A rapid review on the COVID-19's global impact on breast cancer screening participation rates and volumes from January-December 2020

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Title: A Rapid review on the COVID-19's Global Impact on Breast Cancer Screening Participation Rates and Volumes from January-December 2020

Rapid Review Question: Document and estimate the disruption to breast screening due to COVID-19

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On behalf of UNCOVER and the International Partnership for Resilience in Cancer Systems (I-PaRCS), Breast Cancer Working Group 2

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Abstract

COVID-19 has strained population breast mammography screening programs that aim to diagnose and treat breast cancers earlier. As the pandemic has affected countries differently, we aimed to quantify changes in breast screening volume and uptake during the first year of COVID-19 crisis. We systematically searched Medline, the WHO (World Health Organization) COVID-19 database, and governmental databases. Studies covering January 2020 to March 2022 were included. We extracted and analyzed data regarding study methodology, screening volume and uptake. To assess for risk-of-bias, we used the Joanna Briggs Institute Critical Appraisal tool.
Twenty-six cross-sectional descriptive studies (focusing on 13 countries) were included out of 935 independent records. Reductions in screening volume and uptake rates were observed among eight countries. Changes in screening participation volume in five countries with national population-based screening ranged from -13% to –31%. Among two countries with limited population-based programs the decline ranged from -61% to -41%. Within the USA, population participation volumes varied ranging from +18% to -39% with suggestion of differences by insurance status (HMO, Medicare, and low-income programs). Almost all studies had high risk-of-bias due to insufficient statistical analysis and confounding factors. Extent of COVID-19-induced reduction in breast screening participation volume differed by region and data suggested potential differences by healthcare setting (e.g., national health insurance vs private health care). Recovery efforts should monitor access to screening and early diagnosis to determine if prevention services need strengthening to increase coverage of disadvantaged groups and reduce disparities.

Impact Statement:

A rapid review of 26 studies globally observed a reduction in breast screening participation volume during COVID-19 that differed by region and healthcare setting suggesting monitoring of screening access by disadvantaged groups to reduce disparities.

Introduction

Breast cancer is the most common cancer worldwide with 2.3 million cases diagnosed and 685000 deaths in 2020 (WHO, 2021). Mammography-based screening programs allow for early detection of breast cancers, for earlier intervention and disease stage that improves patient outcomes (IARC, 2022). Early detection and diagnosis from screening may reduce mortality up to 65% among breast cancer patients (Berry *et al*. 2005). Populations with a good uptake rate in screening programs can achieve a 90% 5-year survival rate in patients who received an early diagnosis attributed to screening (WHO, 2020).

COVID-19 affected global health systems and has strained population breast mammography screening programs. Previous work on modelled evaluations and a focus on tumor staging and mortality as outcomes, suggested scenarios are likely to differ by region and organization of delivery of breast cancer screening (*Figueroa et al. Prev Med 2021*). In different countries, screening models vary from population-based to opportunistic screening (offered to patients in healthcare settings – more common in private healthcare) (IARC, 2016).

Here we aimed to quantify systematically breast screening participation rates before and after the first COVID-19 wave amidst the suspensions in nations with/without opportunistic screening programs. This was performed by investigating two primary study outcomes: changes in screening volume and participation uptake rates.

Results

Figure 1 summarizes the search strategy. The initial search retrieved 1207 articles and 935 independent records. After screening (see Methods), 26 cross-sectional studies from 12 countries were eligible for inclusion (**Table 1)**. Seven reports came from Europe (Campbell et al, 2021; Jidkova et al, 2022; Knoll et al, 2022; Eijkelboom et al, 2021; Losurdo et al, 2022; Toss et al, 2021; NHS England, 2021), two from Oceania (BreastScreen Australia, 2020; BreastScreen Aoteroa, 2022), one from Asia (Shen et al, 2022), two from South America (Bessa et al, 2021; Riberio et al, 2022) and 14 from North America (Chiarelli et al, 2021; Walker et al, 2021; Doubouva et al, 2021; Chen et al, 2021; Amornsiripanitch et al, 2021; Becker et al, 2021; DeGroff et al, 2021; Dennis et al, 2021; Fedewa et al, 2021; Lehman et al, 2021; London et al, 2022; Miller et al, 2021; Sprague et al, 2021; Nyante et al, 2021). The most frequently reported country was the USA (n = 11). Studies examined either regional (n = 13) or national populations (n = 13).

During COVID-19, many countries implemented various mitigation methods to reduce transmission and of course mortality. To summarize these different infection control measures, **Table 1** shows that all 12 countries had international movement controls in place, 23 study-specific regions had internal movement controls, 21 study-specific regions had stay-at home requirements in place, one study-specific region (Northern Italy, Emilia Romagna) had public transport closures, 23 study-specific regions had bans on gatherings >10 people, 24 study-specific regions had public events bans in place, 24 study-specific regions had workplace closures in place, and 23 study-specific regions had in-person school closures in place (Mathieu et al, 2022; CIHI, 2022; Commonwealth of Massachuetts, 2021; Commonwealth of Virginia, 2023; Executive Office of Health and Human Services, 2023; SPICe, 2023, State of Michigan, 2020; State of North Carolina, 2020). Analysis of data from all studies was limited from 1 January 2020 to 31 December 2020.

Table 1. Descriptive characteristics of included cross-sectional studies (n=26)

Study	Publication type	Study design	Country	Region (If not national)	Total Female Population of Study Area	Sample size	Study screening data source	Screening (National/Regional)	Screening age range	Screening type	Screening time comparison	Types of Restrictions present over study period#								COVID-19 7-day new infection rate in region of focus (per 100000)*	
												International Travel Limits	Internal Movement Controls	Stay at home requirement	Public transport closure	Ban on gatherings of >10 people	Public events ban	Workplace closure	School closure	Minimum infection rate in study period	Maximum infection rate in study period
Europe (n=7)																					
Campbell et al, 2021	Peer-reviewed	Cross sectional	Scotland (UK)		2728000	Not specified	NHS Scotland	National	50-70	Digital Mammography	Aug – Dec 2019 vs Aug -Dec 2020	Yes	Yes	No	No	Yes	Yes	Yes	No	10.14	212.67
Jidkova et al, 2022	Peer-reviewed	Cross secti	Belgium	Flanders	3382265	Not specified	Flanders Online Screening	Regional	50-69	Digital Mammography	Jul – Nov 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	3.58	580.63

		onal					Database				vs Jul – Nov 2020										
Knoll et al, 2022	Preprint	Cross sectional	Austria	Innsbruck	5673000	596	Database from gynecological oncological center in Austria, Tyrol	Local	45 - 69 years invited for screening. Women aged 40 – 44 years and 70 - 75 years may opt in	Digital Mammography	Mar – Dec 2019 vs Mar – Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	no data	no data
Eijkelboom et al, 2021	Peer-reviewed	Cross sectional	Netherlands		8701000	3371	Netherlands Cancer Registry	National	50-75	Digital Mammography	Jan – Feb 2020 vs Jul – Aug 2020	Yes	No	No	No	Yes	No	Yes	No	0.32	67.25
Losurdo et al,	Peer-review	Cros s	Italy	Friuli Venezia	624418	58643	“Data-Breast”	Regional	50-69	Digital Mammo	Oct – Dec	Yes$	Yes$	Yes$	No$	Yes$	Yes $	Yes$	Yes $	19.2	497.6

2022	ed	sectional		Giulia			database of the “Eusoma certified SSD Breast Unit of Trieste and from the Surgical Department of DAI Chirurgia Generale—ASUGI.			graphy	2019 vs Oct – Dec 2020										
Toss et al, 2021	Peer-reviewed	Cross sectional	Italy	Northern Italy, Emilia Romagna	2291000	24994	Emilia Romagna National Healthcare System	Regional	45-79	Digital Mammography	2019 vs 2020	Yes$	Yes$	Yes$	Yes$	Yes$	Yes $	Yes$	Yes $	4.00	390.9
NHS England, 2021	Government paper	Cross sectional	England (UK)		33940000	2230000	NHS England	National	50-71	Digital Mammography	2019 vs 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.00	92.36
Oceania (n=2)																					
BreastScr	Gover	Cros	Austral		12780	Not	BreastScre	National	50-74	Digital	May –	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0.18	13.31

een Australia, 2020	nment Paper	s sectional	ia		000	specified	en Australia			Mammography	Sep 2018 vs May – Sep 2020										
BreastScreen Aotearoa, 2022	Government Paper	Cross sectional	New Zealand		2497000	Not specified	BreastScreen Aotearoa	National	45-69	Digital Mammography	May – Dec 2018 vs May - Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0	1.06
Asia (n=1)																					
Shen et al, 2022	Peer-reviewed	Cross sectional	China	Taiwan	11981657	699911	Taiwan National Infectious Disease Statistics system	Regional	40-69	Digital Mammography	Jan – Apr 2019 vs Jan – Apr 2020	Yes	No	No	No	No	No	No	Yes	no data	no data
Americas (n=16)																					
Bessa et al, 2021	Peer-reviewed	Cross sectional	Brazil		106500000	(2019: 20636636; 2020: 21140958)	Brazilian Unified Health System (SUS)	National	50-69	Digital Mammography	2019 vs 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.00	149.68

Riberio et al, 2022	Peer-reviewed	Cross sectional	Brazil		106500000	5996798	Brazilian National Health Service (SUS) Outpatient Information System (SIA/SUS), SUS Hospital Information System (SIH/SUS), High Complexity Procedure Authorizations database (APAC), Cancer Information System (ISCAN).	National	50-69	Digital Mammography	Jul – Dec 2019 vs Jul – Dec 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	53.72	149.68

Chiarelli et al, 2021	Peer-reviewed	Cross sectional	Canada	Ontario	7371000	426967	Ontario Breast Screening Program (OBSP)	Regional	50-74	Digital Mammography, MRI (High risk)	Jul - Dec 2019 vs Jul - Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	3.99	117.01
Walker et al, 2021	Peer-reviewed	Cross sectional	Canada	Ontario	7371000	605889 (2019) 284242 (2020)	Ontario Breast Screening Program (OBSP)	Regional	50-74	Digital Mammography	Modelled 2019 data vs Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	75.74	117.01
Doubova et al, 2021	Peer-reviewed	Cross sectional	Mexico		64570000	1431216	Mexican Institute of Social Security (IMSS)	National	40 - unspecified	Digital Mammography	Jan 2019 – Mar 2020 vs Apr – Dec 2020	Yes	Yes	Yes	No	No	Yes	Yes	Yes	2.60	61.12
Chen et al, 2021	Peer-reviewed	Cross sectional	USA		167500000	Not specified	HealthCore Integrated Research Database	National	50-79 years	Digital Mammography	Jul 2019 vs Jul 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	119.03	142.00

Amornsiripanitch et al, 2021	Peer-reviewed	Cross sectional	USA	Massachusetts	3537000	32387	Electronic medical record (Epic, Verona, WI) - Massachusetts. One tertiary care academic center, a community hospital, a specialized cancer center, three outpatient imaging centers, one urban healthcare center, and one mobile mammography van	Regional	40 - unspecified years	Digital Mammography	Jun – Aug 2019 vs Jun – Aug 2020	Yes	Yes	No	No	Yes	Yes	No	No	17.06	53.09

Becker et al, 2021	Peer-reviewed	Cross sectional	USA	Michigan	5062000	7250080	Women enrolled in Health Managed Organization (HMO) Blue Cross Blue Shield (BCBS) in Michigan	Regional	40-74	Digital Mammography	Dec 2019 vs Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	147.56	328.94
DeGroff et al, 2021	Peer-reviewed	Cross sectional	USA		167500000	630264	Breast and Cervical Cancer Early Detection Program (NBCCEDP) Database, which provides cancer screening services to women with low income and	National	40-74	Digital Mammography	Jun 2019 vs Jun 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	45.46	103.84

							inadequate health insurance													
Dennis et al, 2021	Peer-reviewed	Cross sectional	USA		167500000	475083	Behavioral Risk Factor Surveillance System (BRFSS) survey database	National	40-74	Digital Mammography	2014-2019 vs 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.00	460.68
Fedewa et al, 2021	Peer-reviewed	Cross sectional	USA		167500000	2019:142003 2020:150630	Data from 32 CHCs of the American Cancer Society's Community Health Advocates Implementing Nationwide Grants for	National	50-74	Digital Mammography	2019 vs 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.00	460.68

							Empowerment and Equity (CHANGE) grant program to increase BCSRs and follow-up care														
Lehman et al, 2021	Preprint	Cross sectional	USA		167500000	29276	Screening database over 5 facilities	National	Unspecified	Digital Mammography	2019 vs 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0.00	460.68
London et al, 2022	Peer-reviewed	Cross sectional	USA		167500000	34000000 (full study including colorectal cancers	TriNetX Research Network	National	Unspecified	Digital Mammography	Jul – Dec 2019 vs Jul – Dec 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	74.54	460.68
Miller et al, 2021	Peer-reviewed	Cross secti	USA	Virginia	2757460	Not specified	Instituition Database, University	Regional	Unspecified (45 -	Digital Mammography	Jan – Nov 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	no data	no data

		onal					of Virginia		70)		vs Jan - Nov 2020										
Sprague et al, 2021	Peer-reviewed	Cross sectional	USA		167500000	461083	62 radiology facilities of Breast Cancer Surveillance Consortium	National	40-79	Digital Mammography	Jan-Jul 2019 vs Jan-Jul 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0.00	142.00
Nyante et al, 2021	Peer-reviewed	Cross sectional	USA	North Carolina	5099371	42412	7 academic and community breast imaging facilities in North Carolina	Regional	40-79	Digital Mammography	Modelled Sep 2019 data vs Sep 2020	Yes	No	No	No	No	Yes	Yes	Yes	80.27	91.26

N.B. England's and Scotland's NHS systems are devolved and therefore, are separate national entities. However, they hold similar screening criterion where Breast screening policy in NHS (across the UK) is that all women aged 50-70 years +364 days are invited for breast screening once every three years.

* - These infection rates were region-specific and analogous to the region the study involved. If study period was ≤1 month, only infection data from the first and last week of the period will be collected. If study period was over the whole year of 2020 the earliest available public health data was used (e.g. Study period started from January 2020 but data was only available in March, March data used as 1st interval of analysis). It should be noted that there is reporting bias here as

testing rates may differ between countries. These infection incidence rates were based on national/regional data depending on whether the study population originated from an entire nation or a limited region within a nation.

- Types of restrictions will include restrictions that were withdrawn at any point of the study period.   Restrictions present were classified as per non-pharmacological interventions mentioned by the paper ***Li et al, 2020 'The Temporal Association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (R) of SARS-COV-2: A modelling study across 131 countries', The Lancet Infectious Diseases,*** if restrictions were introduced/withdrawn during the study period, it will still be indicated as a 'Yes', Data from Oxford COVID-19 policy tracker, devolved state-wide healthcare organisation websites in Canada, USA and UK was used to assess this.

$ - Data was unavailable for regions in this country, national restrictions were assessed instead.

Screening volume changes over study period: Summary data from 17 studies in eight countries reporting breast cancer screening volumes, data from 106,484,908 women before and after COVID-19 infection control measures were extracted (data from 2017 to 2020 were the comparison time period, **Table 2;** Doubouva et al, 2021; Bessa et al, 2021; Riberio et al, 2022; Chiarelli et al, 2021; Losurdo et al, 2022; Walker et al, 2021; NHS England, 2021; Shen et al, 2022; BreastScreen Australia, 2020; DeGroff et al, 2021; Lehman et al, 2021; Amornsiripantich et al, 2021; Sprague et al, 2021; London et al, 2022; Miller et al, 2021; Nyante et al, 2021; Becker et al, 2021). Most studies that showed calendar period trends of screening volume, noted temporal variation with declines especially at the height of the pandemic between March- May 2020. In countries with national screening programs, a negative change in screening volume was reported with the lowest volume change estimated at -12.86% in Australia (BreastScreen Australia, 2020) followed by – 15.80% in England (NHS England, 2021). A larger negative change in screening volume was observed in Brazil (-41.49%) (Ribero et al, 2022) and Mexico (-61.30%) (Doubouva et al, 2021. It should be noted that Brazil and Mexico have a lower proportion of population-based breast screening coverage relative to other countries; Brazil having coverage of ~24%, and Mexico having ~20% coverage of the eligible population (OECD, 2021; Unger-Saldaña et al, 2020). A significant proportion of breast screening in Brazil and Mexico consists of opportunistic screening programs.

In the USA, which has mix of insurance providers there was a wide range of change in screening volume. Using data from Health Managed Organization (HMO) Blue Cross Blue Shield (BCBS) from the state of Michigan, the authors observed temporal changes in rates with an increase slightly above 2019 levels in the last few months of 2020, with an 18.10% overall increase in screening volume (Becker et al. 2021). Although rates were above 2019 levels, the authors noted that the odds that a woman received breast cancer screening remained 20% lower in 2020 relative to 2019 (Becker et al. 2021). This was consistent with the decrease in screening volume that was generally observed from six studies with data among populations wholly or partially covered by national insurance (Lehman et al, 2021; Amornsiripanitch et al, 2021; Sprague et al, 2021; London et al, 2022; Miller et al, 2021; Nyante et al, 2021). Percentage decreases ranged from -36.50% (Lehman et al. 2021) to -9.80% (Miller et al. 2021). Data from the USA National Breast and Cervical Cancer Early Detection Program (NBCCEDP), which provides cancer screening services to women with low income and inadequate health insurance, reported a greater decrease (-39.00%) in volume (DeGroff et al. 2021). Two other studies had smaller populations with less certainty and wider confidence intervals with one reporting an 8% increase (Nyante et al. 2021) and the other a -10% decline (London et al. 2021). In the USA, where there is a mix of national (Medicare) and private insurance depending on age, screening volume changes were similar to other national screening programs at -36.50% (Lehman et al, 2021). In contrast, a positive increase in volume was observed among private insurance providers +30% (London et al, 2022)

Table 2. Breast cancer screening volumes change among 106,484,908 subjects from eight countries

Percentage Change in Volume of Breast Cancer Screening (N=17)							
Study	Country	Region	National/Regional (Scope of Study Population*)	Type of breast screening programme employed within the study population	Sample size	Screening timeframe comparison	Volume change relative to non-COVID-19 period
Europe (n=2)							
Losurdo *et al.* 2022	Italy	Friuli Venezia Giulia	Regional	Population-based Screening present in country	58643	Oct – Dec 2019 vs Oct – Dec 2020	-11.90%
NHS England, 2021	UK	England	National	Population-based Screening present in country	3420000	Monthly Average 2019 vs Monthly Average 2020	-15.80%
Oceania (n=1)							
BreastScreen Australia, 2020	Australia	NA	National	Population-based Screening present in country	802146	May – Sep 2018 vs May – Sep 2020	-12.88%
Asia (n=1)							
Shen *et al.* 2022	China	Taiwan	Regional	Population-based Screening present in country	699911	Jan – Apr 2019 vs Jan – Apr 2020	-22.07%
America (n=13)							
Bessa *et al.* 2021	Brazil	NA	National	Population-based Screening present in country#	(2019: 20636636; 2020: 21140958)	2019 vs 2020	-42.72%

Riberio *et al.* 2022	Brazil	NA	National	Population-based screening present in country but private sector databases included (Brazilian National Health Service (SUS), Outpatient Information System (SIA/SUS), SUS Hospital Information System (SIH/SUS), High Complexity Procedure Authorizations database (APAC), Cancer Information System (ISCAN)	5996798	Jul – Dec 2019 vs Jul – Dec 2020	-41.49%
Doubova *et al.* 2021	Mexico	NA	National	Population-based Screening present in country$	1431216	Jan 2019 – Mar 2020 vs Apr – Dec 2020	-61.30%
Chiarelli *et al*. 2021	Canada	Ontario	Regional	Population-based Screening present in country	426967	Jul - Dec 2019 vs Jul - Dec 2020	-31.30%
Walker *et al*. 2021	Canada	Ontario	Regional	Population-based Screening present in country	890131	Modelled 2019 data vs Dec 2020	-22.80%
Lehman *et al.* 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	29276	2019 vs 2020	-36.50%
Miller *et al.* 2021	USA	North Carolina	Regional	Privatised system with mix of national and private insurance usage	8536000	Jan – Nov 2019 vs Jan – Nov 2020	-9.80%

Amornsiripanitch *et al*. 2021	USA	Massachusetts	Regional	Privatised system with mix of national and private insurance usage	32387	Jun – Aug 2019 vs Jun – Aug 2020	-10.50%
London *et al*. 2022	USA	NA	National	Privatised system with mix of national and private insurance usage	34000000	Dec 2019 vs Dec 2020	20.00%
DeGroff *et al*. 2021	USA	NA	National	The National Breast and Cervical Cancer Early Detection Program (NBCCEDP) that provides cancer screening services to women with low income and inadequate health insurance	630264	Jun 2019 vs Jun 2020	-39.00%
Becker *et al*. 2021	USA	Michigan	Regional	Health Managed Care Organization (HMO)-based screening [database covers HMO data from Michigan].	7250080	Dec 2019 vs Dec 2020	18.10%
Sprague *et al*. 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	461083	Jul 2019 vs Jul 2020	-10.30% (-20.40%-6.60%)
Nyante *et al*. 2021	USA	North Carolina	Regional	Privatised system with mix of national and private insurance usage	42412	Modelled Sep 2019 data vs Sep 2020	9.00%

NA: Not applicable

For studies conducted in the USA, ACS guidelines were used as the data collection comparator starting point where Mar-Jun 2020 was considered to be a suspension in screening.

Legend:

* - This column highlights the origin of the study population in which whether it was drawn from a specific region within a nation, or if the study population was drawn from the entire country.

- The study population from this specific study (Bessa et al, 2021) was solely drawn from a national population-based screening database in Brazil. It should be noted that Brazil has a lower proportion of population-based breast screening coverage relative to other countries; having a coverage of 24% in the eligible population (Unger-Saldaña et al, 2020)

$ - It should be noted that Mexico has a lower proportion of population-based breast screening coverage relative to other countries; having ~20% coverage of the eligible population (OECD, 2021)

Table 3. Breast cancer screening participation uptake rates change from nine studies from five countries

Percentage Change in Participation Uptake rate of Breast Cancer Screening (N=9)							
Study	Country	Region	National/Regional (Scope of Study Population*)	Type of breast screening programme employed within the study population	Sample size	Screening timeframe comparison	Participation rate change relative to non-COVID-19 period
Europe (n=3)							
NHS England, 2021	UK	England	National	Population-based Screening available in country	3420000	2019 vs 2020	-11.80%
Campbell *et al*. 2021	UK	Scotland	National	Population-based Screening available in country	NA	Aug – Dec 2019 vs Aug –Dec 2020@	+10.96% (Aug 2020) +2-8% (Sep 2020–Mar 2021 vs Sep 2019 - Mar 2020)@
Jidkova *et al*. 2022	Belgium	Flanders	Regional	Population-based Screening available in country	NA	Jul – Dec 2019 vs Jul – Dec 2020	-1.0% (-1.3; -0.7)
Oceania (n=1)							
BreastScreen Aotearoa. 2022	New Zealand	NA	National	Population-based Screening available in country	NA	Dec 2018/2019 vs May – Dec 2020	-6.70%
Americas (n=5)							

Bessa *et al*. 2021	Brazil	NA	National	Population-based Screening available in country#	(2019: 20636636; 2020: 21140958)	2019 vs 2020	-43.54%
Dennis *et al*. 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	475083 (Age: 50-74) 117498 (Age: 40-49)	2014-2019 vs 2020	-5.30% (50-79) -7.20% (40-49)
Fedewa *et al*. 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	434840	2019 vs 2020	-8.00%
Amornsiripanitch *et al*. 2021	USA	Massachusetts	Regional	Privatised system with mix of national and private insurance usage	32387	Jun – Aug 2019 vs Jun – Aug 2020	-14.80%
Chen *et al*. 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	NA	Jul 2019 vs Jul 2020	-3.33%

NA: Not applicable

For studies conducted in the USA, ACS guidelines were used as the data collection comparator starting point where Mar-Jun 2020 was considered to be a suspension in screening.

Legend:

* - This column highlights the origin of the study population in which whether it was drawn from a specific region within a nation, or if the study population was drawn from the entire country.

- The study population from this specific study (Bessa et al, 2021) was solely drawn from a national population-based screening database in Brazil. It should be noted that Brazil has a lower proportion of population-based breast screening coverage relative to other countries; having a coverage of 24% in the eligible population (Unger-Saldaña et al, 2020)

@ - It should be noted that this study presented a range of values (2%-8%) comparing the uptake rate from Sep 2020 - Mar 2021 vs Sep 2019 - Mar 2020. As the timeframe of Jan - Mar 2021 were not within the scope of the study, we used the point estimate of the uptake rate in Aug 2020 vs Aug 2019 as our last available data point instead.

Screening participation uptake rate changes: A total of nine cross-sectional studies reported breast cancer screening participation rates and represented > 46,257,402 participants from varying calendar periods across five countries (Amornsiripantich et al, 2021; Dennis et al, 2021; Fedewa et al, 2021; Chen et al, 2021; NHS England, 2021; Campbell et al, 2021; Bessa et al, 2021; BreastScreen Aoteroa, 2022; Jidkova et al, 2022). There was considerable variability in change (**Table 3**), ranging from +2-8% in Scotland to -43.54% in Brazil (Campbell et al, 2021; Bessa et al, 2021). In the USA, there was a consistent negative change in screening participation uptake rates (Amornsiripantich et al, 2021; Dennis et al, 2021; Fedewa et al, 2021; Chen et al, 2021).

Study quality: The quality of included studies was assessed using the JBI tool (**Table 4**). A weakness across most studies was failure to identify and consider confounding factors. From **Table 4,** twenty-five studies had no issues defining the inclusion sample. Nineteen studies were clear in defining the study setting and subjects. Studies had no issues quantifying exposure of COVID-19, although this was based on temporality since all healthcare systems globally were affected (Worldometer, 2022). All studies apart from Becker et al (2021) had no issue measuring the condition through either screening appointment attendance or insurance claims data. Most studies (65%, N=17) did not define confounding factors regarding measurement of primary outcomes. Regarding comparison of volumes of screening prior to COVID-19 and observed periods, these studies did not provide source of reduction in screening capacity (e.g. due to social distancing or participation uptake). Twenty-three studies failed to provide strategies to address confounding factors (e.g., elucidating reduction in capacity and presenting it as a proportion to overall volume).

Four studies (Bessa et al. 2021; Becker et al. 2021; London et al. 2022; Doubova et al. 2021) had unclear reasons for selection of study subjects and control groups (London et al, 2022), confounding factors that were not indicated, nor strategies included to solve this. Among these four papers, vague definition of control groups resulted in a poor comparator, resulting in unreliable outcome measures.

Twenty-three studies provided basic statistical analyses (e.g. mean, adjusted rates per population) with basic data presentation. Statistical analyses were not performed in three government papers (BreastScreen Australia. 2020; NHS England. 2021;

BreastScreen Aotearoa. 2022). Twenty-two studies were unclear or did not provide sufficient descriptive statistical analyses regarding comparison of control data to observed data. Statistical analyses were performed in four studies. This includes provision of odds ratios by Doubova et al (2021) and Miller et al (2021), Poisson estimation of a 95% confidence interval by Sprague et al (2021) and 95% confidence intervals from comparison of means from Nyante et al (2021).

Table 4. Summary of results of appraisal of all included studies with JBI Critical appraisal tool for Cross-sectional Studies

Joanna Briggs Institute Critical Appraisal Tool for Cross-Sectional Studies Appraisal Table								
Study	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
Amornsiripanitch *et al.* 2021	Y	Y	Y	Y	Y	N	Unclear	Unclear
Becker *et al.* 2021	Y	Y	Y	N	Y	N	N	Unclear
Bessa *et al.* 2021	Y	Unclear	Y	Y	N	N	N	Unclear
Campbell *et al.* 2021	Y	Unclear	Y	Y	Unclear	N	Y	Unclear
Chen *et al.* 2021	Y	Unclear	Y	Y	Y	N	Y	Unclear
Chiarelli *et al.* 2021	Y	Y	Y	Y	Unclear	N	Y	Unclear
DeGroff *et al.* 2021	Y	Y	Y	Y	Y	N	Y	Unclear
Dennis *et al.* 2021	Y	Y	Y	Y	N	N	Y	Unclear
Doubova *et al.* 2021	Y	Unclear	Y	Y	N	N	N	Y
Jidkova *et al.* 2022	Y	Y	Y	Y	Unclear	N	Y	Unclear
Knoll *et al.* 2022	Y	Y	Y	Y	N	N	Y	Unclear
Fedewa *et al.* 2021	Y	Y	Y	Y	N	N	Y	Unclear
BreastScreen Australia. 2020	Y	Y	Y	Y	N	N	Y	N
Eijkelboom *et al.* 2021	Y	Y	Y	Y	Y	Y	Y	Unclear

Lehman *et al.* 2021	N	N	Y	Y	Y	N	Y	Unclear
London *et al.* 2022	N	N	Y	Y	N	N	N	Unclear
Losurdo *et al.* 2022	Y	Y	Y	Y	N	N	Y	Unclear
Walker *et al.* 2021	Y	Y	Y	Y	Unclear	N	Y	Unclear
Toss *et al.* 2021	Y	Y	Y	Y	N	N	Y	Unclear
Shen *et al.* 2022	Y	Y	Y	Y	Unclear	N	Y	Unclear
Riberio *et al.* 2022	Y	Y	Y	Y	N	N	Y	Unclear
Miller *et al.* 2021	Y	Unclear	Y	Y	N	N	Y	Y
Sprague *et al.* 2021	Y	Y	Y	Y	Unclear	Y	Y	Y
Nyante *et al.* 2021	Y	Y	Y	Y	Y	Y	Y	Y
NHS England, 2021	Y	Y	Y	Y	N	N	Y	N
BreastScreen Aotearoa. 2022	Y	Y	Y	Y	N	N	Y	N
Colour Legend: Green = Yes; Yellow = Unclear, Orange = No								

Discussion

We previously reported on modelled evaluations that estimated short- and long-term outcomes for various scenarios and changes in breast screening volume, uptake rates and breast cancer diagnosis rates (Figueroa *et al, 2021;* WHO, 2020). In this rapid review we show that during COVID-19 there was a generally reported reduction in breast cancer screening volume and participation uptake rate that varied by healthcare setting (e.g., national population-based screening vs opportunistic or private health care). Our data suggests volume and participation uptake are important metrics that requires monitoring by health systems and could inform prevention and early diagnosis efforts, especially if certain groups are not participating.

Non-pharmaceutical interventions were essential and effective in containing the spread of COVID-19 in the era without vaccines, these extend to domestic/international movement controls, social distancing, ban on events and gatherings and workplace/school closure (Li et al, 2020, Talic et al, 2021). While these measures were important to reduce the mortality directly related to COVID-19, they also had indirect effects on other health services including breast cancer screening. In this rapid review, we provide evidence that screening volume and participation uptake rates were reduced but this reduction varied by region and healthcare system.

In a systematic review and meta-analysis data from 72 studies were used to investigate the effectiveness of public health measures in reducing COVID-19 incidence, and transmission (Talic et al, 2021). The meta-analysis pooled an estimate from 8 studies and indicated that handwashing (RR: 0.47, 95%CI: 0.19-1.12), mask-wearing (RR: 0.47, 95%CI: 0.29-0.75), and physical distancing (RR: 0.75, 95%CI: 0.59-0.95) were associated with the reduction in COVID-19 incidence. The remaining public health measures including quarantine and isolation, universal lockdowns, and closures of borders, schools, and workplaces which could not be included in the meta-analysis were evaluated in a narrative way. The findings validated the effectiveness of both individual and packages of public health measures on the transmission of SARS-CoV-2 and incidence of COVID-19. However, the majority of included studies had moderate risk-of-bias based on quality assessment. For breast cancer screening the importance of mitigation measures that emphasized physical distancing to have been most important in reducing screening, both for general population participation but also at health care facilities aiming to reduce transmission (Figueroa *et al, 2021)*.

Reductions in screening capacity due for physical distancing are likely another source for screening volume reductions. Screening capacity reductions were caused by social distancing, staggered appointments, staff exposure to COVID-19, and cleaning measures. This likely resulted in reductions in time allocated for screening to occur (Walker et al. 2021; Sprague et al. 2020). Sprague et al (2021) considered screening capacity when assessing screening volume. Even though screening capacity recovered to pre-pandemic levels in July 2020, screening volume experienced a 10.8% decrease relative to the control period. Reductions in screening capacity were potentially not the sole factor to screening volume reductions. However, most publications included in our rapid review did not collect data regarding screening capacity so we cannot determine the proportion of change in screening volume that was attributed to either reduction in screening capacity or change in patient willingness to attend screening. Future analyses are needed where both measures are obtained, which would inform what measures are needed (e.g. information campaigns to alleviate patient fears or increase clinical staffing for catch-up of missed appointments).

Our data supports differences by healthcare system that were particularly evident in data from the USA where there is a mix of private and national healthcare (Medicare for persons 65+ (Medicare.gov). DeGroff et al (2021), who studied populations reliant solely on national health insurance, showed larger screening volume reductions (-39.00%). This was relative to studies focusing solely on populations with private insurances, or studies including patients from both groups (-36.50% to +30%). Amornsiripanitch et al (2021), which included national and private insurance patients, corroborates this. Medicaid and Medicare patients had -17.06% screening volume reduction compared to -10.50% experienced by the entire population. Miller et al (2021) suggests opportunity-cost of attending breast screening in lower income groups (e.g., employment), may have led to decreased breast screening in such populations. Some literature showed increases in screening volumes (Nyante et al. 2021; Becker et al. 2021) and uptake rates (Campbell et al. 2021). Increased volume (+9%) from Nyante et al (2021) could be inconclusive as the observed screening volume was compared against a modelled 2019 population that was used to simulate a 2020 population in the absence of COVID-19. Although this study was robust, limited data collection till September 2020 did not show full extent of change regarding screening volumes after lifting of COVID-19 suspension guidelines in June 2020. From trends explored in study, breast screening rates were possibly recovering in the study population (USA) in late-2020, but more data is required. The Affordable Care Act may have alleviated breast screening cost through health insurance coverage reforms (Zhao et al. 2020). However, this does not address other underlying socio-economic inequalities (e.g. high cost of treatment, time off from work due to sickness). Patients from deprived backgrounds may be fearful of dealing with the consequences of abnormal screening results (e.g., treatment). This may strain patient finances worsened by COVID-19, potentially explaining lower screening volumes and uptake. Future data on patient characteristics including insurance status, socioeconomic and race/ethnicity could inform targeted campaigns to reduce inequities if disparities exist.

Becker et al (2021) showed a screening volume increase after the lifting of COVID-19 suspension guidelines. This study focused on patients who utilize solely private insurance. Patients already paying for services may be more inclined to maximize utilization of coverage. However, this study states that the odds that a woman received breast cancer screening remained 20% lower in 2020 (OR = 0.80 (0.80, 0.81)) relative to 2019. This study scored poorly in the JBI appraisal tool due to poor outcome measurement; it was unclear how odds ratio was derived, therefore, increasing the risk of bias of this study. Unusual outcome measures were used, that being the claims invoice for the service. This appeared unreliable; it was unclear whether paying for the service equates to a fulfilled appointment. Invoices could be delayed, making it unclear when the screening took place. This study's evidence quality needs to be increased for results to be conclusive.

Campbell et al (2021) states a 10.96% increase in uptake rate in Scotland. This study population (within study period) solely included patients who had their appointments cancelled in March 2020 due to the 1st lockdown, and high-risk patients. This particular patient group may have an increased urgency to catch up on screening. This could have contributed to the increased uptake rate of screening in Scotland in the study period. Increase in uptake rates could also be attributed to increased accessibility for patients due to the "work-from-home" model and increased health consciousness due to COVID-19. Neither raw data nor sample size was defined in the study and will require future analysis. Due to the inherent weaknesses of a rapid review, certain limitations are present within the study as explored below. However, this study can be expanded upon by various means (also explored below) to further elucidate the global impact of COVID-19 on breast cancer detection and subsequent care. Other limitations include COVID-19 context as an evolving field with fast publication turnovers; more papers could have been published since the review started. This issue could be partially addressed by completing a repeat search with employment of forwards and backwards citation tracking, while including more grey literature sources apart from governmental databases (e.g., private screening databases). Other limitations included studies had insufficient data for combined analysis regarding COVID-19 waves past December 2020. Additionally, data obtained was cross-sectional instead of cohort-based; we were unable to analyze trends and recovery in breast cancer screening rates and incidence rates over time. Exclusion of non-English language literature was a weakness. Many countries with extensive population-based breast screening programs that were affected by COVID-19 in Europe and Asia were unaccounted for; the inclusion of additional data would be useful to clarify the impact of the pandemic on breast cancer screening program uptake. Furthermore, it should also be noted that COVID-19 infection rates were not reported by the included studies and data from governmental/health board websites may not report study specific region infection rates.

In summary, screening volume and uptake rates were generally reduced but many studies showed gains over time even if overall a decline in screening volume observed. These declines were likely due to the first COVID-19 wave where many health care facilities paused non-essential services. Volume and uptake reductions of smaller magnitudes were observed and our data suggest some difference depending on region and health care coverage. Access to screening services may increase marginalization of some vulnerable groups in the USA due to the pandemic and recovery efforts to reduce disparities in access to screening and early diagnosis should be monitored to determine if prevention services need strengthening. Participation uptake and volume are not conclusive endpoints themselves and future work on from registries and other data sources are needed to determine if there has been any impact on incidence, stage and mortality outcomes.

Methods

We performed a rapid review (Tricco et al. 2015), where systematic review processes were modified to facilitate project completion within a shortened timeframe. Searches were limited to two databases and English-language governmental grey literature.

Literature search: RL ran a systematic search in on "Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations" Database and WHO COVID-19 Literature Database with entry date limits from 1 January 2020 to 12 March 2022. In brief, we performed the search with MeSH subject headers and free text terms for "COVID-19", "Breast Neoplasms" and "Mass screening". Our search strategies are listed in **Table 5**. We searched grey literature from government health websites known to have data from population-based screening programs. These consisted of the National Cancer Institute (USA), CDC (USA), NHS (National Healthcare Service) UK database, BreastScreen Australia and BreastScreen Aotearoa New Zealand. We further screened reference lists of the retrieved eligible publications to identify additional relevant studies. An English language restriction was placed on the searches. Deduplication was carried out as part of upload to Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org

Table 5: Search strategies for rapid review of breast cancer participation and volume during Covid

Search String for Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations		
Search Number	**Search Domain**	**Search string in: [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]**
1	COVID-19	(COVID-19 OR 2019 novel coronavirus disease OR 2019 novel coronavirus infection OR 2019 ncov disease OR 2019 ncov infection OR 2019-ncov disease OR 2019-ncov diseases OR 2019-ncov infection OR 2019-ncov infections OR covid 19 OR covid 19 pandemic OR covid 19 virus disease OR covid 19 virus infection OR covid-19 OR covid-19 pandemic OR covid-19 pandemics OR covid-19 virus disease OR covid-19 virus diseases OR covid-19 virus infection OR covid-19 virus infections OR covid19 OR coronavirus disease 19 OR coronavirus disease 2019 OR coronavirus disease-19 OR disease 2019, coronavirus OR sars cov 2 infection OR sars coronavirus 2 infection OR sars-cov-2 infection OR sars-cov-2 infections OR severe acute respiratory syndrome coronavirus 2 infection OR disease, 2019-ncov OR disease, covid-19 virus OR infection, 2019-ncov OR infection, covid-19 virus OR infection, sars-cov-2 OR pandemic, covid-19 OR virus disease, covid-19 OR virus infection, covid-19 OR Coronavirus, 2019 Novel OR ncov OR covid* OR coronavirus* OR SARS* OR severe acute respiratory syndrome OR coronavirus pandemic OR coronavirus disease pandemic)
2	Breast Cancer	(Breast Neoplasms OR Breast Carcinoma In Situ OR Carcinoma, Ductal, Breast OR Carcinoma, Lobular OR breast cancer OR breast carcinoma* OR breast malignant neoplasm* OR breast malignant tumo?r* OR breast neoplasm* OR breast tumo?r* OR cancer of breast? OR cancer of the breast? OR mammary carcinoma* OR mammary neoplasm* OR malignant neoplasm? of breast OR malignant tumo?r? of breast OR mammary cancer* OR neoplasm?, breast OR tumo?r, breast OR tumo?rs, breast OR cancer?, breast OR cancer?, mammary OR carcinoma?, human mammary OR carcinoma?, breast OR neoplasm?, human mammary OR breast carcinoma in situ OR lobular carcinoma in situ OR lcis, lobular carcinoma in situ OR mammary ductal carcinoma? OR carcinoma, ductal, breast OR carcinoma, infiltrating duct OR carcinoma, invasive ductal, breast OR carcinoma, mammary ductal OR carcinomas, infiltrating duct OR carcinomas, mammary ductal OR invasive ductal carcinoma, breast OR lobular carcinoma? OR carcinoma?, lobular OR breast* OR breast tumo?r OR breast tumo?rs OR breast malignant tumo?rs OR breast malignan* OR mammary malignan* OR malignant tumo?rs of breast OR neoplasm? of breast OR breast neoplasm OR lcis)
3	Mass Screening	(Mass Screening OR Mass Chest X-ray OR Early Diagnosis OR Early Detection of Cancer OR Mammography OR screening* OR Ultrasonography, Mammary OR Ultrasonography OR mass chest x ray OR mass chest x-ray* OR mass chest xray* OR x-ray, mass chest OR x-rays, mass chest OR xray, mass chest OR xrays, mass chest OR disease early detection OR early detection of disease OR early diagnosis OR diagnosis, early OR cancer early detection OR cancer early

		diagnosis OR early detection of cancer OR early diagnosis of cancer OR digital breast tomosyntheses OR digital breast tomosynthesis OR x ray breast tomosynthesis OR x-ray breast tomosyntheses OR x-ray breast tomosynthesis OR breast tomosyntheses, digital OR breast tomosyntheses, x-ray OR breast tomosynthesis, digital OR breast tomosynthesis, x-ray OR breast tissue imaging OR mastography OR mass breast xray OR mass breast x-ray OR chest xray OR chest x-ray OR mammogra* OR program* OR ultrasonic* OR echograph* OR echotomograph* OR sonography* OR ultrasonograph* OR ultrasound* OR exam*)
4	Search String	1 AND 2 AND 3
5	Final Search String	limit 4 to english language
Search String for WHO COVID-19 Literature Database (updated to 12 March 2022)		
Search Number	**Search Concept**	**Title, Abstract, Subject**
#1	Breast Cancer	((Breast Neoplasms) OR (Breast Carcinoma In Situ) OR (Carcinoma, Ductal, Breast) OR (Carcinoma, Lobular) OR (breast cancer*) OR (breast carcinoma*) OR (breast malignant neoplasm*) OR (breast malignant tumo?r*) OR (breast neoplasm*) OR (breast tumo?r*) OR (cancer of breast?) OR (cancer of the breast?) OR (mammary carcinoma*) OR (mammary neoplasm*) OR (malignant neoplasm? of breast) OR (malignant tumo?r? of breast) OR (mammary cancer*) OR (breast carcinoma in situ) OR (lobular carcinoma in situ) OR (mammary ductal carcinoma*) OR (breast ductal carcinoma*) OR (infiltrating duct carcinoma*) OR (invasive ductal carcinoma) OR (mammary ductal carcinoma*) OR (invasive ductal breast carcinoma) OR (lobular carcinoma*) OR (breast tumo?r*) OR (breast malignant tumo?r*) OR (breast malignan*) OR (mammary malignan*) OR (malignant tumo?rs of breast*) OR (neoplasm? of breast) OR (lcis*))
#2	Screening	((Mass Screening) OR (Mass Chest X-ray) OR (Early Diagnosis) OR (Early Detection of Cancer) OR (Mammography) OR (Ultrasonography, Mammary) OR (Ultrasonography) OR (national screening) OR (screening*) OR (mass chest x ray) OR (mass chest x-ray*) OR (mass chest xray*) OR (mass chest x-ray*) OR (disease early detection) OR (early detection of disease) OR (early diagnosis) OR (diagnosis, early) OR (cancer early detection) OR (cancer early diagnosis) OR (early detection of cancer) OR (early diagnosis of cancer) OR (digital breast tomosyntheses) OR (digital breast tomosynthesis) OR (x ray breast tomosynthesis) OR (x-ray breast tomosyntheses) OR (breast tomosynthesis*) OR (breast tissue imaging) OR (mastography) OR (mass breast xray) OR (mass breast x-ray) OR (chest xray) OR (chest x-ray) OR (mammogra*) OR (program*) OR (ultrasonic*) OR (echograph*) OR (ultrasonographic*) OR (sonography*) OR (echotomograph*) OR (ultrasound*) OR (exam*))
#3	Final Search string	#1 AND #2 English language filter

Inclusion and Exclusion Criteria: The Population, Interventions, Comparator, Outcomes, and Study Characteristics (PICOS) model (Schardt et al. 2007) was used to determine eligibility criteria. A pilot literature screen (n = 10) was performed by RL with guidance from MD and JF to confirm validity of criteria. The population of focus are women eligible for breast cancer screening programs globally (population-based or opportunistic) or breast screening programs that are a part of the International Screening Cancer Network (ISCN). The intervention investigated involves the introduction of COVID-19 infection control measures. These were assumed to be present globally due to worldwide prevalence of COVID-19 by March 2020, chosen due to WHO's declaration of a pandemic. We also added data on infection control measures based on Li et al, 2020 'The Temporal Association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (R) of SARS-COV-2: A modelling study across 131 countries', *The Lancet Infectious Diseases*., (see data extraction section for more detail). The comparator involved breast cancer screening statistics after COVID-19 related screening shutdown versus an analogous period in the previous years (e.g., comparing statistics in Australia from May-Sep 2020 against data from May-Sep 2018/2019) or any relevant period.
Outcomes assessed were the percentage change in "volume" of breast screening participation, defined as total number of breast screening procedures; the percentage change in participation "uptake rate" of breast screening program, defined as the percentage of the eligible population who attend screening; and incidence of breast cancer diagnosis. These were obtained through direct data extraction or calculated with data derived from the comparison of values fromeach comparator period. Full-text, English-language primary papers or governmental published grey literature were included. Studies with data entirely pertaining to diagnostic imaging were excluded or with future modelled data were excluded. All studies focused on women. Studies were required to have data on breast screening following the resumption of breast screening in countries with a screening shutdown.

Title, Abstract, Full text Screen: Two reviewers (RL, JF) parallelly independently reviewed titles, abstracts, and subsequently full texts based on pre-defined inclusion and exclusion criteria. Deduplication of articles and screening was performed on Covidence. Conflict resolution was performed by discussion.

Data Extraction:
Data extraction for each article was conducted by a single reviewer (RL). A second reviewer (WX) then checked for eligibility of extracted data in 70% of the texts. Any conflicts were resolved by a third reviewer (JF). Data relevant to the evidence for population-based or

opportunistic breast cancer screening programs during COVID-19 were extracted including citation details, publication type, study design, country, region, population, study setting, screening sample size, screening timeframe, screening volumes change (before/after COVID-19 infection control guidelines), screening participation uptake rates change (before/after COVID-19 infection control guidelines), breast cancer incidence rates. A standardized data extraction form was created and piloted for extraction of primary outcome measures. Data pertaining to the presence of COVID-19 infection control measures and COVID-19 infection rates within the study region were also collected. We used the categories of infection control measures as presented in Li et al, 2020 '*The Temporal Association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (R) of SARS-COV-2: A modelling study across 131 countries'*. In addition, we pulled data on infection rates collected from the Oxford COVID-19 policy tracker, and devolved state-wide healthcare organisation websites in Canada, USA and UK (Mathieu et al, 2022; CIHI, 2022; Commonwealth of Massachuetts, 2021; Commonwealth of Virginia, 2023; Executive Office of Health and Human Services, 2023; SPICe, 2023, State of Michigan, 2020; State of North Carolina, 2020).

COVID-19 infection rates were defined as the incidence of COVID-19 cases within the area of focus per 100000 people over 7 days (Formula = (Number of new cases within population over 7 days/Total estimated population number) x 100000). This was collected from the WHO COVID-19 Dashboard and various devolved health agencies of specific regions (WHO, 2023, UK Government, 2023; Dipartimento della Protezione Civile. 2023; Government of Ontario, 2023; Government of the Netherlands, 2023; MDHHS, 2023; MCDHHS, 2023; The Scottish Government, 2022).

Risk of Bias Assessment: All studies included had cross-sectional designs. We used the Joanna Briggs Institute Critical appraisal tool for cross-sectional studies to assess the risk of bias of each article (Joanna Briggs Institute, 2022). The JBI checklist is available in Table 4. Risk-of-bias for each article was assessed by a single reviewer [RL], and a second reviewer [WX] cross-assessed the results and verified all related judgement and rationales. Discrepancies were resolved through discussion and a joint reassessment of studies.

Data Synthesis: Data were synthesized descriptively since a meta-analysis was not appropriate due to heterogeneity of data. Data was collected by comparing outcome measures before and after COVID-19 infection control measures were introduced; this was presumed due to the worldwide prevalence of COVID-19 by March 2020.

Data were obtained from any point after lifting of COVID-19 breast screening suspension measures until an endpoint of 31 December 2020. If quantitative data was limited or if raw data was unavailable, the last data point of the study was analyzed. This was compared to data from an analogous pre-COVID-19 period in 2018-2019, or if data was unavailable, against any relevant pre-pandemic period. For countries with no breast screening suspension in 2020, data from during COVID-19 was compared with an analogous period of 2018-2019. This phenomenon only occurred in Taiwan, China (Shen et al. 2022). A percentage change against the overall comparator period was calculated.

References

Amornsiripanitch, N., Chikarmane, S. A., Bay, C. P. & Giess, C. S. 2021. Patients characteristics related to screening mammography cancellation and rescheduling rates during the COVID-19 pandemic. *Clinical Imaging* 80**,** 205-210. DOI: 10.1016/j.clinimag.2021.07.009

Becker, N. V., Moniz, M. H., Tipirneni, R., Dalton, V. K. & Ayanian, J. Z. 2021. Utilization of Women's Preventive Health Services During the COVID-19 Pandemic. *JAMA Health Forum,* 2**,** e211408-e211408. DOI: 10.1001/jamahealthforum.2021.1408

Bessa, J. D. F. 2021. Breast imaging hindered during covid-19 pandemic, in Brazil. *Revista de saude publica* 55**,** 8-8. DOI: 10.11606/s1518-8787.2021055003375

Berry, D. A., Cronin, K. A., Plevritis, S. K., Fryback, D. G., Clarke, L., Zelen, M., Mandelblatt, J. S., Yakovlev, A. Y., Habbema, J. D., Feuer, E. J., Cancer, I. & Surveillance Modeling Network, C. 2005. Effect of screening and adjuvant therapy on mortality from breast cancer. N Engl J Med 353, 1784-92. DOI: 10.1056/NEJMoa050518

Campbell, C., Sommerfield, T., Clark, G. R. C., Porteous, L., Milne, A. M., Millar, R., Syme, T. & Thomson, C. S. 2021. COVID-19 and cancer screening in Scotland: A national and coordinated approach to minimising harm. *Preventive Medicine* 151**,** 106606. DOI: 10.1016/j.ypmed.2021.106606

Caplan, L. S., May, D. S. & Richardson, L. C. 2000. Time to diagnosis and treatment of breast cancer: results from the National Breast and Cervical Cancer Early Detection Program, 1991-1995. *Am J Public Health* 90**,** 130-4. DOI: 10.2105/ajph.90.1.130

Chen, R. C., Haynes, K., Du, S., Barron, J. & Katz, A. J. 2021. Association of Cancer Screening Deficit in the United States With the COVID-19 Pandemic. *JAMA Oncology* 7**,** 878-884. DOI: 10.1001/jamaoncol.2021.0884

Chiarelli, A. M., Walker, M. J., Espino-Hernandez, G., Gray, N., Salleh, A., Adhihetty, C., Gao, J., Fienberg, S., Rey, M. A. & Rabeneck, L. 2021. Adherence to guidance for prioritizing higher risk groups for breast cancer screening during the COVID-19 pandemic in the Ontario Breast Screening Program: a descriptive study. *CMAJ Open* 9**,** E1205-E1212.

Adherence to guidance for prioritizing higher risk groups for breast cancer screening during the COVID-19 pandemic in the Ontario Breast Screening Program: a descriptive study

DeGroff, A., Miller, J., Sharma, K., Sun, J., Helsel, W., Kammerer, W., Rockwell, T., Sheu, A., Melillo, S., Uhd, J., Kenney, K., Wong, F., Saraiya, M. & Richardson, L. C. 2021. COVID-19 impact on screening test volume through the National Breast and Cervical Cancer early detection program, January–June 2020, in the United States. *Preventive Medicine* 151**,** 106559. DOI: 10.1016/j.ypmed.2021.106559

Dennis, L. K., Hsu, C.-H. & Arrington, A. K. 2021. Reduction in Standard Cancer Screening in 2020 throughout the U.S. *Cancers* 13**,** 5918. DOI: 10.3390/cancers13235918

Dhahri, A. & Tegene, T. 2021. The impact of COVID-19 on breast cancer care: Delays in screening. *Journal of Clinical Oncology* 39**,** 130.

Doubova, S. V., Leslie, H. H., Kruk, M. E., Pérez-Cuevas, R. & Arsenault, C. 2021. Disruption in essential health services in Mexico during COVID-19: an interrupted time series analysis of health information system data. *BMJ Global Health* 6**,** e006204. DOI: 10.1136/bmjgh-2021-006204

Eijkelboom, A. H., De Munck, L., Lobbes, M. B. I., Van Gils, C. H., Wesseling, J., Westenend, P. J., Guerrero Paez, C., Pijnappel, R. M., Verkooijen, H. M., Broeders, M. J. M. & Siesling, S. 2021. Impact of the suspension and restart of the Dutch breast cancer screening program on breast cancer incidence and stage during the COVID-19 pandemic. *Preventive Medicine* 151**,** 106602. DOI: 10.1016/j.ypmed.2021.106602

Fedewa, S. A., Cotter, M. M., Wehling, K. A., Wysocki, K., Killewald, R. & Makaroff, L. 2021. Changes in breast cancer screening rates among 32 community health centers during the COVID-19 pandemic. *Cancer* 127**,** 4512-4515. DOI: 10.1002/cncr.33859

Figueroa, J. D., Gray, E., Pashayan, N., Deandrea, S., Karch, A., Vale, D. B., Elder, K., Procopio, P., Van Ravesteyn, N. T., Mutabi, M., Canfell, K. & Nickson, C. 2021. The impact of the Covid-19 pandemic on breast cancer early detection and screening. *Prev Med* 151**,** 106585. DOI: 10.1016/j.ypmed.2021.106585

IARC, 2016. *Breast cancer screening: IARC Handbooks of Cancer Prevention,* 15th Ed, International Agency for Research on Cancer.

Jidkova, S., Hoeck, S., Kellen, E., Le Cessie, S. & Goossens, M. C. 2022. Flemish population-based cancer screening programs: impact of COVID-19 related shutdown on short-term key performance indicators. *BMC Cancer* 22**,** 183. DOI: 10.1186/s12885-022-09292-y

Knoll, K., Reiser, E., Leitner, K., Kögl, J., Ebner, C., Marth, C. & Tsibulak, I. 2022. The impact of COVID-19 pandemic on the rate of newly diagnosed gynecological and breast cancers: a tertiary center perspective. *Archives of gynecology and obstetrics* 305**,** 945-953. DOI: 10.1007/s00404-021-06259-5

Lehman, C. D., Mercaldo, S. F., Wang, G. X., Dontchos, B. N., Specht, M. C. & Lamb, L. R. 2021. Screening Mammography Recovery After COVID-19 Pandemic Facility Closures: Associations of Facility Access and Racial and Ethnic Screening Disparities. *American Journal of Roentgenology***,** 1-9.

Li, Y. et al. (2020) 'The Temporal Association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (R) of SARS-COV-2: A modelling study across 131 countries', The Lancet Infectious Diseases, 21(2), pp. 193–202. doi:10.1016/s1473-3099(20)30785-4.

London, J. W., Fazio-Eynullayeva, E., Palchuk, M. B. & Mcnair, C. 2022. Evolving Effect of the COVID-19 Pandemic on Cancer-Related Encounters. *JCO Clinical Cancer Informatics***,** e2100200. DOI: 10.2214/AJR.21.26890

Losurdo, P., Samardzic, N., Di Lenarda, F., De Manzini, N., Giudici, F. & Bortul, M. 2022. The real-word impact of breast and colorectal cancer surgery during the SARS-CoV-2 pandemic. *Updates in Surgery* 74(3), 1063-1072. DOI: 10.1007/s13304-021-01212-2

Miller, M. M., Meneveau, M. O., Rochman, C. M., Schroen, A. T., Lattimore, C. M., Gaspard, P. A., Cubbage, R. S. & Showalter, S. L. 2021. Impact of the COVID-19 pandemic on breast cancer screening volumes and patient screening behaviors. *Breast Cancer Research and Treatment* 189**,** 237-246. DOI: 10.1007/s10549-021-06252-1

Nyante, S. J., Benefield, T. S., Kuzmiak, C. M., Earnhardt, K., Pritchard, M. & Henderson, L. M. 2021. Population-level impact of coronavirus disease 2019 on breast cancer screening and diagnostic procedures. *Cancer* 127**,** 2111-2121. DOI: 10.1002/cncr.33460

OECD (2021), Primary Health Care in Brazil, OECD Reviews of Health Systems, OECD Publishing, Paris, https://doi.org/10.1787/120e170e-en.

Otto, P. M. & Blecher, C. B. 2014. Controversies surrounding screening mammography. *Mo Med* 111**,** 439-43.

Page, M. J., Mckenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., Mcdonald, S., Mcguinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P. & Moher, D. 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372**,** n71. DOI: 10.1136/bmj.n71

Peng, S. M., Yang, K. C., Chan, W. P., Wang, Y. W., Lin, L. J., Yen, A. M., Smith, R. A. & Chen, T. H. 2020. Impact of the COVID-19 pandemic on a population-based breast cancer screening program. *Cancer* 126**,** 5202-5205. DOI: 10.1002/cncr.33180

Ribeiro, C. M., Correa, F. M. & Migowski, A. 2022. Short-term effects of the COVID-19 pandemic on cancer screening, diagnosis and treatment procedures in Brazil: a descriptive study, 2019-2020. *Epidemiol Serv Saude* 31**,** e2021405. DOI: 10.1590/S1679-49742022000100010

Schardt, C., Adams, M. B., Owens, T., Keitz, S. & Fontelo, P. 2007. Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC Med Inform Decis Mak* 7, 16. DOI: 10.1186/1472-6947-7-16

Shen, C.-T., Hsieh, H.-M., Chang, Y.-L., Tsai, H.-Y. & Chen, F.-M. 2022. Different impacts of cancer types on cancer screening during COVID-19 pandemic in Taiwan. *Journal of the Formosan Medical Association* 121(10):1993-2000. DOI: 10.1016/j.jfma.2022.02.006

Sprague, B. L., Lowry, K. P., Miglioretti, D. L., Alsheik, N., Bowles, E. J. A., Tosteson, A. N. A., Rauscher, G., Herschorn, S. D., Lee, J. M., Trentham-Dietz, A., Weaver, D. L., Stout, N.

K. & Kerlikowske, K. 2021. Changes in Mammography Use by Women's Characteristics During the First 5 Months of the COVID-19 Pandemic. *J Natl Cancer Inst* 113**,** 1161-1167. DOI: 10.1093/jnci/djab045

Talic, S. et al. (2021) ‘Effectiveness of public health measures in reducing the incidence of COVID-19, SARS-COV-2 transmission, and COVID- 19 mortality: Systematic review and meta-analysis’, BMJ [Preprint]. doi:10.1136/bmj-2021-068302.

Toss, A., Isca, C., Venturelli, M., Nasso, C., Ficarra, G., Bellelli, V., Armocida, C., Barbieri, E., Cortesi, L., Moscetti, L., Piacentini, F., Omarini, C., Andreotti, A., Gambini, A., Battista, R., Dominici, M. & Tazzioli, G. 2021. Two-month stop in mammographic screening significantly impacts on breast cancer stage at diagnosis and upfront treatment in the COVID era. *ESMO Open* 6**,** 100055. DOI: 10.1016/j.esmoop.2021.100055

Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., Perrier, L., Hutton, B., Moher, D. & Straus, S. E. 2015. A scoping review of rapid review methods. *BMC Med* 13**,** 224. DOI: 10.1186/s12916-015-0465-6

Unger-Saldaña, K., Guadiamos, MC., Vega, AMD., Anderson, B., Romanoff, R,. 2020. Delays to diagnosis and barriers to care for breast cancer in Mexico and Peru: A Cross Sectional Study. The Lancet Global Health, 8(Special Issue). Available at: https://doi.org/10.1016/s2214-109x(20)30157-1.

Walker, M. J., Meggetto, O., Gao, J., Espino-Hernández, G., Jembere, N., Bravo, C. A., Rey, M., Aslam, U., Sheppard, A. J., Lofters, A. K., Tammemägi, M. C., Tinmouth, J., Kupets, R., Chiarelli, A. M. & Rabeneck, L. 2021. Measuring the impact of the COVID-19 pandemic on organized cancer screening and diagnostic follow-up care in Ontario, Canada: A provincial, population-based study. *Preventive Medicine* 151**,** 106586. DOI: 10.1016/j.ypmed.2021.106586

Zhao, J., Mao, Z., Fedewa, S. A., Nogueira, L., Yabroff, K. R., Jemal, A. & Han, X. 2020. The Affordable Care Act and access to care across the cancer control continuum: A review at 10 years. *CA Cancer J Clin* 70, 165-181. DOI: 10.3322/caac.21604

Web References

BreastScreen Aoteroa. 2022, April 20. Breast Screening [Online]. Available: https://www.timetoscreen.nz/breast-screening/ [Accessed 20/04/2022].

BreastScreen Australia. 2020, Dec 17. Breast Screening [Online]. Available: https://www.aihw.gov.au/reports/cancer-screening/cancer-screening-and-covid-19-in-australia/data [Accessed 20/04/2022].

CIHI. 2022, October 13. Canadian COVID-19 Intervention Timeline. Available at: https://www.cihi.ca/en/canadian-covid-19-intervention-timeline (Accessed: 03 June 2023).

Commonwealth of Massachusetts. 2021, June 15. Covid-19 State of emergency, Previously issued emergency orders and guidance associated with the COVID-19 State of Emergency, which terminated on June 15, 2021. Available at: https://www.mass.gov/info-details/covid-19-state-of-emergency#:~:text=NOTE%3A%20Governor%20Baker%20ended%20the,is%20listed%20for%20reference%20only. (Accessed: 03 June 2023).

Commonwealth of Virginia. 2023, March 26. Executive Order No 53. Available at: https://www.governor.virginia.gov/media/governorvirginiagov/executive-actions/EO-53-Temporary-Restrictions-Due-To-Novel-Coronavirus-%28COVID-19%29.pdf (Accessed: 01 June 2023).

Critical appraisal tools. 2022, December 8. Joanna Briggs Institute. Available at: https://jbi.global/critical-appraisal-tools (Accessed: December 8, 2022).

Dipartimento della Protezione Civile. 2023, May 25. Development of number of coronavirus cases: Emilia-Romagna, Italy, Development of Coronavirus cases: Emilia-Romagna, Italy (2,154,377 cases) [Online]. Available at: https://coronalevel.com/Italy/Emilia-Romagna/ (Accessed: 01 June 2023).

Dipartimento della Protezione Civile. 2023, May 25. Development of number of coronavirus cases: Friuli Venezia Giulia, Italy, Development of Coronavirus cases: Friuli Venezia Giulia, Italy (581,121 cases) [Online]. Available at: https://coronalevel.com/Italy/Friuli_Venezia_Giulia/ (Accessed: 01 June 2023).

Government of Ontario. 2023, April 13. Status of covid-19 cases in Ontario, Status of COVID-19 cases in Ontario - Ontario Data Catalogue [Online]. Available at: https://data.ontario.ca/en/dataset/status-of-covid-19-cases-in-ontario/resource/ed270bb8-340b-41f9-a7c6-e8ef587e6d11 (Accessed: 01 June 2023).

Government of the Netherlands. 2023, March 31. Confirmed cases: Coronavirus dashboard: Government.nl, Coronavirus Dashboard [Online]. Available at: https://coronadashboard.government.nl/landelijk/positief-geteste-mensen (Accessed: 01 June 2023).

Health, D. of P. and Executive Office of Health and Human Services. 2023, June 1. Covid-19 response reporting, COVID-19 Response Reporting [Online]. Available at: https://www.mass.gov/info-details/covid-19-response-reporting (Accessed: 02 June 2023).

IARC, 2022, April 11. Cancer Today [Online]. IARC. Available: https://gco.iarc.fr/today/online-analysis-map?v=2020&mode=population&mode_population=continents&population=900&populations=900&key=crude_rate&sex=2&cancer=20&type=2&statistic=1&prevalence=1&population_group=0&ages_group%5B%5D=0&ages_group%5B%5D=17&nb_items=10&group_cancer=1&include_nmsc=0&include_nmsc_other=0&projection=natural-earth&color_palette=default&map_scale=quantile&map_nb_colors=5&continent=0&show_ranking=0&rotate=%255B10%252C0%255D [Accessed 11/04/2022].

Mathieu, E. et al. 2022, December 31. Policy responses to the coronavirus pandemic, Our World in Data. Available at: https://ourworldindata.org/policy-responses-covid (Accessed: 03 June 2023).

McKenzie, J. 2022, April 2. Grey literature: What it is & how to find it [Online]. Available: https://www.lib.sfu.ca/help/research-assistance/format-type/grey-literature#:~:text=Grey%20literature%20is%20information%20produced,urban%20plans%2C%20and%20so%20on. [Accessed 20/04/2022].

MDHHS. 2023, May 30. Michigan Data Coronavirus [Online]. Available at: https://www.michigan.gov/coronavirus/stats (Accessed: 02 June 2023).

Medicaid.gov. 2022, April 20. Medicaid Eligibility [Online]. Available: https://www.medicaid.gov/ [Accessed 20/04/2022].

NCDHHS. 2023, May 10. (Archive) COVID-19 Cases and Deaths Dashboard [Online]. Available at: https://covid19.ncdhhs.gov/dashboard/cases-and-deaths (Accessed: 03 June 2023).

NHS England. 2021, February 24. Breast Screening Programme: National statistics, Official statistics. NHS Digitial: NHS England. Available: https://digital.nhs.uk/data-and-information/publications/statistical/breast-screening-programme [Accessed 20/04/2022].

OECD. 2021, July 1. Breast cancer screening (mammography), survey data and programme data [Online]. In: OECD, OECD Health Statistics 2021. Available: https://stats.oecd.org/FileView2.aspx?IDFile=eb5acd7d-2445-401a-b624-62fcdad85091 [Accessed 20/04/2022]

PAHO, 2020, unknown. Mexico Cancer Country Profile. In: Organisation, PAHO, Cancer Country Profile 2020 [Online], World Health Organisation. Available: https://www3.paho.org/hq/index.php?option=com_docman&view=download&category_slug=4-cancer-country-profiles-2020&alias=51536-mexico-cancer-profile-2020&Itemid=270&lang=en [Accessed 20/04/2022].

Sciensano, the Belgian Institute for Health. 2023, May 23. COVID-19 epidemiological situation, COVID-19 Sciensano Epistat [Online]. Available at: https://epistat.sciensano.be/covid/ (Accessed: 01 June 2023).

SPICe. 2023, May 10. Timeline of coronavirus (covid-19) in Scotland, SPICe Spotlight | Solas air SPICe. Available at: https://spice-spotlight.scot/2023/05/10/timeline-of-coronavirus-covid-19-in-scotland/ (Accessed: 03 June 2023).

State of Michigan. 2020, November 15. MDHHS issues three-week epidemic order to save lives, protect frontline heroes during fall covid-19 surge. Available at: https://www.michigan.gov/coronavirus/news/2020/11/15/mdhhs-issues-three-week-epidemic-order-to-save-lives-protect-frontline-heroes-during-fall-covid-19- (Accessed: 04 June 2023).

State of North Carolina. 2020, September 16. COVID-19 Orders. Available at: https://www.nc.gov/covid-19/covid-19-orders (Accessed: 03 June 2023).

The Scottish Government. 2022, April 21. Coronavirus (COVID-19): Trends in Daily Data, Scottish Government [Online]. Available at: https://www.gov.scot/publications/coronavirus-covid-19-trends-in-daily-data/ (Accessed: 01 June 2023).

UK Government. 2023, May 24. Cookies on the UK Coronavirus Dashboard - England Summary, Cases in England [Online]. Available at: https://coronavirus.data.gov.uk/details/cases?areaType=nation&areaName=England (Accessed: 01 June 2023).

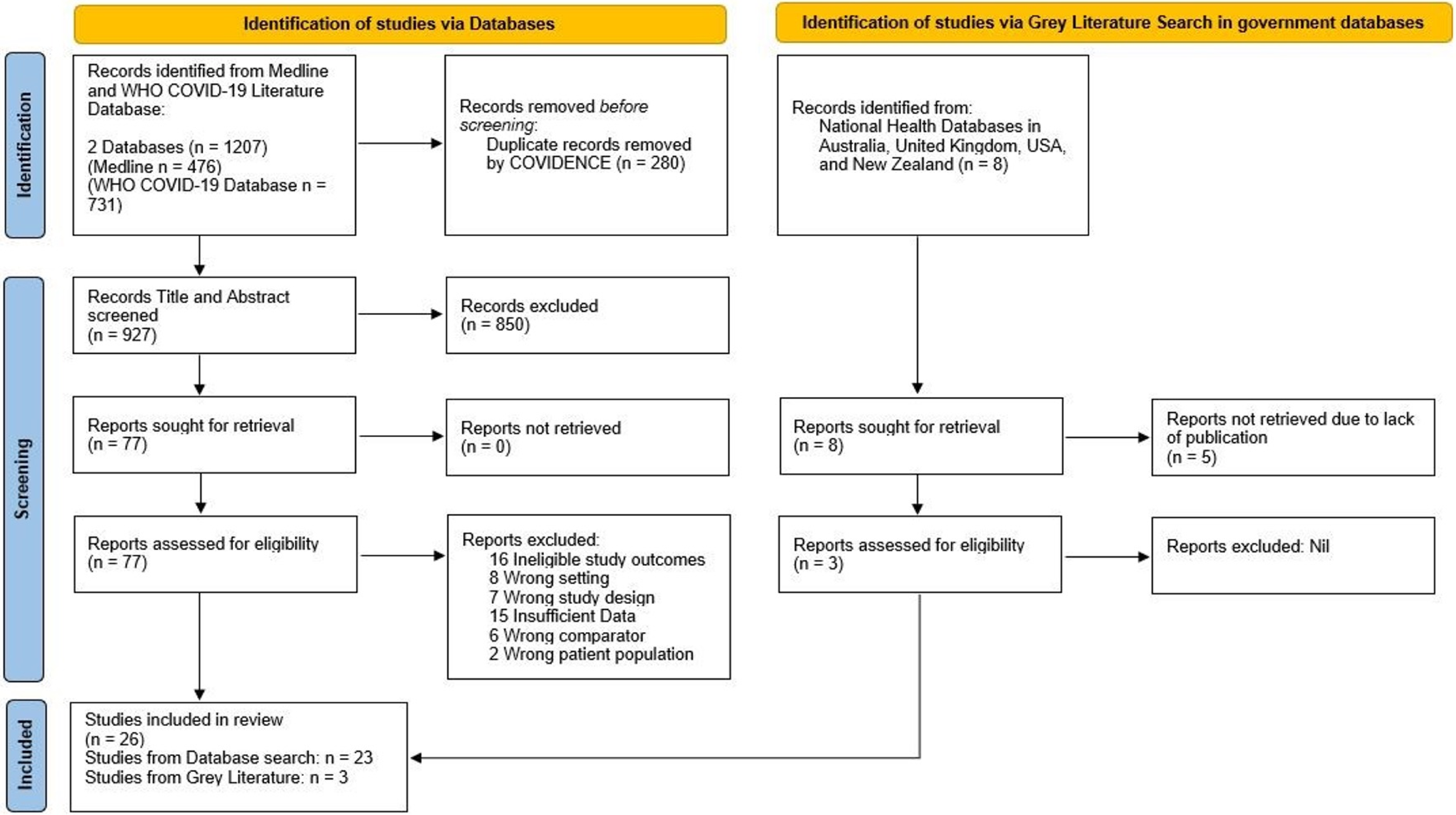
WHO. 2023, May 31. WHO coronavirus (COVID-19) dashboard, World Health Organization [Online]. Available at: https://covid19.who.int/ (Accessed: 01 June 2023).

WHO. 2022, February 3. Cancer Fact Sheet [Online]. World Health Organisation. Available: https://www.who.int/news-room/fact-sheets/detail/cancer [Accessed 20/04/2022].

Worldometer. 2022, April 20. COVID-19 Coronavirus Pandemic Meter [Online]. Available: https://www.worldometers.info/coronavirus/ [Accessed 20/04/2022].

WHO, 2021, March 26. Breast cancer. [online] Who.int. Available at: <https://www.who.int/news-room/fact-sheets/detail/breast-cancer> [Accessed 20/04/2022].

Yucatan Times. 2021, October 8. More and more Yucatecan women are visiting IMSS for breast cancer prevention exams. Yucatan Times. [online] Available at: < https://www.theyucatantimes.com/2021/10/more-and-more-yucatecan-women-are-visiting-imss-for-breast-cancer-prevention-exams/> [Accessed 20/04/2022]



Identification of studies via Databases
Identification of studies via Grey Literature Search in government databases
Identification
Records identified from Medline and WHO COVID-19 Literature Database:
2 Databases (n = 1207)
(Medline n = 476)
(WHO COVID-19 Database n = 731)
Records removed *before screening*:
Duplicate records removed by COVIDENCE (n = 280)
Records identified from:
National Health Databases in Australia, United Kingdom, USA, and New Zealand (n = 8)
Screening
Records Title and Abstract screened
(n = 927)
Records excluded
(n = 850)
Reports sought for retrieval
(n = 77)
Reports not retrieved
(n = 0)
Reports sought for retrieval
(n = 8)
Reports not retrieved due to lack of publication
(n = 5)
Reports assessed for eligibility
(n = 77)
Reports excluded:
16 Ineligible study outcomes
8 Wrong setting
7 Wrong study design
15 Insufficient Data
6 Wrong comparator
2 Wrong patient population
Reports assessed for eligibility
(n = 3)
Reports excluded: Nil
Included
Studies included in review
(n = 26)
Studies from Database search: n = 23
Studies from Grey Literature: n = 3