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ORIGINAL PAPER

Trends in breast and prostate cancer screening and diagnostic procedures during the COVID-19 pandemic in central Massachusetts

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Abstract

Purpose We calculated rates of breast and prostate cancer screening and diagnostic procedures performed during the COVID-19 pandemic through December 2021 compared to the same months in 2019 in a large healthcare provider group in central Massachusetts.

Methods We included active patients of the provider group between January 2019 and December 2021 aged 30–85 years. Monthly rates of screening mammography and digital breast tomosynthesis, breast MRI, total prostate specific antigen (PSA), and breast or prostate biopsy per 1,000 people were compared by year overall, by age, and race/ethnicity. Completed procedures were identified by relevant codes in electronic health record data.

Results Rates of screening mammography, tomosynthesis, and PSA testing reached the lowest levels in April–May 2020. Breast cancer screening rates decreased 43% in March and 99% in April and May 2020, compared to 2019. Breast cancer screening rates increased gradually beginning in June 2020 through 2021, although more slowly in Black and Hispanic women and in women aged 75–85. PSA testing rates decreased 34% in March, 78% in April, and 53% in May 2020, but rebounded to pre-pandemic levels by June 2020; trends were similar across groups defined by age and race/ethnicity.

Conclusion The observed decline in two common screening procedures during the COVID-19 pandemic reflects the impact of the pandemic on cancer early detection and signals potential downstream effects on the prognosis of delayed cancer diagnoses. The slower rate of return for breast cancer screening procedures in certain subgroups should be investigated to ensure all women return for routine screenings.

Keywords Screening · COVID-19 · Breast cancer · Prostate cancer · Mammography · Prostate specific antigen

Introduction

Coronavirus disease (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected over 550 million people and has caused over 6.3 million deaths worldwide as of 5 July 2022. The COVID-19 pandemic, which arose in late 2019, was widespread in the United States by March 2020, and led to stay-at-home orders, economic shutdowns, and a declaration of a national emergency by mid-March. In Massachusetts, a state of emergency was declared on 10 March 2020, and all non-essential businesses were ordered closed on 24 March through mid-May. The first peak in COVID-19 infections in Massachusetts was reached in late April 2020, with the rate of infection declining through late June. However, cases of COVID-19 surged again in Massachusetts in late October 2020,

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with an exponential increase thereafter toward a peak in early January 2021 [1]. Massachusetts experienced additional surges in COVID-19 in 2021, with peaks in late March and mid-September preceding the Omicron variant, which peaked in Massachusetts on 8 January 2022 with a 7-day average of new, confirmed cases of 22,933. Vaccines against COVID-19 were first available to prioritized groups in Massachusetts in December 2020, followed by most adults aged 55 and older between February and April 2021, and all individuals over age 12 by April 2021. Booster vaccines were made available to adults aged 18 and older in mid-November 2021.

In March and April 2020, hospitals and clinics closed to in-person medical appointments and elective procedures, which included cancer screening tests such as mammograms, prostate specific antigen (PSA) tests, lung cancer screening, colonoscopy and sigmoidoscopy. Routine cancer screening tests often detect asymptomatic cancers at an earlier stage than if the patient had waited for symptoms to develop, resulting in reduced mortality. If the reduction in screening rates due to COVID-19 endures for an extended period, an increased number of cancers could be diagnosed at a later stage and may result in an excess number of cancer deaths [2–4]. We analyzed data from a large multispecialty provider group to quantify trends in screening and diagnostic procedures for breast and prostate cancer during the first 22 months of the COVID-19 pandemic in central Massachusetts in comparison to the previous pre-pandemic year. We selected two common cancers with differences in the evidence base supporting regular screening recommendations [5, 6] as well as different testing modalities (X-ray mammography versus PSA blood test) to illustrate the trends in screening practices over nearly two years of the COVID-19 pandemic.

Materials and methods

Study population

Women and men aged 30–85 who were active patients of Reliant Medical Group, a multispecialty provider group in central Massachusetts, between January 2019 and December 2021 were eligible for inclusion in this study. Active patients were defined as those who had at least one interaction with the provider group in the previous 18 months; insurance coverage was not required. Individuals with a prior diagnosis of prostate or breast cancer were identified through International Classification of Diseases for Oncology, Third Edition (ICD-O-3) codes in tumor registry data and excluded from the analysis.

Data source

All data for this analysis were collected from the Virtual Data Warehouse at Reliant, an electronic health records (EHR)-based standardized database containing information on patient demographics, encounters, procedures, diagnoses, laboratory tests, and other clinical information populated through the Epic Clarity system [7]. Completed cancer screening and diagnostic tests were identified through Current Procedural Terminology (CPT) and Healthcare Common Procedure Coding System (HCPCS) codes in EHR data (Supplementary Table 1). We excluded tests that were ordered but not completed during the study period. Monthly counts of COVID-19 cases diagnosed in Massachusetts were extracted from publicly available raw data from the COVID-19 Daily Dashboard published by the Massachusetts Department of Public Health (available from: https://www.mass.gov/info-details/covid-19-response-reporting#covid-19-daily-dashboard- First accessed 2 January 2021).

Analysis

For analyses of breast cancer screening and diagnostic procedures, we identified monthly counts of screening and diagnostic mammography and digital tomosynthesis, total breast MRI, and diagnostic breast and lymph node biopsy in women. We were unable to distinguish between screening and diagnostic breast MRI procedures, and thus analyzed all MRIs together. For prostate cancer, we identified monthly counts of PSA tests, transurethral resection of the prostate (TURP) and prostate biopsy in men. Denominators were defined as the number of eligible, active patients receiving care at the provider group as of 1 January of the given year. We calculated rates of selected procedures per 1,000 eligible participants overall, by age group and race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, Other/Unknown). Age categories were defined by current US Preventive Services Task Force (USPSTF) and American Urological Association screening guidelines (Breast cancer: 30–39, 40–49, 50–74, 75–85; Prostate cancer: 30–54, 55–69, 70–85) [5, 6, 8]. Monthly rates of each procedure were calculated and compared between 2019, 2020, and 2021. Mammography and tomosynthesis procedures performed on the same day were counted once in the analysis.

We used an interrupted time series (ITS) study design with ordinary least squares segmented linear regression models to test changes in the trends (slopes and levels) of overall mammography/tomosynthesis and PSA testing at different stages of the pandemic. We defined three time

periods: (1) January 2019 to February 2020 (pre-pandemic); (2) March 2020 to June 2020 (initial shutdown); and (3) July 2020 to December 2021 (reopening). We used Durbin's alternative test to examine the presence of serial autocorrelation among the monthly observations.

Descriptive analyses were conducted using SQL and Microsoft Excel. Time series analyses were conducted using Stata software version 16 (Stata Corporation, College Station, TX). This project was approved by the Institutional Review Board at the University of Massachusetts Chan Medical School.

Results

There were 145,874 active patients in the provider group as of January 2019, with 149,092 patients in January 2020, and 149,793 patients in January 2021. The median age for women in the study population was 52 years, and 53 years for men. The study population was about 71% non-Hispanic White (Table 1).

Breast cancer

During 2019, there were an average of 1,567 screening and 186 diagnostic mammography and tomosynthesis procedures completed per month, with mean monthly rates of 19.4 screening and 2.3 diagnostic procedures per 1,000 women. In 2020 overall, there was an average of 1,226 screening tests completed per month, representing a 22% decrease in volume, and a mean monthly rate of 14.8 screening procedures per 1,000 women. In contrast, the volume of diagnostic procedures only declined by 10% in 2020, with a mean monthly rate of 2 per 1,000 women. Thousands of screening mammograms were canceled or rescheduled in the provider group between mid-March and May 2020 during the period of Massachusetts' stay-at-home order (personal communication, Reliant Medical Group) and thus screening rates dropped near zero during those 3 months. In 2021, an average of 1,755 screening procedures were completed per month, with a mean monthly rate of 21.1 tests per 1,000 women in 2021, representing a 43% increase in volume over the previous year, and a 12% increase compared to 2019. Diagnostic mammograms also increased in 2021 with an average of 201 per month, a 20% increase in volume over 2020, and an 8% increase over 2019.

Comparing monthly rates of screening tests between 2019 and 2020, there was a 43% decrease in tests performed in March, and a 99% decrease in April and May. Screening rates increased beginning in June 2020 following the first peak in COVID-19, and mean monthly screening rates for July through December 2020 were just 3% below the previous year. Rates continued to increase slowly during 2021 despite additional COVID-19 case surges, and overall average monthly screening rates in 2021 were about 6% higher than pre-pandemic rates in 2019 (Fig. 1). The decline in rates of diagnostic mammography and tomosynthesis during the initial peak of the pandemic was less than that observed for screening tests. Diagnostic testing decreased 72% in April and 55% in May 2020 compared to 2019, with rates between July and December 6% lower in 2020 than in 2019. Overall average diagnostic testing rates in 2021 were 5% higher than pre-pandemic rates in 2019 (Supplementary Fig. 1).

Across age groups, screening rates in April and May 2020 were between 91 and 100% lower than 2019 rates (Fig. 2) before rebounding somewhat in June. However, average rates of screening between July and December 2020 among women aged 30–39 remained 22% below 2019 rates. In women aged 50–74, the population targeted for biennial preventive screenings by the USPSTF, screening rates were nearly equivalent between July and December 2019 and 2020. In 2021, average screening rates increased the most in women aged 40–49 (21%) compared to 2019. However,

Table 1 Characteristics of the study population, active male and female patients of the medical provider group aged 30–85, by year

Characteristic	Year[a]		
	2019	2020	2021
Active eligible patients (N)	145,874	149,092	149,793
Women	80,562	82,696	83,134
Age, years, N (%)			
30–39	18,573 (23%)	19,129 (23%)	18,569 (22%)
40–49	17,015 (21%)	17,228 (21%)	16,720 (20%)
50–74	38,772 (48%)	39,933 (48%)	40,975 (49%)
75–85	6201 (8%)	6406 (8%)	6873 (8%)
Self-reported race/ethnicity			
Non-Hispanic white	58,116 (72%)	58,322 (71%)	57,335 (69%)
Non-Hispanic black	2371 (3%)	2463 (3%)	2437 (3%)
Hispanic	3192 (4%)	3284 (4%)	3283 (4%)
Asian	3466 (4%)	3453 (4%)	3328 (4%)
Other/unknown	13,417 (17%)	15,174 (18%)	16,751 (20%)
Men	65,312	66,396	66,659
Age, years			
30–54	35,055 (54%)	35,159 (53%)	34,191 (51%)
55–69	21,970 (34%)	22,482 (34%)	22,873 (34%)
70–85	8287 (13%)	8755 (13%)	9590 (14%)
Self-reported race/ethnicity			
Non-Hispanic white	46,170 (71%)	45,603 (69%)	44,709 (67%)
Non-Hispanic black	2121 (3%)	2113 (3%)	2075 (3%)
Hispanic	2268 (3%)	2352 (4%)	2404 (4%)
Asian	2568 (4%)	2599 (4%)	2456 (4%)
Other/unknown	12,185 (19%)	13,729 (21%)	15,015 (22%)

[a]Data collected as of 1 January of the given year

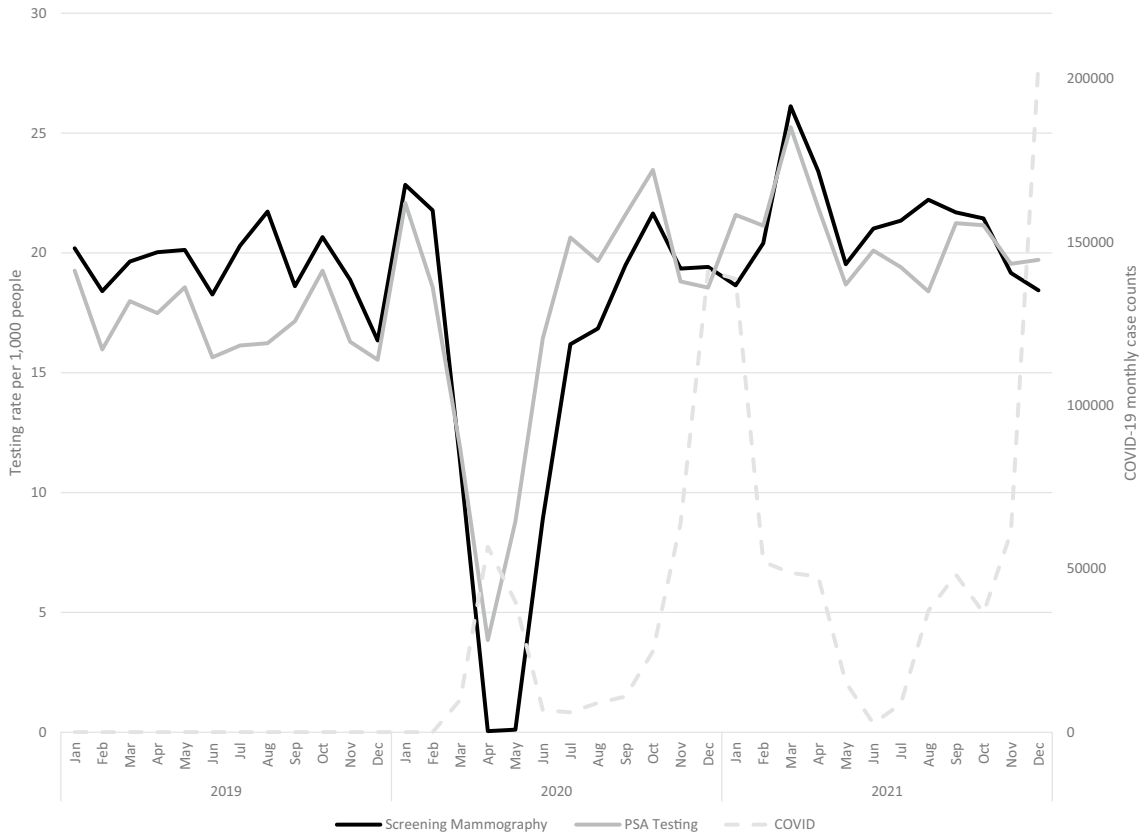

Fig. 1 Overall rates of screening mammography and tomosynthesis and Prostate Specific Antigen (PSA) testing per 1,000 people with COVID-19 monthly case counts in Massachusetts, January 2019–December 2021. Massachusetts COVID-19 case data acquired from the Massachusetts Department of Public Health COVID-19 Raw Data, accessed 17 September 2021 and 31 March 2022

in the oldest women (aged 75–85), average monthly testing rates in 2021 were 6% lower than in 2019, suggesting that this age group did not return to screening at the same frequency as younger women.

We also analyzed trends in testing across groups defined by race/ethnicity (Fig. 3). In 2019, non-Hispanic Black women averaged 24 screening procedures, Hispanic women averaged 21 procedures, non-Hispanic White women averaged 21 procedures, and Asian women averaged 17 procedures per 1,000 women per month. These rates dropped between 96 and 100% across all race/ethnic groups in April and May 2020 compared to the same months in 2019. During the reopening months of July–December, while average screening rates among White women were equivalent to 2019 rates, screening rates among Hispanic and Black women were 13 and 10% lower, respectively, and rates among Asian women were 19% lower than the same months in 2019. Screening rates gradually increased across all race/ethnic groups through 2021, although the increase was greater among White (10%) and Asian (20%) women, and less among Black (1%) and Hispanic (4%) women when compared to 2019 rates. Across groups defined by race/ethnicity, rates of diagnostic testing decreased between 60 and 76% in April and 0–71% in May 2020 compared to 2019, but numbers in some groups were small.

Rates of breast MRI also declined during the spring peak of COVID-19, with a 50% decrease in April and May 2020 compared to the same months in 2019 but rebounded by June 2020 (Supplementary Fig. 2). However, few breast MRIs were conducted in the population overall (mean 69 MRIs per month in 2019 and 74 per month in 2020), and we were unable to examine trends by race/ethnicity.

We also examined trends in diagnostic breast and lymph node biopsy procedures (Supplementary Fig. 3). There was an average of 72 biopsies performed per month in 2019, at a rate of 0.89 biopsies per 1,000 women. Most biopsies were performed in women aged 40–49 (39%) or 50–74 (45%). In 2020, an average of 59 biopsies were performed per month, with a rate of 0.71 per 1,000 women. There was a 64% decrease in biopsies performed in April and an 85% decrease in May 2020 compared to the same months in 2019; rates were nearly equivalent by August, and were 21% higher in September 2020 compared to 2019. However, the average rate of biopsies in 2021 (63 biopsies per month; 0.75 per 1,000 women) remained 16% below that observed in 2019.

Fig. 2 Monthly rates of screening mammography and tomosynthesis testing per 1,000 women overall and by age group in a central Massachusetts medical provider group, 2019–2021

ITS analyses showed a large and significant decrease of about 14 procedures per 1,000 women in mammography and tomosynthesis tests between February and March 2020 (95% Confidence Interval [CI]: − 21.62 to − 6.08; $p = 0.001$). Testing significantly increased between June and July 2020 as clinics reopened (15.63; 95% CI: 9.94 to 21.32; $p < 0.001$). ITS analyses also revealed the slope of monthly mammography and tomosynthesis testing rates remained steady in the period between January 2019 and February 2020 ($p = 0.58$) and between July 2020 and December 2021 ($p = 0.23$; Fig. 4 and Supplementary Table 2), representing the pre-pandemic and reopening periods, respectively.

Prostate cancer

In 2019, an average of 1,119 PSA tests were conducted per month, with a mean monthly rate of 17.1 tests per 1,000 men. On average in 2020, 1,130 PSA tests were performed per month, with a similar average rate of 17.0 procedures per 1,000 men, despite a precipitous drop in testing in April and May of 2020. Testing rates increased gradually in late 2020 and through 2021, with a mean of 1,378 PSA tests conducted each month in 2021. Similar to trends observed for mammography and tomosynthesis, PSA testing declined greatly between March and May 2020, reaching the lowest level in April 2020, when tests were performed at a rate of 3.8 per 1,000 men (Fig. 1). Comparing monthly testing rates between 2019 and 2020, there was a 34% decrease in March, a 78% decrease in April, and a 53% decrease in May. Despite the lack of clear screening recommendations by the USPSTF [5], PSA testing rates did not decline as much as those of mammography and tomosynthesis and experienced a faster rebound. Average monthly PSA testing rates observed in June–December 2020 (19.9 tests per 1,000 men) were 20% higher than the same months in 2019 (16.6 per 1,000) and remained high through 2021 (19.9 per 1,000).

Similar patterns were observed across age groups, with a decline in PSA testing in April 2020 of between 73 and 84% compared to April 2019. In May 2020, men aged 30–69 continued to experience lower screening rates of 55–58% below May 2019, with rates in the oldest men aged 70–85 only 42% below May 2019 levels. PSA testing rates rebounded as the clinics reopened to rates similar to 2019 during the months of June through December 2020 (Fig. 5). During 2021, we observed a 21% increase in rates of PSA testing among younger men aged 30–69, but just a 4% increase among the

Fig. 3 Rates of screening mammography and tomosynthesis per 1,000 women by race/ethnic group in a central Massachusetts medical provider group, 2019–2021

oldest men, compared to 2019 rates. We also observed similar trends in PSA testing across groups defined by race/ethnicity, despite small numbers in some groups (Fig. 6). At the lowest point in April 2020, testing rates were between 64% (Hispanic) and 91% (Asian) below April 2019 rates. PSA testing rates rebounded in all groups beginning in June–July 2020 to levels approaching those observed in 2019. In 2021, PSA testing rates were up 19–22% in all race/ethnic groups compared to 2019 rates, and were not impacted by subsequent COVID-19 surges.

Few prostate biopsies were conducted in this population, with a mean number of 12 biopsies per month in 2019,18 biopsies per month in 2020, and 24 per month in 2021 (Supplementary Fig. 4). Between 72 and 76% of prostate biopsies were performed among men aged 55–69. In contrast to PSA testing, the rate of prostate biopsies did not decline during the initial peak of the COVID-19 pandemic in April and May 2020, or during any subsequent surge. We could not draw conclusions about trends in TURP procedures, as an average of 5 procedures were conducted per month throughout the study period.

ITS analyses showed a large and significant decrease of about 13 procedures per 1,000 men in PSA testing between February and March 2020 (95% CI: -18.85 to -6.26; $p < 0.001$). Testing significantly increased between June and July 2020 as clinics reopened (8.19; 95% CI: 3.58 to 12.80; $p = 0.001$). ITS analyses also showed that the slopes of monthly PSA testing rates increased slightly during the shutdown period between March and June 2020 (1.87, $p = 0.08$). Testing rates remained steady between January 2019 and February 2020 ($p = 0.61$) and between July 2020 and December 2021 ($p = 0.54$; Fig. 4 and Supplementary Table 2).

Discussion

In this analysis, we examined the impact of COVID-19 on trends in screening for two common cancers with contrasting recommendations and different testing modalities through the first 22 months of the pandemic. The first peak of the COVID-19 pandemic resulted in a drastic reduction in the number of completed cancer screening tests in our multispecialty provider group serving a large population in central Massachusetts, although subsequent COVID-19 surges did not have a noticeable impact on screening rates. Beginning

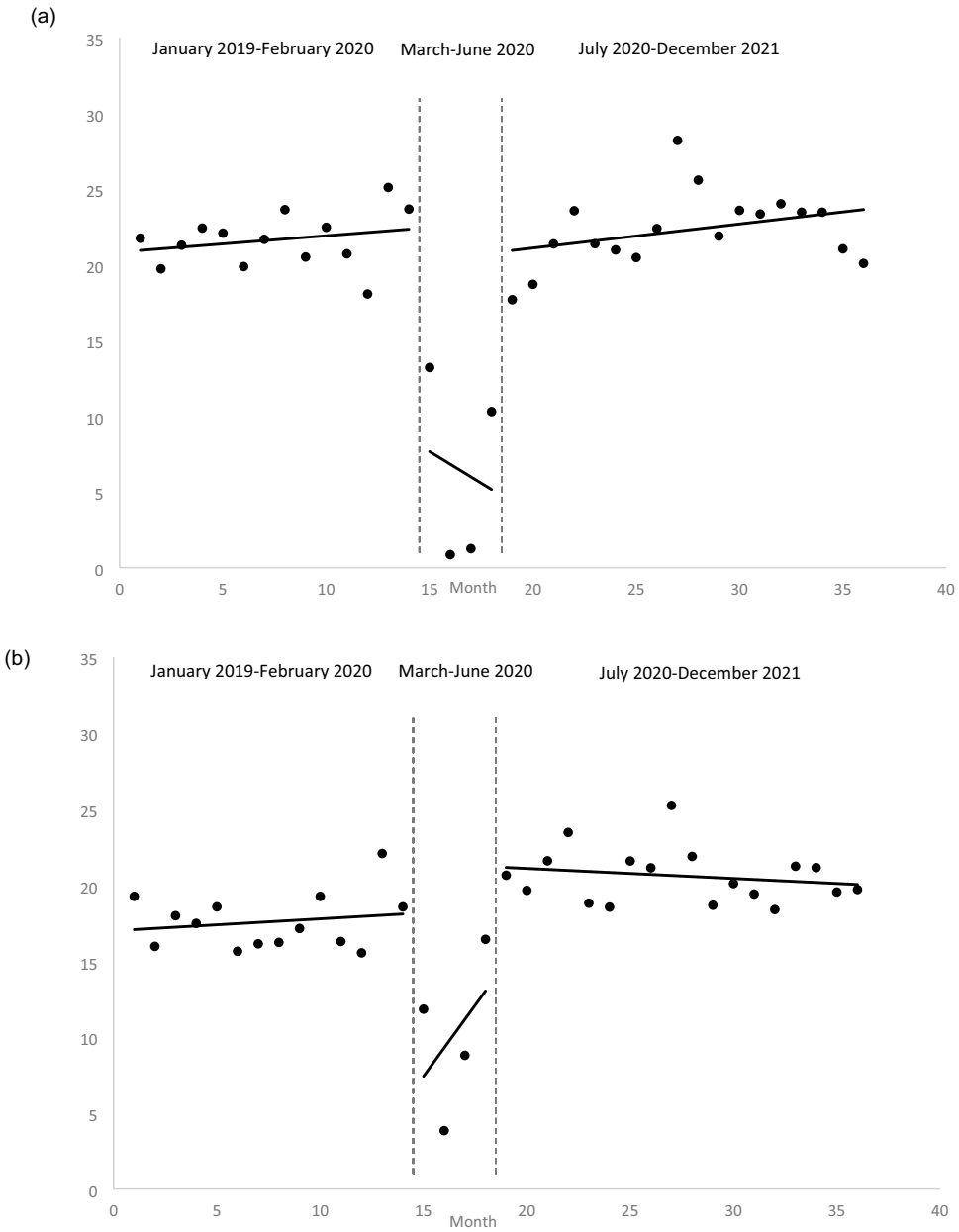

Fig. 4 Results of Interrupted Time Series analysis comparing trends in **a** overall mammography and tomosynthesis and **b** PSA testing rates between three time periods defined by the COVID-19 pandemic: January 2019–February 2020 (pre-pandemic), March 2020–June 2020 (initial pandemic shutdown), and July 2020–December 2021 (reopening)

on 16 March 2020, non-essential visits, including routine preventive cancer screenings, were canceled by the provider group due to COVID-19, resulting in a 99% decrease in the rate of screening mammography and digital tomosynthesis and a 78% decrease in PSA testing in April 2020 compared to April 2019. Similar trends were observed across age groups, including women in the 50–74 year age group targeted by current USPSTF recommendations, and groups defined by race/ethnicity [6]. In-person visits resumed in June 2020 with well-established practices to reduce risk to providers and patients. Although mammography services remained open throughout the pandemic for patients requiring urgent diagnostic breast studies, including biopsies and high-risk screenings, we observed a sizable decline in the rates of diagnostic mammograms between March and June 2020 that could indicate a delay in women receiving needed diagnostic procedures. Furthermore, thousands of screening mammograms were canceled or rescheduled between mid-March and May 2020, as evidenced by screening rates near zero during these months. Although mammography rates began to increase in June 2020 and remained steady through subsequent surges, screening rates among the oldest women remained below pre-pandemic rates through 2021, and rates were slower to recover in Black and Hispanic women, suggesting a lasting deficit in mammography rates in certain subgroups almost two years after the onset of the COVID-19 pandemic. Our results agree with some, but not all, studies in other populations [9–11]. Future research will determine

Fig. 5 Rates of PSA testing per 1,000 men overall and by age group in a central Massachusetts medical provider group, 2019–2021

the true impact of screening and diagnostic breast cancer procedures that were missed or delayed due to COVID-19 on cancer diagnoses and stage at diagnosis in the coming years.

We also observed a steep decline in PSA testing at the onset of the pandemic, followed by a relatively quick rebound, despite the lack of strong screening recommendations from the USPSTF. Current USPSTF guidelines suggest that men aged 55–69 discuss potential benefits and harms with their doctor prior to screening, while recommending against PSA-based screening in older men [5]. Despite these guidelines, a small amount of PSA tests continued throughout the COVID-19 pandemic, including in the oldest age group. Because the blood laboratory was never completely closed during the pandemic, a patient could get a PSA test if their provider had previously ordered the test. Furthermore, 2021 data demonstrate a higher volume of PSA testing when compared to the same months in 2019. Future studies should determine whether men whose appointments were canceled eventually receive a screening test, the length of the delay, and whether the delay impacted patient outcomes.

Our findings agree with other analyses of imaging and cancer screening procedures during the COVID-19 pandemic. In May 2020, the Epic Health Research Network (EHRN) analyzed data from 2.7 million patient EHRs and observed a 86–94% decline in preventive colon, breast, and cervical cancer screenings in 2020 compared to the same weeks in 2017–19 [12]. An updated EHRN analysis suggested that by June 2020, breast cancer screening volumes were still 29% lower than in 2019 [13]. The authors estimated 285,000 screenings for breast cancer were missed in the studied populations between March and June 2020. An analysis of imaging volume in New York State observed an 87% decline in all outpatient imaging procedures by mid-April 2020 compared to 2019 [14]. An analysis of claims data from over 6 million Medicare beneficiaries observed 85% fewer breast cancer screenings and 74% fewer prostate cancer screenings in March–July 2020 compared to 2019 [15]. Similar results were found in analyses of health insurance claims from 6.8 million individuals, which reported a relative reduction of 90.4% in mammograms among women aged 46–64 in April 2020 compared to 2019 [16]. However, few studies have been able to examine longer-term trends in cancer screening procedures through the second year of the COVID-19 pandemic and through 2021.

Models from both the US and the United Kingdom suggest a large number of cancer deaths over the next 5 years may be attributable to delays in diagnostic and screening procedures [2–4]. Cancers that could have been diagnosed

Fig. 6 Rates of PSA testing per 1,000 men by race/ethnicity in a central Massachusetts medical provider group, 2019–2021

by screening at an early stage may eventually be diagnosed at a later stage and with worse prognosis. Maringe et al. estimated a 7.9–9.6% increase in deaths due to breast cancer up to 5 years after diagnosis [4]. Evidence from our study and others suggests a lingering disruption in routine cancer screening tests among certain subgroups in the post-peak period, while overall screening rates may have met or exceeded pre-pandemic rates. [9–11, 17, 18]. It remains to be seen if the estimates of resulting cancer mortality will ensue.

Our analysis of longitudinal EHR data from a large, multispecialty provider group in central Massachusetts provides real-world evidence to document and quantify trends in routine cancer screening and diagnostic procedures during the first 22 months of the COVID-19 pandemic. The results presented in this study come from one healthcare system in one state; however, recently published studies using nationwide databases have reported similar trends in cancer screening tests during 2020 as compared to previous years. We observed similar declines in testing rates across groups defined by age and race/ethnicity in the initial pandemic shutdown. However, between 17 and 19% of our study population was missing definitive data on race, suggesting these results should be confirmed in other populations. We also did not investigate whether high-risk populations had different testing patterns during the pandemic compared to other patient groups. Since high-risk groups (including patients with prior abnormal findings or genetic predisposition) have a greater chance for harm from delayed testing, future studies should specifically identify and follow these groups.

As the COVID-19 pandemic continues, it is essential to understand the factors behind the slower rate of return to breast cancer screening observed among Black and Hispanic women in the post-peak months. Patient-level factors influencing a woman's choice to reschedule a canceled screening test may include perceived safety, financial hardship or lack of insurance brought about directly or indirectly by COVID-19, poor access to care [19], or conflicting and increased responsibilities including working from home and childcare. We did not follow individual patients to determine whether patients who canceled screening tests during the COVID-19 pandemic returned to screening. Future research should also identify patient-level factors contributing to decision-making around routine cancer screening during and after the COVID-19 pandemic to ensure all patients have access to adequate care.

In conclusion, the sizable reduction in both breast and prostate cancer screening tests and in diagnostic

mammography during the first peak of the COVID-19 pandemic in central Massachusetts, and the slower rate of return to breast cancer screening among certain subgroups, illustrates the potential for delayed diagnosis and worse prognosis among patients with missed tests. The impact of the pandemic on cancer prevention and early detection signals potential downstream effects that will become evident at both the patient and organization levels in the coming years.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10552-022-01616-4.

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Author contributions MME, TSF: Conceptualization; MME, TS, LDG, JHG, DS, ETW, HF: Methodology; DS, MF, HF: Formal analysis and investigation; MME: Writing—original draft preparation; ETW, TS, LDG, JHG, DS, MF, HF: Writing—review and editing; JHG, LDG: Funding acquisition; LDG, JHG; TSF: Supervision.

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Data availability The data that support the findings of this study are available on request from the corresponding authors [MME, LDG]. The data are not publicly available due to them containing information that could compromise research participant privacy.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval This project was approved by the Institutional Review Board at the University of Massachusetts Chan Medical School.

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