Impact of the COVID-19 Pandemic on Cancer Screening in Europe: A Systematic Review of Disruptions, Barriers, and Policy Responses

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Highlights

- Cancer screening participation in Europe declined by 30–60% at the peak of the COVID-19 pandemic.
- Breast screening was most affected, followed by cervical and colorectal programmes.
- Disruptions led to missed diagnoses, stage migration, and increased inequality.
- Major barriers included service suspension, workforce redeployment, and fear of infection.
- Recovery was faster in countries using self-sampling, digital tools, and community outreach.
- Findings provide policy guidance for building resilient and equitable screening systems.

Impact of the COVID-19 Pandemic on Cancer Screening in Europe: A Systematic Review of Disruptions, Barriers, and Policy Responses

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Abstract

Background:
Cancer screening is a cornerstone of cancer control, but the COVID-19 pandemic caused unprecedented disruption to preventive healthcare worldwide. In Europe, national screening programmes were severely affected, with consequences extending beyond screening to diagnosis, treatment, and equity. While several country-specific studies exist, cross-regional syntheses remain scarce. Understanding the scale, determinants, and outcomes of these disruptions is crucial to building resilient, equitable screening systems.

Aim/objective:
This systematic review synthesises evidence on the impact of the COVID-19 pandemic on cancer screening across Europe, examining differences by cancer type, screening modality, and national context. It also explores downstream effects, barriers, enablers, and policy responses to guide future preparedness.

Methods:
Following PRISMA guidelines, six databases and grey literature sources were searched for studies published between December 2019 and January 2025. Eligible studies included quantitative and qualitative analyses of screening activity during the pandemic. Data were extracted on study characteristics, outcomes, and contextual factors. Given the heterogeneity of measures, findings were summarised using descriptive statistics and thematic synthesis.

Result:
Forty-five studies from 18 European countries revealed a 30–60% reduction in screening participation at peak disruption, varying by cancer type and country. Consequences included delayed diagnoses, stage migration, increased projected mortality, and widening inequalities. Major barriers included service suspension, staff redeployment, and fear of infection. Enablers comprised adaptive communication, safety protocols, and digital innovations.

Conclusion:
COVID-19 caused substantial and uneven disruption to European cancer screening. Protecting continuity, institutionalising innovations, and addressing inequities are critical to enhancing resilience for future health crises.

Keywords: Cancer screening; COVID-19 pandemic; Europe; health systems resilience; early detection; health equity; preventive services

List of Abbreviations

Abbreviation	Full term
BC	Breast Cancer
CC	Cervical Cancer
CRC	Colorectal Cancer
COVID-19	Coronavirus Disease 2019
FIT	Faecal Immunochemical Test
FOBT	Faecal Occult Blood Test
HPV	Human Papillomavirus
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
NOS	Newcastle–Ottawa Scale
JBI	Joanna Briggs Institute
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
EPOC	Effective Practice and Organisation of Care
SES	Socioeconomic Status
UK	United Kingdom
EU	European Union
WHO	World Health Organization

Introduction

Cancer continues to pose a major public health challenge across Europe and globally. An estimated 4 million new cancer cases and 1.9 million cancer-related deaths were reported in Europe in 2020 [1]. Cancer screening remains one of the most effective tools for early detection, complementing advancements in treatment and management. Evidence from a retrospective cohort study demonstrated that delays in cancer diagnosis during the COVID-19 pandemic were significantly associated with advanced disease stages, with the risk of cancer mortality increasing when diagnosis was postponed by just four weeks [2]. The central aim of cancer screening is to detect disease early, thereby improving survival rates and facilitating optimal treatment outcomes. Screening programmes employ a range of technologies and methods to balance costs, risks, and benefits, primarily targeting both common and increasingly rare cancers [3]. Standard screening tools include mammography for breast cancer, Pap smears or HPV testing for cervical cancer, and faecal testing for colorectal cancer [3].

Over the past two decades, the European Union (EU) and its Member States have invested in organised, population-based cancer screening programmes. For example, most EU countries offer mammography for women aged 50–69 years, though participation and coverage rates vary considerably [4]. Some nations are still conducting pilot projects or have broader target age ranges [5]. As of 2016, seventeen EU countries had initiated colorectal cancer screening programmes [4,6]. These screening initiatives have proven highly beneficial in reducing mortality, facilitating early detection, and improving survival outcomes [7]. An observational European study found that cervical cancer screening reduced mortality rates by 41–92% [7]. However, the stability and effectiveness of such initiatives depend on sustained public engagement and a robust health infrastructure, both of which were severely disrupted by the

COVID-19 pandemic [7,8].

During the pandemic, European health systems faced extraordinary strain, and numerous non-urgent services were suspended or curtailed [8]. To contain viral transmission, governments implemented lockdowns, physical distancing, and suspensions of elective care, leading to a halt in preventive health services. Over 70% of European countries temporarily stopped cervical cancer screening in 2020, with many also suspending follow-up procedures such as colposcopy and precancerous lesion treatment [8]. Lockdowns, resource reallocation, and public uncertainty significantly hampered cancer screening, increasing the likelihood of delayed diagnoses, advanced disease presentations, and lower survival rates [9].

Differences in National Baselines

Before the pandemic, Europe's cancer screening systems were relatively well developed. By 2016, most EU Member States had implemented or planned population-based screening for colorectal, cervical, and breast cancers [5]. Coverage rates for these programmes had improved substantially since 2007, reaching 94.7% for breast cancer, 72.3% for cervical cancer, and 72.4% for colorectal cancer among eligible women [5]. However, baseline systems differed widely. Countries such as the United Kingdom, Finland, and the Netherlands operate unified national programmes covering all three major cancers [10]. In contrast, several Central and Eastern European countries, including Hungary, Slovenia, and Estonia, still face challenges such as limited coverage, weak population data systems, and low public awareness [11]. These disparities created structural vulnerabilities that amplified the impact of pandemic-related disruptions, underscoring the need for systematic comparative analysis.

In addition to programme maturity, European countries differ in underlying socioeconomic conditions and health-system capacity, which influence screening access and participation. Cross-national evidence shows variation in the presence, organisation, and equity of access to breast screening programmes across European countries, and differences in health-system barriers affecting population-based cervical and colorectal screening implementation [6,11]. Reported programme coverage and participation also vary across countries and over time, reflecting differences in infrastructure, population data systems, and outreach capacity [5]. These baseline disparities provide important context for interpreting why disruption and recovery during the pandemic were uneven and why existing inequities may have been amplified.

Differences in National Actions

European countries also exhibited diverse responses to the crisis. The Netherlands, for instance, suspended its national screening programmes for colorectal, breast, and cervical cancers but resumed them swiftly [12]. In contrast, the United Kingdom experienced substantial service declines across breast, colorectal, lung, and prostate cancer screenings, with some services operating at only 5–20% of pre-pandemic levels [13]. Between March 2020 and December 2021, an estimated 18,000 breast, 13,000 colorectal, 10,000 lung, and 21,000 prostate cancer cases were potentially missed in the UK[13]. Notably, Sweden did not formally suspend its cancer screening programmes during the first wave but adapted workflows,

reduced patient density, and promoted home-based testing, thereby maintaining service coverage [14]. These variations highlight the influence of health system organisation, policy agility, and adaptive capacity on screening resilience.

Differences in Cancer Types and Screening Methods

Cancer screening encompasses multiple modalities and cancer types, each with differing epidemiology, efficacy, and cost-effectiveness [15,16]. While research has explored novel screening technologies for lung, prostate, and other malignancies, the primary focus of most population-based programmes, and this review, remains breast, cervical, and colorectal cancers [17-19]. These cancers are the cornerstone of organised screening due to their high burden and the strong evidence that early detection reduces mortality. Over 80 countries have national screening programmes for at least one of these cancers, with many offering all three [15,16]. Nevertheless, multi-cancer analyses remain limited, and most studies focus on single cancer types. Broader analyses are needed to assess systemic resilience and multi-cancer response capacity during public health emergencies.

Screening modalities differ by cancer type and were variably affected by the pandemic. Breast cancer screening relies predominantly on mammography, recommended annually or biennially for women aged 40–74, with peak efficacy between ages 50–69 [20]. Cervical cancer screening includes cytology (Pap smear), HPV testing, and visual inspection with acetic acid (VIA), targeting women aged 21–65 [21-23]. Colorectal cancer screening methods include colonoscopy and faecal immunochemical testing (FIT), recommended for adults aged 45–75 [24,25]. Evidence suggests that facility-based procedures were more severely disrupted than home-based or self-sampling methods [26,27]. This underscores the potential value of remote screening strategies for maintaining service continuity during crises.

Evidence Gaps and Rationale for the Study

Despite extensive national reporting, the evidence on pandemic-related screening disruption in Europe remains fragmented. Many studies are country- or cancer-specific or focus on short-term outcomes [28-31]. Reviews such as those by Elemes et al. and Shah et al. identified global declines in breast and cervical screening volumes but lacked cross-European comparisons [28,87]. Similarly, Li's review focused exclusively on breast cancer, omitting multi-cancer and methodological heterogeneity [31]. Shah's 2025 review examined screening for only three cancer types and highlighted issues with cancer services and treatments more than screening [87]. Other studies noted temporary reductions in screening across age groups and settings but offered little insight into long-term effects [29,30]. Interruptions in screening may contribute to stage migration, excess mortality, and widening inequalities [32,33]. Moreover, few studies systematically examined both supply- and demand-side barriers, such as workforce redeployment, service suspension, fear of infection, and public mistrust [29,30,34]. This review adds value by providing a Europe-focused, cross-country synthesis across 18 countries and integrating evidence across the three core population-based screening programmes (breast, cervical, colorectal). In addition to quantifying disruption and recovery patterns, we synthesise supply-side and demand-side barriers and enablers, and collate policy

and service responses reported in included studies to inform preparedness and resilience planning. By combining descriptive and thematic synthesis, the review aims to clarify how screening systems responded across differing contexts and which adaptations may support continuity and equity during future health emergencies.

Methodology

Research Question: How did the COVID-19 pandemic affect cancer screening activity across Europe, and what barriers, enablers, downstream consequences, and policy responses were reported across countries and screening modalities?
Accordingly, the objectives were to: (1) summarise the magnitude and timing of screening disruptions and recovery across Europe; (2) compare patterns by cancer type and screening modality; (3) synthesise supply-side and demand-side barriers and enablers; (4) summarise reported downstream impacts (e.g., missed diagnoses, stage shifts, mortality projections); and (5) identify policy and service responses reported in the included evidence to inform future continuity and resilience planning.

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [35]. As the study used secondary data, no human participants were directly involved, and ethical approval was not required. Nevertheless, rigorous measures were taken to ensure transparency and responsible data use, including independent quality assessment, strict eligibility criteria, and appropriate source attribution. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO; CRD420251066715) to ensure methodological transparency and reproducibility. Research questions were developed using the PICOS (Population, Intervention, Comparison, Outcome, Study design) framework, and detailed search and analysis plans were pre-specified to minimise reporting bias. The registry record is accessible and reflects the eligibility criteria, search approach, and synthesis methods reported in this manuscript.

Eligible studies included quantitative or qualitative research investigating the impact of the COVID-19 pandemic on cancer screening in European populations, as defined by the WHO regional classification. Included study designs encompassed descriptive, observational, cohort, cross-sectional, modelling, and time-series studies. Qualitative study designs were eligible in principle; however, no standalone qualitative-design studies met the inclusion criteria among the 45 studies retained for analysis.Editorials, commentaries, and secondary reviews were excluded.
Studies published between December 2019 and January 2025 (final search conducted in January 2025) in English (or translatable into English) were included. Articles had to provide pre- and post-pandemic comparison data or specify screening outcomes linked to COVID-19 disruptions. Non-European, duplicate, incomplete, or inaccessible studies were excluded. Grey literature was eligible if it originated from authoritative sources (e.g., the NHS and the WHO) and reported empirical screening indicators consistent with the eligibility criteria. Preprints were eligible if they provided relevant empirical data and met the inclusion criteria, and were

identified as such in the reference list. These criteria ensured that findings accurately reflected the pandemic's impact on European cancer screening systems. Full eligibility criteria are detailed in Appendix 1.

Search Strategy

Scopus, PubMed, Web of Science, Global Health, Embase, and MEDLINE are primary literature search databases. The search term is primarily broken down into four primary concept groups across various disciplines and combines free-text keywords, Boolean operators, and medical subject headings (MeSH). Keywords including "cancer*", "neoplasm*", "tumour*", "tumour*" and "oncology*" were used, along with other terms connected to cancer. The phrases "COVID-19", "SARS-CoV-2","Coronavirus" and "pandemic" were used to identify investigations related to the pandemic. Additionally, terms like "cancer screening*","screening program*","screening service*","early detection*"to restrict the search and the use of keywords like "Europe" and the names of European nations to limit regions. Boolean operators (AND/OR) and Medical Subject Headings (MeSH) were applied to tailor queries for each database. Grey literature was sourced from repositories such as CORE, OpenDOAR, trial registries, and official government or public health portals. Reference lists of included studies were manually screened to capture additional relevant literature. A complete reproducible example of a database search query (PubMed) is provided in Appendix 2, alongside database-specific strategy structures.
The selection process followed three stages: deduplication, title and abstract screening, and full-text review. All records were imported into Covidence, a screening software [85], which automatically removed duplicates, with manual verification for residual overlaps. Two reviewers independently screened titles and abstracts against predefined inclusion criteria, excluding studies unrelated to Europe, cancer screening, or empirical data. A third reviewer resolved disagreements. Full-text screening followed the same three-reviewer format and applied stricter eligibility criteria, focusing on the availability of pre-pandemic comparators and defined outcome measures. Reasons for exclusion were categorised (e.g., wrong setting, outcome, or design). The selection process is illustrated in a PRISMA flowchart (Figure 1).

Data Extraction

Data were systematically extracted into structured Excel spreadsheets rather than Covidence to allow analytical flexibility. Extracted variables included: study title, country, design, duration, setting, target population, objectives, outcomes, barriers, enablers, and recommendations. Primary outcomes focused on quantitative indicators of screening activity (e.g., changes in screening numbers or uptake rates). Secondary outcomes captured downstream effects, including missed diagnoses, increased cancer stage at detection, and changes in mortality.
Qualitative data on barriers and facilitators were categorised as supply-side (e.g., service suspension, workforce redeployment) or demand-side (e.g., fear of infection, economic barriers). Opportunities and recommendations from the included studies were synthesised to inform actionable policy insights that bridge research and practice. Data extraction was performed using a standardised form to ensure consistency across studies. A second reviewer cross-checked extracted fields for completeness and accuracy, with discrepancies resolved by

consensus.

Risk of Bias and Quality Assessment

Quality appraisal was performed independently using validated instruments appropriate to the study design:

- The Newcastle–Ottawa Scale (NOS) for cross-sectional and cohort studies [36],
- The Joanna Briggs Institute (JBI) Critical Appraisal Checklists for observational and narrative designs [37],
- The CHEERS 2022 checklist for modelling studies [38], and
- The EPOC Risk of Bias Tool for time-series analyses [39].

For NOS-scored studies, higher star totals were interpreted as lower risk, and categorised into low/moderate/high risk bands consistent with the scoring ranges. For JBI appraisals, overall risk followed the proportion of "Yes" responses. For EPOC, studies were categorised by domain-level judgement distribution (low/moderate/high). For CHEERS, reporting completeness was used to identify potential concerns relevant to modelling transparency, and an overall low/moderate risk judgement was assigned accordingly. A study-level summary of the tool used and the final overall risk category is provided in the Supplementary table (Appendix 3). Because no standalone qualitative-design studies were included in the final set of studies, qualitative-specific appraisal tools were not applied. Interrater agreement statistics were not formally calculated; however, independent screening and dual review with third-reviewer adjudication were used to minimise selection and classification errors.

Statistical Analyses

Given the methodological and contextual heterogeneity of included studies, a meta-analysis was not feasible. Instead, a mixed-methods synthesis combining descriptive statistics and qualitative thematic analysis was conducted.

Descriptive analysis quantified screening reductions across Europe by cancer type and country, identifying trends in participation, coverage, and subsequent clinical outcomes (e.g., delayed diagnosis, mortality).

Thematic synthesis was used to identify recurring patterns in reported barriers, enablers, and mitigation strategies across studies, including organisational adaptations, behavioural responses, and access challenges. Findings from both strands were integrated to elucidate patterns in service disruption, recovery, and resilience. This combined approach enabled the generation of data-informed, context-sensitive recommendations to strengthen future continuity of cancer screening during public health emergencies.

Result

As illustrated in Figure 1 (PRISMA flow diagram), a total of 1,287 potentially relevant records were identified across six major databases: Scopus (n = 335), PubMed (n = 157), Web of Science (n = 114), Global Health (n = 239), Embase (n = 100), and MEDLINE (n = 342). An

additional four grey literature sources were retrieved from official websites and repositories. After applying Covidence's automatic and manual deduplication processes, 744 duplicates were removed, leaving 547 unique records for title and abstract screening. Following the eligibility assessment, 426 articles were excluded for failing to meet the inclusion criteria, leaving 121 for full-text review. The primary reasons for exclusion at this stage were irrelevant research focus or ineligible study design.

Of the 121 full-text articles screened, 45 studies met all inclusion criteria and were retained for analysis. Discrepancies between reviewers were resolved through discussion with a third reviewer. A total of 76 studies were excluded after full-text review for the following reasons: non-empirical or theoretical design (n = 33), absence of key screening indicators (n = 17), inaccessible full text (n = 3), non-eligible population (n = 5), wrong setting (n=1), wrong comparator and interventions (n=4), and unrelated topic (n = 13). The full selection process and exclusion breakdown are depicted in Figure 1.

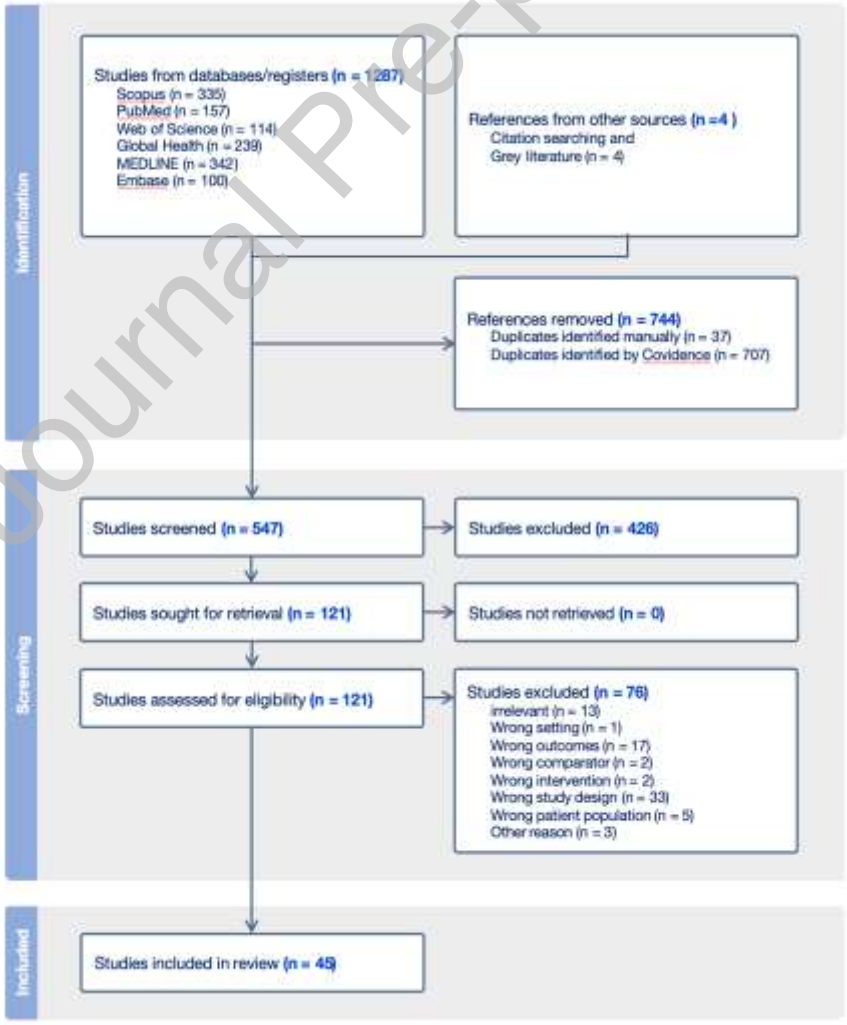

Figure 1: PRISMA flowchart of data selection

Geographical distribution

In terms of geographical division, a total of 45 research papers were included in this review, encompassing data from 18 European countries (Figure 2). The most frequently studied countries were Italy (n=9), Denmark (n=5), the Netherlands (n=6), Germany (n=4), Spain (n=3) and the United Kingdom (n=2). Other countries include France, Belgium, Poland, etc. (1-2 studies each). However, the majority of the included studies were concentrated in Western and Northern Europe, and reports from many Eastern and Southern European countries were underrepresented; thus, there may be a geographical bias. But this also indirectly shows the baseline differences within Europe.

Cancer types

In terms of cancer types, most of the studies were about screening for breast cancer (n=18), colorectal cancer (n=16), and cervical cancer (n=10). A few studies (n=4) addressed multiple cancers or other types (e.g., lung, prostate).

Research Period

Regarding the temporal scope, all included studies compared data from pre-pandemic periods (2017–2019) with one or more pandemic phases (2020–2022). Most studies (n = 32; 71.1%) specifically focused on the initial lockdown phase between March and May 2020, capturing the immediate disruption to screening services. In addition, 28 studies (62.2%) extended their analysis to include the post-lockdown recovery phases, providing insight into service adaptation and resumption.

Research types

Most of the included studies (n = 22) used descriptive and observational study designs, reflecting the pressing need to document the pandemic's effects in real time. Retrospective cohort studies that used pre-existing screening registries to assess outcomes both before and after the pandemic were also prevalent (n = 13). There were fewer cross-sectional studies (n = 6), most of which were based on regional or single-institution reports. The study also included two interrupted time-series (ITS) studies and two modelling studies that evaluated potential delays in diagnosis and increases in mortality resulting from screening interruptions.

Figure 2 Characteristic table

ref	Author (Year)	Country	Study Design	Study Period	Cancer Type	Change of cancer screening	The subsequent impacts after screening delays
40	Acuti M. C. et al. (2024)	Italy	Cohort	2018–2021	Colorectal	FIT uptake rate: Intervention group stable, control group decreased by 4%	Increased GP engagement improved local screening adherence
41	Atadag YB et al. (2023)	Turkey	Record-based descriptive	2017–2020	Breast, Cervical, Colorectal	Screening rates dropped by 4.4% (breast), 6.2% (cervical), 1.9% (colorectal)	Reduced early detection
42	Bărbulescu L-N et al. (2023)	Romania	Observational retrospective	2019–2023	Colorectal	Screening participation decreased during pandemic, rebounded by 128.4% post-pandemic	Positive correlation between vaccination and screening participation
43	Barclay NL et al. (2024)	UK	Population-based cohort	2017–2021	Breast, Colorectal, Lung, Prostate	Incidence rate ratios (IRR) reduced: Breast (0.69), Colorectal (0.74), Prostate (0.71)	Estimated missed diagnoses: Breast (18,000), Colorectal (13,000), Prostate (21,000)
44	Battisti F et al. (2022)	Italy	Retrospective cohort	2011–2020	Breast, Cervical, Colorectal	Screening tests decreased by 37.6% (breast), 45.5% (colorectal), 43.4% (cervical)	Participation rates dropped by 15–20%
45	Bosch M et al. (2022)	Spain	Cohort	2012–2021	Breast	Participation declined by 37% (regular participants), 10% (first-time invitees)	False positives decreased by 28%
46	Bright D et al. (2023)	UK	Cohort	2018–2020	Colorectal	Uptake dropped by 30–40%, especially in older and urban populations	Increased socio-demographic inequalities
47	Comm ES Neamțiu L. et al. (2022)	Europe	Cross-sectional survey	2019-2020	Multiple	84% of registries reported disrupted screening programs	Severe delays in cancer diagnosis and treatment
48	Dabkeviciene D. et al. (2021)	Lithuania	Retrospective observational	2019–2020	Breast, Cervical, Colorectal	Screening participation fell: Breast (−62%), Colorectal (−25%), Cervical (−29%)	Increased telemedicine use
49	D'Ovidio V. et al. (2021)	Italy	Retrospective cohort	2019–2020	Colorectal	Fewer check-ups but higher cancer detection rates during lockdown	Higher detection of high-risk adenomas
50	Eijkelboom AH et al. (2023)	Norway	Retrospective registry-based	2018–2021	Breast	Median screening interval extended by 3.0 months	No link between prolonged intervals and tumour characteristics
51	Elek P. et al. (2022)	Hungary	Observational cohort	2015–2021	Breast	Significant reduction in mammography screening	New diagnoses dropped; lagged 1–2 months behind screening declines
52	Giorgi Rossi P. et al. (2022)	Italy	National cross-sectional surveys	2019–2020	Breast, Colorectal, Cervical	Invitations and tests dropped significantly	Larger declines among low education and economically disadvantaged groups
53	Girardi D. et al. (2024)	Italy	Retrospective observational	2019–2020	Breast, Colorectal, Cervical	Coverage decreased: Breast (−16.3%), Cervical (−8.5%)	Disparities increased for non-nationals and rural residents
54	Gremke K. et al. (2022)	Germany	Cross-sectional	2018–2021	Cervical	Screening decreased: 25.6% (ages 20–34), 15.2% (ages >50)	Drop in patients screened per practice

55	Hajek A. et al. (2021)	Germany	Cross-sectional survey	2019-2020	Multiple	10% of participants postponed screenings; 46% among eligible	Higher among women (14.1%) and ages 30–49 (15.4%), higher postponement linked to COVID-19 anxiety
56	Hinterberger A et al. (2021)	Austria	Retrospective cohort	2019–2020	Colorectal	Colonoscopy volume decreased significantly	No change in detection rates for advanced adenomas or cancers
57	Ivanuš U et al. (2021)	Slovenia	Population-based observational	2017–2020	Cervical	Screening rate dropped by 23%; lockdown period: −92%	Precancerous lesion detection decreased by 32%
58	Jidkova S et al. (2022)	Belgium	Observational retrospective	2019–2020	Breast, Colorectal, Cervical	Invitation coverage: Breast dropped from 97.5% to 88.7%	Screening intervals increased by 2.1 months (breast)
59	Katsara MA et al. (2025)	Netherlands	Observational retrospective	2017-2021	Colorectal	There is a delay	The pandemic's temporary delays had no appreciable impact on the CRC screening program's efficacy.
60	Kirac, I. et al, (2020)	Croatia	Retrospective observational	2019-2020	Colorectal	Colonoscopy numbers dropped sharply in April 2020	Colonoscopy volume recovered to an average pace within three months post-lockdown
61	Koivogui A. et al. (2023)	France	Descriptive and etiological	2017-2020	Colorecta	FIT decreased. Proportion of tests not analysed reached peaking at 2020(increased to 8.3%)	Time to colonoscopy increased, with a higher proportion of patients waiting ≥24 months
62	Kortlever TL. et al. (2021)	Netherlands	Retrospective observational	2018–2020	Colorectal	FIT invitations decreased by 23.5%; participation dropped by 7%	5,500 advanced tumours potentially missed
63	Laurent L et al. (2022)	France	Retrospective cross-sectional	2019–2020	Breast, Colorectal	Breast screening reduced by 19.5%; FIT screening halted during first wave	No evidence of post-pandemic volume recovery
64	Mangone L. et al. (2022)	Italy	Retrospective observational	2019–2020	Breast	In screening age, interval cancers decreased (26.9% → 22.6%)	Interval cancers decreased (26.9% → 22.6%)
65	Mendes D. et al. (2023)	Portugal	Retrospective population-level analysis	2015–2022	Breast, Cervical, Colorectal	Screening reductions: Breast (−12.8%), Cervical (−15.1%), Colorectal (−8.9% to −11.4%)	Projected mortality increases: Breast (+4.6%), Cervical (+8.6%) over 25 years Missed diagnoses: breast cancer (2,425 cases), cervical cancer (246 cases), colorectal cancer (892 cases)
66	Muschol J. et al. (2023)	Germany	Retrospective observational	2017–2020	Multiple	Total screenings declined by 21.46%; largest drops in elderly (−37.02%) and women (−32.94%)	Older adults and women disproportionately affected
67	Nonboe M. T. (2023)	Denmark	Register-based time-series	2017–2021	Breast, Cervical	Mammography: −43.3% (2020); Cervical: −61.9% (2020)	Pre-existing annual decline in cervical screening (−1.9%)
68	Nonboe M.H. et al. (2023)	Denmark	Register-based time-series	2017–2021	Breast, Cervical	Mammography: −43% (2020); Cervical: −62% (2020)	Rapid return to pre-pandemic levels post-lockdown
69	O'Driscoll J et al. (2024)	Ireland	Descriptive observational	2019–2021	Breast	Mammograms reduced by 67.1% in 2020	Increase in Grade 3 cancers (24.8% → 32.4%)

70	Olesen TB et al. (2022)	Denmark	Observational	2018–2021	Colorectal	Minimal decline in FIT participation during pandemic	Colonoscopy compliance remained high
71	Olthof, E.M.G et al. (2023)	Netherlands	Observational cohort	2018–2020	Cervical	Participation dropped from 56.8% to 49.8% in 2020	Near-full recovery by August 2020
72	Pedersen BT et al. (2024)	Denmark	Observational registry-based	2017–2023	Cervical	Regular screening dropped by 8.4% (2020); HPV self-sampling peaked at 21.2%	Older women more likely to use self-sampling
73	Pedersen BT et al. (2024)	Denmark	Population-based register study	2018–2021	Cervical	Screening samples declined during lockdown; coverage dropped from 73% to 68% by 2021	HPV self-sampling uptake increased to 21.2% during pandemic
74	Poelhekken K. et al. (2023)	Netherlands	Computational modelling	2019–2020	Breast	3-month interruption increased interval cancer rate by 19%	No clinically relevant tumor size changes for short interruptions
75	Ricciardiello L et al. (2021)	Italy	Modelling and meta-analysis	2019-2020	Colorectal	Screening delays predicted stage migration and increased mortality	Early cancers detected at advanced stages
76	Robles C. et al. (2024)	Spain	Time-series analysis	2020–2021	Cervical	Participation dropped by 38.8% in 2020; abnormal cytology prevalence 1.4× higher	Screening intervals extended to 48 months by 2021
77	Rossi P.G. et al. (2023)	Italy	Cross-sectional repeated surveys	2019–2021	Breast, Colorectal, Cervical	Invitation coverage and test rates dropped sharply	Pre-existing inequalities worsened (low education, immigrants)
78	Stuebs FA et al. (2024)	Germany	Retrospective observational	2018–2022	Cervical	Biopsies stable; cancer detection slightly increased (6.6% → 7.4%)	No significant diagnostic delays
79	Ticozzi E.M. (2025)	Italy	Descriptive temporal analysis	2016–2022	Breast	Screening activities decreased during pandemic; rebound in 2021–2022	Urban/rural participation gaps persisted
80	Toes-Zoutendijk E. et al. (2022)	Netherlands	Observational registry-based	2018–2020	Colorectal	CRC diagnoses dropped by 42% (April 2020); catch-up reached +24% by December 2020	Stage I cancers dominated post-restart
81	Trojanowski M et al. (2024)	Poland	Population-based cohort	2010–2020	Breast, Cervical, Colorectal	Incidence gaps: Breast (−12%), Cervical (−15%), Colorectal (−15% females, −16% males)	Pre-existing low participation exacerbated impact Breast cancer diagnoses decreased by 12%, cervical cancer by 15%, colorectal cancer by 15-16%
82	Vives N et al. (2022)	Spain	Retrospective cohort	2019–2020	Colorectal	Participation dropped by 5.1% initially; rebounded to 45.7% by late 2020	Advanced neoplasia detection fell from 19.8% to 15.2%
83	Wolfkamp W et al. (2024)	Netherlands	Retrospective cohort	2017–2021	Breast, Colorectal	BC diagnoses dropped by 47%; CRC by 36% during first peak	Diagnostic procedures shifted (e.g., increased PET-CT for BC)
84	Zheng S et al. (2024)	Belgium	Retrospective observational	2018–2022	Colorectal	Uptake declined in low-SES areas during pandemic	Short-lived impact; rates rebounded post-2020

Quality assessment and Risk of bias

Following risk assessments and quality evaluations of all 45 papers, the results indicated that most were moderate to low risk and lacked significant potential for bias. Twenty-one of them are low-risk, twenty-three are medium-risk, and one is high-risk. These studies showed varying degrees of quality overall, with cohort studies generally receiving higher scores than cross-sectional studies. The following are the specific findings.

Study Type	Total study	Low Risk/High Quality	Moderate Risk/Quality	High Risk/Low Quality
Cross-Sectional (NOS)	6	2	4	0
Cohort (NOS)	13	5	8	0
Observational (JBI)	22	12	9	1
Modelling (CHEERS)	2	1	1	0
Time- series (EPOC)	2	1	1	0
Total	45	21	23	1

Figure 3: Quality assessment summary

As shown in Figure 3, overall study quality was satisfactory. Among the six cross-sectional studies evaluated using the NOS, two achieved high quality (7–9 stars) and four moderate qualities (5–6 stars). While all demonstrated adequate sampling and exposure assessment, approximately half did not fully control for confounding, introducing potential selection bias. Of the 13 cohort studies, five met high-quality thresholds and ten appropriately adjusted for confounders, though some lacked complete baseline or follow-up data, which affected longitudinal robustness.

Using the JBI checklist, 22 observational studies were appraised: 12 (55%) were low risk, 9 moderate, and 1 high risk due to outcome measurement limitations or unmeasured confounding. The four modelling and time-series studies, assessed via CHEERS and EPOC tools, showed no major methodological concerns.

Overall, most included studies were of low to moderate risk of bias, providing reliable evidence. However, subjective scoring, tool limitations, and CHEERS' emphasis on economic aspects may have led to understated bias or underrepresentation of clinical validity. A study-level summary of the quality appraisal tool applied in Appendix 3, along with the corresponding overall risk-of-bias classification for each included study, is provided in Appendix 4.

Disruptions and changes in screening services

Overall, the literature above indicates a strong correlation between the pandemic and delays in cancer screening and diagnosis. Of the 45 papers we evaluated, 44 predicted that the screening rate would drop or that cancer screening initiatives would be delayed during the pandemic. According to a single German report, cervical cancer screening rates either remained the same or increased marginally during the pandemic (6.6%–7.4%) [78]. It may be due to self-sampling promotion or regional policy differences. At the peak of the epidemic, the average drop in screening tests ranged from 30% to 60% [45,64]. However, services have been gradually restored in 2022-2023. The decrease in the breast cancer screening rate was the

largest among the three main cancer screenings: breast cancer, cervical cancer, and colon cancer [52]. The details are as shown in Figure 4.

Figure 4: Pre-Pandemic vs. Pandemic Screening Rates [45,52, 53, 54, 57, 62, 64,67, 72,73,78,82]

Type Period	Peak Disruption (range reported)	Recovery pattern (brief)
Breast (Mammography)	−12.8% to −67.1%	Recovery reported in several settings; persistent shortfalls noted in some regions into 2021–2023
Cervical (Pap/HPV)	−8.4% to −92%	Recovery reported; HPV self-sampling uptake increased in Denmark (up to 21.2%) supporting continuity/re-engagement
Colorectal (FIT)	−5.1% to −45.5%	Catch-up and partial recovery reported in organised programmes; follow-up/procedural backlogs persisted in some pathways

Legend: Ranges summarise percentage changes reported in the cited studies (not pooled estimates). Measures differ across studies (e.g., participation, test volumes, invitation coverage) and baselines vary by programme and country; therefore, the figure is intended as a structured summary of magnitude and direction of disruption and recovery rather than a meta-analytic effect size.

In terms of the type of cancer, the biggest reduction has been in breast cancer screening. Some mammography programmes experienced prolonged recovery, with 10% remaining below pre-pandemic levels in some regions by 2023 [53]. Participation in cervical cancer screening decreased by an average of 33% [54,57]. German research indicated age-specific declines, especially among younger women [45], whereas Slovenian research reported a 23% drop [57]. But advances like HPV self-sampling, which Denmark adopted at a rate of 21.2%, helped reduce losses [72,73]. As for colorectal cancer, the screening disruptions were less severe but more prolonged, with FIT participation falling by 28% [62,82]. Colonoscopy-based programs faced sharper declines, such as a 50% reduction in Spain [82]. While backlogs for colonoscopies continued in some nations, mail-based FIT systems, such as those in the Netherlands, recovered more rapidly [61].

In nations such as Italy, Spain, and Germany, participation rates fell by 35–62% during the pandemic's peak [45,49,66]. Southern European countries (Italy, Spain) saw sharp declines (e.g., breast screening rates dropped by >40%), with slow recovery and widening socioeconomic disparities [45,67,77]. Nordic nations (Denmark, Netherlands) experienced rapid rebounds post-lockdown, aided by organised programmes and self-sampling innovations (e.g., HPV tests) [55,56,71,72]. Central Europe (Germany, Austria) maintained screening quality but faced participation gaps among the elderly and women [54,56].

Potential consequences of service disruption

We summarised the potential long-term effects of delaying cancer screening after extracting the data and combining them with the summary of the characteristic table. First and foremost, the number of missed cancer diagnoses has increased, which is the most significant change in the effectiveness and quality of screening. Of the 45 publications, 7, involving seven nations, including Portugal, Italy, and the United Kingdom, mentioned this impact either directly or indirectly [43,62,65,75,80,81,82,83]. Consider the United Kingdom; it's possible that 18,000 instances of breast cancer and 13,000 cases of colon cancer could have been overlooked during the lengthy screening interruption [43]. A five-month short-term screening stoppage in

Spain may also result in the missing diagnosis of hundreds of colorectal cancer patients [82]. Even some studies (such as those conducted in Portugal and the UK) estimate the number using models, and the results may exceed the screening data [43,65]. However, actual statistical data from the Netherlands and Spain also support its severity [82,83].

Additionally, 10 studies have shown that delayed screening can lead to an increase in advanced cancer cases and even have long-term health impacts, resulting in a higher mortality rate [43,47,57,60,62,65,69,75,76,80]. According to Italian research, postponing colorectal cancer screening may cause the cancer to stage migrate, meaning that more instances are found when the disease is already advanced [75]. A study of the UK also found that a delay in diagnosis could lead to an accumulation of more advanced cases [43]. A study in Ireland also proved the percentage of Grade 3 breast cancer increased from 24.8% to 32.4% by 2020 [69]. Furthermore, long-term health can be impacted. According to a Portuguese study, over the next 25 years, the mortality rate of breast cancer is predicted to climb by 4.6%, while the mortality rate of colorectal cancer is predicted to rise by 8.9–11.4% [65].

Finally, there will be certain societal repercussions from the screening delay, including the emergence and escalation of socioeconomic inequality (6 articles) [52,53,66,77,79,84]. Socioeconomic status can reflect inequality. Statistics show that low-income groups are declining at a rate that is 15-20% higher than that of high-income groups [52]. And the recovery in participation rates is considerably slower in Belgium's low-SES regions [84]. Italian research has shown that the participation rate of people with less than a junior high school education has decreased by twice as much as that of people with a university education, and this disparity is likely to widen [77].

A structured summary of inequality-related findings reported across the included studies (e.g., socioeconomic status, education, age/sex patterns, rurality, and migrant/non-national status, where reported) is presented in Appendix 5.

Barriers

Analysis of 45 studies across 18 European countries identified nine major barriers to cancer screening during the COVID-19 pandemic, grouped and summarised into supply-side and demand-side factors (Figure 5).

On the supply side, the most prevalent challenge was the suspension of screening services, reported in all countries. This was exacerbated by shortages of medical resources, administrative and process backlogs, particularly in Italy, Germany, the United Kingdom, and the Netherlands. Additional issues included unequal regional resource distribution and reduced clinical capacity, which may be due to COVID-19 care.

On the demand side, the leading barriers were fear of infection, economic hardship (e.g., income loss, medical costs), and information gaps regarding screening safety. Structural inequalities, including socioeconomic disparities and limited rural access, further reduced participation. Italy demonstrated the widest range of barriers, reflecting greater social and systemic pressures, while countries such as Austria and Slovenia reported fewer but notable

demand-side challenges.

Summary of recommendations

Mitigation strategies were identified across the studies and clustered into supply-side (health system) and demand-side (public engagement) interventions (Figure 6).

On the supply side, countries introduced mobile screening units, COVID-free centres, digital scheduling systems, and extended operating hours, with risk-based prioritisation to manage backlogs. Northern European nations such as the Netherlands and Denmark advanced self-sampling initiatives, home testing kits, and digital healthcare solutions, demonstrating rapid adaptability.

On the demand side, measures focused on public awareness campaigns, multilingual outreach, and targeted support for vulnerable or rural populations, as implemented in Italy and Spain. The UK and Germany combined digital health integration with communication initiatives to maintain screening uptake.

Overall, resource-rich countries leveraged technology and infrastructure to sustain service continuity, while others focused on equity-oriented, community-based approaches to overcome structural barriers. These adaptive strategies collectively highlight Europe's varied yet complementary pathways to building more resilient cancer screening systems.

Figure 5: Barriers to Screening (References from 40-84)

		Supply-side					Demand -Side			
	Country Barrier	Screening services suspension	Lack of medical resources	Administrative and process delays	Restrictions on protective measures	Uneven regional resources	Fear of infection	Economic pressures	Information asymmetry	Structural inequality
1	Italy	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Germany	✓	✓				✓		✓	✓
3	UK	✓	✓			✓	✓			✓
4	Netherlands	✓	✓	✓			✓			
5	Spain	✓				✓	✓		✓	✓
6	Denmark	✓	✓				✓			
7	France	✓	✓	✓			✓			
8	Portugal	✓		✓			✓	✓	✓	✓
9	Belgium	✓				✓	✓			✓
10	Austria	✓					✓			
11	Hungary	✓					✓	✓	✓	
12	Poland	✓				✓	✓	✓	✓	✓
13	Lithuania	✓					✓			
14	Romania	✓					✓		✓	
15	Slovenia	✓					✓			
16	Croatia	✓					✓			
17	Turkey	✓					✓		✓	✓
18	Norway	✓					✓			

Note: ✓ indicates the presence of a barrier reported in the included studies for that country.

Note: Portugal (2), Poland (2), Lithuania (1), Romania (1), Turkey (1), Norway (1), Hungary (1), Austria (1), Slovenia (1), Croatia

Figure 6. Measures Implemented by European Countries to Address Cancer Screening Disruptions

Country	Supply-Side Measures (Healthcare System Improvements)	Demand-Side Measures (Public Participation Enhancement)
Italy	- Established COVID-free screening centres - Extended operating hours - Targeted GP engagement	- Mobile units for rural areas - Multilingual outreach programs
Germany	- Digital appointment systems - Staff reallocation	- Anxiety management campaigns - Bundled screening with other health services
Netherlands	- Home-based FIT tests - Priority invitations for high-risk groups	- HPV self-sampling kits - SMS appointment reminders
Denmark	- Maintained uninterrupted services - Fast-track recovery programs	- Self-sampling promotion - Dedicated support for elderly
Spain	- High-risk patient prioritisation - Adjusted screening intervals	- Transportation support for low-income groups - Community health worker outreach
UK	- Mobile screening units deployment	- Targeted public service announcements - Extended clinic hours
France	- Centralised resources in COVID-safe facilities	- Simplified testing processes
Portugal	- National screening recovery plan	- Digital health education initiatives
Poland	- Expanded rural coverage	- Community education seminars
Other Countries	- Flexible scheduling - Telemedicine triage	- Self-testing kits - Integrated screening with routine checkups

(1) *The number of articles from that country is indicated in parentheses

Discussion

This systematic review of 45 studies from 18 European countries demonstrates that the COVID-19 pandemic caused substantial and heterogeneous disruptions to cancer screening programmes across Europe. Consistent with earlier projections, most studies reported declines in screening rates between 30% and 60%, indicating a widespread interruption of preventive services. One exception was a German study reporting stable or slightly increased cervical cancer screening rates, likely attributable to regional policy adaptations and the adoption of new screening modalities [78]. Among the three major screening programmes, breast cancer screening was most severely affected, declining by 35%, followed by cervical and colorectal screening. Variations in recovery trajectories and the magnitude of disruption across countries reflect differences in baseline health system capacity, policy responses, and population engagement.

Three main consequences emerged consistently across studies: missed diagnoses, cancer stage migration, and widening social inequities.

First, delayed or suspended screening led to a considerable increase in missed cancer diagnoses, implying that many patients remained undetected until later disease stages. Second, diagnostic delays contributed to a higher proportion of advanced-stage cancers and increased treatment complexity and mortality risk. Third, the pandemic amplified existing socioeconomic disparities, with disadvantaged populations experiencing larger declines in participation and slower recovery. Together, these outcomes threaten the long-term effectiveness of national cancer control strategies and impose additional strain on healthcare systems.

The European findings align with global trends, with similar declines in screening observed in other regions [26,28,29,30]. The magnitude of decline across breast, cervical, and colorectal screening mirrors previous global analyses [26,28,29]. For instance, Teglia et al. reported an approximate 50% reduction in screening participation during the 2020 peak [26]. However, their results indicated the largest fall in cervical screening, differing from our observation that breast screening was most affected, potentially reflecting Europe's demographic and infrastructural variations. International comparisons also highlight the resilience of faecal immunochemical testing (FIT), a non-invasive colorectal screening modality, which showed smaller declines than colonoscopy-based programmes [86].

Countries that implemented catch-up strategies, digital innovations, and targeted outreach recovered screening volumes more quickly than those enforcing prolonged lockdowns or lacking adaptable health systems. Similar patterns were reported outside Europe, in Argentina, Brazil, Chile, Morocco, and Australia, where flexible strategies supported faster service restoration [87–89].

Across included studies, screening modalities and delivery models appeared to shape disruption and recovery. Programmes with home-based components (e.g., FIT-based colorectal screening and HPV self-sampling options) were described as more adaptable during periods of restricted facility access, supporting faster stabilisation or recovery in some settings [62,67,71–73]. In contrast, modalities requiring face-to-face visits and diagnostic follow-up capacity (e.g., mammography and colonoscopy-dependent pathways) were more vulnerable to service suspension and backlog accumulation, contributing to prolonged deficits in some regions [44,56,69,82]. Comparisons between public and private funding models were not feasible because this attribute was inconsistently reported across included studies; this is highlighted as a priority for future comparative research.

Several studies in this review documented the downstream consequences of screening suspension, including missed diagnoses, advanced-stage presentation, and increased mortality [43,62,65,69,75,80–83]. For instance, an estimated 18,000 breast and 13,000 colorectal cancer cases may have been missed in the United Kingdom alone [43]. In Italy and Spain, temporary suspensions were associated with stage migration, with more cancers diagnosed at advanced stages [75,82]. Irish data similarly revealed an increase in Grade 3 breast cancers from 24.8% to 32.4% [69].

Modelled projections underscore the gravity of these effects: the Portuguese study estimated long-term mortality increases of 4.6% for breast and 8.9–11.4% for colorectal cancer over 25 years [65], while a UK analysis predicted a 15.3–16.6% rise in colorectal cancer mortality based on delayed diagnoses [92]. Although Yin et al. suggested that short-term interruptions may not significantly alter cancer stage distribution [93], prolonged disruptions appear to exacerbate late detection and mortality trends. These estimates are modelled projections derived from country-specific inputs and should not be interpreted as direct measures for all European settings.

The pandemic deepened pre-existing inequalities in cancer screening participation. Several European studies showed that lower socioeconomic position and lower education were associated with sharper declines and/or slower recovery in screening participation [52,53,77,84]. Where reported, inequalities also intersected with other access constraints, including disparities affecting non-nationals and rural residents, suggesting that social vulnerability and service accessibility could compound one another during service disruption and recovery phases [53,66,77,84]. A study-level summary of inequality dimensions reported (e.g., SES, education, age, sex, rurality, and migrant/non-national status where available) is provided in Table S2 (Appendix 4).

Our synthesis identified nine major barriers contributing to screening disruption across 18 countries, divided into supply-side and demand-side categories. The most prevalent supply-side obstacles were screening service suspensions, resource shortages, and procedural backlogs, particularly in Italy, Germany, France, the UK, and the Netherlands. On the demand side, common barriers included fear of infection, economic hardship, and poor communication, alongside structural inequalities in rural and low-income populations.

These barriers often intersected: administrative suspensions were compounded by infection control policies and workforce reallocations, while inconsistent public messaging amplified fear and reduced participation [52,53,65,77]. The pandemic thus exposed both operational fragilities and communication gaps within European cancer screening systems.

Policy recommendations

The findings of this review highlight the urgent need for European countries to strengthen the resilience, adaptability, and equity of cancer screening systems in preparation for future public health crises. We distinguish between short-term recovery actions from long-term resilience measures, and link recommendations to empirical findings reported in included studies.

Short-term recovery actions (service restoration and backlog management):

- Implement catch-up strategies (extended operating hours, prioritisation of higher-risk groups, and targeted recall) to restore screening volumes and manage backlogs [58,80,82].
- Use outreach through primary care and local service coordination to re-engage eligible populations, as suggested by evidence of improved uptake with targeted GP engagement [40].
- Maintain COVID-safe service pathways (e.g., COVID-free sites and protected capacity) to sustain essential preventive services during waves of infection and reduce disruption-related avoidance [44,64].

Long-term resilience measures (institutionalising adaptable and equitable delivery models):

- Embed home-based and self-sampling approaches within routine programmes where appropriate: HPV-based screening adaptations and self-sampling uptake were associated with maintained activity or recovery in some settings [71–73], and FIT-based programmes demonstrated adaptability during disruption and recovery phases [62].
- Strengthen digital infrastructure (appointment systems, reminders, and communication platforms) to support continuity and reduce missed invitations and delayed follow-up

[58,71–73].

- Institutionalise equity-focused delivery strategies (targeted outreach, support for underserved groups, and improved accessibility for rural and socially disadvantaged populations) given evidence of disproportionate declines and slower recovery among disadvantaged groups [52,53,77,84].

Cross-cutting (preparedness and shared learning):

- Integrate screening continuity into emergency preparedness planning and strengthen cross-country learning through shared evaluation and data harmonisation to accelerate dissemination of effective adaptations across systems [47,58].

Research strengths and limitations

This review's key strength lies in its comprehensive synthesis across 18 European countries, covering multiple cancer types and integrating both quantitative and qualitative evidence. The use of recognised appraisal tools (NOS, JBI, CHEERS, EPOC) and an independent dual screening enhanced methodological rigour. By combining descriptive and thematic analyses, the study captured both the magnitude and context of screening disruption, providing policymakers with actionable insights.

However, several limitations should be acknowledged. The heterogeneity of study designs, outcome measures, and reporting periods limited direct comparability across countries and prevented meta-analysis or pooled quantitative effect sizes. Several outcomes, including missed diagnoses and mortality impacts, relied partly on modelling rather than observed long-term follow-up data. Geographic imbalance, with predominance of Western and Northern European evidence, may underrepresent disruption patterns and recovery trajectories in Eastern and parts of Southern Europe. Finally, publication bias is possible, as settings reporting more pronounced disruption may have been more likely to publish evaluations. These limitations should be considered when interpreting cross-country contrasts and drawing causal inferences.

Future studies

Although this review synthesises extensive evidence on the pandemic's impact on cancer screening in Europe, several knowledge gaps remain that warrant further investigation. The priority is to address geographical and population-level data disparities. Most available evidence comes from Western and Northern Europe, leaving Eastern and Southern Europe underrepresented. Additionally, there is limited data on vulnerable subgroups, including low-income populations, migrants, and residents of rural or underserved areas. Future research should therefore prioritise equitable geographical representation and explore barriers faced by socially disadvantaged groups through both quantitative and qualitative approaches. Multinational collaborative networks could play a pivotal role in achieving these goals by promoting standardised data collection and enabling robust cross-country comparisons.

Secondly, there is a pressing need for long-term follow-up studies to evaluate the lasting effects of screening interruptions on cancer stage at diagnosis, patient survival, and mortality. Current evidence largely relies on modelling studies or short-term observational data spanning one to two years post-pandemic, which may not capture delayed or cumulative outcomes. Future longitudinal research should employ cohort- or registry-based designs to track the health trajectories of individuals affected by missed or delayed screening opportunities over 5 to 10 years, integrating clinical, behavioural, and sociodemographic data where feasible.

Furthermore, the effectiveness, sustainability, and scalability of different mitigation strategies remain insufficiently studied. Few comparative analyses have examined which interventions, such as digital reminders, self-sampling, or decentralised outreach, are most effective across different healthcare contexts. Future research should incorporate multicentre evaluations and cost-effectiveness analyses to identify the most effective and equitable models of cancer screening delivery. Importantly, successful innovations developed during the pandemic, such as home-based testing and digital coordination platforms, should be institutionalised within national screening programmes to improve resilience to future disruptions.

By addressing these research gaps, European health systems can not only strengthen their preparedness for future health emergencies but also ensure that advances in screening technologies and service design translate into sustained, equitable gains in cancer prevention and early detection across all populations.

Finally, there is a need for more qualitative research exploring patient and provider perspectives, motivations, beliefs, and contextual barriers shaping screening participation during crises. Such studies would complement the quantitative evidence base synthesised here and strengthen understanding of mechanisms driving inequities and behavioural responses during service disruption and recovery.

Conclusion

COVID-19 caused major and uneven disruption to cancer screening across Europe, with substantial reductions reported across breast, cervical, and colorectal programmes during peak pandemic phases. Evidence across 45 studies from 18 countries indicates downstream risks, including missed diagnoses, stage shifts, and modelled increases in mortality in some settings, alongside widening inequalities in participation and recovery. Reported barriers spanned service suspension, workforce redeployment, procedural backlogs, fear of infection, and structural access constraints, while mitigation approaches included adaptable delivery models such as home-based testing/self-sampling, digital coordination, and targeted outreach. Strengthening resilient and equitable screening systems requires institutionalising effective adaptations, embedding continuity planning in emergency preparedness, and improving cross-country learning to protect preventive services during future crises.

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Appendices

Appendix 1: Inclusion and Exclusion Criteria

Category	Inclusion Criteria	Exclusion Criteria
Study Design	- Original research: cohort, case-control, cross-sectional studies, clinical trials. - Grey literature: official reports from WHO, NHS, ECDC, national ministries of health, or public health authorities. - Systematic reviews/meta-analyses: used for contextual background only.	- Editorials, commentaries, opinion pieces.- Case reports.- Review studies (narrative, scoping, systematic, unless providing relevant background only).
Population	- Target population: individuals eligible for or participating in cancer screening programmes in Europe. - All cancer types, stages, and age groups included.- Studies comparing pandemic vs. pre-pandemic screening data.	- Non-cancer populations.- Studies without relevance to cancer screening (e.g., treatment-only or diagnostic imaging-only studies).
Exposure / Intervention	- Studies explicitly addressing the impact of COVID-19 on cancer screening (accessibility, utilisation, continuity, service organisation).	- Studies focused only on treatment, clinical management, or diagnostic technologies unrelated to screening.
Comparator	- Studies with pre-pandemic baseline data, or longitudinal comparisons across pre-, during, and post-pandemic periods.	- Studies without baseline or comparator data (e.g., only reporting “disruption” without reference period).
Outcomes	- Quantitative outcomes: participation/screening rates, diagnostic follow-up delays, delay times, missed diagnoses, stage distribution, mortality predictions. - Qualitative outcomes: barriers and enablers, policy impacts, workforce capacity, equity considerations.	- Claims without measurable outcomes.- Outcomes not related to cancer screening services.
Timeframe & Language	- Studies published between Dec 2019 and present.- English-language studies included.- Non-English studies included if full text available and translatable.	- Studies published prior to Dec 2019.- Inaccessible full texts.
Geographical Scope	- Studies conducted in Europe as defined by WHO European Region.	- Studies clearly conducted outside Europe, or where study location cannot be identified.

Appendix 2: Search strategies and keywords

PubMed	(("COVID-19"[Mesh] OR "SARS-CoV-2"[Mesh] OR COVID-19[tiab] OR SARS-CoV-2[tiab] OR Coronavirus[tiab]) AND ("Early Detection of Cancer"[Mesh] OR "Mass Screening"[Mesh] OR cancer screening[tiab] OR screening service*[tiab] OR screening program*[tiab]) AND ("Neoplasms"[Mesh] OR cancer[tiab] OR neoplasm*[tiab] OR tumor*[tiab] OR tumour*[tiab] OR malignan*[tiab]) AND (Albania[tiab] OR Andorra[tiab] OR Armenia[tiab] OR Austria[tiab] OR Azerbaijan[tiab] OR Belarus[tiab] OR Belgium[tiab] OR "Bosnia and Herzegovina"[tiab] OR Bulgaria[tiab] OR Croatia[tiab] OR Cyprus[tiab] OR "Czech Republic"[tiab] OR Denmark[tiab] OR Estonia[tiab] OR Finland[tiab] OR France[tiab] OR Georgia[tiab] OR Germany[tiab] OR Greece[tiab] OR Hungary[tiab] OR Iceland[tiab] OR Ireland[tiab] OR Italy[tiab] OR Kazakhstan[tiab] OR Kosovo[tiab] OR Latvia[tiab] OR Liechtenstein[tiab] OR Lithuania[tiab] OR Luxembourg[tiab] OR Malta[tiab] OR Moldova[tiab] OR Monaco[tiab] OR Montenegro[tiab] OR Netherlands[tiab] OR "North Macedonia"[tiab] OR Norway[tiab] OR Poland[tiab] OR Portugal[tiab] OR Romania[tiab] OR "San Marino"[tiab] OR Serbia[tiab] OR Slovakia[tiab] OR Slovenia[tiab] OR Spain[tiab] OR Sweden[tiab] OR Switzerland[tiab] OR Turkey[tiab] OR Ukraine[tiab] OR "United Kingdom"[tiab] OR "Vatican City"[tiab]))	157

Scopus	TITLE-ABS-KEY (((covid-19 OR sars-cov-2 OR coronavirus) AND ("cancer screening" OR "screening program*" OR "screening service*" OR "early detection") AND (cancer OR neoplasm* OR tumour* OR tumor* OR malignan*) AND (albania OR andorra OR armenia OR austria OR azerbaijan OR belarus OR belgium OR "Bosnia and Herzegovina" OR bulgaria OR croatia OR cyprus OR "Czech Republic" OR denmark OR estonia OR finland OR france OR georgia OR germany OR greece OR hungary OR iceland OR ireland OR italy OR kazakhstan OR kosovo OR latvia OR liechtenstein OR lithuania OR luxembourg OR malta OR moldova OR monaco OR montenegro OR netherlands OR "North Macedonia" OR norway OR poland OR portugal OR romania OR "San Marino" OR serbia OR slovakia OR slovenia OR spain OR sweden OR switzerland OR turkey OR ukraine OR "United Kingdom" OR "Vatican City")))	335
Web of Science	((covid-19 OR coronavirus OR sars-cov-2) AND ("cancer screening" OR "screening service*" OR "screening program*" OR "early detection") AND (cancer OR neoplasm* OR tumour* OR tumor* OR malignan*) AND (Europe OR European))	114
Ovid (Embase) (MedLine) (Global Health)	1. exp Neoplasms/ 2. cancer*.mp. 3. neoplasm*.mp. 4. tumo?r*.mp. 5. oncology.mp. 6. COVID-19.mp. or COVID-19/ 7. sars cov 2.mp. or SARS-CoV-2/ 8. coronavirus.mp. or Coronavirus/ 9. pandemic*.mp. or Pandemics/ or SARS-CoV-2/ 10. "Early Detection of Cancer"/ 11. screening service*.mp. 12. screening*.mp. 13. screening program*.mp. 14. early detection of cancer.mp. 15. Europe.mp. or Europe/ 16. European Union/ 17. (((Albania or Andorra or Armenia or Austria or Azerbaijan or Belarus or Belgium or Bosnia) and Herzegovina) or Bulgaria or Croatia or Cyprus or Czech Republic or Denmark or Estonia or Finland or France or Georgia or Germany or Greece or Hungary or Iceland or Ireland or Italy or Kazakhstan or Kosovo or Latvia or Liechtenstein or Lithuania or Luxembourg or Malta or Moldova or Monaco or Montenegro or Netherlands or North Macedonia or Norway or Poland or Portugal or Romania or San Marino or Serbia or Slovakia or Slovenia or Spain or Sweden or Switzerland or Turkey or Ukraine or United Kingdom or Vatican City).mp. \[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, population supplementary concept word, anatomy supplementary concept word] 18. 1 or 2 or 3 or 4 or 5 19. 6 or 7 or 8 or 9 20. 10 or 11 or 12 or 13 or 14 21. 15 or 16 or 17 22. 18 and 19 and 20 and 21 23. limit 22 to yr="2020 -Current"	239 342 100

Appendix 3: Quality Assessment Standards

1. NOS:

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort
   a) truly representative of the average _____ (describe) in the community ✸
   b) somewhat representative of the average _____ in the community ✸
   c) selected group of users eg nurses, volunteers
   d) no description of the derivation of the cohort

2) Selection of the non exposed cohort
   a) drawn from the same community as the exposed cohort ✸
   b) drawn from a different source
   c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure
   a) secure record (eg surgical records) ✸
   b) structured interview ✸
   c) written self report
   d) no description

4) Demonstration that outcome of interest was not present at start of study
   a) yes ✸
   b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) study controls for _____ (select the most important factor) ✸
   b) study controls for any additional factor ✸ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome
   a) independent blind assessment ✸
   b) record linkage ✸
   c) self report
   d) no description

2) Was follow-up long enough for outcomes to occur
   a) yes (select an adequate follow up period for outcome of interest) ✸
   b) no

3) Adequacy of follow up of cohorts
   a) complete follow up - all subjects accounted for ✸
   b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) ✸
   c) follow up rate < ____% (select an adequate %) and no description of those lost
   d) no statement

Newcastle-Ottawa Scale adapted for cross-sectional studies

Selection:

1. Representativeness of the sample:
    a. Truly representative of the average in the target population. * (all subjects or random sampling)
    b. Somewhat representative of the average in the target group. * (non-random sampling)
    c. Selected group of users/convenience sample.
    d. No description of the derivation of the included subjects.

2. Sample size:
    a. Justified and satisfactory (including sample size calculation). *
    b. Not justified.
    c. No information provided

3. Non-respondents:
    a. Proportion of target sample recruited attains pre-specified target or basic summary of non-respondent characteristics in sampling frame recorded. *
    b. Unsatisfactory recruitment rate, no summary data on non-respondents.
    c. No information provided

4. Ascertainment of the exposure (risk factor):
    a. Vaccine records/vaccine registry/clinic registers/hospital records only. **
    b. Parental or personal recall and vaccine/hospital records. *
    c. Parental/personal recall only.

Comparability: (Maximum 2 stars)

1. Comparability of subjects in different outcome groups on the basis of design or analysis. Confounding factors controlled.
    a. Data/ results adjusted for relevant predictors/risk factors/confounders e.g. age, sex, time since vaccination, etc. **
    b. Data/results not adjusted for all relevant confounders/risk factors/information not provided.

Outcome:

1. Assessment of outcome:
    a. Independent blind assessment using objective validated laboratory methods. **
    b. Unblinded assessment using objective validated laboratory methods. **
    c. Used non-standard or non-validated laboratory methods with gold standard. *
    d. No description/non-standard laboratory methods used.

2. Statistical test:
    a. Statistical test used to analyse the data clearly described, appropriate and measures of association presented including confidence intervals and probability level (p value). *
    b. Statistical test not appropriate, not described or incomplete.

Cross-sectional study

Author	Year	Selection Bias Assessment (Maximum 5 stars)								Comparability (Maximum 2 stars)		Outcome (Maximum 3 stars)				Total score (Maximum 10 stars)
		Representativeness of the sample		Sample size		Non-respondents		Ascertainment of the exposure (risk factor)		Confounding factors are controlled		Assessment of the outcome		Statistical Test		
		selection	score	selection	score	selection	score	selection	score	selection	score	selection	score	selection	score	
Neamțiu L. et al	2022	Yes/1		Yes/1		No/0		Yes/1		Yes/2		Yes/1		Yes/1		7
Rossi P.G. et al.	2023	Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		7
Gremke K. et al.	2022	Yes/1		Yes/1		Yes/1		Yes/1		Yes/2		Yes/1		Yes/1		8
Hajek A. et al.	2021	Yes/1		Yes/1		Yes/2		Yes/1		Yes/2		Yes/1		Yes/1		9
Laurent L et al.	2022	Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		Yes/2		Yes/1		8
Rossi P.G. et al.	2022	Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		Yes/1		7

Cohort study

Author	Year	Selection Bias Assessment (Maximum 5 stars)	Comparability (Maximum 2	Outcome (Maximum 3 stars)	Total score (Maximum

						Stars)				10 stars)
		Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that the outcome of interest was not present at the start of the study	Comparability of cohorts based on the design or analysis	Assessment of the outcome	Was the follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
		selection / score	selection / score	selection / score	selection / score	selectio / score	selectio / score	selection / score	selection / score	
Laura M. et al.	2024	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	8
Barclay NL et al.	2024	Yes/1	Yes/1	Yes/1	No/0	Yes/2	Yes/1	Yes/1	Yes/1	8
Battisti F et al.	2022	Yes/1	Yes/1	Yes/1	Yes/1	Yes/2	Yes/1	Yes/1	Yes/1	9
Bosch M, et al.	2022	Yes/1	Yes/1	Yes/1	No/0	Yes/2	Yes/1	Yes/1	NO/0	7
Bright D et al.	2023	Yes/1	Yes/1	Yes/1	Yes/1	Yes/2	Yes/1	Yes/1	Yes/1	9
D'OvidioV. et al.	2021	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/0	7
Elek P. et al.	2022	Yes/1	Yes/1	Yes/1	Yes/1	Yes/2	Yes/1	Yes/1	Yes/1	9
Hinterberger A et	2021	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	8
Olthof, E.M.G et	2023	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	8
Trojanowski M et al	2024	Yes/1	Yes/1	Yes/1	No/0	Yes/1	Yes/1	Yes/1	Yes/1	7
Vives N et al.	2022	Yes/1	Yes/1	Yes/1	Yes/1	Yes/2	Yes/1	Yes/1	Yes/1	9
Wolfkamp W et al.	2024	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	Yes/1	8

2. JBI

JBI Checklist (descriptive and observational）										
	Author (Year)	1. Clear inclusion criteria?	2. Detailed setting and subjects?	3. Valid and reliable exposure measurement?	4. Objective measurement of condition?	5. Confounding factors identified?	6. Confounding strategies stated?	7. Valid and reliable outcome measurement?	8. Appropriate statistical analysis?	Overall Risk of Bias
		Yes/No/Unclear/Not applicable	Yes/No/Unclear/ Not applicable	Yes/No/Unclear/Not applicable	Yes/No/Unclear/Not applicable	Yes/No/Unclear/ Not applicable	Yes/No/Unclear/ Not applicable	Yes/No/Unclear/Not applicable	Yes/No/Unclear/Not applicable	Low/Moderate/High
1	Küçükakça G, et al. 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
2	Bărbulescu L-N et al. 2023	Yes	Unclear	Yes	No	Yes	Unclear	Yes	Yes	Moderate
3	Dabkeviciene D. et al 2021	No	Yes	Yes	Yes	No	No	Yes	Unclear	Moderate
4	Anouk H. et al. 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
5	Girardi D. et al. 2024	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Low
6	Ivanuš U et al. 2021	Unclear	Yes	No	Yes	Yes	No	Yes	Yes	Moderate
7	Jidkova S et al. 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
8	Katsara MA et al. 2025	Yes	No	Yes	Unclear	Unclear	Yes	No	Yes	Moderate
9	Kirac, I. et al. 2020	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Low
10	Akoi K. et al. 2023	No	Unclear	Yes	Yes	No	Unclear	Yes	Yes	Moderate
11	Kortlever TL. et al. 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
12	Mangone L. et al. 2022	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Moderate
13	Mendes D. et al. 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
14	Muschol J., et al. 2023	Unclear	Yes	Yes	No	Yes	No	Yes	Yes	Moderate
15	O'Driscoll J et al. 2024	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
16	Olesen TB et al. 2022	Yes	No	Yes	Yes	Unclear	Yes	Yes	Yes	Moderate
17	Ticozzi E.M. 2025	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
18	Zheng S et al. 2024	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low

19	Pedersen B. T. et al. 2024	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Moderate
20	Nonboe M. T. 2023	No	Yes	Unclear	No	No	Yes	No	Unclear	High
21	Toes-Zoutendijk E. et al. 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
22	Stuebs FA et al. 2024	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low

Risk of bias:
Low risk: ≥ 75% of the items are Yes
Moderate risk: 50% - 74% is Yes, or part of Unclear/No
HIgh risk: < 50% is Yes, or there are key areas No

3. EPOC

EPOC Risk of Bias Tool (Time-series)									
	Study (Author, Year)	1. Intervention independent of other changes	2. Shape of the intervention effect pre-specified	3. Intervention unlikely to affect data collection	4. Knowledge of the allocated interventions adequately prevented during the study	5. Incomplete outcome data adequately	6. Selective outcome reporting	7. Other risks of bias	Overall Risk of Bias
1	Robles C. et al. 2024	Low	Low	Low	Not applicable	Low	Low	Low	Low risk of bias
2	Nonboe M.H. et al. 2023	Low	Low	High	Not applicable	Unclear	Low	Low	Moderate risk of bias

Risk of bias:
Low risk: All key areas are Low risk, or only one is Unclear
Moderate risk: Have 1-2 High risks, or more Unclear
HIgh risk: Three or more items are considered High risk

4.CHEERS 2022 Modelling study 1: Poelhekken K. et al. 2023 (Low risk)

	Item	Guidance for Reporting	Reported in section
TITLE			
Title	1	Identify the study as an economic evaluation and specify the interventions being compared.	Yes
ABSTRACT			
Abstract	2	Provide a structured summary that highlights context, key methods, results and alternative analyses.	Yes
INTRODUCTION			
Background and objectives	3	Give the context for the study, the study question and its practical relevance for decision making in policy or practice.	Yes
METHODS			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Yes
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Yes
Setting and location	6	Provide relevant contextual information that may influence findings.	Yes
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Yes
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Partial
Time horizon	9	State the time horizon for the study and why appropriate.	Yes
Discount rate	10	Report the discount rate(s) and reason chosen.	Yes
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Yes
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Yes
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Yes
Measurement and valuation of resources and costs	14	Describe how costs were valued.	NO
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	NO
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Yes
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Partial
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the study vary for sub-groups.	Yes
Characterizing distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	NO
Characterizing uncertainty	20	Describe methods to characterize any sources of uncertainty in the analysis.	Yes
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (e.g., clinicians or payers) in the design of the study.	Yes
RESULTS			
Study parameters	22	Report all analytic inputs (e.g., values, ranges, references) including uncertainty or distributional assumptions.	Yes
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Yes
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Yes
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Yes
DISCUSSION			
Study findings, limitations, generalizability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could impact patients, policy, or practice.	Yes
OTHER RELEVANT INFORMATION			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Yes
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Yes

Modelling study 2: Ricciardiello L et al. 2021 (Moderate risk)

	Item	Guidance for Reporting	Reported in section
TITLE			
Title	1	Identify the study as an economic evaluation and specify the interventions being compared.	Yes
ABSTRACT			
Abstract	2	Provide a structured summary that highlights context, key methods, results and alternative analyses.	Partial
INTRODUCTION			
Background and objectives	3	Give the context for the study, the study question and its practical relevance for decision making in policy or practice.	Yes
METHODS			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Yes
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Yes
Setting and location	6	Provide relevant contextual information that may influence findings.	Partial
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Partial
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Partial
Time horizon	9	State the time horizon for the study and why appropriate.	Yes
Discount rate	10	Report the discount rate(s) and reason chosen.	NO
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Yes
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Yes
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Yes
Measurement and valuation of resources and costs	14	Describe how costs were valued.	NO
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	NO
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	NO
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Partial
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the study vary for sub-groups.	NO
Characterizing distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	NO
Characterizing uncertainty	20	Describe methods to characterize any sources of uncertainty in the analysis.	Yes
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (e.g., clinicians or payers) in the design of the study.	Yes
RESULTS			
Study parameters	22	Report all analytic inputs (e.g., values, ranges, references) including uncertainty or distributional assumptions.	Yes
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Yes
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Partial
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Yes
DISCUSSION			
Study findings, limitations, generalizability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could impact patients, policy, or practice.	Yes
OTHER RELEVANT INFORMATION			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Yes
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Yes

Appendix 4: Study-level quality appraisal summary and overall risk-of-bias classification.

Study group	Study (Author, Year)	Appraisal tool	Overall risk-of-bias
Cross-sectional studies	Neamțiu L. et al. (2022)	NOS (cross-sectional)	High quality
	Rossi P.G. et al. (2023)	NOS (cross-sectional)	High quality
	Gremke K. et al. (2022)	NOS (cross-sectional)	High quality
	Hajek A. et al. (2021)	NOS (cross-sectional)	High quality
	Laurent L. et al. (2022)	NOS (cross-sectional)	High quality
	Rossi P.G. et al. (2022)	NOS (cross-sectional)	High quality
Cohort studies	Laura M. et al. (2024)	NOS (cohort)	High quality
	Barclay N.L. et al. (2024)	NOS (cohort)	High quality
	Battisti F. et al. (2022)	NOS (cohort)	High quality
	Bosch M. et al. (2022)	NOS (cohort)	High quality
	Bright D. et al. (2023)	NOS (cohort)	High quality
	D'Ovidio V. et al. (2021)	NOS (cohort)	High quality
	Elek P. et al. (2022)	NOS (cohort)	High quality
	Hinterberger A. et al. (2021)	NOS (cohort)	High quality
	Olthof E.M.G. et al. (2023)	NOS (cohort)	High quality
	Trojanowski M. et al. (2024)	NOS (cohort)	High quality
	Vives N. et al. (2022)	NOS (cohort)	High quality
	Wolfkamp W. et al. (2024)	NOS (cohort)	High quality
	Hajek A. et al. (2021) *(duplicate entry as provided)*	NOS (cohort)	High quality
Observational/descriptive studies	Küçükakça G. et al. (2023)	JBI checklist	Low
	Bărbulescu L.N. et al. (2023)	JBI checklist	Moderate
	Dabkeviciene D. et al. (2021)	JBI checklist	Moderate
	Anouk H. et al. (2023)	JBI checklist	Low
	Girardi D. et al. (2024)	JBI checklist	Low
	Ivanuš U. et al. (2021)	JBI checklist	Moderate
	Jidkova S. et al. (2022)	JBI checklist	Low
	Katsara M.A. et al. (2025)	JBI checklist	Moderate
	Kirac I. et al. (2020)	JBI checklist	Low
	Akoi K. et al. (2023)	JBI checklist	Moderate
	Kortlever T.L. et al. (2021)	JBI checklist	Low
	Mangone L. et al. (2022)	JBI checklist	Moderate
	Mendes D. et al. (2023)	JBI checklist	Low
	Muschol J. et al. (2023)	JBI checklist	Moderate
	O'Driscoll J. et al. (2024)	JBI checklist	Low
	Olesen T.B. et al. (2022)	JBI checklist	Moderate
	Ticozzi E.M. (2025)	JBI checklist	Low
	Zheng S. et al. (2024)	JBI checklist	Low
	Pedersen B.T. et al. (2024)	JBI checklist	Moderate
	Nonboe M.T. (2023)	JBI checklist	High
	Toes-Zoutendijk E. et al. (2022)	JBI checklist	Low
	Stuebs F.A. et al. (2024)	JBI checklist	Low
Time-series studies	Robles C. et al. (2024)	EPOC RoB tool	Low
	Nonboe M.H. et al. (2023)	EPOC RoB tool	Moderate
Modelling studies	Poelhekken K. et al. (2023)	CHEERS 2022	Low
	Ricciardiello L. et al. (2021)	CHEERS 2022	Moderate

Appendix 5: Summary of inequality-related findings reported across included studies

Ref ID	Country	Cancer type(s)	Inequality dimension reported	Direction of effect	Notes

46	UK (Wales)	Colorectal	Socio-demographic inequalities (incl. older and urban populations)	Greater decline / widened inequalities	Uptake dropped by 30–40%, especially in older and urban populations; inequalities increased.
52	Italy	Breast/Colorectal/Cervical	Education; economic disadvantage	Greater decline among disadvantaged	Larger declines among low education and economically disadvantaged groups.
53	Italy	Breast/Colorectal/Cervical	Migrant/non-national status; rural residence	Disparities intensified	Disparities increased for non-nationals and rural residents (health equity audit).
66	Germany	Multiple	Age; sex	Greater decline among elderly and women	Declines most pronounced in elderly patients and women.
77	Italy	Breast/Colorectal/Cervical	Education; immigrant status	Worsening inequalities	Pre-existing inequalities worsened (low education, immigrants) as summarised in manuscript.
79	Italy	Breast	Urban/rural participation gaps	Persistent gap	Urban/rural participation gaps persisted
84	Belgium	Colorectal	Socioeconomic status (SES)	Lower uptake / slower recovery in low-SES areas	Uptake declined in low-SES areas during the pandemic; recovery patterns differed by SES.
55	Germany	Multiple	Sex; age; anxiety-related postponement	Higher postponement in some groups	Postponement higher among women and ages 30–49; linked to COVID-19 anxiety (demand-side barrier).
81	Poland	Breast/Cervical/Colorectal	Baseline low participation (programme context)	Impact exacerbated where participation low	Incidence gaps and exacerbation noted alongside pre-existing low participation (contextual vulnerability).

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: