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Impact of the Covid pandemic on timely cancer diagnosis across European healthcare settings: a scoping review

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Keywords: COVID-19; Cancer; Delayed Diagnosis; Europe; Healthcare disparities
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Abstract

Introduction. *The COVID-19 pandemic presented unprecedented challenges to European healthcare systems. The study aimed to review the available evidence on the impact of the pandemic on the timely diagnosis of cancer across European countries. The primary objective was to examine changes in diagnostic pathways and stage at diagnosis during the pandemic, compared to the pre-pandemic period, across European countries, taking healthcare system characteristics and COVID-19 policies into account.*
Methods. *We conducted a review of the impact of the pandemic on cancer diagnosis in Europe, analyzing primary studies from 2018 to 2023 using both quantitative and qualitative methods through searches in PubMed and Scopus databases. Study quality was assessed using the Mixed Methods Appraisal Tool. The main explanatory factors analyzed were grouped into two categories: Covid-policies (government responses, using the Oxford COVID-19 Government Response Tracker and its stringency index as key metrics) and healthcare characteristics (healthcare system models, expenditure and resources, including hospital beds and the ratio of medical doctors).*
Study design. *Scoping review.*
Results. *Overall, 127 papers were screened, 80 retrieved for full-text evaluation and 50 articles were included in the review. The studies encompassed a total of 509,753 patients from 17 European countries. The pandemic period was characterised by worse process and outcome measures for all examined cancers, except for lung cancer, compared to the pre-pandemic period. Grouping countries based on government actions and policy responses (stringency index) did not show any differences in timely cancer diagnosis. Countries with lower healthcare expenditure (per capita expenditure <2,000 euros) or lower investments in prevention reported more cancer diagnostic delays during the pandemic. Countries with >20% of General Practitioners over the total number of physicians and with more hospital beds per population experienced fewer diagnostic delays during the pandemic.*
Conclusions. *Overall, the review suggests that diagnostic pathways and cancer stage at diagnosis during the COVID-19 pandemic varied across Europe, with countries' healthcare expenditure, investments in prevention, the proportion of General Practitioners and the number of hospital beds per population possibly playing a role. This analysis can inform healthcare policies aimed at addressing post-pandemic challenges and formulating resilience plans for future emergencies.*

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Introduction

Since late 2019, the COVID-19 outbreak has had a major impact on health systems worldwide. Over 7 million cases and 220,000 deaths were reported in EU countries, Iceland, Norway, Switzerland, and the United Kingdom on October 31, 2020 and a total of almost 2 millions. Strict containment and physical distancing posed significant societal challenges with diverse impacts on health systems in different countries (1).

Amidst the initial focus on acute COVID-19 cases, attention and resources for the management of non-communicable diseases (NCDs) declined. Patients with NCDs were de-prioritised, resulting in delayed or cancelled appointments (2). Moreover, concerns about the risk of infection discouraged people from seeking care, leading to longer waiting times and difficulties in accessing health services. Real-world evidence has shown that the outbreak of the COVID-19 pandemic in March 2020 was followed by a substantial reduction in the overall number of cancer-related referrals (3,4). The European Network of Cancer Registries (ENCR) reported a decline of approximately 20-30% in the number of newly diagnosed cancer cases during the pandemic. Additionally, in certain nations, screening programs had to be temporarily halted as well (5).

The variation in the severity of COVID-19 restriction measures suggests that the consequences of delayed cancer treatments may have affected patients in different European nations to varying degrees (6). Additionally, healthcare system factors characterizing each country, including hospital beds, healthcare personnel and availability of specific healthcare services, may have played a significant role c s, especially during the most critical phases of the emergency (7).

Through the synthesis of available literature, this review aimed to offer a comprehensive panorama of the cancer diagnostic landscape in Europe during the COVID-19 pandemic. The primary objective of this study was to assess variations in diagnostic timeliness across European countries considering the pre- and intra-pandemic periods. In particular, we focused on identifying the types of cancer affected by delays in diagnosis differences in the cancer-related process or outcome measures and the contributing factors underlying these delays, including political considerations and organizational, economic, and healthcare system-related aspects. This analysis aims not only to illuminate the past challenges but also to inform health planning to ensure preparedness for managing and mitigating long-term challenges and developing effective responses to address future pandemics and epidemics.

Methods

Search strategy and data sources

The literature search was conducted between 20 June 2023 and 27 June 2023, on the two major academic databases, PubMed and Scopus with keywords related to cancer diagnosis, the COVID-19 pandemic, Europe, and diagnostic pathways. The search strategy included a combination of Boolean operators, truncation, and MeSH terms and additionally screened reference lists of included articles for further relevant publications (Appendix-Table 2A).

We included primary studies based on quantitative and qualitative methods that focused on diagnostic delays related to cancer during the COVID-19 pandemic in Europe. Incorporating qualitative studies is valuable because it offers context-specific insights, explores patient experiences, identifies systemic issues, captures healthcare provider perspectives, informs policies, and provides a more comprehensive understanding, thereby enhancing the overall review. Studies conducted between 2018 and 2023 were included to analyze the pandemic period, taking also the pre-pandemic years into account. Specifically, the review included studies that compared the pre-pandemic and intra-pandemic periods or reported trends over time, encompassing both the pre-pandemic and intra-pandemic periods. Only original papers written in English and with full text available were included to ensure the accessibility and comprehension of the review process.

Initially, duplicate articles were removed using the reference management software Mendeley or manual checks. Subsequently, articles were assessed based on title and abstract and only eligible articles were evaluated in full by the researchers (FP, SO, FM, SB). Full-text articles that passed the initial screening were then assessed for eligibility by carefully reviewing the content and methodology. The reference lists of included articles were also reviewed to identify additional relevant studies.

Data extraction was performed using a pre-piloted spreadsheet elaborated in Microsoft Excel® for Windows (Microsoft Corporation, Redmond, Washington, USA). Four authors performed data extraction (FP, SO, FM, SB) revised and supervised by a fifth senior researcher (CR). Qualitative and quantitative information was extracted from the original studies. Qualitative information included the name of the first author, year and country in which the study was conducted, study design, methods used to assess diagnostic delays, outcome measures, impact evaluation, cancer site and screening programmes. Quantitative data extracted included sample size, number of hospitals and quality assessment.

Included studies were evaluated using the Mixed Methods Appraisal Tool (MMAT), a valid quality assessment tool for systematic reviews including qualitative, quantitative and mixed methods studies and evaluates each study based on various criteria specific to the different study designs. The highest possible score is 100% if all criteria are met. Four reviewers (FP, SB, SO, FM) assigned quality scores independently. Considering the limited number of studies, we decided not to exclude studies based on the quality scores, but rather to take an inclusive approach aimed at identifying research that could give a relevant contribution.

Main outcome variables

To assess the impact of the COVID-19 pandemic on cancer diagnostic pathways and the timely diagnosis of cancer, a number of process and outcome measures were identified. For each included article, we extracted the available information on the following measures:

- Emergency Presentation (EP): Defined as cancer diagnosed in the context of an emergency presentation.
- Stage: The stage of cancer at the time of diagnosis.
- Patient or Help-Seeking Interval: The time between a patient first noticing a symptom and the first medical visit for that symptom. This interval can relate to the actual experience or intended help-seeking behavior and aligns with the Aarhus statement (8).
- Time to Diagnosis: The time from the first symptomatic presentation to the diagnosis of cancer. This definition is in line with the Aarhus statement.
- Referrals/Diagnostic Process or pathways: A sequence of events and related actions leading to a diagnosis of cancer. This definition includes events from the onset of possible cancer symptoms or the first cancer-related investigation (including screening tests) up to the diagnosis of cancer. Definitions of the diagnostic process/pathways vary, and we used as reference the Model of Pathways to Treatment, (9,10), Routes to Diagnosis (11), and The National Institute for Health and Care Excellence (NICE) pathways guidance (12).

Main explanatory variables

Two overarching categories of explanatory variables were identified: COVID-19 policies and healthcare system characteristics. The first category included government actions and policy responses to the pandemic. The Oxford COVID-19 Government Response Tracker (OxCGRT) (13) was employed, as a robust and standardized database, covering a substantial three-year period (from January 1, 2020, to December 31, 2022). To evaluate the strictness of government policies, we applied the *stringency index*, which is a composite measure of nine response metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, cancellation of public transport, public information campaigns, restrictions on internal movement, restrictions on international travel, and stay-at-home requirements. Countries were categorized according to their stringency index into three groups: "Countries with Very Stringent Rules" for those with a stringency index exceeding 55, "Countries with Stringent Rules" for those with an index ranging from 50 to 55, and "Countries with Less Stringent Rules" for those with an index below 50.

For the second category, referring to healthcare system characteristics, we considered the following pre-pandemic healthcare characteristics: healthcare system models, healthcare expenditure (with a focus on spending allocated to prevention), and resources (including hospital bed capacities and the ratio of medical doctors per 100 inhabitants, distinguishing between general practitioners (GPs) and specialists). Additionally, each country was assigned to one out of three healthcare system models, Beveridge, Bismarck, or a mixed approach, based on online research (Box 1).

Box1. Healthcare system model by European country.

Beveridge model	Public funding based on general taxation, with universal coverage	Italy, Denmark, Spain, Portugal, Germany, UK, Ireland, Croatia, Turkey
Bismarck model	Financing based on compulsory contributions (generally from employers and employees): Health and social insurance system	Belgium, France, Netherlands, Serbia, Romania, Poland, Switzerland
Mixed model	Predominantly private financing based on voluntary insurance and/or direct payments: Private health insurance.	Greece

To assess variations in healthcare expenditure among European countries prior to the onset of the pandemic, we utilized healthcare expenditure data compiled according to the System of Health Accounts (SHA) methodology (14). This methodology has been universally adopted by all European Union (EU) Member States and is governed by EU Regulation No. 3/2015, which became effective in 2016. It serves as a comprehensive health accounting system that meticulously quantifies financial flows associated with the consumption of health goods and services. Key indicators include current per capita health expenditures and the ratio of health expenditures to the country's gross domestic product (GDP). Thus, countries were categorized into two groups based on their healthcare expenditure in the years 2018/2019, preceding the pandemic: those with healthcare expenditure per capita below 2000 euros and those exceeding 3000 euros.

Using the same data source, a sub-analysis was also conducted, focusing on the healthcare expenditure allocated to disease prevention. In this instance, countries were classified into those with healthcare expenditure on disease prevention less than 2% and those with expenditure exceeding 2%.

To evaluate the number of hospital beds per 100,000 inhabitants in public hospitals in each European country, we used Eurostat 2018 data (15). Additionally, drawing upon data from the OCSE Health Statistics 2022 (16) and Eurostat databases, we assessed the total number of doctors per 1,000 inhabitants in 2020. This dataset included not only doctors directly engaged in patient care but also those occupying various roles within the healthcare sector, such as managers, educators, researchers; trainees and residents were excluded from this dataset. For both the number of hospital beds and the number of GPs, we employed a classification system that involved two groups based on whether the proportion was above or below the European average. Subsequently, a more granular examination was performed to distinguish between the GPs and specialist physicians.

Results

Characteristics of included studies

A total of 127 papers were initially retrieved by the literature search. After duplicates removal, 124 articles were selected for comprehensive evaluation based on their title and abstract. Among them, 44 articles were excluded based on the title-abstract, while the remaining 80 were screened by reading the full-text. At the end of the selection process, 50 articles were included in the current review (Figure 1). The selected studies, conducted between 2018 and 2023, encompassed patients diagnosed with various types of cancer. Studies were conducted in various European countries: Italy (n=18), Spain (n=5) (17–21), Netherlands (n=4) (22–25), Romania (n=3) (26–28), Turkey (n=3) (29–31), France (n=2) (32,33), Germany (n=2) (34,35) Portugal (n=2) (36,37), Serbia (n=2) (38,39), UK (n=2) (40,41), Belgium (n=1) (42), Croatia (n=1) (43), Denmark (n=1) (44), Greece (n=1) (45), Ireland (n=1) (46), Poland (n=1) (47), Switzerland (n=1) (48). The overall number of cancer patients included 509,753 individuals, with sample sizes ranging from 119 to 170291 patients (median 7785 mean 10.19506). Patients were stratified into two groups: those in the pre-pandemic period (n=280109) and those in the pandemic period (n=229644). However, in 4 articles (26,29,32,33), there was no clear distinction between the pre-pandemic and pandemic periods (11559).

The number of hospitals examined per study varied widely, ranging from 81 in one study to single-hospital studies (n=27). Moreover, three studies relied on external data sources, including cancer registries, while most studies were based only on hospital records.

All the studies employed quantitative research methods, with one article additionally incorporating qualitative methods. The Modified Methodological Quality Assessment Tool (MMAT) scores varied across the studies: 20 studies scored 100%, 25 studies scored 75%, and 5 studies scored 50% (40,42,45,46,49) (Appendix-Table 1A). The limitations identified in the studies included insufficient attention or information regarding the selection and characteristics of study participants, as well as inadequate consideration of potential biases, confounding factors, and other methodological constraints that could influence the study outcomes.

Cancer pathways, time to diagnosis and cancer outcomes across studies

The studies provided insights into various aspects of cancer diagnosis, including cancer stage (n=41) (see Table 1), emergency presentation (n=9), help-seeking behavior (n=4) (27,36,43,49), time to diagnosis and delays (n=30), and referrals and diagnostic processes (n=19). The impact of SARS-CoV-2 on these aspects varied across the studies: in 3 studies (6%)(19,24,48), the pandemic period was characterized by earlier diagnosis, improved help-seeking behavior, early-

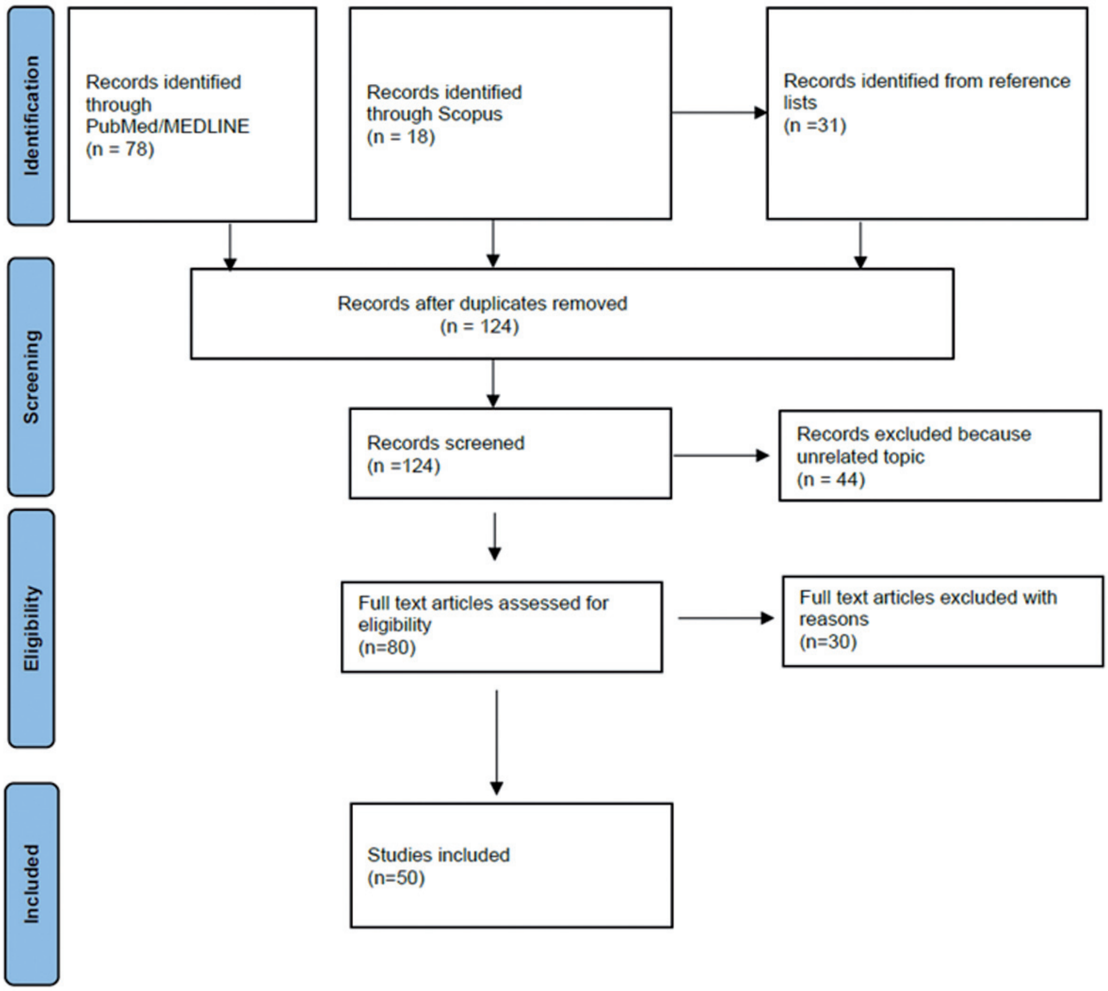

Figure 1 - Flow diagram of the selection process.

stage detection, or non-emergency presentations; in 28 studies (56%), the pandemic period resulted in delayed diagnosis, delayed help-seeking, advanced-stage detection, or emergency presentations; and in 19 studies (38%), no clear changes compared to the pre-pandemic period were reported.

Cancer-specific diagnostic delays

Almost one-third of the reviewed articles (n=15,30%) focused on colorectal cancer (CRC). Within this subset, the majority a variation in the timely diagnosis of cancer between the pandemic and pre-pandemic periods. Specifically, 10 articles (Appendix-Table 1A) highlighted the occurrence of diagnostic delays during the pandemic period, four (22,33,39,44) reported no variation, and one article (19) highlighted more timely diagnosis.

A total of 14 articles presented data on skin cancer, with a dual focus on cancer stage (n=11) and temporal parameters (n=8). In the context of breast cancer (n=11), a notable dichotomy emerged: 6 of these articles confirmed the presence of delayed diagnosis, while the remaining 5 (29,35,50–52) articles did not report any delay. These selected articles focused on the assessment of cancer staging (n=9), time to diagnosis (n=6), and referral patterns/ diagnostic processes (n=5) (20,31,35,41,52). Only one article (36) reported findings related to emergency diagnoses. Head and neck cancer was examined in 8 studies: the majority (n=5) (20,43,47,49,53) reported diagnostic delays, while two articles (34,54) indicated no significant variation between the pre- and intra-pandemic periods, and a single article (24) suggested an earlier diagnosis. Outcome measures included referral/diagnostic processes (n=6), time to diagnosis (n=5) (34,43,47,49,54), stage (n=4) (20,24,34,53), EP (n=1)(53), and help-seeking behaviours (n=1) (49). In contrast, 4 articles (32,55–57) pertaining to lung cancer asserted the absence of pandemic-induced disruptions in diagnostic timelines, analyzing cancer staging (n=8), time (n=6), and referral practices (n=3) (32,41,55). Remarkably, no study has reported on emergency diagnoses. Most articles (n=7) on urological cancers highlighted diagnostic delays during the pandemic (n=5) (20,23,36,37,57) whereas two articles reported a reduction in diagnostic time (25,58). Again, most papers examined stage (n=7), time to diagnosis (n=4) (36,37,57,58) and referrals (n=3) (20,25,58). Gastric cancer was the focus of 5 articles (20,36,37,59,60), which indicated delays in cancer diagnosis during the pandemic.

Cancer Screening Campaigns

Among the 50 selected articles, 23 specifically mentioned delays in screening campaigns during the pandemic period. Specifically, 8 articles mentioned screening campaigns in Italy, 4 in Spain (17,19–21), two in Portugal (36,37), two in Turkey (29,31), one in Denmark (44), one in the Netherlands (22), one in Romania (26), one Germany (35), one in the UK (41), one in Serbia (38), and one in Switzerland (48). The cancers involved were mainly colorectal cancer (CRC) (n=9), breast cancer (n=7), skin cancers (n=2) (38,48), and lung cancer (n=1) (56). In 4 articles (20,36,37,41), various cancers were discussed, including CRC (n=2) (36,41), breast cancer (n=3) (20,36,41), gastric cancer (n=3) (20,36,37), lung cancer (n=3) (36,37,41), and skin cancers (n=3) (20,36,37). Half of these articles highlighted how the failure to implement screening campaigns throughout 2020 has led to diagnostic delays.

Stratification by COVID-19 policies and healthcare system characteristics across European countries

Table 1 provides a summary of results stratified according to the main explanatory variables.

Each circle represents a quantitative study. Different colours correspond to specific process/outcome variable described in each study. Letters within each circle specify the cancer examined in the study, with V indicating that several ('various') cancers were included. Thus, each circle provides information on the specific explanatory variable and cancer type examined by the study. The three columns (left to right) indicate possible variations in cancer diagnosis (less timely/no association/more timely cancer diagnosis, respectively). The same study appears in multiple cells if it provides evidence on more than one process and/or outcome measure (21,25,30,48,61–66).

Cancer Diagnosis Delays Stratified by Stringency of COVID-19 Response

Among the included articles, 14 reported data on "Countries with Very Stringent Rules," (Belgium, Denmark, Germany, Greece, Portugal, Spain, UK) 18 on "Countries with Stringent Rules," (Italy) and 18 on "Countries with Less Stringent Rules" (Croatia, France, Ireland, Netherlands, Poland, Romania, Serbia, Switzerland, Turkey). Overall, the analysis did not reveal clear differences in diagnostic timeliness between the three groups defined by Covid-rules stringency. Among countries with Very Stringency Rules, 57% reported delayed diagnosis, 36% indicated no variation, and 7% reported earlier diagnosis. In the group with Stringent Rules, 61% reported delayed diagnosis, 39% noted no variation, and there were no studies reporting earlier diagnosis. Lastly, among countries with a Less Stringency Index, 50% reported delayed diagnosis, 39% indicated no variation, and 11% reported earlier diagnosis.

Comparative Analysis of Diagnostic Delays in the Beveridge and Bismarck Health Models

Results from countries following the Beveridge healthcare model (n=35) exhibit a discernible pattern, wherein a majority (60%) reported instances of delayed diagnosis during the pandemic period in contrast to the pre-pandemic era. Furthermore, 37% of the studies indicated no discernible variation, while 3% reported instances of earlier cancer diagnosis.

In the examination of countries adhering to the Bismarck model (n=14), articles indicated that 43% reported diagnostic delays, 43% observed no variation, and 14% documented instances of early diagnosis.

Furthermore, in papers specifically examining CRC (n=15), a disparity in outcome measures emerged between the two healthcare models. Emergency diagnosis was observed in 40% of the countries with a Beveridge healthcare model and only 7% of the articles focusing on Bismarck healthcare model. Details on process/measures outcomes are described in Table 1.

The mixed model was excluded from consideration due to the paucity of available literature, with only one article meeting the criteria.

Table 1. Variations in the diagnosis of cancer across European countries according to COVID-19 policies and healthcare system characteristics.

	Diagnostic Timeless		
Covid Policies	**Early diagnosis**	**No Effect**	**Delayed diagnosis**
stringency index < 50	S 48, H 24	B 29, C 33, L 30, C 2, C 39, U 25	S 27, H 43, S 38, C 2, B 31, S 46, U 23, C 2, H 47, S 28
50< stringency index <55		L 55, B 50, L 56, U 58, H 54, B 51, B 52	C 61, H 49, H 53, S 6, G 59, C 63, B 64, C 65, C 66, G 60, V 57
stringency index > 55	C 19	S 40, H 34, S 42, B 3, L 32, C 44	C 17, S 18, V 36, S 45, V 37, V 41, V 20
Healthcare characteristics			
Healthcare system model-Beveridge	C 19	S 40, H 34, L 55, B 3, B 29, L 30, B 50, L 5, U 58, H 54, C 44, B 5, B 52	S 27, C 17, C 61, H 4, H 53, S 18, S 62, G 5, V 41, H 43, B 31, S 2, C 63, B 64, V 37, V 3, C 65, V 20, C 66, G 6, C 21, V 57
Healthcare system model-Bismarck	S 48, H 24	S 42, C 33, C 22, L 3, C 39, U 25	S 38, C 26, U 23, H 47, S 28
Healthcare system model-Mixed			S 27, S 45
health expenditure per capita< 2k euros		S 42	H 43, C 26, S 45, H 47, S 28
health expenditure per capita >3k euros	H 24	S 40, H 34, B 35, C 3, C 28, L 32, C 44, U 2	S 27, V 41, S 46, U 2
healthcare expenditure on disease prevention < 2%		S 42, C 33, L 32	C 26, S 45, V 37, V 3, S 28
healthcare expenditure on disease prevention > 2%	C 19	S 40, H 34, L 55, B 3, B 50, L 56, U 58, H 5, C 44, B 51, B 52	C 17, C 61, H 49, H 5, S 18, S 62, G 59, V 4, H 43, S 46, C 63, B 6, C 65, V 20, C 66, G 6, C 21, H 47, V 57
n° of GP> 20%	H 24	S 42, C 33, C 22, L 32, U 25	S 27, S 46, V 37, V 3, U 23
lowest n° of GP		H 34, B 35	S 27, H 43, S 45, H 4
n°of beds> EU average		H 34, S 42, B 35, C 3, L 32	H 43, C 26, H 47, S 2
n°of beds< EU average	C 19, H 24	S 40, L 55, B 50, L 5, C 22, U 58, H 54, C 4, B 51, U 25, B 52	C 17, C 61, H 49, H 5, S 18, S 62, G 59, V 4, S 45, S 46, C 63, B 6, V 37, V 36, U 23, C 6, V 20, C 66, G 60, C 2, V 57

process or outcome	cancer type
help seeking	B, breast C, colorectal G, gastric H, head and neck L, lung S, skin U, urothelial V, various
ep	
stage	
time to diagnosis or delays	
Referrals/diagnostic process	

Analysis Based on Healthcare Expenditure of Various European Countries: Utilizing the System of Health Accounts Methodology (14,16,67,68)

Among nations with a per capita expenditure below 2,000 euros, our comprehensive analysis included data from Romania, Croatia, Poland, and Greece, revealing a consistent pattern of diagnostic delays during the pandemic period across all identified articles (n=6). In contrast, among countries with a per capita expenditure exceeding 3,000 euros, including Germany, the Netherlands, Denmark, Belgium, France, Ireland, and the United Kingdom, a total of 13 articles were reviewed. Notably, the majority (n=9) of these studies indicated no relevant variation in diagnostic timelines between the pre-pandemic and pandemic periods. However, three articles highlighted delayed diagnosis, while one article reported occurrences of early diagnosis.

The analysis of healthcare expenditure dedicated to disease prevention, detailed in Appendix-Table 3A, unveils a notable pattern among countries allocating less than 2% of their expenditure, including Romania, Portugal, Greece, France, and Belgium (n=9). Most of these studies (n=6) consistently reported diagnostic delays during the pandemic period. Particularly noteworthy is that a subset of these delays was concentrated in cancers covered by established screening programs, such as colorectal cancer (n=1) (26) and lung cancer (n=2) (36,37).

Analysis of pre-pandemic numbers of doctors in European Healthcare Systems

Among included articles, 30 displayed a doctor-to-population ratio equal to or above the European average (doctors per 1,000 inhabitants) before the pandemic, while 20 had ratios below the European average. Details are presented in Appendix- Figure 1A and Table 4A. This analysis did not observe variations in diagnostic delays according to the overall number of physicians. An analysis was also conducted comparing countries where the percentage of GPs relative to the total number of physicians was >20% (Portugal, Belgium, France, Ireland, and the Netherlands) with the four countries where the percentage was the lowest (Greece, Poland, Germany, and Croatia). In the first group (n=10), 50% reported no variation between pre and post-pandemic periods, 40% reported delays in diagnosis, and 10% reported earlier cancer diagnosis (one article on CRC cancer). Conversely, among countries with lower percentages of GPs (n=5) (34,35,43,45,47), 60% reported delays in diagnoses, while the remaining 40% reported no variation.

Therefore, overall findings suggested that in countries with a higher percentage of GPs, there were fewer diagnostic delays during the pandemic period.

Analysis of variations in pre-pandemic hospital bed numbers across European Healthcare Systems

Among included studies, 6 referred to countries with a higher number of hospital beds than the European average (Belgium, France, Romania, Germany, Croatia, and Poland) before the pandemic, resulting in a total of 10 articles included. The remaining 10 countries had fewer hospital beds on average compared to the rest of Europe (n=40). In the first group, half of the studies reported delayed cancer diagnoses, while the other half reported no significant variation, and none indicated earlier diagnoses. The most frequently studied cancers were head-neck cancer (n=3) (34,43,47), skin cancer (n=3)(27,28,42), and CRC (n=2) (26,33). Conversely, in the second group, most articles reported delayed cancer diagnoses (n=24), 14 reported no significant variation, and three (19,24,48) indicated earlier diagnoses. There was an increase in EP in 8 articles.

Hence, the analysis suggested that countries with a higher number of hospital beds had lower risks of delays in cancer diagnosis during the pandemic.

Discussion

Cancer diagnosis has been affected to different degrees across Europe during the COVID-19 pandemic. Findings of the 50 papers included in our study highlighted significant delays in the diagnosis of CRC and skin cancer, while lung cancer diagnosis did not differ compared to the pre-pandemic period. The review did not find evidence on a possible relationship between strictness of pandemic measures and cancer diagnostic delays. In contrast, in countries with greater healthcare investments, both in terms of overall healthcare spending and targeted prevention efforts, with higher proportion of GPs in the workforce and higher number of available hospital beds appeared to be partially protected from delays in cancer diagnosis during the pandemic.

Cancer Diagnosis Delays by Type of Cancer

The diagnosis of CRC is emblematic in understanding oncological delays caused by the pandemic. Our analysis has highlighted a significant increase in diagnostic delays and in the severity of diagnosed cases of CRC. The suspension of screening programs varied across different countries, but it has certainly had a significant impact (69–71). The burden of the delays accumulated during the pandemic could have a strong impact in the future with more frequent advanced disease and an expected 17% increase in colorectal cancer death. In fact, even a four-month diagnostic delay of CRC can lead to 20% reduction of 10 years survival (72). Our analysis also highlighted an increasing rate of emergency diagnoses, that are associated with three-fold greater odds of one-year mortality compared with non-emergency routes (73). Implementing FIT screening and investing in primary care are essential measures for preventing emergency diagnoses and mitigating the harm caused by delayed or missed diagnoses (74).

Well-established and extensively validated screening systems are offered for breast cancer across Europe. The review has shown an interesting dichotomy, with half of the studies indicating delayed diagnosis, and the other half not identifying substantial delays. Emergency diagnosis appeared to be a minor issue. This could be due to a prompt resumption of screening, that may have limited the delays (50). Most studies, while stating that there were no delays in the diagnostic pathway, acknowledge that the total number of diagnoses was lower than in the period prior to the pandemic. The future impact on stage at diagnosis will need to be monitored. We advocate for increasing and expanding organized screening campaigns within the target age groups and promoting public health initiatives to enhance awareness and early diagnosis.

Most articles concerning head and neck cancer suggest that the COVID-19 pandemic is linked to a decrease in the number of new diagnoses, and a significant delay in diagnosis can be attributed to lockdown measures and long waiting lists due to anesthesiologist and intensive care unit reassignments during the pandemic. Additionally, patients' fear of COVID infection may have deterred particularly older patients and those with pre-existing conditions (49).

Lung cancer diagnosis, staging, and treatment showed no significant differences during the pandemic compared to the pre-pandemic period. Emergency diagnoses were not increased, which might be related to the clinical presentation of lung cancer resembling COVID-19 symptoms (55). The overlap between symptoms of the virus and those of smoke-related tumors may have resulted in a more frequent and timely use of radiographic imaging, helping to mitigate the pandemic's impact on lung cancer diagnosis compared to other types of malignancies.

In conclusion, urological cancers, skin cancer and gastric cancers exhibited a common discernible trend of increasing diagnostic delays during the pandemic, which was not observed for lung cancer.

Cancer Diagnosis Delays stratified by Stringency of COVID-19 Response and healthcare models

Central to our review is the heterogeneous response of healthcare systems in different European countries. We employed the Oxford COVID-19 Government Response Tracker (OxCGRT) to analyze the stringency of the policies implemented (1). Surprisingly, the tightness of restrictive measures implemented during the pandemic did not appear to have a significant impact on oncological delays This shows how applying the same emergency response strategies alone is not enough to have the same outcomes. The structural features of the healthcare systems of the various European countries had the potential to play a pivotal role. Therefore, we decided to focus on the determining factors characterizing the diverse healthcare systems, such as healthcare models, healthcare expenditure, the number of doctors, and hospital bed capacity, in order to conduct a more comprehensive analysis of the factors influencing oncological delays (75).

We conducted a comparative study between countries operating under the Beveridge model and those adhering to the Bismarck model. This analysis revealed that countries belonging to both models have experienced consistent diagnostic delays, albeit with subtle variations. Contextualizing these trends within the broader context of each country's healthcare model is essential to fully understand their implications and develop targeted interventions (76). A very important aspect emerges from the analysis of the emergency diagnosis' rate of colorectal cancer, that was more frequent in the Beveridge healthcare model. The notable prevalence of advanced stage diagnoses suggests possible changes in patient behaviour and health service modalities (77). An alternative explanation may be that emergency presentations frequently constitute key indicators assessed in countries following the Beveridge model, such as the UK, together with tendency of the population to prior investigations and healthcare factors (74) . This result needs further investigations.

Healthcare Expenditure, Pre-pandemic numbers of doctors and hospital beds

Our examination of healthcare expenditure showed that countries allocating less than 2% of their healthcare budgets to prevention reported more frequently delayed cancer diagnosis during the pandemic. Additionally, when examining countries with per capita expenditures below 2,000 euros in comparison to those with per capita expenditures exceeding 3,000 euros, indicated that lower expenditure is strongly associated with diagnostic delays. This could underscore the critical role of healthcare investment and prevention strategies in building health system resilience in times of crisis.

Furthermore, it has been claimed that countries investing less in health may be inclined to enact more stringent policies (78). The years 2020 and 2021 witnessed an unparalleled surge in healthcare spending. The COVID-19 pandemic has underscored the importance of investments in infectious disease surveillance and emerging pathogen detection systems as part of pandemic preparedness efforts. However, without proactive measures, chronic underfunding for pandemic preparedness may endure in the future (79).

The analysis of the correlation between the total number of physicians and oncological delays didn't reveal any correlation between the overall number of physicians and diagnostic delays.

On the other hand, the analysis of the percentage of GPs in relation to the total number of physicians indicated that countries with a higher percentage of GPs experienced fewer diagnostic delays. This shows that GPs could have had a crucial role in the diagnostic pathway during the pandemic (80). In fact, within healthcare systems primarily centered on primary care, most cancer patients receive their diagnosis following symptomatic presentation and subsequent referral by a GP (81). The role of GPs gained increased significance in light of the widespread fear of contagion associated with specialist examinations in hospitals, and they had to face shifts in patient help-seeking behavior when presenting symptoms and an increase adoption of remote consultations (82). This also highlighted crucial aspects of the GPs' role that need to be improved, such as a collaborative approach among GPs, a deeper collaboration with secondary care, wider employment of referral algorithms and triage guidelines (80–83). For all these reasons, we concluded that the role of GPs and primary care could have been pivotal during the pandemic, and in our view, it will need further enhancement in the future to ensure flexibility and resilience to European healthcare systems.

Examining hospital beds available in public hospitals, our analysis revealed that a higher number of hospital beds had a partial influence on mitigating diagnostic delays. Our interpretation is that it provided more flexibility to convert hospital areas to manage COVID-positive patients or to set up temporary intensive care units without disrupting oncological activities.

Strength and Limitation

Strengths of the review include the adoption of a comprehensive approach, offering a panoramic view of the COVID-19 pandemic's impact on oncological diagnostic delays across Europe. By incorporating diverse studies and sources, it provides a rich and nuanced understanding of the challenges faced by European healthcare systems. Another strength lies in its multinational perspective, examining experiences from various European countries to uncover patterns and disparities, facilitating cross-country comparisons and the identification of best practices.

Limitations include the heterogeneity in data sources, methodologies, and healthcare systems among the included studies, making it more complicated to draw universally applicable conclusions. Moreover, as a scoping review, our study delves into only a fraction of the abundant existing literature on the topic; this undeniably represents a limitation to our analysis, and a systematic review could offer additional rigor and potential validation to the outcomes under scrutiny. Additionally, as it focuses on English-language studies, this may exclude valuable research in other languages.

Conclusion

The COVID-19 pandemic disrupted cancer care, resulting in cancelled surgeries, reduced diagnoses, and suspended screenings, potentially leading to advanced cancer stages. As we found out, this led to significant delays in the diagnosis of CRC and skin cancer, while lung cancer diagnosis did not differ compared to the pre-pandemic period. Our research highlighted the pivotal role of healthcare expenditure, investments in prevention, the proportion of General Practitioners and the number of hospital beds per population, but it also did not find evidence on a possible relationship between strictness of pandemic measures and cancer diagnostic delays. This analysis can offer valuable insights to shape healthcare policies for addressing post-pandemic challenges and developing robust resilience plans for future emergencies.

Riassunto

Impatto della pandemia di Covid sulla tempestività della diagnosi di tumore nei contesti sanitari europei: una scoping review

Introduzione. La pandemia da COVID-19 ha posto sfide senza precedenti ai sistemi sanitari europei. Lo studio si proponeva di esaminare le evidenze disponibili sull'impatto della pandemia sulla diagnosi tempestiva del cancro nei Paesi europei. L'obiettivo primario era quello di esaminare i cambiamenti nei percorsi diagnostici e nello stadio al momento della diagnosi durante la pandemia, rispetto al periodo pre-pandemico, in tutti i Paesi europei, tenendo conto delle caratteristiche del sistema sanitario e delle politiche della COVID-19.

Metodi. Abbiamo condotto una revisione dell'impatto della pandemia sulla diagnosi del cancro in Europa, analizzando studi primari dal 2018 al 2023 utilizzando metodi quantitativi e qualitativi, attraverso ricerche nei database PubMed e Scopus. La qualità degli studi è stata valutata utilizzando il Mixed Methods Appraisal Tool. I principali fattori analizzati sono stati raggruppati in due categorie: Covid-policies (risposte governative, utilizzando l'Oxford COVID-19 Government Response Tracker e il suo indice di severità come metriche chiave) e caratteristiche dell'assistenza sanitaria (modelli di sistema sanitario, spesa e risorse, inclusi i posti letto ospedalieri e il rapporto di medici).

Disegno dello studio. Scoping Review.

Risultati. Complessivamente, sono stati vagliati 127 articoli, di 80 è stato valutato il testo completo e 50 sono stati inclusi nella revisione. Gli studi hanno riguardato un totale di 509.753 pazienti provenienti da 17 Paesi europei. Il periodo pandemico è stato caratterizzato da misure di processo e di esito peggiori per tutti i tumori esaminati, ad eccezione del tumore al polmone, rispetto al periodo pre-pandemico. Il raggruppamento dei Paesi in base alle azioni governative e alle risposte politiche (indice di severità) non ha evidenziato differenze nella tempestività della diagnosi del cancro. I Paesi con una spesa sanitaria inferiore (spesa pro capite <2.000 euro) o con minori investimenti nella prevenzione hanno registrato maggiori ritardi nella diagnosi del cancro durante la pandemia. I Paesi con un numero di medici di medicina generale superiore al 20% rispetto al numero totale di medici e con un numero maggiore di letti ospedalieri per popolazione hanno registrato meno ritardi diagnostici durante la pandemia.

Conclusioni. Nel complesso, la revisione suggerisce che i percorsi diagnostici e lo stadio del cancro alla diagnosi, durante la pandemia COVID-19, sono variati in Europa, con un possibile ruolo svolto dalla spesa sanitaria dei Paesi, dagli investimenti nella prevenzione, dalla percentuale di medici di medicina generale e dal numero di letti ospedalieri per popolazione. Questa analisi può informare le politiche sanitarie volte ad affrontare le sfide post-pandemia e a formulare piani di resilienza per le emergenze future.

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Appendix

Table 1A. Description of included studies.

Authors (Country)	Cancer site	N. of participants	N. of hospital	Cancer-related process or outcome measures considered					Findings on cancer diagnosis during the Covid-pandemic vs pre-pandemic			Information on screening	MMAT score (%)
				Emergency cancer diagnosis	Stage	Help-seeking	Time to diagnosis or delays	Referrals/ diagnostic process	Earlier diagnosis, help-seeking, early stage or non-EP	Delayed diagnosis	No variation		
Aabed, 2022 (Romania)	Skin cancer	301 cancer patients (163 prepandemic, 138 pandemic)	1		V	V	V			V			100
Andrew, 2021 (UK)	Skin cancer	4755 cancer patients (3619 prepandemic, 1136 pandemic)	1				V				V		50
Balk, 2022 (Germany)	Head and neck cancer	612 cancer patients (319 prepandemic, 293 pandemic)	1		V		V				V		100
Cano-Valderrama, 2022, (Spain)	CRC	389 cancer patients (169 prepandemic, 220 pandemic)	1		V		V	V		V		V	75
Cantini, 2022 (Italy)	Lung cancer	3160 cancer patients (1623 prepandemic, 1523 pandemic)	25		V		V	V			V		100
D'Ovidio, 2021 (Italy)	CRC	375 cancer patients (238 prepandemic, 137 pandemic)	1		V		V			V		V	75
De Luca, 2022 (Italy)	Head and neck cancer	205 cancer patients (158 prepandemic, 47 pandemic)	1			V	V			V			50
Gazzini, 2022 (Italy)	Head and neck cancer	124 cancer patients (79 prepandemic, 45 pandemic)	1	V	V					V			100
Gedeah, 2021 (Belgium)	Skin cancer	367 cancer patients (206 prepandemic, 161 pandemic)	1		V						V		50
Gil-Pallares, 2023 (Spain)	Skin cancer	119 cancer patients (65 prepandemic, 54 pandemic)	1		V		V			V			75
Gisondi, 2021 (Italy)	Skin cancer	1190 cancer patients (634 prepandemic, 556 pandemic)	4					V		V			75

Giuliani, 2023 (Italy)	Gastric cancer	8250 cancer patients (4370 prepandemic, 3880 pandemic)	62	V	V		V			V			75
Greene, 2022 (UK)	Various cancer (CCR, breast, lung cancer)	12291 cancer patients (6651 prepandemic, 5640 pandemic)	Cancer Network		V		V	V		V		V	75
Gršić, 2021 (Croatia)	Head and neck cancer	691 cancer patients (320 prepandemic, 271 pandemic)	1			V	V	V		V			100
Hijos, 2023 (Spain)	CRC	1430 cancer patients (888 prepandemic, 542 pandemic)	7	V	V		V	V	V			V	100
Jacob, 2021 (Germany)	Breast cancer	102009 cancer patients (54867 prepandemic, 47142 pandemic)	1160 doctors					V			V	V	75
Jeremić, 2022 (Serbia)	Skin cancer	305 cancer patients (230 prepandemic, 75 pandemic)	1	V	V		V			V		V	75
Kara, 2022 (Turkey)	Breast cancer	332 cancer patients (prepandemic e pandemic)	2		V		V				V	V	75
Kempf,2022 (France)	CRC	4685 cancer patients (prepandemic e pandemic)	27		V			V			V		75
Kiss BI, 2022 (Romania)	CRC	302 cancer patients (prepandemic e pandemic)	1	V	V		V			V		V	75
Kizilimark, 2022 (Turkey)	Lung cancer	246 cancer patients (145 prepandemic, 101 pandemic)	1		V		V				V		100
Koca, 2021 (Turkey)	Breast cancer	148 cancer patients (70 prepandemic, 78 pandemic)	1		V			V		V		V	100
Koster, 2022 (Switzerland)	Skin cancer	1240 cancer patients (938 prepandemic, 302 pandemic)	5		V		V		V			V	100
Lallas, 2021 (Greece)	Skin cancer	4018 cancer patients (3420 prepandemic, 598 pandemic)	Skin Cancer Registry in the No		V					V			50
Mangone, 2022 (Italy)	Breast cancer	1159 cancer patients (570 prepandemic, 589 pandemic)	Reggio Emilia Cancer Registry		V						V	V	75

Mangone, 2023 (Italy)	Lung cancer	627 cancer patients (303 prepandemic, 324 pandemic)	Reggio Emilia Cancer Registry		V						V	V	100
McFeely, 2021 (Ireland)	Skin cancer	162 cancer patients (78 prepandemic, 84 pandemic)	1		V					V			50
Meijer, 2022 (Netherlands)	CRC	38021 cancer patients (26816 prepandemic, 11205 pandemic)	Netherlands Cancer Registry		V		V	V			V	V	100
Mentrasti, 2022 (Italy)	CRC	866 cancer patients (506 prepandemic, 360 pandemic)	8		V		V	V		V		V	100
Mentrasti, 2022 (Italy)	Breast cancer	1556 cancer patients (890 prepandemic, 666 pandemic)	6		V		V			V		V	100
Morais, 2021 (Portugal)	Various cancer (gastric, skin, lung, urothelial cancer)	2072 cancer patients (1309 prepandemic, 763 pandemic)	1		V		V			V		V	75
Morais, 2022 (Portugal)	Various cancer (gastric, CRC, lung, breast, urothelial, skin, lymphoid cancer)	2296 cancer patients (1430 prepandemic, 866 pandemic)	1	V	V	V	V			V		V	75
Oderda, 2022 (Italy)	Urothelial cancer	1859 cancer patients (930 prepandemic, 929 pandemic)	1		V		V	V			V		100
Oymans, 2023 (Netherlands)	Urothelial cancer	9665 cancer patients (4832 prepandemic, 4833 pandemic)	Netherlands Cancer Registry		V					V			75
Pirozzi, 2023 (Italy)	CRC	280 cancer patients (147 prepandemic, 133 pandemic)	1	V						V		V	75
Priou, 2022 (France)	Lung cancer	6240 cancer patients (prepandemic e pandemic)	1		V			V			V		75
Radulovic, 2021 (Serbia)	CRC	201 cancer patients (152 prepandemic, 49 pandemic)	1		V						V		75
Ralli, 2021 (Italy)	Head and neck cancer	193 cancer patients (101 prepandemic, 92 pandemic)	1				V	V			V		75

Ribes, 2022 (Spain)	Various cancer (Gastric, lymphoidurothelial, breast, head and neck, skin cancer)	1240 cancer patients (91700 prepandemic, 78591 pandemic)	Catalan Pathology Registry		V			V		V		V	100
Rottoli, 2022 (Italy)	CRC	17938 cancer patients (10142 prepandemic, 7796 pandemic)	81	V	V					V			100
Schoonbeek, 2022 (Netherlands)	Head and neck cancer	5082 cancer patients (3384 prepandemic, 1698 pandemic)	Netherlands Cancer Registry		V			V	V				75
Smith, 2021 (Denmark)	CRC	2794 cancer patients (1807 prepandemic, 987 pandemic)	Danish Cancer Registry	V	V						V	V	100
Solaini, 2023 (Italy)	Gastric cancer	632 cancer patients (427 prepandemic, 205 pandemic)	9		V		V			V			100
Suarez, 2021 (Spain)	CRC	169 cancer patients (111 prepandemic, 58 pandemic)	1	V	V		V			V		V	75
Szewczyk, 2021 (Poland)	Head and neck cancer	618 cancer patients (278 prepandemic, 340 pandemic)	1				V	V		V			75
Toss, 2021 (Italy)	Breast cancer	406 cancer patients (229 prepandemic, 177 pandemic)	1		V		V				V	V	100
Trama, 2022 (Italy)	Various cancer (CRC, breast, lung, urothelial cancer)	88048 cancer patients (49012 prepandemic, 39036 pandemic)	1		V		V			V			75
Ungureanu, 2022 (Romania)	Skin cancer	616 cancer patients (341 prepandemic, 275 pandemic)	2		V					V			75
Van Deukeren, 2022 (Netherlands)	Urothelial cancer	9986 cancer patients (5233 prepandemic, 4753 pandemic)	1		V			V			V		100
Vanni, 2020 (Italy)	Breast cancer	432 cancer patients (209 prepandemic, 223 pandemic)	4					V			V	V	75

Table 2A. Research strategy.

Search Block	**Search terms**
Delay	late OR postponed OR deferred OR Delayed Diagnosis
Diagnosis	identification OR discovery OR detection OR result OR Diagnostic process OR recognition OR attribution OR examination OR analysis OR Diagnostic Techniques and Procedures OR signs and symptoms OR before diagnosis OR pre-diagnos* pre-diagnos*
Cancer	cancer registry OR cancer* OR neoplas* OR tumo* OR carcinoma* OR adenocarcinoma* OR metasta* OR malignan* OR oncolog*
Screening Campaign	mass screening OR screening service OR Cancer Screening OR Cancer Screening Tests OR Cancer Screening Test OR Screening Test, Cancer OR Screening Tests, Cancer OR Test, Cancer Screening ORTests, Cancer Screening OR Early Diagnosis of Cancer OR Cancer Early Diagnosis OR Early Detection of Cancer
Pandemic	Covid 19 OR SARS-CoV-2
Period	phase OR time Or season OR interval
Emergency Presentation	emergency diagnosis OR critical situation OR emergency admission OR Emergency Service, Hospital OR Emergency Medical Services OR Emergency Treatment OR Emergencies
Stage	phase
Time to diagnosis	time to investigation OR Time-to-Treatment RO Early Diagnosis
Help seeking	Help seeking Behaviours

Table 3A. Current health expenditure (values per 100) by health function as a percentage of total current health expenditure for European Union - Year 2018.

Countries	Disease prevention service (%)
Belgium	1.7
Croatia	3.2
Denmark	2.4
France	1.8
Germany	3.2
Greece	1.3
Ireland	2.6
Poland	2.3
Portugal	1.7
UK	5.1
Romania	1.4
Spain	2.1
Italy	4.4

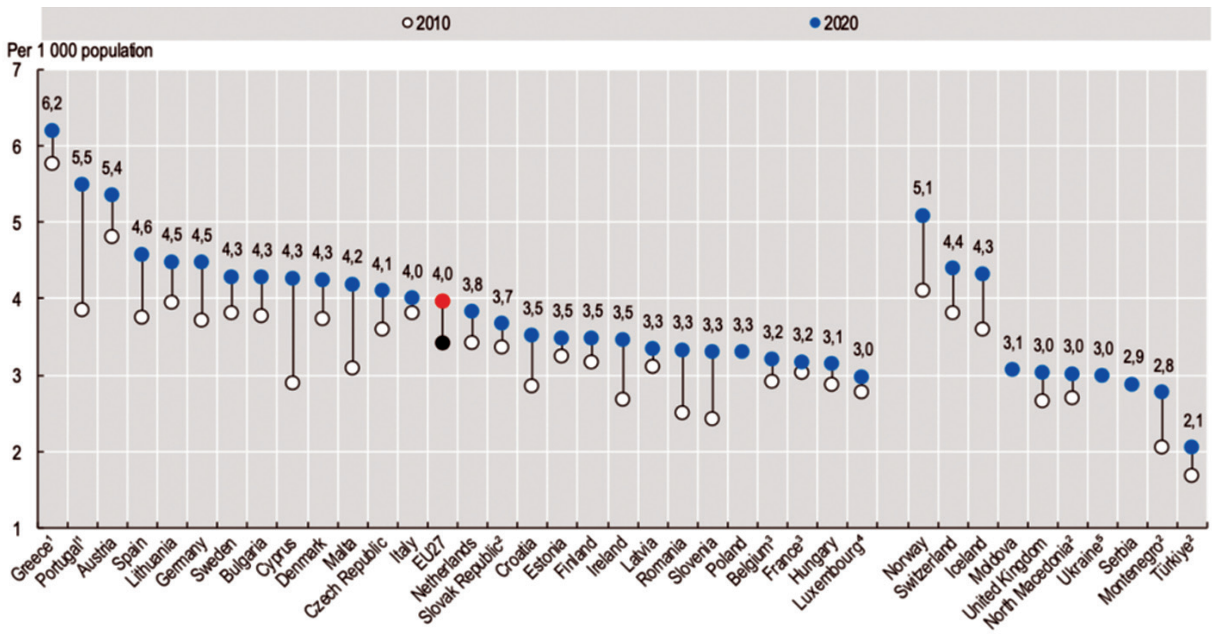

Figure 1A. Number of doctors per 1,000 inhabitants in 2010 and 2020. Source: OCSE Health Statistics 2022; Eurostat Database; WHO National Health Workforce Accounts for Moldova and Ukraine

Table 4A. Stratification by number of doctors per 1,000 inhabitants.

		>= European average	< European average
Countries		Italy, Spain, Denmark, Portugal, Germany, Greece, Switzerland	Belgium, France, Netherlands, Serbia, Romania, UK, Ireland, Croatia, Poland, and Turkey
Process Measures	Stage	23	18
	Time to diagnosis	19	11
	Referral/diagnostic process	10	9
	EP	8	1
	Help seeking	2	2
Impact of Covid-pandemic	Delayed diagnosis	62%	48%
	No effect	31%	48%
	Earlier diagnosis	7%	5%
	Cancer type	CRC (n=11), breast cancer (n=9) and skin cancer (n=9)	Skin cancer (n=6), CRC (n=5), head and neck cancer (n=4)

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