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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.

1 **Introduction**

2

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

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

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

22

23

24

25 **Results**

26 **Figure 1** summarizes the search strategy. The initial search retrieved 1207 articles
27 and 935 independent records. After screening (see Methods), 26 cross-sectional
28 studies from 12 countries were eligible for inclusion (**Table 1**). Seven reports came
29 from Europe (Campbell *et al.* 2021; Jidkova *et al.* 2022; Knoll *et al.* 2022;
30 Eijkelboom *et al.* 2021; Losurdo *et al.* 2022; Toss *et al.* 2021; NHS England, 2021),
31 two from Oceania (BreastScreen Australia, 2020; BreastScreen Aoteroa, 2022), one
32 from Asia (Shen *et al.* 2022), two from South America (Bessa *et al.* 2021; Riberio *et*
33 *al.* 2022) and 14 from North America (Chiarelli *et al.* 2021; Walker *et al.* 2021;
34 Doubouva *et al.* 2021; Chen *et al.* 2021; Amornsiripanitch *et al.* 2021; Becker *et al.*
35 2021; DeGroff *et al.* 2021; Dennis *et al.* 2021; Fedewa *et al.* 2021; Lehman *et al.*,

36 2021; London et al, 2022; Miller et al, 2021; Sprague et al, 2021; Nyante et al, 2021).
37 The most frequently reported country was the USA (n = 11). Studies examined
38 either regional (n = 13) or national populations (n = 13).
39
40 During COVID-19, many countries implemented various mitigation methods to
41 reduce transmission and of course mortality. To summarize these different infection
42 control measures, **Table 1** shows that all 12 countries had international movement
43 controls in place, 23 study-specific regions had internal movement controls, 21
44 study-specific regions had stay-at home requirements in place, one study-specific
45 region (Northern Italy, Emilia Romagna) had public transport closures, 23
46 study-specific regions had bans on gatherings >10 people, 24 study-specific regions
47 had public events bans in place, 24 study-specific regions had workplace closures in
48 place, and 23 study-specific regions had in-person school closures in place (Mathieu
49 et al, 2022; CIHI, 2022; Commonwealth of Massachusetts, 2021; Commonwealth of
50 Virginia, 2023; Executive Office of Health and Human Services, 2023; SPICe,
51 2023, State of Michigan, 2020; State of North Carolina, 2020).
52 Analysis of data from all studies was limited from 1 January 2020 to 31 December
53 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	Work place 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)		272800	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 sectional	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	567300	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		870100	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	Cross	Italy	Friuli Venezia	624418	58643	“Data-Breast”	Regional	50-69	Digital Mammography	Oct – Dec	Yes\$	Yes\$	Yes\$	No\$	Yes\$	Yes\$	Yes\$	Yes\$	19.2	497.6

2022	ed	secti onal		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- review ed	Cros s secti onal	Italy	Northern Italy, Emilia Romagn a	22910 00	24994	Emilia Romagna National Healthcare System	Regional	45-79	Digital Mammo graphy	2019 vs 2020	Yes\$	Yes\$	Yes\$	Yes\$	Yes\$	Yes \$	Yes\$	Yes \$	4.00	390.9	
NHS England, 2021	Gover nment paper	Cros s secti onal	Englan d (UK)		33940 000	223000 0	NHS England	National	50-71	Digital Mammo graphy	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	

Screening in Australia, 2020	Government Paper	Sectional	Asia		10000	Specific	Screening in Australia			Mammography	Sep 2018 vs May – Sep 2020												
BreastScreen Aotearoa, 2022	Government Paper	Cross sectional	New Zealand		249700	Not specific	BreastScreen Aotearoa	National	45-69	Digital Mammography	May – Dec 2018 vs May – Dec 2020	Yes	Yes	Yes	No	Yes	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	No	Yes	no data	no data	
Americas (n=16)																							
Bessa et al, 2021	Peer-reviewed	Cross sectional	Brazil		10650000	(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	Yes	0.00	149.68	

Riberio et al, 2022	Peer-reviewed	Cross sectional	Brazil	10650000	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
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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

Amornsir ipanitch et al, 2021	Peer- review ed	Cros s secti onal	USA	Massach usetts	35370 00	32387	Electronic medical record (Epic, Verona, WI) - Massachus etts. One tertiary care academic center, a community hospital, a specialized cancer center, three outpatient imaging centers, one urban healthcare center, and one mobile mammogra phy van	Regional	40 - unspec ified years	Digital Mammo graphy	Jun - Aug 2019 vs Jun - Aug 2020	Yes	Yes	No	No	Yes	Yes	No	No	17.06	53.09
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Becker et al, 2021	Peer-reviewed	Cross sectional	USA	Michigan	506200	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		16750000	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		16750000	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	Yes	0.00	460.68
Fedewa et al, 2021	Peer-reviewed	Cross sectional	USA		16750000	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	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		16750000	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		16750000	340000 (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 sectional	USA	Virginia	2757460	Not specified	Institution 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- review ed	Cros s secti onal	USA		16750 0000	461083	62 radiology facilities of Breast Cancer Surveillanc e Consortium	National	40-79	Digital Mammo graphy	Jan-Jul 2019 vs Jan-Jul 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0.00	142.0 0
Nyante et al, 2021	Peer- review ed	Cros s secti onal	USA	North Carolina	50993 71	42412	7 academic and community breast imaging facilities in North Carolina	Regional	40-79	Digital Mammo graphy	Modell ed 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.

54 **Screening volume changes over study period:** Summary data from 17 studies in
55 eight countries reporting breast cancer screening volumes, data from 106,484,908
56 women before and after COVID-19 infection control measures were extracted (data
57 from 2017 to 2020 were the comparison time period, **Table 2**; Doubouva et al, 2021;
58 Bessa et al, 2021; Riberio et al, 2022; Chiarelli et al, 2021; Losurdo et al, 2022;
59 Walker et al, 2021; NHS England, 2021; Shen et al, 2022; BreastScreen Australia,
60 2020; DeGroff et al, 2021; Lehman et al, 2021; Amornsiripantich et al, 2021;
61 Sprague et al, 2021; London et al, 2022; Miller et al, 2021; Nyante et al, 2021;
62 Becker et al, 2021). Most studies that showed calendar period trends of screening
63 volume, noted temporal variation with declines especially at the height of the
64 pandemic between March- May 2020. In countries with national screening programs,
65 a negative change in screening volume was reported with the lowest volume change
66 estimated at -12.86% in Australia (BreastScreen Australia, 2020) followed by –
67 15.80% in England (NHS England, 2021). A larger negative change in screening
68 volume was observed in Brazil (-41.49%) (Riberio et al, 2022) and Mexico (-61.30%)
69 (Doubouva et al, 2021. It should be noted that Brazil and Mexico have a lower
70 proportion of population-based breast screening coverage relative to other countries;
71 Brazil having coverage of ~24%, and Mexico having ~20% coverage of the eligible
72 population (OECD, 2021; Unger-Saldaña et al, 2020). A significant proportion of
73 breast screening in Brazil and Mexico consists of opportunistic screening programs.

74
75 In the USA, which has mix of insurance providers there was a wide range of change
76 in screening volume. Using data from Health Managed Organization (HMO) Blue
77 Cross Blue Shield (BCBS) from the state of Michigan, the authors observed
78 temporal changes in rates with an increase slightly above 2019 levels in the last few
79 months of 2020, with an 18.10% overall increase in screening volume (Becker et al.
80 2021). Although rates were above 2019 levels, the authors noted that the odds that a
81 woman received breast cancer screening remained 20% lower in 2020 relative to
82 2019 (Becker et al. 2021). This was consistent with the decrease in screening
83 volume that was generally observed from six studies with data among populations
84 wholly or partially covered by national insurance (Lehman et al, 2021;
85 Amornsiripantich et al, 2021; Sprague et al, 2021; London et al, 2022; Miller et al,
86 2021; Nyante et al, 2021). Percentage decreases ranged from -36.50% (Lehman et al.
87 2021) to -9.80% (Miller et al. 2021). Data from the USA National Breast and
88 Cervical Cancer Early Detection Program (NBCCEDP), which provides cancer
89 screening services to women with low income and inadequate health insurance,

90 reported a greater decrease (-39.00%) in volume (DeGroff et al. 2021). Two other
91 studies had smaller populations with less certainty and wider confidence intervals
92 with one reporting an 8% increase (Nyante et al. 2021) and the other a -10% decline
93 (London et al. 2021). In the USA, where there is a mix of national (Medicare) and
94 private insurance depending on age, screening volume changes were similar to other
95 national screening programs at -36.50% (Lehman et al, 2021). In contrast, a positive
96 increase in volume was observed among private insurance providers +30% (London
97 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 <i>et al.</i> 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 <i>et al.</i> 2022	China	Taiwan	Regional	Population-based Screening present in country	699911	Jan – Apr 2019 vs Jan – Apr 2020	-22.07%
America (n=13)							
Bessa <i>et al.</i> 2021	Brazil	NA	National	Population-based Screening present in country#	(2019: 20636636; 2020: 21140958)	2019 vs 2020	-42.72%

Riberio <i>et al.</i> 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 <i>et al.</i> 2021	Mexico	NA	National	Population-based Screening present in country\$	1431216	Jan 2019 – Mar 2020 vs Apr – Dec 2020	-61.30%
Chiarelli <i>et al.</i> 2021	Canada	Ontario	Regional	Population-based Screening present in country	426967	Jul - Dec 2019 vs Jul - Dec 2020	-31.30%
Walker <i>et al.</i> 2021	Canada	Ontario	Regional	Population-based Screening present in country	890131	Modelled 2019 data vs Dec 2020	-22.80%
Lehman <i>et al.</i> 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	29276	2019 vs 2020	-36.50%
Miller <i>et al.</i> 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 <i>et al.</i> 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 <i>et al.</i> 2022	USA	NA	National	Privatised system with mix of national and private insurance usage	34000000	Dec 2019 vs Dec 2020	20.00%
DeGroff <i>et al.</i> 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 <i>et al.</i> 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 <i>et al.</i> 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 <i>et al.</i> 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

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

100

101 Legend:

102 * - 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
103 population was drawn from the entire country.

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

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

109

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 <i>et al.</i> 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 <i>et al.</i> 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 <i>et al.</i> 2021	Brazil	NA	National	Population-based Screening available in country#	(2019: 20636636; 2020: 21140958) 475083	2019 vs 2020	-43.54%
Dennis <i>et al.</i> 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	(Age: 50-74) 117498 (Age: 40-49)	2014-2019 vs 2020	-5.30% (50-79) -7.20% (40-49)
Fedewa <i>et al.</i> 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	434840	2019 vs 2020	-8.00%
Amornsiripanitch <i>et al.</i> 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 <i>et al.</i> 2021	USA	NA	National	Privatised system with mix of national and private insurance usage	NA	Jul 2019 vs Jul 2020	-3.33%

110 NA: Not applicable

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

113

114 Legend:

115 * - 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
116 population was drawn from the entire country.

117 # - The study population from this specific study (Bessa et al, 2021) was solely drawn from a national population-based screening database in
118 Brazil. It should be noted that Brazil has a lower proportion of population-based breast screening coverage relative to other countries; having a
119 coverage of 24% in the eligible population (Unger-Saldaña et al, 2020)
120 @ - 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
121 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
122 2019 as our last available data point instead.

123 **Screening participation uptake rate changes:** A total of nine cross-sectional
124 studies reported breast cancer screening participation rates and represented >
125 46,257,402 participants from varying calendar periods across five countries
126 (Amornsiripantich et al, 2021; Dennis et al, 2021; Fedewa et al, 2021; Chen et al,
127 2021; NHS England, 2021; Campbell et al, 2021; Bessa et al, 2021; BreastScreen
128 Aoteroa, 2022; Jidkova et al, 2022). There was considerable variability in change
129 (**Table 3**), ranging from +2-8% in Scotland to -43.54% in Brazil (Campbell et al,
130 2021; Bessa et al, 2021). In the USA, there was a consistent negative change in
131 screening participation uptake rates (Amornsiripantich et al, 2021; Dennis et al,
132 2021; Fedewa et al, 2021; Chen et al, 2021).

133
134 **Study quality:** The quality of included studies was assessed using the JBI tool
135 (**Table 4**). A weakness across most studies was failure to identify and consider
136 confounding factors. From **Table 4**, twenty-five studies had no issues defining the
137 inclusion sample. Nineteen studies were clear in defining the study setting and
138 subjects. Studies had no issues quantifying exposure of COVID-19, although this
139 was based on temporality since all healthcare systems globally were affected
140 (Worldometer, 2022). All studies apart from Becker et al (2021) had no issue
141 measuring the condition through either screening appointment attendance or
142 insurance claims data. Most studies (65%, N=17) did not define confounding factors
143 regarding measurement of primary outcomes. Regarding comparison of volumes of
144 screening prior to COVID-19 and observed periods, these studies did not provide
145 source of reduction in screening capacity (e.g. due to social distancing or
146 participation uptake). Twenty-three studies failed to provide strategies to address
147 confounding factors (e.g., elucidating reduction in capacity and presenting it as a
148 proportion to overall volume).

149
150 Four studies (Bessa et al. 2021; Becker et al. 2021; London et al. 2022; Doubova et
151 al. 2021) had unclear reasons for selection of study subjects and control groups
152 (London et al, 2022), confounding factors that were not indicated, nor strategies
153 included to solve this. Among these four papers, vague definition of control groups
154 resulted in a poor comparator, resulting in unreliable outcome measures.

155
156 Twenty-three studies provided basic statistical analyses (e.g. mean, adjusted rates
157 per population) with basic data presentation. Statistical analyses were not performed
158 in three government papers (BreastScreen Australia. 2020; NHS England. 2021;

159 BreastScreen Aotearoa. 2022). Twenty-two studies were unclear or did not provide
160 sufficient descriptive statistical analyses regarding comparison of control data to
161 observed data. Statistical analyses were performed in four studies. This includes
162 provision of odds ratios by Doubova et al (2021) and Miller et al (2021), Poisson
163 estimation of a 95% confidence interval by Sprague et al (2021) and 95%
164 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 <i>et al.</i> 2021	Y	Y	Y	Y	Y	N	Unclear	Unclear
Becker <i>et al.</i> 2021	Y	Y	Y	N	Y	N	N	Unclear
Bessa <i>et al.</i> 2021	Y	Unclear	Y	Y	N	N	N	Unclear
Campbell <i>et al.</i> 2021	Y	Unclear	Y	Y	Unclear	N	Y	Unclear
Chen <i>et al.</i> 2021	Y	Unclear	Y	Y	Y	N	Y	Unclear
Chiarelli <i>et al.</i> 2021	Y	Y	Y	Y	Unclear	N	Y	Unclear
DeGroff <i>et al.</i> 2021	Y	Y	Y	Y	Y	N	Y	Unclear
Dennis <i>et al.</i> 2021	Y	Y	Y	Y	N	N	Y	Unclear
Doubova <i>et al.</i> 2021	Y	Unclear	Y	Y	N	N	N	Y
Jidkova <i>et al.</i> 2022	Y	Y	Y	Y	Unclear	N	Y	Unclear
Knoll <i>et al.</i> 2022	Y	Y	Y	Y	N	N	Y	Unclear
Fedewa <i>et al.</i> 2021	Y	Y	Y	Y	N	N	Y	Unclear
BreastScreen Australia. 2020	Y	Y	Y	Y	N	N	Y	N
Eijkelboom <i>et al.</i> 2021	Y	Y	Y	Y	Y	Y	Y	Unclear

Lehman <i>et al.</i> 2021	N	N	Y	Y	Y	N	Y	Unclear
London <i>et al.</i> 2022	N	N	Y	Y	N	N	N	Unclear
Losurdo <i>et al.</i> 2022	Y	Y	Y	Y	N	N	Y	Unclear
Walker <i>et al.</i> 2021	Y	Y	Y	Y	Unclear	N	Y	Unclear
Toss <i>et al.</i> 2021	Y	Y	Y	Y	N	N	Y	Unclear
Shen <i>et al.</i> 2022	Y	Y	Y	Y	Unclear	N	Y	Unclear
Riberio <i>et al.</i> 2022	Y	Y	Y	Y	N	N	Y	Unclear
Miller <i>et al.</i> 2021	Y	Unclear	Y	Y	N	N	Y	Y
Sprague <i>et al.</i> 2021	Y	Y	Y	Y	Unclear	Y	Y	Y
Nyante <i>et al.</i> 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

165 **Discussion**

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

176
177 Non-pharmaceutical interventions were essential and effective in containing the
178 spread of COVID-19 in the era without vaccines, these extend to
179 domestic/international movement controls, social distancing, ban on events and
180 gatherings and workplace/school closure (Li et al, 2020, Talic et al, 2021). While
181 these measures were important to reduce the mortality directly related to COVID-19,
182 they also had indirect effects on other health services including breast cancer
183 screening. In this rapid review, we provide evidence that screening volume and
184 participation uptake rates were reduced but this reduction varied by region and
185 healthcare system.

186
187 In a systematic review and meta-analysis data from 72 studies were used to
188 investigate the effectiveness of public health measures in reducing COVID-19
189 incidence, and transmission (Talic et al, 2021). The meta-analysis pooled an
190 estimate from 8 studies and indicated that handwashing (RR: 0.47, 95%CI:
191 0.19-1.12), mask-wearing (RR: 0.47, 95%CI: 0.29-0.75), and physical distancing
192 (RR: 0.75, 95%CI: 0.59-0.95) were associated with the reduction in COVID-19
193 incidence. The remaining public health measures including quarantine and isolation,
194 universal lockdowns, and closures of borders, schools, and workplaces which could
195 not be included in the meta-analysis were evaluated in a narrative way. The findings
196 validated the effectiveness of both individual and packages of public health
197 measures on the transmission of SARS-CoV-2 and incidence of COVID-19.
198 However, the majority of included studies had moderate risk-of-bias based on
199 quality assessment. For breast cancer screening the importance of mitigation
200 measures that emphasized physical distancing to have been most important in

201 reducing screening, both for general population participation but also at health care
202 facilities aiming to reduce transmission (Figueroa *et al*, 2021).

203

204

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

221

222 Our data supports differences by healthcare system that were particularly evident in
223 data from the USA where there is a mix of private and national healthcare (Medicare
224 for persons 65+ (Medicare.gov). DeGroff *et al* (2021), who studied populations
225 reliant solely on national health insurance, showed larger screening volume
226 reductions (-39.00%). This was relative to studies focusing solely on populations
227 with private insurances, or studies including patients from both groups (-36.50% to
228 +30%). Amornsiripanitch *et al* (2021), which included national and private
229 insurance patients, corroborates this. Medicaid and Medicare patients had -17.06%
230 screening volume reduction compared to -10.50% experienced by the entire
231 population. Miller *et al* (2021) suggests opportunity-cost of attending breast
232 screening in lower income groups (e.g., employment), may have led to decreased
233 breast screening in such populations. Some literature showed increases in screening
234 volumes (Nyante *et al*. 2021; Becker *et al*. 2021) and uptake rates (Campbell *et al*.
235 2021). Increased volume (+9%) from Nyante *et al* (2021) could be inconclusive as
236 the observed screening volume was compared against a modelled 2019 population

237 that was used to simulate a 2020 population in the absence of COVID-19. Although
238 this study was robust, limited data collection till September 2020 did not show full
239 extent of change regarding screening volumes after lifting of COVID-19 suspension
240 guidelines in June 2020. From trends explored in study, breast screening rates were
241 possibly recovering in the study population (USA) in late-2020, but more data is
242 required. The Affordable Care Act may have alleviated breast screening cost
243 through health insurance coverage reforms (Zhao et al. 2020). However, this does
244 not address other underlying socio-economic inequalities (e.g. high cost of treatment,
245 time off from work due to sickness). Patients from deprived backgrounds may be
246 fearful of dealing with the consequences of abnormal screening results (e.g.,
247 treatment). This may strain patient finances worsened by COVID-19, potentially
248 explaining lower screening volumes and uptake. Future data on patient
249 characteristics including insurance status, socioeconomic and race/ethnicity could
250 inform targeted campaigns to reduce inequities if disparities exist.

251
252 Becker et al (2021) showed a screening volume increase after the lifting of
253 COVID-19 suspension guidelines. This study focused on patients who utilize solely
254 private insurance. Patients already paying for services may be more inclined to
255 maximize utilization of coverage. However, this study states that the odds that a
256 woman received breast cancer screening remained 20% lower in 2020 (OR = 0.80
257 (0.80, 0.81)) relative to 2019. This study scored poorly in the JBI appraisal tool due
258 to poor outcome measurement; it was unclear how odds ratio was derived, therefore,
259 increasing the risk of bias of this study. Unusual outcome measures were used, that
260 being the claims invoice for the service. This appeared unreliable; it was unclear
261 whether paying for the service equates to a fulfilled appointment. Invoices could be
262 delayed, making it unclear when the screening took place. This study's evidence
263 quality needs to be increased for results to be conclusive.

264
265 Campbell et al (2021) states a 10.96% increase in uptake rate in Scotland. This study
266 population (within study period) solely included patients who had their
267 appointments cancelled in March 2020 due to the 1st lockdown, and high-risk
268 patients. This particular patient group may have an increased urgency to catch up on
269 screening. This could have contributed to the increased uptake rate of screening in
270 Scotland in the study period. Increase in uptake rates could also be attributed to
271 increased accessibility for patients due to the "work-from-home" model and

272 increased health consciousness due to COVID-19. Neither raw data nor sample size
273 was defined in the study and will require future analysis.
274 Due to the inherent weaknesses of a rapid review, certain limitations are present
275 within the study as explored below. However, this study can be expanded upon by
276 various means (also explored below) to further elucidate the global impact of
277 COVID-19 on breast cancer detection and subsequent care. Other limitations include
278 COVID-19 context as an evolving field with fast publication turnovers; more papers
279 could have been published since the review started. This issue could be partially
280 addressed by completing a repeat search with employment of forwards and
281 backwards citation tracking, while including more grey literature sources apart from
282 governmental databases (e.g., private screening databases). Other limitations
283 included studies had insufficient data for combined analysis regarding COVID-19
284 waves past December 2020. Additionally, data obtained was cross-sectional instead
285 of cohort-based; we were unable to analyze trends and recovery in breast cancer
286 screening rates and incidence rates over time. Exclusion of non-English language
287 literature was a weakness. Many countries with extensive population-based breast
288 screening programs that were affected by COVID-19 in Europe and Asia were
289 unaccounted for; the inclusion of additional data would be useful to clarify the
290 impact of the pandemic on breast cancer screening program uptake. Furthermore, it
291 should also be noted that COVID-19 infection rates were not reported by the
292 included studies and data from governmental/health board websites may not report
293 study specific region infection rates.

294
295 In summary, screening volume and uptake rates were generally reduced but many
296 studies showed gains over time even if overall a decline in screening volume
297 observed. These declines were likely due to the first COVID-19 wave where many
298 health care facilities paused non-essential services. Volume and uptake reductions of
299 smaller magnitudes were observed and our data suggest some difference depending
300 on region and health care coverage. Access to screening services may increase
301 marginalization of some vulnerable groups in the USA due to the pandemic and
302 recovery efforts to reduce disparities in access to screening and early diagnosis
303 should be monitored to determine if prevention services need strengthening.
304 Participation uptake and volume are not conclusive endpoints themselves and future
305 work on from registries and other data sources are needed to determine if there has
306 been any impact on incidence, stage and mortality outcomes.

307

308

309 **Methods**

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

314

315 **Literature search:** RL ran a systematic search in on “Ovid MEDLINE(R) and
316 In-Process, In-Data-Review & Other Non-Indexed Citations” Database and WHO
317 COVID-19 Literature Database with entry date limits from 1 January 2020 to 12
318 March 2022. In brief, we performed the search with MeSH subject headers and
319 free text terms for “COVID-19”, “Breast Neoplasms” and “Mass screening”. Our
320 search strategies are listed in **Table 5**. We searched grey literature from government
321 health websites known to have data from population-based screening programs.
322 These consisted of the National Cancer Institute (USA), CDC (USA), NHS
323 (National Healthcare Service) UK database, BreastScreen Australia and
324 BreastScreen Aotearoa New Zealand. We further screened reference lists of the
325 retrieved eligible publications to identify additional relevant studies. An English
326 language restriction was placed on the searches. Deduplication was carried out as
327 part of upload to Covidence systematic review software, Veritas Health Innovation,
328 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

330 **Inclusion and Exclusion Criteria:** The Population, Interventions, Comparator, Outcomes,
331 and Study Characteristics (PICOS) model (Schardt et al. 2007) was used to determine
332 eligibility criteria. A pilot literature screen (n = 10) was performed by RL with guidance from
333 MD and JF to confirm validity of criteria. The population of focus are women eligible for
334 breast cancer screening programs globally (population-based or opportunistic) or breast
335 screening programs that are a part of the International Screening Cancer Network (ISCN).
336 The intervention investigated involves the introduction of COVID-19 infection control
337 measures. These were assumed to be present globally due to worldwide prevalence of
338 COVID-19 by March 2020, chosen due to WHO's declaration of a pandemic. We also added
339 data on infection control measures based on Li et al, 2020 'The Temporal Association of
340 introducing and lifting non-pharmaceutical interventions with the time-varying reproduction
341 number (R) of SARS-COV-2: A modelling study across 131 countries', *The Lancet*
342 *Infectious Diseases.*, (see data extraction section for more detail). The comparator involved
343 breast cancer screening statistics after COVID-19 related screening shutdown versus an
344 analogous period in the previous years (e.g., comparing statistics in Australia from May-Sep
345 2020 against data from May-Sep 2018/2019) or any relevant period.
346 Outcomes assessed were the percentage change in "volume" of breast screening participation,
347 defined as total number of breast screening procedures; the percentage change in participation
348 "uptake rate" of breast screening program, defined as the percentage of the eligible
349 population who attend screening; and incidence of breast cancer diagnosis. These were
350 obtained through direct data extraction or calculated with data derived from the comparison
351 of values from each comparator period. Full-text, English-language primary papers or
352 governmental published grey literature were included. Studies with data entirely pertaining to
353 diagnostic imaging were excluded or with future modelled data were excluded. All studies
354 focused on women. Studies were required to have data on breast screening following the
355 resumption of breast screening in countries with a screening shutdown.

356

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

361

362 **Data Extraction:**

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

366 opportunistic breast cancer screening programs during COVID-19 were extracted including
367 citation details, publication type, study design, country, region, population, study setting,
368 screening sample size, screening timeframe, screening volumes change (before/after
369 COVID-19 infection control guidelines), screening participation uptake rates change
370 (before/after COVID-19 infection control guidelines), breast cancer incidence rates. A
371 standardized data extraction form was created and piloted for extraction of primary outcome
372 measures. Data pertaining to the presence of COVID-19 infection control measures and
373 COVID-19 infection rates within the study region were also collected. We used the categories
374 of infection control measures as presented in Li et al, 2020 '*The Temporal Association of*
375 *introducing and lifting non-pharmaceutical interventions with the time-varying reproduction*
376 *number (R) of SARS-COV-2: A modelling study across 131 countries*'. In addition, we pulled
377 data on infection rates collected from the Oxford COVID-19 policy tracker, and devolved
378 state-wide healthcare organisation websites in Canada, USA and UK (Mathieu et al, 2022;
379 CIHI, 2022; Commonwealth of Massachusetts, 2021; Commonwealth of Virginia, 2023;
380 Executive Office of Health and Human Services, 2023; SPICe, 2023, State of Michigan, 2020;
381 State of North Carolina, 2020).
382 COVID-19 infection rates were defined as the incidence of COVID-19 cases within the area
383 of focus per 100000 people over 7 days (Formula = (Number of new cases within population
384 over 7 days/Total estimated population number) x 100000). This was collected from the
385 WHO COVID-19 Dashboard and various devolved health agencies of specific regions (WHO,
386 2023, UK Government, 2023; Dipartimento della Protezione Civile. 2023; Government of
387 Ontario, 2023; Government of the Netherlands, 2023; MDHHS, 2023; MCDHHS, 2023; The
388 Scottish Government, 2022).

389

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

396

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

401

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

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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

