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Annual Report to the Nation on the Status of Cancer, Part 2: Early Assessment of the COVID-19 Pandemic's Impact on Cancer Diagnosis

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Abstract

Background: With access to cancer care services limited because of COVID-19 control measures, cancer diagnosis and treatment have been delayed. We explored changes in the counts of U.S. incident cases by cancer type, age, sex, race, and disease stage in 2020.

Methods: Data were extracted from selected U.S. population-based cancer registries for diagnosis years 2015–2020 using first-submission data from the North American Association of Central Cancer Registries. Following a quality assessment, the monthly numbers of newly diagnosed cancer cases were extracted for six cancer types: colorectal, female breast, lung, pancreas, prostate, and thyroid. The observed numbers of incident cancer cases in 2020 were

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Conflict of Interest Statement

The other authors have no conflicts of interest to disclose.

compared with the estimated numbers by calculating observed to expected (O/E) ratios. The expected numbers of incident cases were extrapolated using Joinpoint trend models.

Results: We report an O/E ratio less than one for major screening-eligible cancer sites, indicating fewer newly diagnosed cases than expected in 2020. The O/E ratios were lowest in April 2020. For every cancer site except pancreas, Asian/Pacific Islander persons (API) had the lowest O/E ratio of any race group. O/E ratios were lower for cases diagnosed at localized stages than for cases diagnosed at advanced stages.

Conclusions: Our analysis provides strong evidence for declines in cancer diagnoses, relative to the expected numbers, between March and May 2020. The declines correlate with reductions in pathology reports and are greater for cases diagnosed at *in situ* and localized stage, triggering concerns about potential poor cancer outcomes in the coming years, especially in API persons.

Plain Language Summary:

To help control the spread of COVID-19, health care organizations suspended non-essential medical procedures, including preventive cancer screening, during early 2020. Many individuals canceled or postponed cancer screening, potentially delaying cancer diagnosis. This study examines the impact of the COVID-19 pandemic on the number of newly diagnosed cancer cases in 2020 using first-submission population-based cancer registry database. The monthly numbers of newly diagnosed cancer cases in 2020 were compared with the expected numbers based on past trends for six cancer sites April 2020 had the sharpest decrease in cases compared with previous years, most likely due to the pandemic.

Precis:

Our analysis provides strong evidence for sharp declines in the numbers of new cancer cases diagnosed between March and May 2020. The declines are correlated with reductions in pathology reports and are more substantial for cases diagnosed at *in situ* and localized stage, triggering concerns for potential poor cancer outcomes in certain demographic subgroups in the coming years.

Keywords

COVID-19; cancer surveillance; cancer incidence; cancer stage; observed-to-expected; pathology reports

BACKGROUND

Access to timely cancer care continues to be a concern as the Coronavirus Disease 2019 (COVID-19) pandemic lingers worldwide. In early 2020, several health professional organizations and governmental agencies issued guidance suggesting that all elective surgeries and non-essential medical procedures, including cancer screening, be suspended due to the SARS-CoV-2 outbreak.[1] Evidence documented that the use of cancer screenings across the United States declined at the beginning of the COVID-19 pandemic.[2] Although screening use has since increased, it has not reached pre-pandemic expected levels.[3] Suspension of cancer-related procedures has created a backlog of health services such as

increasing wait times for cancer surgery.[4,5] Despite the Biden administration's plan to declare the public health emergency over on May 11, 2023[6], it might be some time before cancer services return to pre-pandemic volumes.

Population-based cancer registries are in a unique position to detect changes in cancer trends and patterns that could be related to COVID-19 pandemic control interventions. Changes in the number and stage distribution of cancer cases reported to registries could be an informative first indication of the COVID-19 pandemic's impact on the cancer care continuum. This study analyzes cancer case counts and pathology reports submitted to central cancer registries for diagnosis year 2020 and compares these counts to expected counts based on the past trends to understand whether early evidence points toward changes in cancer incidence during the early phase of the COVID-19 pandemic.

METHODS

Registry and Case Selection

Data about newly diagnosed cancer cases were obtained from the North American Association of Central Cancer Registries (NAACCR) database, which comprises data from population-based registries that participate in the CDC's National Program of Cancer Registries (NPCR) and/or the NCI's Surveillance, Epidemiology, and End Results (SEER) Program. Case counts for 2015–2020 were extracted from the NAACCR database using SEER*Stat software (8.4.0.1). Registries report newly diagnosed cases first at 12 months following the end of the diagnosis year, and then with every successive annual call for data. Thus, cases diagnosed in 2015 were first reported to NAACCR at the end of 2016 and then resubmitted at the end of 2017. Similarly, cases diagnosed during 2020 were first submitted at the end of 2021 and were resubmitted in 2022 and later. Registries with a case count ratio greater than 0.7 for a specific cancer site between first and second submission for five successive submissions (years 2015 through 2019) were considered high quality for 12-month case capture and were included in the analysis for that cancer site. We conducted an assessment of the above-mentioned ratio for the selected NAACCR registries for the following six primary sites: Colorectal (*International Classification of Diseases for Oncology, 3rd edition* [ICD-O-3] codes C180, C182–189, C199, C209)[7], Female Breast (C500–506, C508–C509)[7], Lung (C340–343, C348–C349)[7], Pancreas (C250–C254, C257–C259)[7], Prostate (C619)[7] and Thyroid (C739)[7]. The selection of sites included cancers with screening recommendations (female breast, lung, colorectal), cancers with frequent incidental detection (prostate, thyroid), and a cancer with rapid progression and unfavorable outcomes (pancreas). Male breast cancer cases were excluded due to small numbers and the absence of a recommendation for screening.

The number of registries selected and the population covered by the selected registries varied by cancer site, as shown in Table 1. For the purposes of this analysis, age groups were selected based on The American Cancer Society's screening recommendations[8]. To facilitate comparison, similar age groups were used for cancer sites without a screening recommendation (Table 1). The highest population coverage was observed for female breast cancer (17 registries covering 26% of the U.S. population in the age category of interest [40–74 years]), with an average annual case count of 11,139. The lowest coverage was

observed for prostate cancer (11 registries covering 18% of the U.S. male population ages 50–74 years).

All cancer reportability criteria for cases included in this study followed the NAACCR standards.[9] Similarly, all data elements used for the analysis conformed to the NAACCR Data Dictionary.[10]

Case counts were stratified by NAACCR month and year of diagnosis, sex, race (NAACCR recode), and stage (SEER Summary Stage 2000 for diagnosis years 2015–2017 and Summary Stage 2018 for diagnosis years 2018–2020). Race was categorized into four groups: White, Black, Asian or Pacific Islander (API), and American Indian or Alaska Native (AIAN). Data for Hispanic origin was not available in this dataset as it was not required by NAACCR for this particular call for data. Cancer stage was categorized as *in situ*, localized, advanced (regional and distant), and unknown.

Statistical Analysis and Modeling

To evaluate the impact of the COVID-19 pandemic on cancer incidence counts, we calculated ratios of the observed to expected number of cancer diagnoses (O/E ratio) using NCI's Joinpoint Regression Program version 4.9.0.0.[11] The default settings were used to quantify temporal trends from 2015 to 2019 based on log-scale with Poisson variance. Data were stratified by month of diagnosis and revealed monthly fluctuation in cases. To account for such variation, we modeled each month separately. The last segment from the model was extrapolated to 2020 and considered the expected 2020 counts in the absence of the COVID-19 pandemic. The sum of the projected counts for all 12 months was considered the expected count for 2020. An O/E ratio close to one implies that the 2020 observed count is in line with data from previous years. If the O/E ratio is less than one, this implies that there were fewer cases reported than expected. The standard error for the ratio was obtained by the delta method[12], which was then used to determine the p-value for testing whether the O/E ratio is different from one as well as the 95% confidence interval (CI) for each O/E ratio; these 95% CIs also allow for informal comparisons between groups, without specifying a referent group.

Pathology Report Volume Comparison

Electronic pathology reports for specimens collected for the period January 2019 through December 2020 from 11 participating central cancer registries (CT, GA, HI, IA, KY, LA, NJ, NM, NY, SEA, UT) were compiled by the SEER Program for a separate analysis. Central cancer registries participating in the Program received pathology reports transmitted electronically in real time and therefore the acquisition of pathology reports has not been affected by functional delays that could have affected cancer abstraction in hospital registries. To ensure consistency over time, we limited the analysis to facilities that transmitted reports every month between 2018 and 2020. A convolutional neural network algorithm was used to classify reports by the site and histology of the primary tumor (female breast, lung, colorectal, pancreas, prostate, thyroid) and by report type (biopsy, cytology, molecular and biomarker, surgical, blood/bone marrow/flow cytometry and autopsy).[13] Specimen collection date was used to subset and categorize the reports by the month of

collection. Reportable biopsy counts by month of collection were compared to NAACCR case counts by cancer site and month of diagnosis between January 2019–December 2020.

RESULTS

Figure 1 presents the O/E ratio for newly diagnosed cases calculated for each cancer by month of diagnosis in 2020. Between April and May, registries recorded significantly fewer cases than expected for every cancer type. For all six cancer types, April 2020 was the month with the lowest ratio. The most dramatic decline in the O/E ratio was seen for cancers that generally have a more favorable prognosis: thyroid, prostate, female breast, and colorectal. In contrast, the decline in O/E ratio was markedly attenuated for cancers with poor survival: pancreas and lung. While the O/E ratios for most cancer sites clearly declined in March 2020, the O/E ratio for female breast cancer was an exception; it appeared that a longer lead time was necessary for the ratio to change in female breast cancer than in other sites.

Figure 2 shows that the variation in counts of newly diagnosed cases correlated with changes in the counts of biopsy pathology reports transmitted to the registries. Not every case reported to a registry has been confirmed by a biopsy. Additionally, a case may have multiple biopsy reports; therefore, there is no predetermined number of pathology reports per case. A dramatic decline in pathology report counts was seen starting in March 2020 for all cancer sites. Some rebound that exceeded 2019 pathology report counts were seen for pancreas, prostate, and thyroid cancers.

When data were aggregated over all 12 months of the year 2020, the observed number of newly diagnosed cases was statistically significantly lower than the expected number for all major cancer sites eligible for screening (colorectal, female breast, lung), and prostate (Figure 3).

The O/E was 0.90 for colorectal cancer (females and males), 0.89 for prostate cancer, 0.92 for female breast cancer, and 0.94 for lung cancer (males and females). Among screening-eligible cancers, the absolute difference in the O/E ratio for males versus females was less than 0.1, indicating little difference by sex. We calculated the O/E for two cancer sites with no screening recommendations: pancreas and thyroid. Among males, we observed no statistically significant difference in observed versus expected counts for those sites. However, lower than expected counts were recorded for females with thyroid (statistically significant) and pancreatic cancers (not statistically significant).

Figure 4 shows the O/E ratios for newly diagnosed cases by cancer site and race category. Among the four race groups, API persons had the lowest O/E ratio for every cancer site except pancreas. The confidence interval for the pancreatic cancer O/E ratio included one for every race category. In contrast, the confidence interval for the lung cancer O/E ratio excluded one for every race group. In fact, significantly fewer cases than expected were observed among White, Black, and API persons for each cancer site included in this analysis, with the exception of pancreas and thyroid among White persons. While O/E

ratios for AIAN persons were generally higher compared to the other race groups, the wide confidence intervals made it difficult to interpret these results.

Figure 5 presents the O/E ratios for newly diagnosed cases by cancer site and age category. For colorectal, breast, and prostate cancers, there were fewer diagnosed cases than expected among people 40 years or older, but not among people younger than 40 years. For lung and thyroid cancers, there were fewer diagnosed cases than expected among all age groups. The number of pancreatic cancer cases was as expected, regardless of age. The variation of O/E ratio between age categories was small for all other cancer sites, except for lung cancer, where the ratio was particularly low for cases diagnosed below 40 years of age.

Table 2 shows the O/E ratio for newly diagnosed cases by cancer site and stage at diagnosis. A clear pattern emerges, with every cancer site showing a lower O/E ratio for localized cancer than for advanced cancer. This indicates that proportionally fewer localized cases were diagnosed during the year 2020. Cancer sites with no screening recommendations (i.e., thyroid and pancreas) showed no decline from expected in the number of advanced cases, 6–10% decline in localized case counts and 62% decline in *in situ* cases for thyroid. Excluding the Unknown stage category, the most dramatic declines from the expected number of cases (lowest O/E ratios) were seen for *in situ* and localized cases of female breast (localized only), colorectal, lung, and prostate cancers.

DISCUSSION

Decline in Cancer Case Counts and Pathology Reports

Using population-based cancer registry data, we report that the number of newly diagnosed cancer cases of six major cancers declined during the first calendar year of the COVID-19 pandemic in the United States. Specifically, this investigation quantifies differences between observed versus expected (O/E) cases reported to cancer registries. For most cancer types and population groups analyzed, the incident cases decreased abruptly starting in March 2020, coinciding with the COVID-19 mitigation efforts. The disparity between observed and expected cases was most pronounced in April and improved minimally in May. Subsequently, for most cancer types the deficit decreased in June and generally was not measurable in the second half of 2020. Furthermore, we report some evidence of a rebound effect for certain cancer types, although the rebound did not offset the deficit in the first half of the year. This study provides quantitative information on the impact of COVID-19 on the diagnosis of major cancers during the first year of the pandemic.

The decreases in cases paralleled the declines in the numbers of pathology reports. These reports are transmitted to central cancer registries automatically in real time and require little to no additional processing effort from registry staff. Currently, the NCI SEER Program can conduct real time monitoring of pathology reports trends using a suite of tools developed by NCI in collaboration with the Department of Energy as part of the *Joint Design of Advanced Computing Solutions for Cancer.*[14,15] The transmission mechanisms of pathology reports differ from other registry data streams, such as transmission of cancer abstracts, which could have been delayed by operational challenges such as staff shortages or limited physical access to medical records. Therefore, the reductions in pathology reports in the first half

of 2020 are most likely related to decreases in screening procedures[16,17], rescheduling of surgical procedures[18] and fewer in-person medical visits.[19]

Decline Varies Across Demographic Groups

For screen-detected cancers, the O/E ratio was similar for males and females. However, a sex-related association was observed for thyroid and pancreatic cancers. There is evidence that subclinical papillary thyroid tumors are diagnosed more often in females than in males.[20] Subclinical diagnosis is frequently the result of an ultrasound examination. Several papers reported a decline in ultrasound utilization in emergency departments during 2020.[21,22] Other reports asserted that the decrease in the number of imaging exams was even sharper in ambulatory settings than in hospitals.[23] Pancreatic cancer is often detected because of acute abdominal pain and symptoms of biliary blockage. While the proportion of cases diagnosed with regional or distant disease is approximately the same in males and females, there is evidence that males have more comorbidities at the time of diagnosis and are diagnosed at younger ages.[24] Given the awareness that patients with multiple comorbidities are at higher risk of severe disease[25], it is possible that male patients with non-specific symptoms were more likely to be hospitalized or that they received risk-based priority in outpatient care settings. This may, in part, explain why more pancreatic cancer cases were reported in males than in females. In contrast, the recommendations to delay screening applied to all patients irrespective of sex, and therefore the declines in newly diagnosed cases of those cancers were observed almost equally in males and females.

In the United States, Black, AIAN, Pacific Islander, and Hispanic and Latino persons have experienced higher rates of infection, hospitalization, and deaths from SARS-CoV-2 than non-Hispanic White persons, while Asian persons have experienced lower rates.[26,27,28] When compared to White persons, the observed cancer case count among API tended to be lower than the expected for colorectal, female breast, lung, and thyroid cancers. Various financial, linguistic, and cultural barriers had prevented Asian immigrants' utilization of health care services before the COVID-19 pandemic.[29] In general, during the pre-pandemic era, there was low cancer screening prevalence among API, even after the enactment of the Affordable Care Act, which required most insurance plans to provide certain recommended cancer screenings at no cost. This was exacerbated by the COVID-19 pandemic, with API having the largest decline in cancer screening compared to other racial/ethnic groups, and no rebound in sight. [30–31] Several factors may have contributed to this decline, in particular the psychological impact of anti-Asian stigma due to the SARS-CoV-2 outbreak. [32] This could explain why fewer than expected cases were diagnosed in the Asian community for cancers diagnosed through screening. In contrast, Black persons experienced a smaller decline in observed prostate cancer cases than White persons. The less pronounced impact of COVID-19 on prostate cancer counts among Black persons may reflect improved awareness of higher prostate cancer risk for Black persons, or alternatively, increased health care utilization during the pandemic.[33–34]

Deficit in Cases Diagnosed at In Situ and Localized Stage Varies by Cancer Site

We report statistically significantly fewer than expected cases diagnosed with localized female breast, colorectal, lung, prostate, thyroid, and pancreatic cancers. In addition,

we report fewer than expected *in situ* tumors diagnosed for female breast, colorectal, and thyroid cancers. If in fact the underlying population with progressing but clinically undetectable tumors has not changed significantly year-to-year, it could be assumed that each case expected but not observed in 2020 is a potentially missed opportunity for early detection. For the subset of registries included in this study, 7,147 colorectal cancer cases were expected to be detected at an *in situ* or localized stage, but only 5,983 (83.7%) were diagnosed. This under detection resulted in potentially up to 1,164 (16.3%) missed opportunities for early detection. Likewise, there were 4,020 fewer than expected *in situ* and localized female breast cancer cases (9.0%), 1,267 (14.7%) fewer than expected *in situ* and localized lung cancer cases, and 3,447 (14.8%) fewer than expected localized prostate cancer cases. Similar results were observed for the two cancer sites with no screening recommendations, thyroid (470 fewer than expected *in situ* and localized cases, 11.8%) and pancreas (115 fewer than expected *in situ* and localized cases, 9.9%). Thus, the survival benefits of early detection may be limited for a large segment of cancer patients.

At the same time, the number of patients diagnosed with advanced disease were not found to be statistically different from the expected for female breast cancer, thyroid, and pancreatic cancers, and the counts were marginally lower than the expected for colorectal and lung. The only exception to this pattern is prostate cancer, where the number of advanced cases was only 89% of the expected. This finding could be partially explained by the unusually high number of cases with unknown stages. To the best of our knowledge, there is no direct evidence of decreased utilization of positron emission tomography (PET) imaging for bone metastasis detection, or of computed tomography (CT) and magnetic resonance imaging (MRI) for pelvic and abdominal initial evaluation of prostate cancer patients. However, there is indirect evidence of a more general reduction in the number of imaging procedures during the year 2020.[22] Fewer bone scans may result in an increased number of cases with incomplete risk stratification and incomplete evaluation of the extent of disease.[35]

There is a growing body of literature pointing to a decrease in screening procedures during the year 2020.[36] Data from the Behavioral Risk Factor Surveillance System (BRFSS) indicate lower screening prevalence in 2020 than in 2012, 2014, 2016, and 2018.[37] The adjusted prevalence ratio for breast cancer screening was 0.94 (95% CI, 0.92–0.95), which is similar to the O/E ratio we report in this paper for *in situ* tumors (i.e., 0.95), suggesting that the decline in cancer cases diagnosed in early 2020 could be explained largely by decreases in screening prevalence.[37] Results presented here are consistent with previous analyses describing the correlation of breast and colorectal cancer case counts with fewer screening events during the COVID-19 pandemic.[38,39] With cancer screening having been disrupted, detection of cancer cases may be delayed, affecting cancer survival outcomes.[40] Additionally, a fraction of the overall case count decline could be due to the excess all-cause mortality observed in 2020 in the U.S.[41] Furthermore, not all states paused or reopened screening services at the same time. Thus our findings might not reflect the experience of each cancer registration jurisdiction in the United States.

Strengths and Limitations

We used population-based cancer registry data, with demographic and tumor characteristics meeting NAACCR standards, from a subset of geographically diverse registries having high 12-month data completeness. While not necessarily representative of the U.S. population, this is the largest study to estimate the effect of the COVID-19 pandemic on the number of newly diagnosed cancer cases in the United States.

A limitation of this study is that, given the nature of cancer reporting operations, more information about cases diagnosed in 2020 will be reported to NAACCR in subsequent years. While we compared cases diagnosed in 2020 with comparable datasets collected for the previous 5 years, the final stage distribution of cases diagnosed in 2020 could potentially evolve with further data curation, and additional cases may be reported. The U.S. population covered by registries for each cancer site in this analysis (18–26%) also serves as a potential limitation to the representativeness of the data. While overall racial minority groups were over-represented in this study (25% vs 22% in U.S. population), API and AIAN populations were underrepresented. Additionally, persons of Asian and Pacific Islander origin are presented together in the API category. The numbers of people of Asian ancestry in the general population are much larger than the number of Pacific Islander persons. Other limitations are the unavailability of Hispanic ethnicity for this analysis and the lack of information about social determinants of cancer (e.g., education and socioeconomic status).

CONCLUSIONS

Our analysis provides evidence for declines in the numbers of newly diagnosed cancer cases of six major cancer types between March and May 2020, consistent with decreases in the numbers of pathology reports. This points toward declines not attributable to operational delays in cancer reporting, but instead to missed opportunities for early detection during screening, preventive care visits, diagnostic procedures, and other health care visits. Evidence from other studies suggests that these delays in cancer detection may lead to negative long-term consequences including shorter survival and higher mortality. Efforts to remove barriers to preventive care visits can help get people back on track for cancer screening and reduce disparities in early detection. Our findings suggest that during the beginning of the COVID-19 pandemic in the United States, many people with cancer were not diagnosed. Novel strategies to increase guideline-concordant cancer care may help alleviate detrimental consequences on survival, mortality, and quality of life among these persons with cancer.

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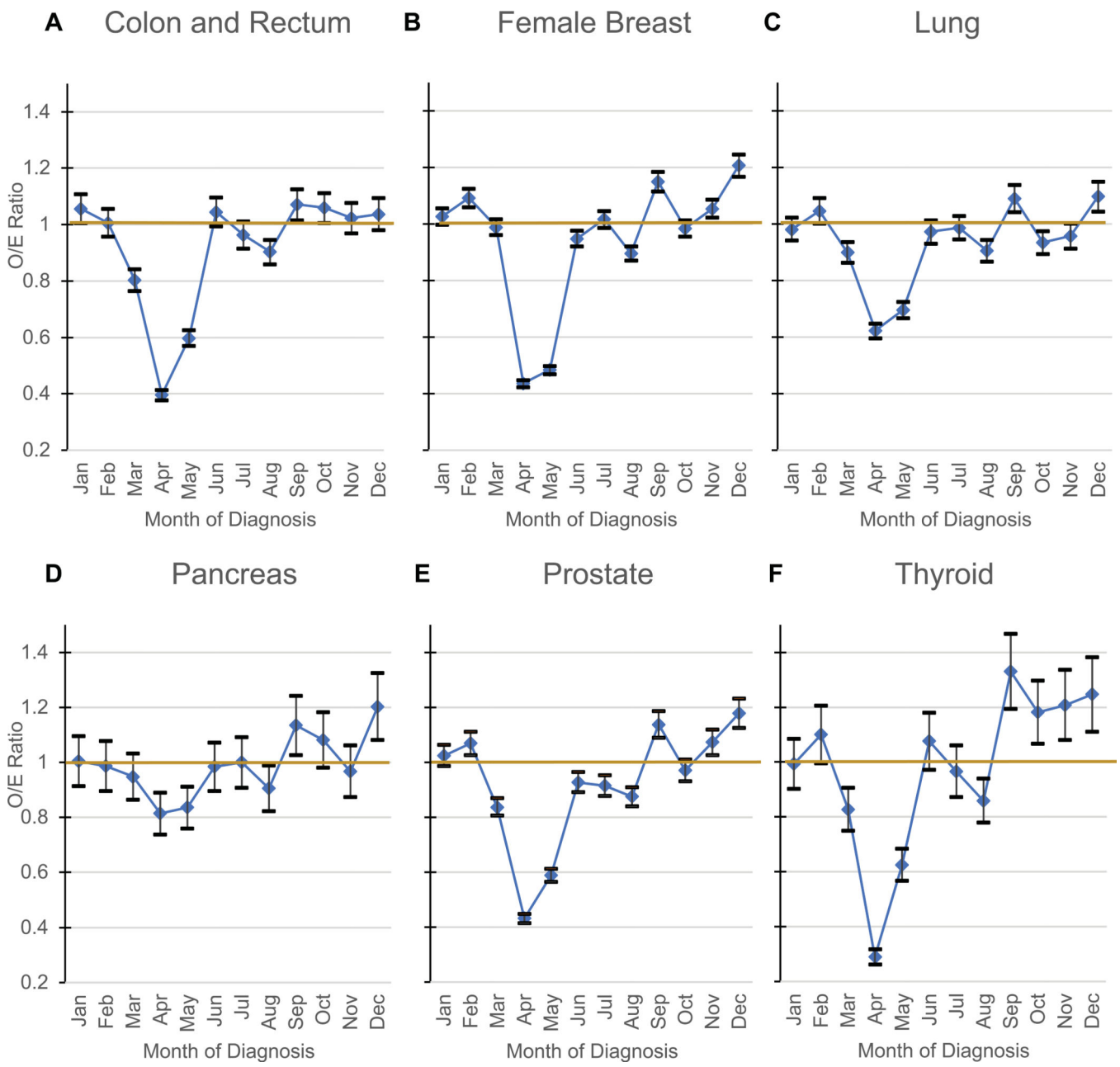

Figure 1.

Observed-to-expected ratio for newly diagnosed cancer cases, diagnosis year 2020, by month of diagnosis and cancer site

The observed 2020 count was compared to the expected count by ratio (O/E ratio). The standard error for the ratio was obtained by the delta method, which was used to determine the p-value and 95% confidence interval for each O/E ratio. Data source for observed counts: SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and NCI's Surveillance, Epidemiology, and End Results (SEER) Program Registries), certified by

the North American Association of Central Cancer Registries (NAACCR) as meeting high-quality incidence data standards for the specified time periods, submitted December 2021.

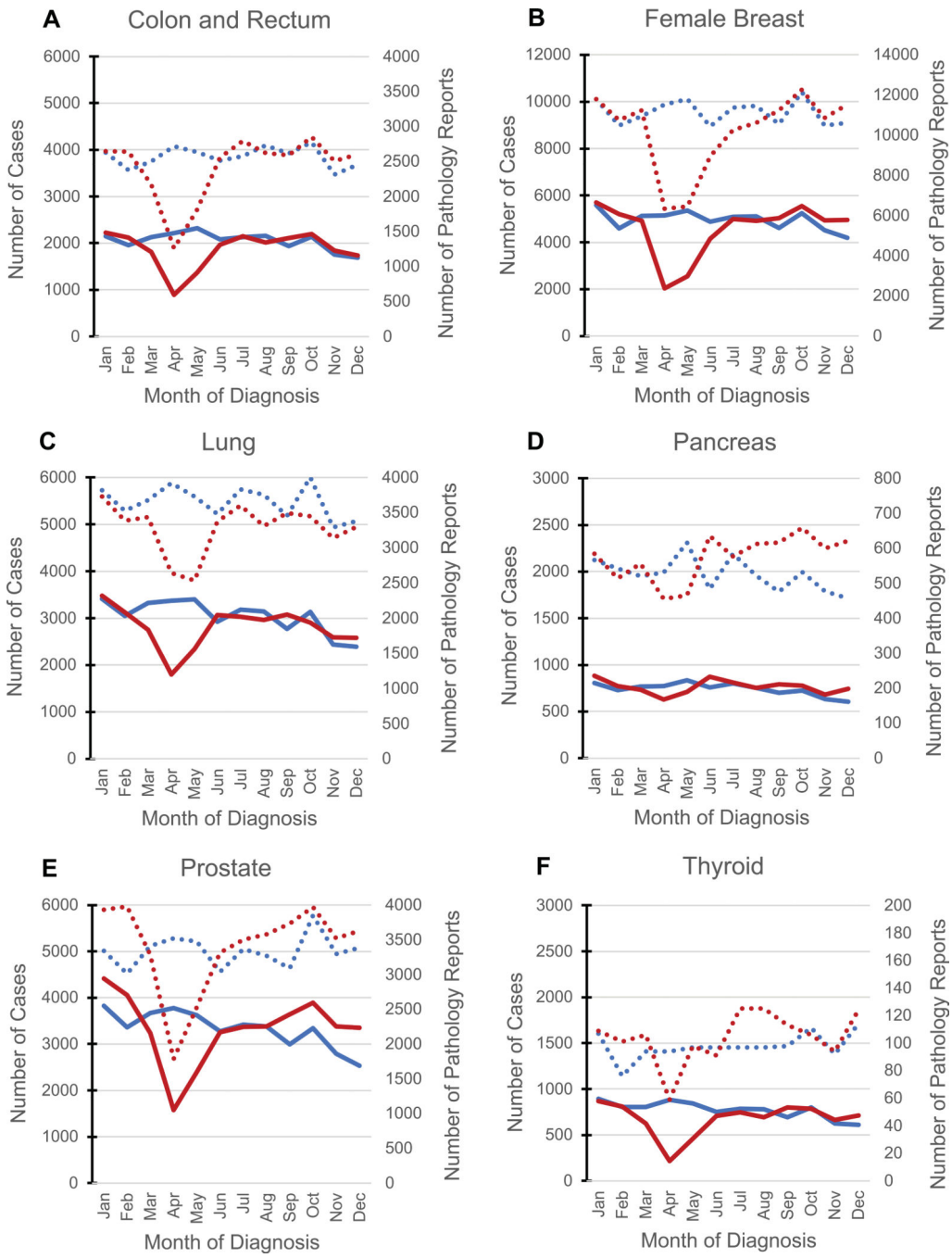

Figure 2.

Monthly number of reportable biopsy pathology reports vs. newly diagnosed cancer cases by cancer site in 2019 and 2020

The frequency distribution of cases are compared to the frequency distribution of reportable biopsy pathology reports in 2019 and 2020 by month of diagnosis for 6 cancer sites. SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and the NCI's Surveillance,

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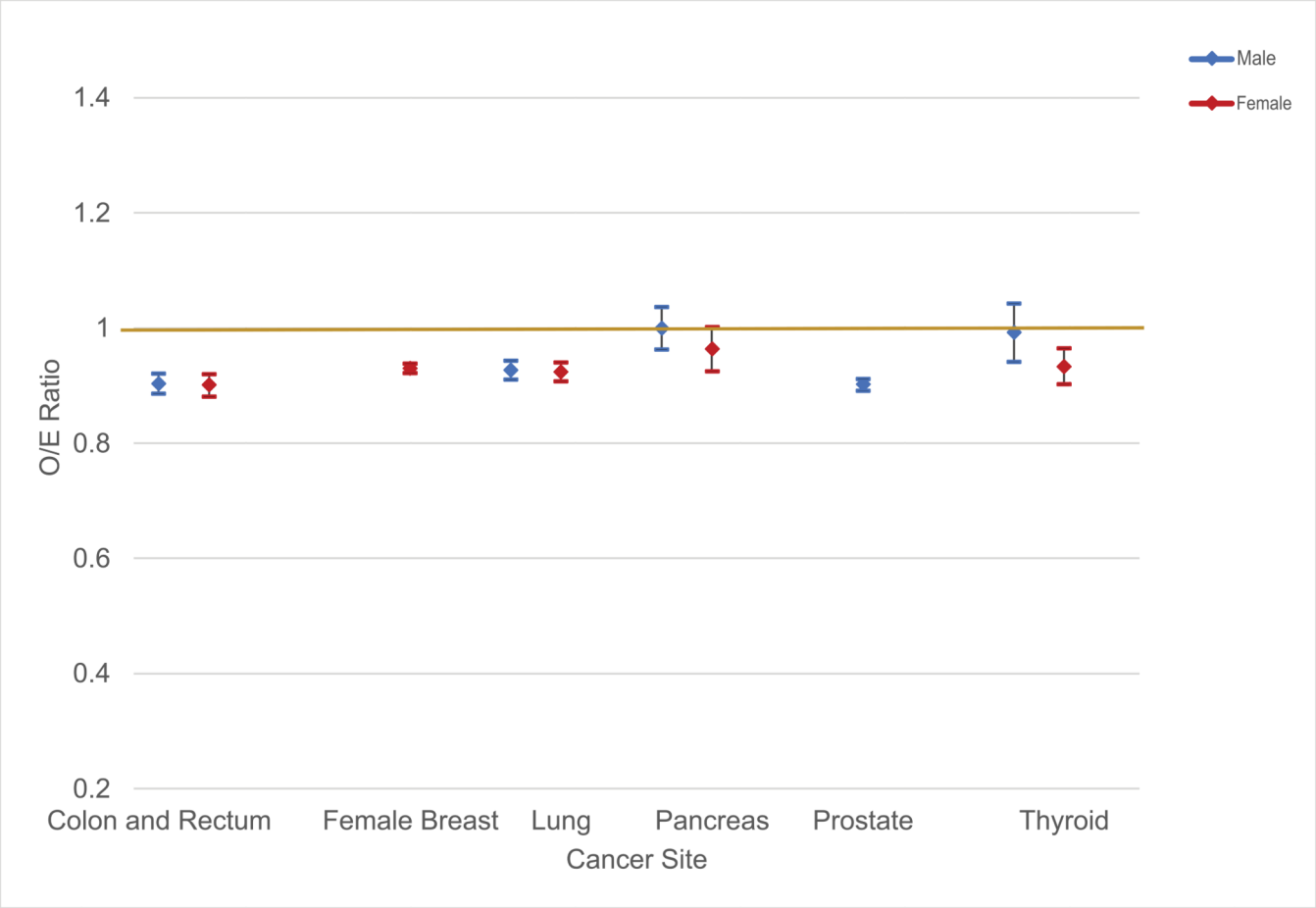

Figure 3.

Sex-specific observed-to-expected ratio for newly diagnosed cancer cases by cancer site in 2020

The observed 2020 count was compared to the expected count by ratio (O/E ratio). The standard error for the ratio was obtained by the delta method, which was used to determine the p-value and 95% confidence interval for each O/E ratio. Data source for observed counts: SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and NCI's Surveillance, Epidemiology, and End Results (SEER) Program Registries), certified by the North American Association of Central Cancer Registries (NAACCR) as meeting high-quality incidence data standards for the specified time periods, submitted December 2021.

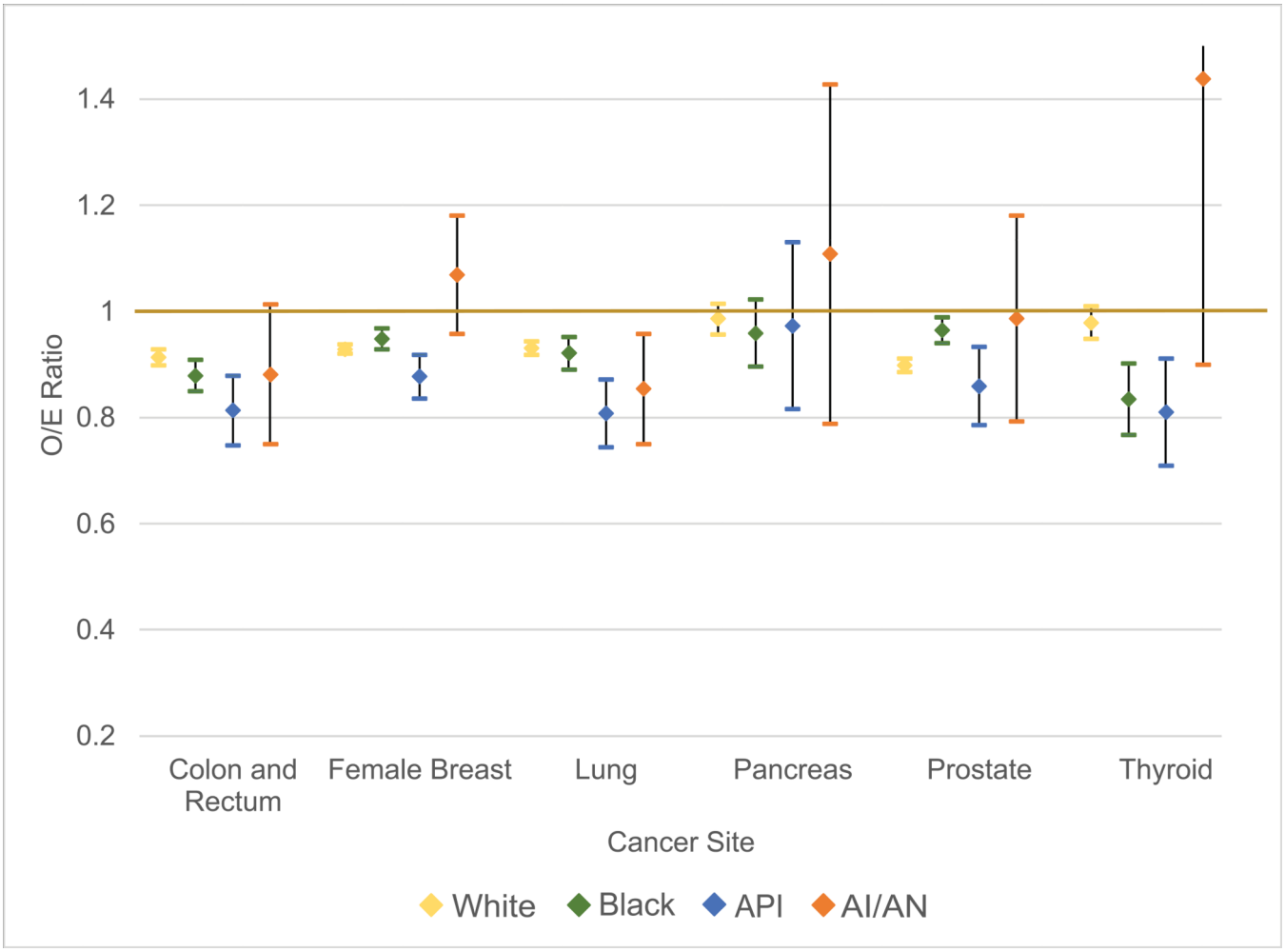

Figure 4.

Race-specific observed-to-expected ratio for newly diagnosed cancer cases by cancer site in 2020

Abbreviations. API, Asian or Pacific Islander, AIAN, American Indian or Alaska Native

The observed 2020 case count was compared to the expected count by ratio (O/E ratio). The standard error for the ratio was obtained by the delta method, which was used to determine the p-value and 95% confidence interval for each O/E ratio. Data source for observed counts: SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and NCI's Surveillance, Epidemiology and End Results (SEER) Program Registries), certified by the North American Association of Central Cancer Registries (NAACCR) as meeting high-quality incidence data standards for the specified time periods, submitted December 2021.

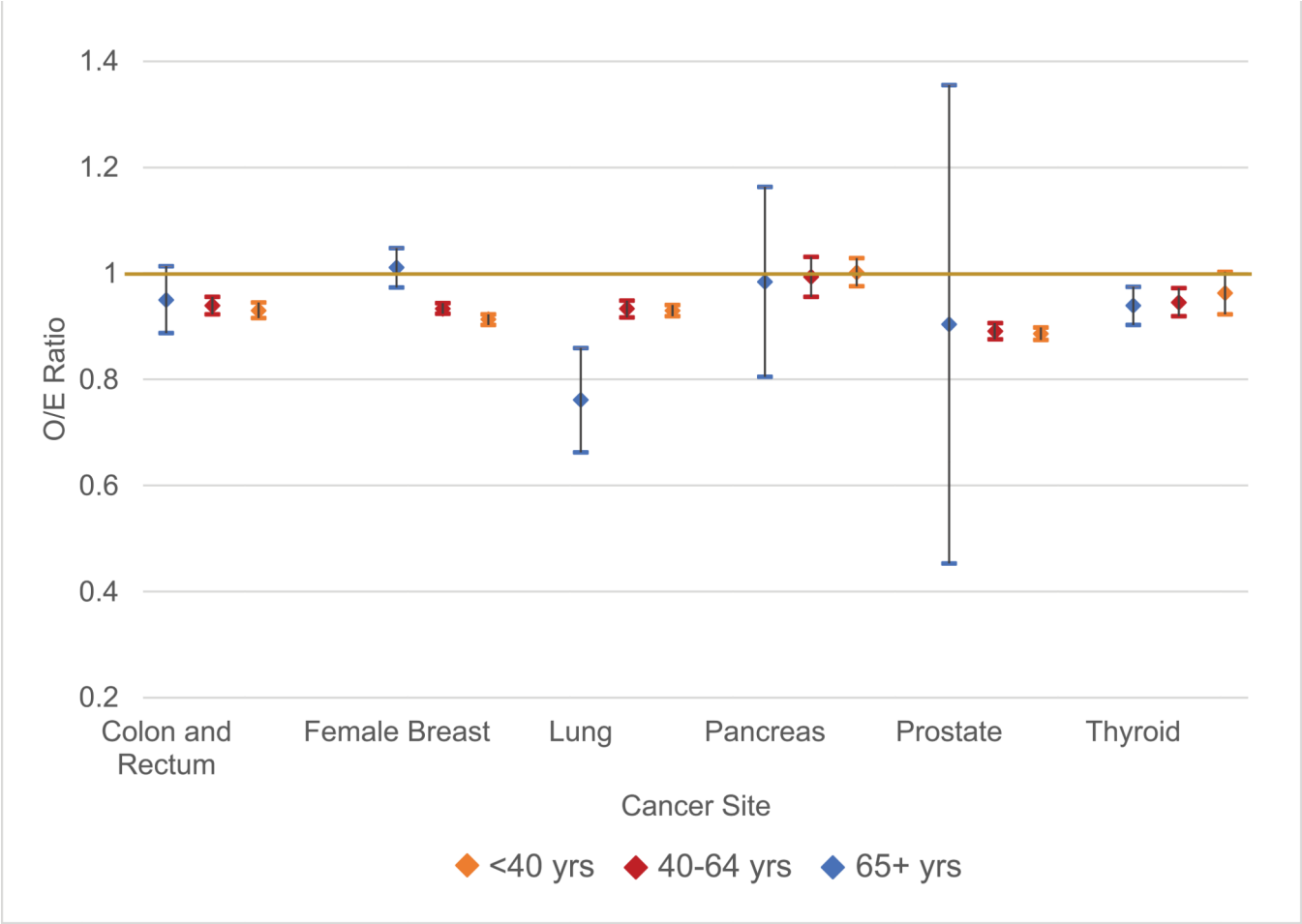

Figure 5.

Observed- to- expected ratio for newly diagnosed cancer cases in 2020 by age category and cancer site

Abbreviations. Yrs, Years

The observed 2020 case count was compared to the expected count by ratio (O/E ratio). The standard error for the ratio was obtained by the delta method, which was used to determine the p-value and 95% confidence interval for each O/E ratio. Data source for observed counts: SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and NCI's Surveillance, Epidemiology and End Results (SEER) Program Registries), certified by the North American Association of Central Cancer Registries (NAACCR) as meeting high-quality incidence data standards for the specified time periods, submitted December 2021.

Table 1.

Population-based cancer registries with high 12-month data completeness by cancer site, age and sex categories of interest, percent coverage of U.S. population (2020) and average annual case count (2015–2019)

Cancer site	Age/Sex group	Registries included (state abbreviation)	U.S. population covered (2020)[a] (%)	Average annual case count[b] (2015–2019)
Colorectal	Male and Female, 50–74 years	AL, GA, IA, KY, LA, ME, MT, NE, NY, NC, ND, OH, OK, WV, WY	25	3,649
Breast	Female, 40–74 years	AL, DE, GA, IA, KY, LA, ME, MS, MT, NE, NY, NC, ND, OH, OK, WV, WY	26	11,139
Lung	Male and Female, 55–74 years	KY, LA, ME, MS, MT, NY, NC, ND, OH, OK, WV	20	5,106
Pancreas	Male and Female, 50–74 years	KY, LA, ME, MS, MT, NY, NC, ND, OH, OK, WV	20	1,214
Prostate	Male, 50–74 years	GA, KY, LA, ME, MT, NE, NY, NC, ND, WV, WY	18	6,037
Thyroid	Male and Female, 50–74 years	AL, DE, GA, KY, LA, ME, MS, MT, NY, NC, ND, OH, OK, WV, WY	25	971

[a] Calculated using Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Populations - Total U.S. (1969–2020) <Katrina/Rita Adjustment> - Linked To County Attributes - Total U.S., 1969–2020 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, released January 2022.

[b] Calculated using SEER*Stat Database: NAACCR Incidence Data - Certification year and 12-month data, 2014–2020, for U.S. (which includes data from CDC's National Program of Cancer Registries (NPCR), CCR's Provincial and Territorial Registries, and NCI's Surveillance, Epidemiology, and End Results Program (SEER) Registries), certified by the North American Association of Central Cancer Registries (NAACCR) as meeting high-quality incidence data standards for the specified time periods, submitted December 2021.

Table 2.

Stage-specific observed-to-expected (O/E) ratio for newly diagnosed cases in 2020 by cancer type

Cancer Type	Stage	Observed[a]		Expected[b]		O/E ratio (95% CI)
		N	%	N	%	
Female breast	In situ	11,284	20.3	11,914	19.8	0.95 (0.93 – 0.97)
	Localized	29,366	52.7	32,756	54.5	0.90 (0.89 – 0.91)
	Advanced	13,292	23.9	13,579	22.6	0.98 (0.96 – 1.00)
	Unknown	1,753	3.1	1,815	3.0	0.97 (0.91 – 1.02)
Colorectal	In situ	481	2.6	645	3.2	0.75 (0.69 – 0.80)
	Localized	5,502	30.2	6,502	32.0	0.85 (0.83 – 0.87)
	Advanced	11,012	60.4	11,620	57.2	0.95 (0.93 – 0.97)
	Unknown	1,231	6.8	1,542	7.6	0.80 (0.75 – 0.84)
Lung	In situ	112	<0.1	136	<0.1	0.82 (0.60 – 1.04)
	Localized	7,218	28.3	8,461	30.4	0.85 (0.83 – 0.87)
	Advanced	17,396	68.1	17,992	64.7	0.97 (0.95 – 0.99)
	Unknown	804	3.1	1,200	4.3	0.67 (0.60 – 0.74)
Prostate	In situ [c]	NA	NA	NA	NA	NA
	Localized	19,850	65.8	23,297	69.6	0.85 (0.84 – 0.86)
	Advanced	5,376	17.8	6,056	18.1	0.89 (0.86 – 0.91)
	Unknown	4,950	16.4	4,126	12.3	1.20 (1.16 – 1.24)
Thyroid	In situ	170	3.5	442	8.3	0.38 (0.31 – 0.46)
	Localized	3,359	69.2	3,557	66.8	0.94 (0.90 – 0.97)
	Advanced	1,128	23.2	1,119	21.9	1.01 (0.94 – 1.08)
	Unknown	196	4.0	206	3.0	0.95 (0.78 – 1.13)
Pancreas	In situ	30	0.5	30	0.5	1.00 (0.69 – 1.31)
	Localized	1,014	16.7	1,129	18.1	0.90 (0.81 – 0.99)
	Advanced	4,781	78.8	4,747	76.0	1.01 (0.97 – 1.05)
	Unknown	245	4.0	343	5.5	0.71 (0.58 – 0.84)

[a] Observed counts for diagnosis year 2020, reported to NAACCR 12-month submission, December 2022.

[b] Estimated counts for diagnosis year 2020, based on counts reported to NAACCR for diagnosis years 2015–2019.

[c] Prostatic intraepithelial neoplasia (PIN III) not reportable to cancer registries.