £553	No data
	HD	EHD: 42 (12.2%)	EHD: 39 (91.8%)		EHD: 41 (74.5%)	EHD: 4 (8.5%)	No data	No data	EHD: 3 (0.9%)		No data
O'Carroll 2020	HD	5	5	3 (progressive infiltrates and worse COVID-related hypoxia)	4	0	No data	No data	0	No data	No data
Gaeta 2020	HD	90 (18.4%) virtual LOS for admission: 3 days	90 (18.4%)	No data	43 (8.8%)	direct: 2 transfer fr ward: 5	No data	No data	Direct ICU: 2 ICU transfer fr ward: 4	Cumulative home monitoring costs: $621,800 (incl hosp charges) projected cumulative mitigated hosp charges: $6,718,296 (IQR: $4,767,344, $9,902,496)	No data
Clarke 2021	ALL	No data	52	No data	40	No data	No data	No data	All-cause: 28 (3.1), COVID: 26 With 4+ comorbids: 17 (60.1) ≥65yo: (9.3) O2s >95 (2.6) O2s 93-94 (6.1) O2s <95% (5.5)	No data	No data

Study ID	Patient source [1]	Escalation of care (hypoxia or other concern)	ED attendance/ reattendance	Pneumonia/ abnormal CXR	Admission/ readmission	ICU Admission	Other complications	Length of hospital stay	Mortality	Cost vs savings	Patient satisfaction
	OPD	No data	ref	No data	No data	No data	No data	No data	ref	No data	No data
	ED	No data	OR 0.42 (0.02-0.89; *p* 0.024)	No data	No data	No data	No data	No data	(OR 3.40 (0.62-18.55) p0.157)	No data	No data
	HD	No data	OR 0.31 (0.15-0.68; *p* 0.003)	No data	No data	No data	No data	No data	OR 8.70 (2.53-29.89), p0.001)	No data	No data
Lancet 2021	Pre-ED	887 (53.0%)	No data	1232 (73.6%)	1514 (90.5%)	No data	No data	Median LOS, days (survivors): 5 (2-10) vs (died): 6 (3-12)	527 (31.5%)	No data	No data
Grutters 2020	HD	6 (18%)	0	COVID: CT 1, CXR: 1	3	No data	No data	Ave reduction in LOS: 5 (+3.8)	0	No data	Patient satisfaction: 97% rated home tele-monitoring as user friendly
Gordon 2020	HD	O2sats <92%: 11/315 (Patient-triggered: 34% Questionnaire-triggered: 15%)	11 (4.9%)	No data	3 (1.3%)	No data	No data	No data	No data	No data	No data
Kodama 2020	HD	29 (13 patients)	3 (6%)	No data	1 (2% of enrolled)	No data	1 (pulmonary embolism)	No data	No data	No data	Simplicity of sign up: 74% Ease of use: 65% Adequate handling of concerns: 74% Confidence with taking VS: 74% Satisfaction with care: 74% Likelihood of

Study ID	Patient source [1]	Escalation of care (hypoxia or other concern)	ED attendance/ reattendance	Pneumonia/ abnormal CXR	Admission/ readmission	ICU Admission	Other complications	Length of hospital stay	Mortality	Cost vs savings	Patient satisfaction
											recommendation: 74%
Silven 2020	ED/ HD	No data	No data	No data	5 (9%)	No data	No data	No data	No data	No data	No data
Francis 2020 [pre print]	ED OPD	76	No data	48.90%	58 (5.5%)	No data	No data	No data	18 (0.5%)	No data	No data
	HD		No data	77.50%	11.70%	No data	No data	No data	3.80%	No data	No data
Wilcock 2021 [pre print]	OPD	SpO2≤94: 9 SpO2≤92% 3 (ave time to max SpO2 drop fr dx: 6.4±1.5d)	No data	No data	SpO2 93-94: 0; SpO2 <92%: 3	No data	No data	No data	0	No data	Ave Likert score anxiety reduction (1=more anxious 5=much less anxious) 4.0 Ave Likert score usefulness (1=not at all useful; 5=very useful): 4.6
Dirikgil 2021	HD	No data	No data	No data	5/ 55 (9%) RR 0.27 (95%CI 0.097-0.733; p=0.007)	No data	Completed 28 days w/o ED reassess- ment: 47 (85%)	LOS Bed occupancy days per 100 patients: 20	No data	No data	No data
	Matched control	No data	No data	No data	30/ 110 (27%)	No data	76 (69%)	LOS Bed occupancy days per 100 patients: 47	No data	No data	No data

Table 3. Accuracy outcomes of included studies

Study ID	Sub group	Sn (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	Mc Nemar's Test (sensitivity) - *P* (Chi2-DOF)	Mortality	cost vs savings	Other Remarks
Schrading 2020	Oxy-Watch	92.17% (87.27-97.08)	60% (49.59-70.41)	75.75% (68.61-82.82)	85% (75.97-94.03)	0.001 (14.53 - 1)	NA	Almost 10-fold cost difference between medical-grade (Onyx) and consumer-grade pulse oximeters (SM, OxyWatch)	Devices selected were sensitive in detecting hypoxia using a 92% cutoff and had a strong correlation with standard ED oximetry at SpO2 cutoff of 92%, sensitivity increased--all 3 essentially 97% (99.6-94.2)
	SM	90.70% (85.69-95.71)	67.61% (56.72-78.49)	83.57% (77.43-89.71)	80% (69.88-90.12)	0.063 (3.46 - 1)	NA		
	Onyx	92.06% (87.34-96.78)	67.57% (56.90-78.23)	82.85% (73.90-92.76)	83.33% (73.90-92.75)	0.0165 (5.76 - 1)	NA		
Inada-Kim 2020 [preprint]	90%	0.481 (0.445-0.516)	0.885 (0.870-0.899)				as described		Oxygen saturations were the most predictive of mortality or ICU admission (AUROC 0.772 (95 % CI: 0.712-0.833)) followed by the NEWS2 score (AUROC 0.715 (95 % CI: 0.670-0.760) patient age (AUROC 0.690 (95 % CI: 0.642-0.737)) respiration rate (AUROC 0.662 (95 % CI: 0.599-0.729))
	91%	0.553 (0.510-0.597)	0.862 (0.845-0.879)				as described		
	92%	0.624 (0.584-0.664)	0.836 (0.818-0.854)				as described		
	93%	0.664 (0.633-0.695)	0.795 (0.777-0.812)				as described		
	94%	0.713 (0.686-0.739)	0.723 (0.705-0.742)				as described		
	95%	0.760 (0.724-0.796)	0.650 (0.648-0.662)				as described		
	96%	0.841 (0.807-0.875)	0.526 (0.513-0.538)				as described		
	18-49yo	No data	No data	No data	No data	No data	0.60%		
	50-59	No data	No data	No data	No data	No data	1.30%		
	60-69	No data	No data	No data	No data	No data	6.50%		
	70-79	No data	No data	No data	No data	No data	7.00%		
	80+	No data	No data	No data	No data	No data	12.80%		

Appendix 4. Detailed Study Appraisal

	Gootenberg 2021	Galbraith 2021	Shah 2020	Kyriakides 2021	Banzi 2020	Hutchings 2020	Vindrola-Padros 2021	O'Carroll 2020	Gaeta 2020	Clarke 2021	Lancet 2021	Grutters 2020	Gordon 2020	Kodama 2020	Silven 2020	Francis 2020	Wilcock 2021	Inada-Kim 2020	Dirikgil 2021	Schrading 2020
DOMAIN 1: Patient Selection Test																				
Was a consecutive or random sample of patients enrolled?	No	Yes	No	No	Yes	No [no blinding]	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
Was a case-control design avoided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Unsure	No	No	Yes	Yes	Yes	Yes	No	No	No	Yes
Did the study avoid inappropriate exclusions?	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Unsure	Yes	Yes	Unsure	Yes	Yes	Yes	Yes	Yes
Could the selection of patients have introduced bias?	High Risk	No	High Risk [no blinding]	Low risk	Low risk	High RIsk	Yes	Low risk	Low risk	Low risk	Low risk	Unsure	High risk	High risk	High risk	Low risk	High Risk	High Risk	High Risk	High Risk
Are there concerns that the included patients and setting do not match the review question?	Low concern	Low concern	Low concern	Low concern	Low concern	High Risk [only patients with no comorbidities]	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	High concern	Low concern	Low concern	Low concern	Low concern	Low concern
DOMAIN 2: Index Test																				
Were the index test results interpreted without knowledge of the results of the reference standard?	Unsure	Yes	Yes	Yes	Yes	Yes	Unsure	No	No	Yes	Yes	Yes	Unsure	No	No	Unsure	No	Yes	Unsure [no mention of blinding]	Unsure
If a threshold was used, was it pre-specified?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	Yes

Could the conduct or interpretation of the index test have introduced bias?	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	High risk	Low risk	High risk	Low risk	Low risk	Unclear	Unsure	High risk	High risk	Unclear	High risk	Low Risk	High risk	High Risk
Are there concerns that the index test, its conduct, or interpretation differ from the review question?	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	Low concern	High concern	Low concern	Low concern	Low concern	Low concern	Low concern	high concern	Low concern
DOMAIN 3: Reference Standard																				
Is the reference standards likely to correctly classify the target condition?	Yes	No	No	No	No	No	No	No	No	Unsure	Unsure	No	Unsure	No	No	Unsure	No	Unsure [comparison made across ages and SpO2]	No	Yes
Were the reference standard results interpreted without knowledge of the results of the index tests?	Yes	No	Unsure	No	No	No	No	No	No	Unsure	Unsure	No	Unsure	No	No	Unsure	No	Unsure	Unsure	Unsure
Could the reference standard, its conduct, or its interpretation have introduced bias?	Low risk	unclear	unclear	High Risk	High risk	No	Unclear	High risk	High risk	Unclear	Low risk	High risk	High risk	High risk	High risk	Unclear	High risk	High Risk	High risk	High Risk
Are there concerns that the target condition as defined by the reference standard does not match the question?	Low concern	High concern	High concern	High concern	High concern	High concern	High Concern	High risk	High risk	High concern	High concern	High concern	High concern	High concern	High concern	High concern	High concern	Low concern	high concern	Low concern

DOMAIN 4: Flow and Timing																				
Was there an appropriate interval between index test and reference standard?	Yes	No	No	No	No	No	No	No	No	Unsure	Unsure	No	Unsure	No	No	Unsure	No	Unsure	unsure	Yes
Did all patients receive the same reference standard?	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Unsure	No	No	no	Yes
Were all patients included in the analysis?	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Unsure	Unsure	Unsure	Yes	No	Yes	yes	No
Could the patient flow have introduced bias?	Low risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	Unclear	Unclear	High risk	High risk	High risk	High risk	High risk	High risk	High Risk	high risk	high risk

Appendix 5. GRADE Evidence Profile

Table 1. Should medical-grade Nonin Onyx II 9550 (Onyx) be used to diagnose hypoxemia in suspected and confirmed COVID patients?

Sensitivity	0.92 (95% CI: 0.87 to 0.97)	Prevalences	5%	10%	15%
Specificity	0.68 (95% CI: 0.57 to 0.78)				

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested			Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 5%	pre-test probability of10%	pre-test probability of15%	
True positives (patients with hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	46 (44 to 48)	92 (87 to 97)	138 (131 to 145)	⨁⨁◯◯ Low
False negatives (patients incorrectly classified as not having hypoxemia)								4 (2 to 6)	8 (3 to 13)	12 (5 to 19)	
True negatives (patients without hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	642 (541 to 743)	608 (512 to 704)	574 (484 to 665)	⨁⨁◯◯ Low
False positives (patients incorrectly classified as having hypoxemia)								308 (207 to 409)	292 (196 to 388)	276 (185 to 366)	

Table 2. Should consumer-grade OxyWatch be used to diagnose hypoxemia in suspected and confirmed COVID patients?

Sensitivity	0.92 (95% CI: 0.87 to 0.97)					Prevalences	5%	10%	15%		
Specificity	0.60 (95% CI: 0.50 to 0.70)										
Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested			Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 5%	pre-test probability of10%	pre-test probability of15%	
True positives (patients with hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	46 (44 to 49)	92 (87 to 97)	138 (131 to 146)	⊕⊕◯◯ Low
False negatives (patients incorrectly classified as not having hypoxemia)								4 (1 to 6)	8 (3 to 13)	12 (4 to 19)	
True negatives (patients without hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	570 (471 to 665)	540 (446 to 630)	510 (422 to 595)	⊕⊕◯◯ Low
False positives (patients incorrectly classified as having hypoxemia)								380 (285 to 479)	360 (270 to 454)	340 (255 to 428)	

Table 3. Should consumer-grade Santa Medical SM-1665 (SM) be used to diagnose hypoxemia in suspected and confirmed COVID patients?

Sensitivity	0.91 (95% CI: 0.86 to 0.96)	Prevalences	5%	10%	15%
Specificity	0.68 (95% CI: 0.57 to 0.78)				

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested			Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 5%	pre-test probability of10%	pre-test probability of15%	
True positives (patients with hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	45 (43 to 48)	91 (86 to 96)	136 (129 to 144)	⊕⊕◯◯ Low
False negatives (patients incorrectly classified as not having hypoxemia)								5 (2 to 7)	9 (4 to 14)	14 (6 to 21)	
True negatives (patients without hypoxemia)	1 studies 200 patients	cross-sectional (cohort type accuracy study)	serious[a]	serious[b]	not serious	not serious	none	642 (539 to 746)	608 (510 to 706)	575 (482 to 667)	⊕⊕◯◯ Low
False positives (patients incorrectly classified as having hypoxemia)								308 (204 to 411)	292 (194 to 390)	275 (183 to 368)	

Table 4. Should SpO2 94% or below by Pulse Oximetry be used to diagnose risk for mortality/ ICU admission in suspected and confirmed COVID patients?

Sensitivity	0.71 (95% CI: 0.69 to 0.74)	Prevalences	5%	10%	15%
Specificity	0.72 (95% CI: 0.70 to 0.74)				

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested			Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 5%	pre-test probability of10%	pre-test probability of15%	
True positives (patients with risk for mortality/ ICU admission)	1 studies 1080 patients	case-control type accuracy study	serious[a]	serious[b]	not serious	not serious	none	36 (34 to 37)	71 (69 to 74)	107 (103 to 111)	⊕⊕◯◯ Low
False negatives (patients incorrectly classified as not having risk for mortality/ ICU admission)								14 (13 to 16)	29 (26 to 31)	43 (39 to 47)	
True negatives (patients without risk for mortality/ ICU admission)	1 studies 1080 patients	case-control type accuracy study	serious[a]	serious[b]	not serious	not serious	none	687 (670 to 705)	651 (635 to 668)	615 (599 to 631)	⊕⊕◯◯ Low
False positives (patients incorrectly classified as having risk for mortality/ ICU admission)								263 (245 to 280)	249 (232 to 265)	235 (219 to 251)	

[a]Subjective classification of symptoms consistent with COVID-19. Lack of blinding; [b]Only did a single SPO2 measurement, not pulse oximetry monitoring

Table 5. Should SpO2 92% or below by Pulse Oximetry be used to diagnose risk for mortality/ ICU admission in suspected and confirmed COVID patients?

Sensitivity	0.62 (95% CI: 0.58 to 0.66)		Prevalences	5%	10%	15%
Specificity	0.84 (95% CI: 0.82 to 0.85)					

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested			Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 5%	pre-test probability of10%	pre-test probability of15%	
True positives (patients with risk for mortality/ ICU admission)	1 studies 1080 patients	case-control type accuracy study	serious[a]	serious[b]	not serious	not serious	none	31 (29 to 33)	62 (58 to 66)	94 (88 to 100)	⊕⊕◯◯ Low
False negatives (patients incorrectly classified as not having risk for mortality/ ICU admission)								19 (17 to 21)	38 (34 to 42)	56 (50 to 62)	
True negatives (patients without risk for mortality/ ICU admission)	1 studies 1080 patients	case-control type accuracy study	serious[a]	serious[b]	not serious	not serious	none	794 (777 to 811)	752 (736 to 769)	711 (695 to 726)	⊕⊕◯◯ Low
False positives (patients incorrectly classified as having risk for mortality/ ICU admission)								156 (139 to 173)	148 (131 to 164)	139 (124 to 155)	

Explanations

a. Subjective classification of symptoms consistent with COVID-19. Lack of blinding
b. Only did a single SpO2 measurement, not SpO2 monitoring

Table 6. Pulse oximetry monitoring for suspected and confirmed COVID-19 patients

Certainty assessment							No. of patients		Effect		Certainty	Importance
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Pulse oximetry monitoring	[comparison]	Relative (95% CI)	Absolute (95% CI)		
Care escalation (detection of hypoxia or other patient concern) (assessed with: No. of patients in whom hypoxia is detected, or referred for any concern)												
14	observational studies	serious [a]	serious[b]	serious[c]	serious[d]	none	1378/6397 (21.5%)	no data	not pooled	see comment	⨁◯◯◯ Very low	
Emergency Department Visits (assessed with: No. of patients who visited the ED)												
13	observational studies	serious [a]	serious[b]	serious[c]	serious[d]	none	2130/6619 (32.2%)	no data	not pooled	see comment	⨁◯◯◯ Very low	
Hospitalizations (assessed with: No. of patients hospitalized)												
17	observational studies	serious [a]	serious[b]	serious[c]	serious[d]	none	1856/7351 (25.2%)	no data	not pooled	see comment	⨁◯◯◯ Very low	
ICU admissions/ complications (assessed with: No. of ICU admissions)												
5	observational studies	serious [a]	serious[b]	serious[c]	serious[d]	none	23/2478 (0.9%)		not pooled	see comment	⨁◯◯◯ Very low	
Mortality (assessed with: No. of deaths)												
14	observational studies	serious [a]	serious[b]	serious[c]	serious[d]	none	648/7021 (9.2%)		not pooled	see comment	⨁◯◯◯ Very low	

CI: confidence interval

Explanations

a. Convenience sampling, no blinding done
b. Reported outcomes for pre-hospital O2sats only, or reported outcomes for post-inpatients only, or for outpatient only, or patients detected from the community level. Varied in monitoring models. Some are case control studies. Studies could not be pooled.
c. No comparator, different comparator to that of PICO question
d. Studies could not be pooled

Appendix 6. Table of Ongoing Studies

Title: A randomised controlled pilot trial investigating the feasibility of monitoring patients with or at risk for cardiovascular disease who have symptoms suspected of COVID-19 by pulse oximetry at home (CovidSat@Home)	
P	1) Age ≥40 years with cardiovascular risk profile or cardiovascular disease (overweight, hypertension, diabetes, smoking, coronary artery disease, previous myocardial infarction, heart failure), presumably COVID-19 (both SARS-CoV-2 positive and non-COVID-19 confirmed patients), with moderate-severe symptoms and mentally competent
I	Three times daily (and if needed any additional) measurement of oxygen saturation and pulse rate with a pulse oximeter as added to usual (primary) care
C	Usual (primary) care
O	**Primary outcome:** Feasibility defined as successful inclusion of 50 participants within 6 months **Secondary outcome:** - the feeling of safety during the first two weeks of illness as reported by the patient - disability-free survival at 45 days (% change in WHODAS-2 between baseline and day 45) - number of days alive at home during 45 days after inclusion - time to discharge from medical follow-up (defined as last contact with healh care professional according to primary care electronic health record data) - number of primary care contacts during 45 days after inclusion - number of emergency care department visits during 45 days after inclusion - proportion of hospitalised patients within 45 days after inclusion - characteristics of hospital admissions within 45 days after inclusion o clinical profile at time of hospitalisation (according to the warning signs of Dutch College of General Practitioners) o length of stay (total and stratified into ward and ICU) o proportion of patients admitted to ICU o type of treatments - 45 day mortality o overall mortality o out-of-hospital mortality o in-hospital mortality In a parallel process evaluation, we will examine how: - the intervention has been used in practice in terms of: (i) Fidelity - whether the intervention was carried out as planned; (ii) Dose - whether the intervention has been used as long and frequently as planned (iii) Adjustments - whether adjustments have been made to the intervention and why (iv) Reach - whether the intended audience has been reached and - the experiences of patients in the intervention group and their informal caregivers in terms of disease perception, fear and use of the intervention - GPs' experiences with the intervention (usability of pulseoximetry as diagnostic procedure and impact on healthcare utilization)
Status	Ongoing patient inclusion