

Clinical Performance and Accuracy of Nanoparticle-based Biosensors for Diagnosis of COVID-19 Compared to RT-PCR: a Systematic Review

Supplementary Material

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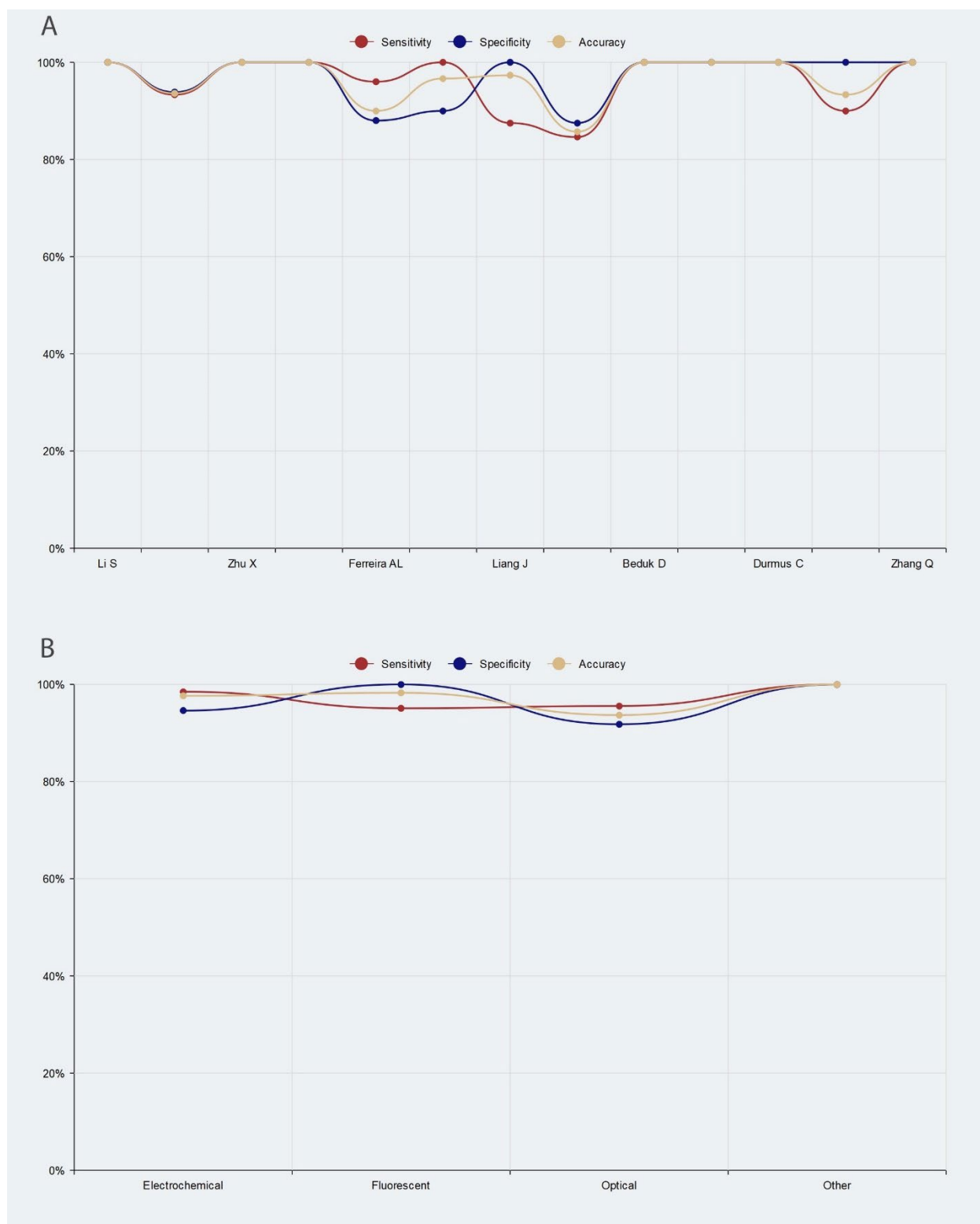
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Figure S1

Comparative bar charts of sensitivity, specificity and accuracy of nanoparticle-based biosensors based on study (A), biosensor type (B), nanoparticle type (C) and the type of target molecule (D).



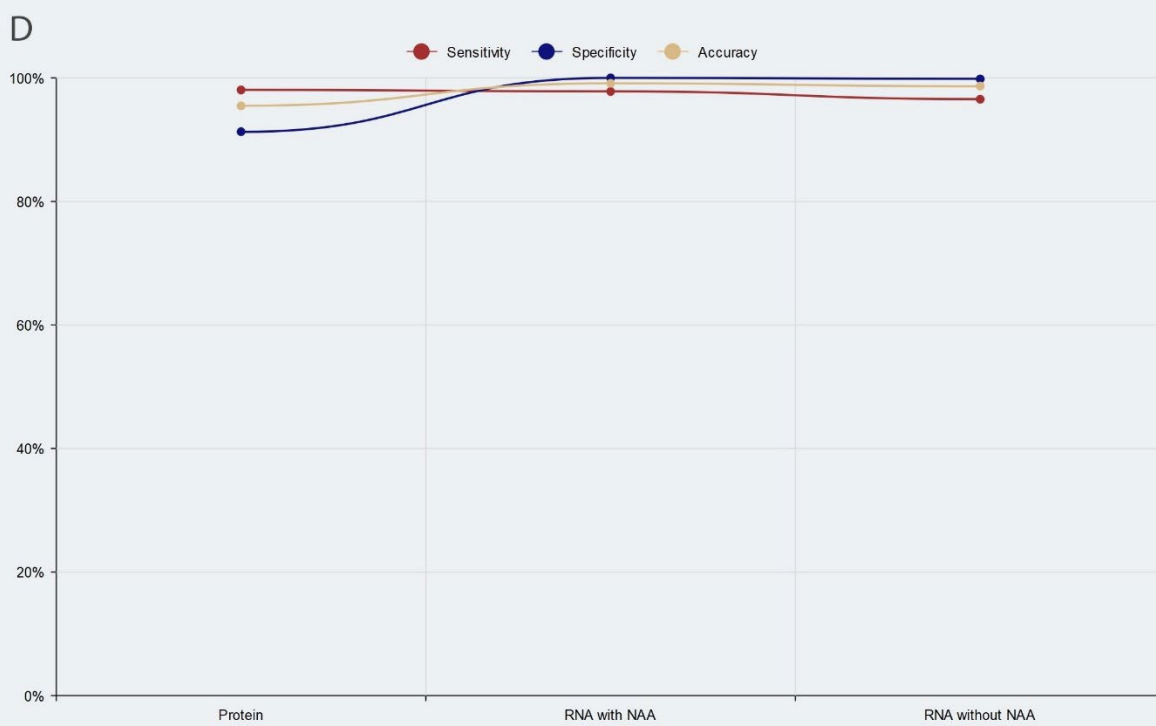
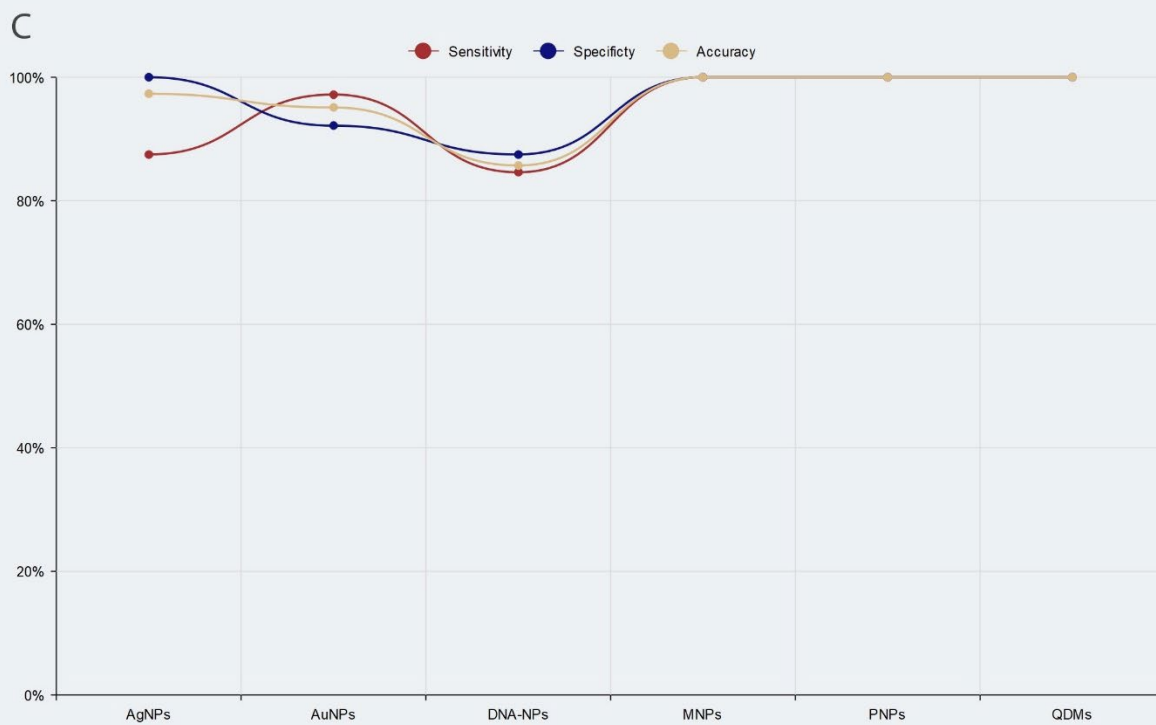


Table S1

List of query strings used for searching Web of Science.

Search Number	Category	Query String
#1	COVID-19 Diagnosis	((TS=(COVID-19) OR TS=(coronavirus disease 2019) OR TS=(SARS-CoV-2) OR TS=(severe acute respiratory syndrome coronavirus 2) OR TS=(nCoV) OR TS=(2019 nCoV)) AND (TS=(diagnos* OR detect* OR test*))) AND DOP=(2019-11-01/2022-04-30)
#2	Diagnostic Accuracy	(AB=(sensitiv*) OR AB=(specific*) OR TS=(sensitivity and specificity) OR TS=(predictive value) OR TS=(diagnostic accuracy) OR TS=(diagnostic efficacy) OR TS=(diagnostic value) OR TS=(limit AND detection)) AND DOP=(2019-11-01/2022-04-30)
#3	RT-qPCR	(TS=(reverse transcription polymerase chain reaction) OR TS=(PCR) OR TS=(RT-PCR) OR TS=(RT-qPCR) OR TS=(RNA)) AND DOP=(2019-11-01/2022-04-30)
#4	Pharyngeal Swab	(TS=(pharynx) OR TS=(throat) OR TS=(nasal) OR TS=(pharyngeal) OR TS=(nasopharyngeal) OR TS=(oropharyngeal) OR TS=(swab*)) AND DOP=(2019-11-01/2022-04-30)
#5	Nanoparticles	(TS=(nano-particle*) OR TS=(nano-scale particle*) OR TS=(nano-sized particle*) OR TS=(nanoparticle*) OR TS=(nanoparticulate) OR TS=(nanoscale particle*) OR TS=(nanosized particle*) OR TS=(nanostructured particle*) OR TS=(nanostructured particulate) OR TS=(particulate nanostructure*)) AND DOP=(2019-11-01/2022-04-30)
#6	Biosensors	(AB=(biosens*) OR TS=(biosensor*) OR TS=(aptasensor*) OR TS=(biochip*) OR TS=(immunosensor*)) AND DOP=(2019-11-01/2022-04-30)
#7	Combined Search	(#1 AND #2 AND #3 AND #4 AND #5 AND #6) NOT TS=(review) AND DT=(Article)

Table S2

List of query strings used for searching Embase.

Search Number	Category	Query String
#1	COVID-19 Diagnosis	('covid 19':ti,ab,kw OR 'coronavirus disease 2019'/exp OR 'sars cov 2':ti,ab,kw OR 'severe acute respiratory syndrome coronavirus 2'/exp OR ncov:ti,ab,kw OR '2019 ncov':ti,ab,kw) AND ('diagnostic procedure'/exp OR diagnos*:ti,ab,kw OR detect*:ti,ab,kw OR test*:ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#2	Diagnostic Accuracy	(sensitiv*:ti,ab,kw OR specific*:ti,ab,kw OR 'sensitivity and specificity'/exp OR 'predictive value'/exp OR 'diagnostic accuracy'/exp OR 'quality control procedures'/exp OR 'diagnostic efficacy':ti,ab,kw OR 'diagnostic value'/exp OR 'limit of detection'/exp OR 'detection limit':ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#3	RT-qPCR	('reverse transcription polymerase chain reaction'/exp OR 'pcr'/exp OR 'rt pcr'/exp OR pcr:ti,ab,kw OR 'rt-pcr':ti,ab,kw OR 'rt-qpcr':ti,ab,kw OR 'rna'/exp OR rna:ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#4	Pharyngeal Swab	('pharynx'/exp OR 'nasopharyngeal swab'/exp OR 'oropharyngeal swab'/exp OR 'throat swab'/exp OR nasopharyngeal:ti,ab,kw OR oropharyngeal:ti,ab,kw OR pharyngeal:ti,ab,kw OR throat:ti,ab,kw OR nasal:ti,ab,kw OR swab*:ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#5	Nanoparticles	('nanoparticle'/exp OR 'nanoparticle*':ti,ab,kw OR 'nano-particle*':ti,ab,kw OR 'nano-scale particle*':ti,ab,kw OR 'nano-sized particle*':ti,ab,kw OR 'nano-structured particle*':ti,ab,kw OR 'nanoparticulate':ti,ab,kw OR 'nanoscale particle*':ti,ab,kw OR 'nanosized particle*':ti,ab,kw OR 'nanostructured particle*':ti,ab,kw OR 'nanostructured particulate':ti,ab,kw OR 'particulate nanostructure*':ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#6	Biosensors	(biosens*:ti,ab,kw OR 'biosensor'/exp OR biosensor*:ti,ab,kw OR 'aptasensor'/exp OR aptasensor*:ti,ab,kw OR 'biochip'/exp OR biochip*:ti,ab,kw OR 'immunosensor'/exp OR immunosensor*:ti,ab,kw) AND [1-11-2019]/sd NOT [01-05-2022]/sd
#7	Combined Search with filters	(#1 AND #2 AND #3 AND #4 AND #5 AND #6) NOT review:ti,ab,kw AND ('article'/it OR 'article in press'/it)

Table S3

List of query strings used for searching Scopus.

Search Number	Category	Query String
#1	COVID-19 Diagnosis	(TITLE-ABS-KEY (COVID-19) OR TITLE-ABS-KEY (coronavirus AND disease 2019) OR TITLE-ABS-KEY (SARS-CoV-2) OR TITLE-ABS-KEY (severe AND acute AND respiratory AND syndrome AND coronavirus 2) OR TITLE-ABS-KEY (nCoV) OR TITLE-ABS-KEY (2019 AND nCoV)) AND (TITLE-ABS-KEY (diagnos*) OR TITLE-ABS-KEY (detect*) OR TITLE-ABS-KEY (test*)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#2	Diagnostic Accuracy	(TITLE-ABS-KEY (sensitiv*) OR TITLE-ABS-KEY (specific*) OR TITLE-ABS-KEY (sensitivity AND specificity) OR TITLE-ABS-KEY (predictive value) OR TITLE-ABS-KEY (diagnostic AND accuracy) OR TITLE-ABS-KEY (diagnostic AND efficacy) OR TITLE-ABS-KEY (diagnostic AND value) OR TITLE-ABS-KEY (limit AND detection)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#3	RT-qPCR	(TITLE-ABS-KEY (reverse AND transcription AND polymerase AND chain AND reaction) OR TITLE-ABS-KEY (PCR) OR TITLE-ABS-KEY (RT-PCR) OR TITLE-ABS-KEY (RT-qPCR) OR TITLE-ABS-KEY (RNA)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#4	Pharyngeal Swab	(TITLE-ABS-KEY (pharynx) OR TITLE-ABS-KEY (pharyngeal) OR TITLE-ABS-KEY (nasopharyngeal) OR TITLE-ABS-KEY (oropharyngeal) OR TITLE-ABS-KEY (throat) OR TITLE-ABS-KEY (nasal) OR TITLE-ABS-KEY (swab*)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#5	Nanoparticles	(TITLE-ABS-KEY (nanoparticle*) OR TITLE-ABS-KEY (nano-particle*) OR TITLE-ABS-KEY (nano-scale particle*) OR TITLE-ABS-KEY (nano-sized particle*) OR TITLE-ABS-KEY (nano-structured particle*) OR TITLE-ABS-KEY (nanoparticulate) OR TITLE-ABS-KEY (nanoscale particle*) OR TITLE-ABS-KEY (nanosized particle*) OR TITLE-ABS-KEY (nanostructured particle*) OR TITLE-ABS-KEY (nanostructured particulate) OR TITLE-ABS-KEY (particulate nanostructure*)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#6	Biosensors	(ABS (biosens*) OR TITLE-ABS-KEY (biosensor*) OR TITLE-ABS-KEY (aptasensor*) OR TITLE-ABS-KEY (biochip*) OR TITLE-ABS-KEY (immunosensor*)) AND (PUBYEAR > 2018 AND PUBYEAR < 2023)
#7	Combined Search	(#1 AND #2 AND #3 AND #4 AND #5 AND #6) AND NOT TITLE-ABS-KEY (review) AND (LIMIT-TO (DOCTYPE , "ar"))

Table S4

List of query strings used for searching ProQuest.

Search Number	Category	Query String
S1	COVID-19 Diagnosis	(ab(COVID-19) OR ab(coronavirus disease 2019) OR ab(SARS-CoV-2) OR ab(Severe Acute Respiratory Syndrome Coronavirus 2) OR ab(nCoV) OR ab(2019 nCoV)) AND (ab(diagnos*) OR ab(detect*) OR ab(test*)) AND PD(20191101-20220430)
S2	Diagnostic Accuracy	(ab(sensitiv*) OR ab(specific*) OR ab(sensitivity and specificity) OR ab(predictive value) OR ab(diagnostic accuracy) OR ab(diagnostic efficacy) OR ab(diagnostic value) OR ab(detection limit)) AND PD(20191101-20220430)
S3	RT-qPCR	(ab(reverse transcription polymerase chain reaction) OR ab(PCR) OR ab(RT-PCR) OR ab(RT-qPCR) OR ab(RNA)) AND PD(20191101-20220430)
S4	Pharyngeal Swab	(ab(pharynx) OR ab(pharyngeal) OR ab(nasopharyngeal) OR ab(oropharyngeal) OR ab(throat) OR ab(nasal) OR ab(swab*)) AND PD(20191101-20220430)
S5	Nanoparticles	(ab(nanoparticle*) OR ab(nano-particle*) OR ab(nano-scale particle*) OR ab(nano-sized particle*) OR ab(nano-structured particle*) OR ab(nanoparticulate) OR ab(nanoscale particle*) OR ab(nanosized particle*) OR ab(nanostructured particle*) OR ab(nanostructured particulate) OR ab(particulate nanostructure*)) AND PD(20191101-20220430)
S6	Biosensors	(ab(biosens*) OR su(biosensor*) OR ab(aptasensor*) OR ab(biochip*) OR ab(immunosensor*)) AND PD(20191101-20220430)
S7	Combined Search	(S1 AND S2 AND S3 AND S4 AND S5 AND S6) NOT ab(review) AND DTYPE(Dissertation/Thesis)

Table S5

List of query strings used for searching EBSCOhost Web.

Search Number	Category	Query
S1	COVID-19 Diagnosis	((AB(COVID-19) OR AB(coronavirus disease 2019) OR AB(SARS-CoV-2) OR AB(Severe Acute Respiratory Syndrome Coronavirus 2) OR AB(nCoV) OR AB(2019 nCoV)) AND (AB(diagnos*) OR AB(detect*) OR AB(test*))) AND DT 20191101-20220430
S2	Diagnostic Accuracy	(AB(sensitiv*) OR AB(specific*) OR AB(sensitivity and specificity) OR AB(predictive value) OR AB(diagnostic accuracy) OR AB(diagnostic efficacy) OR AB(diagnostic value) OR AB(detection limit)) AND DT 20191101-20220430
S3	RT-qPCR	(AB(reverse transcription polymerase chain reaction) OR AB(PCR) OR AB(RT-PCR) OR AB(RT-qPCR) OR AB(RNA)) AND DT 20191101-20220430
S4	Pharyngeal Swab	(AB(pharynx) OR AB(pharyngeal) OR AB(nasopharyngeal) OR AB(oropharyngeal) OR AB(nasal) OR AB(throat) OR AB(swab*)) AND DT 20191101-20220430
S5	Nanoparticles	(AB(nanoparticle*) OR AB(nano-particle*) OR AB(nano-scale particle*) OR AB(nano-sized particle*) OR AB(nano-structured particle*) OR AB(nanoparticulate) OR AB(nanoscale particle*) OR AB(nanosized particle*) OR AB(nanostructured particle*) OR AB(nanostructured particulate) OR AB(particulate nanostructures*)) AND DT 20191101-20220430
S6	Biosensors	(AB(biosens*) OR SU(biosensor*) AB(aptasensor*) OR AB(biochip*) OR AB(immunosensor*)) AND DT 20191101-20220430
S7	Combined Search	(S1 AND S2 AND S3 AND S4 AND S5 AND S6) NOT AB(review) AND PZ Article

Table S6

List of query strings used for searching the WHO Global Literature on Coronavirus Disease.

Search Number	Category	Query String
#1	Diagnostic Accuracy	tw:((sensitiv*) OR (specific*) OR (sensitivity AND specificity) OR (predictive value) OR (diagnostic accuracy) OR (diagnostic efficacy) OR (diagnostic value) OR (detection limit)) AND year_cluster:("2019" OR "2020" OR "2021" OR "2022")
#2	RT-qPCR	tw:((reverse transcription polymerase chain reaction) OR (pcr) OR (rt-pcr) OR (rt-qpcr) OR (rna)) AND year_cluster:("2019" OR "2020" OR "2021" OR "2022")
#3	Pharyngeal Swab	tw:((pharynx) OR (pharyngeal) OR (nasopharyngeal) OR (oropharyngeal) OR (nasal) OR (throat) OR (swab*)) AND year_cluster:("2019" OR "2020" OR "2021" OR "2022")
#4	Nanoparticles	tw:((nanoparticle*) OR (nano-scale particle*) OR (nano-sized particle*) OR (nano-structured particle*) OR (nanoparticulate) OR (nanoscale particle*) OR (nanosized particle*) OR (nanostructured particle*) OR (nanostructured particulate) OR (particulate nanostructure*)) AND year_cluster:("2019" OR "2020" OR "2021" OR "2022")
#5	Biosensors	tw:((biosensor*) OR (aptasensor*) OR (biochip*) OR (immunosensor*)) AND year_cluster:("2019" OR "2020" OR "2021" OR "2022")
#6	Combined Search	(tw:((sensitiv*) OR (specific*) OR (sensitivity AND specificity) OR (predictive value) OR (diagnostic accuracy) OR (diagnostic efficacy) OR (diagnostic value) OR (detection limit)) AND tw:((reverse transcription polymerase chain reaction) OR (pcr) OR (rt-pcr) OR (rt-qpcr) OR (rna)) AND tw:((pharynx) OR (pharyngeal) OR (nasopharyngeal) OR (oropharyngeal) OR (nasal) OR (throat) OR (swab)) AND tw:((nanoparticle*) OR (nano-scale particle*) OR (nano-sized particle*) OR (nano-structured particle*) OR (nanoparticulate) OR (nanoscale particle*) OR (nanosized particle*) OR (nanostructured particle*) OR (nanostructured particulate) OR (particulate nanostructure*)) AND tw:((biosensor*) OR (aptasensor*) OR (biochip*) OR (immunosensor*))) AND year_cluster:("2020" OR "2022" OR "2021") AND NOT tw:(review) AND type:(article)

Table S7

QUADAS-2 domains adapted from the guidelines proposed by Wade et al. in 2013 (Wade et al., 2013).

Domain	Questions	Answers	
Patient Selection	Quality	<ol style="list-style-type: none"> 1. Was a consecutive or random sample of patients enrolled? 2. Was a case-control design avoided? 3. Did the study avoid inappropriate exclusions? 	Yes/No/Unclear
	Bias	<ul style="list-style-type: none"> • Could the selection of patients have introduced bias? 	Low/High/Unclear
Index Test	Quality	<ol style="list-style-type: none"> 1. Were the index test results interpreted without the knowledge of the results of the reference test? 2. If a threshold was used, was it pre-specified? 3. Was the execution of the intervention technology as it would be in practice? 	Yes/No/Unclear
	Bias	<ul style="list-style-type: none"> • Could the methods used to conduct or interpret the index test have introduced bias? 	Low/High/Unclear
Reference Standard	Quality	<ol style="list-style-type: none"> 1. Is the reference standard likely to correctly classify the target condition? 2. Were the reference standard results interpreted without knowledge of the results of the index test? 3. Was the execution of the reference standard as it would be in the practice? 	Yes/No/Unclear
	Bias	<ul style="list-style-type: none"> • Could methods used to conduct or interpret the reference standard have introduced bias? 	Low/High/Unclear
Flow and Timing	Quality	<ol style="list-style-type: none"> 1. Was there an appropriate interval between the index test and reference standard? 2. Did all patients receive the same reference standard? 3. Were all patients included in the analysis? 	Yes/No/Unclear
	Bias	<ul style="list-style-type: none"> • Could the patient flow have introduced bias? 	Low/High/Unclear

Table S8

Number of affirmative answers for each study under the four domains of QUADAS-2.

Study	Patient Selection (D1)		Index Test (D2)		Reference Standard (D3)		Flow and Timing (D4)		Ref.
	Questions	Risk of Bias	Questions	Risk of Bias	Questions	Risk of Bias	Questions	Risk of Bias	
Li S	⊕	Moderate	⊕⊕	Moderate	⊕⊕⊕	Low	⊕	Moderate	(Li et al., 2020)
Ventura BD	⊕	Low	⊕⊕	Moderate	⊕⊕⊕	Low	⊕	Moderate	(Ventura et al., 2020)
Zhu X	⊕	Low	⊕⊕	Moderate	⊕⊕⊕	Low	⊕⊕	Low	(Zhu et al., 2020)
Eissa S	⊕	High	⊕⊕	Moderate	⊕⊕⊕	Low	⊕⊕	Low	(Eissa et al., 2021)
Ferreira AL	⊕	Low	⊕⊕	Moderate	⊕⊕⊕	Low	⊕	Moderate	(Ferreira et al., 2021)
Li J	⊕	High	⊕⊕	Moderate	⊕⊕⊕	Low	⊕	Moderate	(Li et al., 2021)
Liang J	⊕	Low	⊕⊕⊕	Low	⊕⊕⊕	Low	⊕⊕	Low	(Liang et al., 2021)
Zhao H	⊕	High	⊕⊕⊕	Low	⊕⊕⊕	Low	⊕⊕	Low	(Zhao et al., 2021)
Beduk D	⊕	Low		Moderate		Low		Low	(Beduk et al., 2022)
Dighe K	⊕	Moderate	⊕⊕⊕	Low	⊕⊕⊕	Low	⊕⊕⊕	Low	(Dighe et al., 2022)
Durmus C	⊕	Moderate	⊕⊕	Moderate	⊕⊕⊕	Low	⊕⊕	Low	(Durmus et al., 2022)
López-Valls M	⊕	High	⊕⊕	Moderate	⊕⊕⊕	Low	⊕⊕	Low	(López-Valls et al., 2022)
Zhang Q	⊕	Low	⊕⊕	Moderate	⊕⊕⊕	Low	⊕⊕	Low	(Zhang et al., 2022)

Table S9

Number of records identified for each search query string on selected databases.

Literature Database	Search Query Strings						Combined Search					
	Q1	Q2	Q3	Q4	Q5	Q6						
EBSCOhost Web (Academic Search Ultimate)	34,949	600,978	108,404	23,029	76,670	10,204						1
Embase	160,426	1,271,838	441,907	71,309	137,698	1,498						2
ProQuest	27,675	386,140	71,373	11,843	23,922	5,049						7
PubMed/MEDLINE	51,415	705,925	176,087	45,880	86,685	17,056						16
Scopus	97,162	2,034,610	451,642	78,779	246,087	32,411						9
Web of Science Core Collection	69,191	1,171,448	234,168	47,928	227,405	26,293						5
WHO Global Literature on Coronavirus Disease	N/A	78,913	42,206	19,410	1,962	1,281						10
Total	435,030	6,412,843	1,563,232	304,315	782,579	101,220	Cum.	Net.	PE.	Inc.	Exc.	
							50	19	18	13	5	

References

- Beduk, D., Ilton de Oliveira Filho, J., Beduk, T., Harmanci, D., Zihnioglu, F., Cicek, C., Sertoz, R., Arda, B., Goksel, T., Turhan, K., Salama, K.N., Timur, S., 2022. "All In One" SARS-CoV-2 variant recognition platform: Machine learning-enabled point of care diagnostics. *Biosens. Bioelectron.* X 10, 100105. <https://doi.org/10.1016/j.biosx.2022.100105>
- Dighe, K., Moitra, P., Alafeef, M., Gunaseelan, N., Pan, D., 2022. A rapid RNA extraction-free lateral flow assay for molecular point-of-care detection of SARS-CoV-2 augmented by chemical probes. *Biosens. Bioelectron.* 200, 113900. <https://doi.org/10.1016/j.bios.2021.113900>
- Durmus, C., Balaban Hanoglu, S., Harmanci, D., Moulahoum, H., Tok, K., Ghorbanizamani, F., Sanli, S., Zihnioglu, F., Evran, S., Cicek, C., Sertoz, R., Arda, B., Goksel, T., Turhan, K., Timur, S., 2022. Indiscriminate SARS-CoV-2 multivariant detection using magnetic nanoparticle-based electrochemical immunosensing. *Talanta* 243, 123356. <https://doi.org/10.1016/j.talanta.2022.123356>
- Eissa, S., Alhadrami, H.A., Al-Mozaini, M., Hassan, A.M., Zourob, M., 2021. Voltammetric-based immunosensor for the detection of SARS-CoV-2 nucleocapsid antigen. *Microchim. Acta* 188, 199. <https://doi.org/10.1007/s00604-021-04867-1>
- Ferreira, A.L., De Lima, L.F., Torres, M.D.T., De Araujo, W.R., De La Fuente-Nunez, C., 2021. Low-Cost Optodiagnostic for Minute-Time Scale Detection of SARS-CoV-2. *ACS Nano* 15, 17453–17462. <https://doi.org/10.1021/acsnano.1c03236>
- Li, J., Wu, D., Yu, Y., Li, T., Li, K., Xiao, M.M., Li, Y., Zhang, Z.Y., Zhang, G.J., 2021. Rapid and unamplified identification of COVID-19 with morpholino-modified graphene field-effect transistor nanosensor. *Biosens. Bioelectron.* 183, 113206. <https://doi.org/10.1016/j.bios.2021.113206>
- Li, S., Jiang, W., Huang, J., Liu, Y., Ren, L., Zhuang, L., Zheng, Q., Wang, M., Yang, R., Zeng, Y., Wang, Y., 2020. Highly sensitive and specific diagnosis of COVID-19 by reverse transcription multiple cross-displacement amplification-labelled nanoparticles biosensor. *Eur. Respir. J.* 56, 2002060. <https://doi.org/10.1183/13993003.02060-2020>
- Liang, J., Teng, P., Xiao, W., He, G., Song, Q., Zhang, Y., Peng, B., Li, G., Hu, L., Cao, D., Tang, Y., 2021. Application of the amplification-free SERS-based CRISPR/Cas12a platform in the identification of SARS-CoV-2 from clinical samples. *J. Nanobiotechnology* 19, 273. <https://doi.org/10.1186/s12951-021-01021-0>
- López-Valls, M., Escalona-Noguero, C., Rodríguez-Díaz, C., Pardo, D., Castellanos, M., Milán-Rois, P., Martínez-Garay, C., Coloma, R., Abreu, M., Cantón, R., Galán, J.C., Miranda, R., Somoza, Á., Sot, B., 2022. CASCADE: Naked eye-detection of SARS-CoV-2 using Cas13a and gold nanoparticles. *Anal. Chim. Acta* 1205, 339749. <https://doi.org/10.1016/j.aca.2022.339749>
- Ventura, B. Della, Cennamo, M., Minopoli, A., Campanile, R., Censi, S.B., Terracciano, D., Portella, G., Velotta, R., 2020. Colorimetric test for fast detection of SARS-COV-2 in nasal and throat swabs. *ACS Sensors* 5, 3043–3048. <https://doi.org/10.1021/acssensors.0c01742>
- Wade, R., Corbett, M., Eastwood, A., 2013. Quality assessment of comparative diagnostic accuracy studies: our experience using a modified version of the QUADAS-2 tool. *Res. Synth. Methods* 4, 280–286. <https://doi.org/10.1002/jrsm.1080>
- Zhang, Q., Li, J., Li, Y., Tan, G., Sun, M., Shan, Y., Zhang, Y., Wang, X., Song, K., Shi, R., Huang, L., Liu, F., Yi, Y., Wu, X., 2022. SARS-CoV-2 detection using quantum dot fluorescence immunochromatography combined with isothermal amplification and CRISPR/Cas13a. *Biosens. Bioelectron.* 202, 113978. <https://doi.org/10.1016/j.bios.2022.113978>
- Zhao, H., Zhang, Y., Chen, Y., Ho, N.R.Y., Sundah, N.R., Natalia, A., Liu, Y., Miow, Q.H., Wang, Y., Tambyah, P.A., Ong, C.W.M., Shao, H., 2021. Accessible detection of SARS-CoV-2 through molecular nanostructures and automated microfluidics. *Biosens. Bioelectron.* 194, 113629. <https://doi.org/10.1016/j.bios.2021.113629>
- Zhu, X., Wang, X., Han, L., Chen, T., Wang, L., Li, H., Li, S., He, L., Fu, X., Chen, S., Xing, M., Chen, H., Wang, Y., 2020. Multiplex reverse transcription loop-mediated isothermal amplification combined with nanoparticle-based lateral flow biosensor for the diagnosis of COVID-19. *Biosens. Bioelectron.* 166, 112437.

<https://doi.org/10.1016/j.bios.2020.112437>