Breast cancer is the second most common malignant disease, accounting for 12% of all cancers worldwide.\(^1,2\) Given the large number of patients with breast cancer, inefficiencies in care are expected to affect many patients and health care resources. In an effort to improve the timeliness, efficiency and patient outcomes of assessment for breast cancer, Ontario Health (Cancer Care Ontario) designated certain facilities as breast assessment sites, affiliated with the Ontario Breast Screening Program (OBSP).\(^3–5\) To qualify, facilities are required to have a patient navigation system that coordinates referrals through a defined clinical pathway and have access to diagnostic imaging, image-guided biopsies, and pathology and surgical services.\(^3–7\) Although these OBSP-affiliated breast assessment sites (O-BAS) are affiliated with the OBSP, symptomatic women may also be referred to an O-BAS, whether patients were screened or symptomatic. Our findings suggest that individuals with signs and symptoms of breast cancer would benefit from similar referral processes, oversight and standards to those used by the OBSP.

Background: In Ontario, patients with breast cancer typically receive their diagnoses through the Ontario Breast Screening Program (OBSP) after an abnormal screen, through screening initiated by a primary care provider or other referring physician, or through follow-up of symptoms by patients’ primary care providers. We sought to explore the association of the route to diagnosis (screening within or outside the OBSP or via symptomatic presentation) with use of OBSP-affiliated breast assessment sites (O-BAS), wait times until diagnosis or treatment, health care use and overall survival for patients with breast cancer.

Methods: In this retrospective cohort study, we used the Ontario Cancer Registry to identify adults (aged 18–105 yr) who received a diagnosis of breast cancer from 2013 to 2017. We excluded patients if they were not Ontario residents or had missing age or sex, or who died before diagnosis. We used logistic regression to evaluate factors associated with categorical variables (whether patients were or were not referred to an OBAS, whether patients were screened or symptomatic) and Cox proportional hazards regression to identify factors associated with all-cause mortality.

Results: Of 51,460 patients with breast cancer, 42,598 (83%) received their diagnoses at an O-BAS. Patients whose cancer was first detected through the OBSP were more likely than symptomatic patients to be given a diagnosis at an O-BAS (adjusted odds ratio 1.68, 95% confidence interval [CI] 1.57 to 1.80). Patients screened by the OBSP were given their diagnoses 1 month earlier than symptomatic patients, but diagnosis at an O-BAS did not affect the time until either diagnosis or treatment. Patients referred to an O-BAS had significantly better overall survival than those who were not referred (adjusted hazard ratio 0.73, 95% CI 0.66 to 0.80).

Interpretation: Patients screened through the OBSP were given their diagnoses earlier than symptomatic patients and were more likely to be referred to an O-BAS, which was associated with better survival. Our findings suggest that individuals with signs and symptoms of breast cancer would benefit from similar referral processes, oversight and standards to those used by the OBSP.

Competing interests: Steven Habbous, Esha Homenaught, Andriana Barisic, Sharmilaa Kandasamy, Vicky Majpruz, Katharina Forster, Marta Yurcan, Anna Chiarelli, Claire Holloway and Andrea Eisen are employees or consultants of Ontario Health (Cancer Care Ontario), which funds the Ontario Breast Screening Program. No other competing interests were declared.

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Abstract

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**Results:** Of 51,460 patients with breast cancer, 42,598 (83%) received their diagnoses at an O-BAS. Patients whose cancer was first detected through the OBSP were more likely than symptomatic patients to be given a diagnosis at an O-BAS (adjusted odds ratio 1.68, 95% confidence interval [CI] 1.57 to 1.80). Patients screened by the OBSP were given their diagnoses 1 month earlier than symptomatic patients, but diagnosis at an O-BAS did not affect the time until either diagnosis or treatment. Patients referred to an O-BAS had significantly better overall survival than those who were not referred (adjusted hazard ratio 0.73, 95% CI 0.66 to 0.80).

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In the present study, we explored the association of the route to diagnosis (screening within or outside the OBSP or via symptomatic presentation) with use of O-BAS, wait times until diagnosis or treatment, health care use and overall survival for patients with breast cancer.

**Methods**

**Study design and setting**
We conducted a retrospective population-based cohort study of patients in Ontario, Canada, where health care is provisioned under a single-payer system. We reported data in accordance with the Reporting of Studies Conducted Using Observational Routinely Collected Health Data (RECORD) checklist.10

The OBSP has operated since 1990 to deliver organized, population-based breast screening to eligible women aged 50–74 years.11 Men are not eligible for the program. Women are ineligible if they have previously had breast cancer or augmentation mammoplasty, or if they currently have acute breast symptoms. Although most women are screened biennially, those at increased risk of breast cancer are screened annually. The OBSP was expanded in July 2011 to screen women aged 30–69 years at high risk for breast cancer with annual digital mammography and magnetic resonance imaging (MRI), or with ultrasonography if MRI is contraindicated.12 Women who meet at least 1 of the high-risk criteria are eligible for screening (https://www.cancercareontario.ca/en/guidelines-advice/cancer-continuum/screening/breast-cancer-high-risk-women), even if they have a history of breast or other cancers, breast implants or unilateral mastectomy.

**Participants**
We included adult (aged 18–105 yr) patients with breast cancer who received their diagnoses in Ontario, Canada, from Jan. 1, 2013, to Dec. 31, 2017. We identified patients from the Ontario Cancer Registry using the site code C50 for breast cancer, with the behaviour code 3 (indicating primary invasive breast cancer) International Classification of Diseases for Oncology, 3rd edition. We included patients who had a valid Ontario health insurance number and postal code, and who accessed the Ontario Health Insurance Program (OHIP) within 1 year of the diagnosis date. We omitted patients who died before or on the diagnosis date, whose breast cancer was diagnosed by autopsy or who were missing age or sex.

**Data sources**
We identified patients with breast cancer and their date or fact of death from the Ontario Cancer Registry and the Registered Persons Database. We used the Integrated Client Management System (ICMS) to identify patients whose breast cancer was first detected through the OBSP, as well to determine whether these patients were referred to an O-BAS.

We captured measures of health care use and wait times using the physician billing (OHIP) database, the hospital admissions database (Discharge Abstract Database [DAD]) and the outpatient hospital database (National Ambulatory Care Reporting System [NACRS]).13,14 We used the Collaborative Staging database for staging and biomarker status.15 We used the Ontario Cancer Registry to identify topography (i.e., site of origin) and histology (Appendix 1, eTable S1, available at www.cmajopen.ca/content/10/2/E313/suppl/DC1).

We derived sociodemographic characteristics from the Census using the Postal Code Conversion File+ (version 7B for income and rurality, 2016 Census; version 6C for immigrant density, 2006 Census).16 We obtained treatment information from the OHIP, DAD, NACRS, Activity Level Reporting New Drug Funding Program (NDFP) and Ontario Drug Benefits databases.17 We linked databases using health insurance numbers. All databases employed are used for continuous system performance monitoring and undergo routine quality checks.

**Exposure**
We used the ICMS database to classify patients as OBSP-screened if their OBSP-initiated screening led to their breast cancer diagnosis, or as non-OBSP-screened if they had a screening mammogram in the OHIP database less than 12 months before diagnosis (Figure 1). We classified the remaining patients as symptomatic, who we presume engaged the health care system because they discovered a breast lump, or had breast pain, nipple discharge or inflammation.8 Non-OBSP-screened and symptomatic patients may have been screened more than 12 months previously through the OBSP, but this earlier screen did not lead to the breast cancer diagnosed during the study period.

We used the ICMS to identify whether OBSP-screened patients were assessed at an O-BAS (Appendix 1, eTable S2). To determine whether non-OBSP-screened and symptomatic patients were assessed at an O-BAS, we used the location of the patient’s biopsy from billing data, supplemented with the location of the patient’s surgery (OHIP).9,18

![Figure 1: Categorization of patients as screened through the Ontario Breast Screening Program (OBSP-screened), screened outside the OBSP (non-OBSP-screened) or symptomatic. Note: ICMS = Integrated Client Management System, OHIP = Ontario Health Insurance Plan.](image-url)
Covariates
We used the Collaborative Staging database to identify overall cancer stage and the tumours’ estrogen receptor, progesterone receptor and human epidermal growth factor receptor 2 status. We used DAD and NACRS to estimate comorbidity using the Charlson Comorbidity Index, with a window of 3 years before the diagnosis date, excluding cancer (Appendix 1, eFigure S1). We also included sociodemographic characteristics such as neighbourhood income quintile, rurality and neighbourhood immigrant density, as well as Local Health Integration Network (LHIN), which are crown agencies established by the Government of Ontario to plan, coordinate, integrate and fund health services at a local level (e.g., hospitals). To assign a patient to a specific LHIN, we used the postal code of their residence at the time of diagnosis.

Outcomes
As a measure of efficiency, we estimated the time from suspicion of breast cancer until diagnosis (diagnostic interval). For screen-detected cancers, the time of suspicion was the date of the screening test, identified from ICMS (OBSP-screened patients) or of the screening mammogram from OHIP (non-OBSP-screened patients). For symptomatic patients, we searched OHIP, DAD and NACRS for relevant encounters and diagnostic codes using methodology published elsewhere (Appendix 1, eTable S3).

We also estimated the time from diagnosis to start of treatment (pretreatment interval) using the earliest date of breast resection (Appendix 1, eTable S3), antineoplastic systemic therapy (identified from DAD, NACRS, Activity Level Reporting, NDFP and Ontario Drug Benefits) or chest radiation (identified from Activity Level Reporting). We also explored the frequency and timing of diagnostic tests, consultations and visits with health care providers from 6 months before diagnosis until the date of first treatment using OHIP, DAD and NACRS (Appendix 1, eTables S4–5).

As a measure of effectiveness, we measured overall patient survival. The follow-up period started at the time of diagnosis and ended at death (from the Ontario Cancer Registry, supplemented with the Registered Persons Database) or the last known health care encounter until Dec. 31, 2019.

Statistical analysis
We used bivariate or multinomial logistic regression to compare factors between groups, reporting odds ratios (ORs) and 95% confidence intervals (CIs). We used linear regression to explore factors associated with wait times, reporting β coefficients and 95% CIs, which represent the change in days per unit change in the covariate. We confirmed the absence of heteroscedasticity using the autoregression procedure in SAS. We used Cox proportional hazards regression to explore factors associated with all-cause mortality, reporting hazard ratios (HRs) and 95% CIs. For OBSP-screened patients, we corrected lead-time bias by subtracting \((1 - \exp[-\lambda t]) / \lambda\) from each patient’s survival time, where \(\lambda\) is the inverse of the mean sojourn time (24 mo, the average time for an asymptomatic patient to become symptomatic) and \(t\) is the survival time.

Unless otherwise stated, we adjusted all multivariable models for O-BAS status, screened or symptomatic presentation, age, sex, neighbourhood income quintile, neighbourhood immigrant density, rurality, Charlson Comorbidity Index, previous breast or other cancer, laterality, stage, hormone receptor profile, topography, histology and geography (Local Health Integration Network). These covariates were chosen because of data availability, their perceived clinical importance and their potential to control for known or unknown confounders.

We confirmed proportionality by visual inspection of Kaplan–Meier plots, log(–log) survival plots and Loess-smoothed Schoenfeld residuals versus time. We performed all analyses using SAS version 9.4 (SAS Institute Inc.). Statistical tests were 2-sided and evaluated at a 5% significance level. We suppressed all cells less than 6.

Ethics approval
Ethics approval was not required because this work was done for the purposes of health system improvement and aligns with Cancer Care Ontario’s role as a prescribed entity under Section 45 of Ontario’s Personal Health Information Protection Act.

Results
We identified a total of 51 460 patients with breast cancer (Appendix 1, eFigure S2). The mean age at diagnosis was 63 (standard deviation [SD] 13.7) years, 44 382 (86.2%) had no comorbidity, 3845 (7.5%) had a previous breast cancer and 42 598 (82.8%) were given their breast cancer diagnosis at an O-BAS (Table 1). A total of 28 107 (54.6%) patients were symptomatic, 13 615 (26.5%) were OBSP-screened and 9738 (18.9%) were non-OBSP-screened.

Referral to an O-BAS
After adjustment, patients referred to an O-BAS were more likely to be younger, have no comorbidities, live closer to an O-BAS and live in a higher-income urban neighbourhood (\(p < 0.001\) for all) (Table 1). Patients referred to an O-BAS had lower-stage disease (\(p < 0.0001\)), known hormone receptor status (\(p < 0.0001\)), a greater risk of previous breast cancer (\(p = 0.0005\)) and were more likely to have had an OBSP-screened cancer (OR 1.68, 95% CI 1.57 to 1.80) or non-OBSP-screened cancer (OR 1.32, 95% CI 1.23 to 1.41) than to be symptomatic.

Route of cancer detection
The proportion of patients who were OBSP-screened increased from 22.9% in 2013 to 28.8% in 2017, with correspondingly fewer patients presenting with symptoms (Figure 2). Symptomatic patients were more likely to reside in a lower-income neighbourhood (\(p < 0.0001\)) and have more comorbidities (\(p < 0.0001\)). They were also more likely to have...
### Table 1 (part 1 of 3): Sociodemographic, clinical and tumour characteristics of patients with breast cancer who were or were not referred to a Breast Assessment Site affiliated with the Ontario Breast Screening Program

| Characteristic                      | No. (%) of patients* | O-BAS v. non-O-BAS   | O-BAS v. non-O-BAS   |
|-------------------------------------|-----------------------|-----------------------|-----------------------|
|                                     | Non-O-BAS | O-BAS                  | Bivariate | Multivariable†        | p value | OR (95% CI) | p value | OR (95% CI) |
| Screening status                    |           |                        |           |                        |         |             |         |             |
| Symptomatic                         |           |                        |           |                        | < 0.0001| < 0.0001    |         |             |
| Non-OBSP-screened                   | 1477 (16.7)| 8261 (19.4)             | 1.49 (1.40 to 1.58) | 1.32 (1.23 to 1.41)    |
| OBSP-screened                       | 1477 (16.7)| 12 138 (28.5)           | 2.19 (2.06 to 2.33) | 1.68 (1.57 to 1.80)    |
| Sociodemographic                    |           |                        |           |                        |
| Sex                                 |           |                        |           |                        |
| Female                              | 8750 (98.7)| 42 285 (99.3)           | Ref.      | Ref.                  |
| Male                                | 112 (1.3)  | 313 (0.7)               | 0.58 (0.47 to 0.72) | 0.93 (0.73 to 1.19)    |
| Age, yr, mean ± SD (OR per 10-yr increment) | 66 ± 14.6 | 63 ± 13.5               | 0.87 (0.85 to 0.88) | 0.88 (0.86 to 0.90)    |
| Age, yr                             |           |                        |           |                        |
| < 50                                | 1328 (15.0)| 7244 (17.0)             | Ref.      | Ref.                  |
| 50–74                               | 4833 (54.5)| 26 048 (61.1)           | 0.99 (0.93 to 1.06) |         |
| > 74                                | 2701 (30.5)| 9306 (21.8)             | 0.63 (0.59 to 0.68) |         |
| After-tax neighbourhood income quintile‡ |           |                        |           |                        |
| Highest                             | 1756 (19.9)| 9368 (22.2)             | Ref.      | Ref.                  |
| Mid-high                            | 1640 (18.6)| 8235 (19.5)             | 0.94 (0.88 to 1.01) | 0.91 (0.84 to 0.99)    |
| Middle                              | 1678 (19.1)| 8291 (19.7)             | 0.93 (0.86 to 1.00) | 0.93 (0.85 to 1.00)    |
| Mid-low                             | 1797 (20.4)| 8539 (20.3)             | 0.89 (0.83 to 0.96) | 0.88 (0.81 to 0.95)    |
| Lowest                              | 1933 (22.0)| 7695 (18.3)             | 0.75 (0.70 to 0.80) | 0.77 (0.70 to 0.83)    |
| Neighbourhood immigrant density‡    |           |                        |           | 0.004                 | 0.0002  |
| Least dense                         | 5221 (59.4)| 24 537 (58.1)           | Ref.      | Ref.                  |
| Mid-dense                           | 2068 (23.5)| 10 661 (25.2)           | 1.10 (1.04 to 1.16) | 1.09 (1.01 to 1.17)    |
| Most dense                          | 1497 (17.0)| 7061 (16.7)             | 1.00 (0.94 to 1.07) | 0.91 (0.83 to 1.00)    |
| Rurality‡                           |           |                        |           | 0.004                 | 0.0002  |
| Urban                               | 7479 (84.9)| 37 789 (89.7)           | Ref.      | Ref.                  |
| Rural                               | 1326 (15.1)| 4351 (10.3)             | 0.65 (0.61 to 0.69) | 0.65 (0.59 to 0.71)    |
| Distance to closest O-BAS, km, mean ± SD (OR per 100-km increment)§ | 15.7 ± 21.6| 11.9 ± 19.2             | 0.44 (0.40 to 0.49) | 0.36 (0.31 to 0.42)    |
| Clinical                            |           |                        |           |                        |
| Charlson Comorbidity Index          |           |                        |           | < 0.0001              | 0.0002  |
| Missing                             | 3011 (34.0)| 16 228 (38.1)           | 1.12 (1.06 to 1.18) | 1.04 (0.98 to 1.10)    |
| 0                                   | 4318 (48.7)| 20 825 (48.9)           | Ref.      | Ref.                  |
| 1                                   | 935 (10.6) | 3665 (8.6)              | 0.81 (0.75 to 0.88) | 0.89 (0.82 to 0.97)    |
| 2                                   | 316 (3.6) | 1088 (2.6)              | 0.71 (0.63 to 0.81) | 0.88 (0.76 to 1.01)    |
| ≥ 3                                 | 282 (3.2) | 792 (1.9)               | 0.58 (0.51 to 0.67) | 0.78 (0.66 to 0.91)    |
| Previous breast cancer relative to diagnosis, yr |           |                        |           | < 0.0001              | 0.0005  |
| Never                               | 8074 (91.1)| 39 541 (92.8)           | Ref.      | Ref.                  |
| ≤ 5                                 | 72 (0.8)  | 250 (0.6)               | 0.71 (0.55 to 0.92) | 1.06 (0.79 to 1.41)    |
| 5–10                                | 239 (2.7) | 852 (2.0)               | 0.73 (0.63 to 0.84) | 1.21 (1.03 to 1.43)    |
| ≥ 10                                | 477 (5.4) | 1955 (4.6)              | 0.84 (0.76 to 0.93) | 1.25 (1.11 to 1.41)    |
### Table 1 (part 2 of 3): Sociodemographic, clinical and tumour characteristics of patients with breast cancer who were or were not referred to a Breast Assessment Site affiliated with the Ontario Breast Screening Program

| Characteristic | No. (%) of patients* | O-BAS v. non-O-BAS Bivariate | O-BAS v. non-O-BAS Multivariable† |
|---------------|-----------------------|------------------------------|----------------------------------|
|               | Non-O-BAS             | O-BAS                        | OR (95% CI)                       | p value | OR (95% CI) | p value |
|               | n = 8862              | n = 42598                    |                                  |         |             |         |
| Previous other cancer relative to diagnosis, yr | | | | | | |
| Never | 8180 (92.3) | 39563 (92.9) | Ref. | Ref. | < 0.0001 | 0.15 |
| ≤ 5 | 295 (3.3) | 1172 (2.8) | 0.82 (0.72 to 0.94) | 1.01 (0.87 to 1.17) | |
| 5–10 | 136 (1.5) | 686 (1.6) | 1.04 (0.87 to 1.26) | 1.22 (1.00 to 1.50) | |
| ≥ 10 | 251 (2.8) | 1177 (2.8) | 0.97 (0.84 to 1.11) | 1.11 (0.95 to 1.29) | |
| Cancer | | | | | | |
| Laterality | | | | | | |
| Right | 4288 (48.4) | 20701 (48.7) | Ref. | Ref. | | 0.47 | 0.03 |
| Left | 4329 (49.9) | 21516 (50.6) | 1.03 (0.98 to 1.08) | 1.02 (0.97 to 1.08) | |
| Bilateral | 65 (0.7) | 319 (0.7) | 1.02 (0.78 to 1.33) | 1.47 (1.09 to 1.98) | |
| Cancer stage | | | | | < 0.0001 | < 0.0001 |
| 0 | 28 (0.3) | 171 (0.4) | 0.91 (0.61 to 1.36) | 1.57 (1.02 to 2.42) | |
| 1 | 2755 (31.7) | 18463 (44.1) | Ref. | Ref. | | |
| 2 | 2861 (32.9) | 15707 (37.5) | 0.82 (0.77 to 0.87) | 0.91 (0.85 to 0.97) | |
| 3 | 1134 (13.0) | 5023 (12.0) | 0.66 (0.61 to 0.71) | 0.75 (0.69 to 0.82) | |
| 4 | 1085 (12.5) | 1343 (3.2) | 0.19 (0.17 to 0.20) | 0.23 (0.21 to 0.26) | |
| Unknown | 832 (9.6) | 1167 (2.8) | 0.21 (0.19 to 0.23) | 0.37 (0.32 to 0.42) | |
| Histology | | | | | < 0.0001 | < 0.0001 |
| Ductal | 6254 (70.6) | 32661 (76.7) | Ref. | Ref. | | |
| Lobular | 800 (9.0) | 3689 (8.7) | 0.88 (0.81 to 0.96) | 1.00 (0.92 to 1.10) | |
| Ductal and lobular | 298 (3.4) | 1894 (4.4) | 1.21 (1.07 to 1.38) | 1.20 (1.05 to 1.38) | |
| Adenocarcinoma | 366 (4.1) | 930 (2.2) | 0.49 (0.43 to 0.55) | 0.73 (0.62 to 0.84) | |
| Mucinous | 157 (1.8) | 797 (1.9) | 0.97 (0.82 to 1.16) | 1.02 (0.84 to 1.23) | |
| Other | 987 (11.1) | 2627 (6.2) | 0.51 (0.47 to 0.55) | 0.89 (0.81 to 0.98) | |
| Hormone receptor profile | | | | | < 0.0001 | < 0.0001 |
| ER–, PR–, HER2– | 679 (7.7) | 3814 (9.0) | Ref. | Ref. | | 0.08 | < 0.0001 |
| ER–, PR–, HER2+ | 325 (3.7) | 1807 (4.2) | 0.99 (0.86 to 1.14) | 1.02 (0.88 to 1.20) | |
| ER–, PR+, HER2– | 36 (0.4) | 182 (0.4) | 0.90 (0.62 to 1.30) | 1.10 (0.75 to 1.64) | |
| ER–, PR+, HER2+ | 20 (0.2) | 69 (0.2) | 0.61 (0.37 to 1.02) | 0.91 (0.53 to 1.57) | |
| ER+, PR–, HER2– | 561 (6.3) | 2751 (6.5) | 0.87 (0.77 to 0.99) | 0.87 (0.76 to 0.99) | |
| ER+, PR+, HER2– | 204 (2.3) | 1036 (2.4) | 0.90 (0.76 to 1.07) | 0.94 (0.78 to 1.13) | |
| ER+, PR+, HER2+ | 4379 (49.4) | 24116 (56.6) | 0.98 (0.90 to 1.07) | 0.90 (0.82 to 0.99) | |
| ER+, PR+, HER2+ | 473 (5.3) | 2773 (6.5) | 1.04 (0.92 to 1.19) | 0.97 (0.85 to 1.11) | |
| Missing | 2185 (24.7) | 6050 (14.2) | 0.49 (0.45 to 0.54) | 0.66 (0.59 to 0.74) | |
| Topography | | | | | < 0.0001 | < 0.0001 |
| Upper–outer quadrant | 2754 (31.1) | 15672 (36.8) | Ref. | Ref. | | |
| Breast NOS | 1452 (16.4) | 3411 (8.0) | 0.41 (0.38 to 0.44) | 0.70 (0.64 to 0.76) | |
| Overlapping lesion | 1618 (18.3) | 7720 (18.1) | 0.84 (0.78 to 0.90) | 0.93 (0.87 to 1.00) | |
| Upper–inner quadrant | 1007 (11.4) | 5806 (13.6) | 1.01 (0.94 to 1.10) | 0.98 (0.90 to 1.07) | |
| Lower–outer quadrant | 721 (8.1) | 4056 (9.5) | 0.99 (0.90 to 1.08) | 1.00 (0.91 to 1.10) | |
| Central portion | 503 (5.7) | 2205 (5.2) | 0.77 (0.69 to 0.86) | 0.91 (0.81 to 1.02) | |
| Lower–inner quadrant | 470 (5.3) | 2558 (6.0) | 0.96 (0.86 to 1.06) | 0.98 (0.87 to 1.10) | |
| Nipple | 236 (2.7) | 922 (2.2) | 0.69 (0.59 to 0.80) | 0.77 (0.66 to 0.91) | |
| Axillary tail | 101 (1.1) | 248 (0.6) | 0.43 (0.34 to 0.55) | 0.56 (0.43 to 0.72) | |
Table 1 (part 3 of 3): Sociodemographic, clinical and tumour characteristics of patients with breast cancer who were or were not referred to a Breast Assessment Site affiliated with the Ontario Breast Screening Program

| Characteristic | Non-O-BAS | O-BAS | O-BAS v. non-O-BAS | O-BAS v. non-O-BAS |
|---------------|-----------|-------|-------------------|-------------------|
|               | n = 8862  | n = 42 598 |                |                   |
| Year of diagnosis (row percentages provided) | 0.01 | 0.04 |
| 2013          | 1767 (19.9) | 8037 (18.9) | Ref.          | Ref.           |
| 2014          | 1748 (19.7) | 8447 (19.8) | 1.06 (0.99 to 1.14) | 1.03 (0.95 to 1.11) |
| 2015          | 1715 (19.4) | 8518 (20.0) | 1.09 (1.02 to 1.18) | 1.03 (0.96 to 1.12) |
| 2016          | 1882 (21.2) | 8695 (20.4) | 1.02 (0.95 to 1.09) | 0.98 (0.90 to 1.06) |
| 2017          | 1750 (19.7) | 8901 (20.9) | 1.12 (1.04 to 1.20) | 1.10 (1.02 to 1.19) |

Note: CI = confidence interval, ER = estrogen receptor, HER2 = human epidermal growth factor receptor 2, NOS = not otherwise specified, O-BAS = OBSP-affiliated breast assessment site, OBSP = Ontario Breast Screening Program, OR = odds ratio, PR = progesterone receptor, Ref. = reference category, SD = standard deviation.

*Unless indicated otherwise.
†n = 49 420; adjusted for screening status, age, neighbourhood income quintile, neighbourhood immigrant density, rurality, distance to the closest O-BAS, Charlson Comorbidity Index, previous breast cancer, previous other cancer, laterality, cancer stage, hormone receptor profile, topography, year of diagnosis and Local Health Integration Network.
‡Adapted from Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017), which is based on data licensed from Canada Post Corporation.16 We used the patient’s postal code at diagnosis.
§Odds ratio reflects the odds of diagnosis in an O-BAS for every 100-km increase in Euclidean distance to the patient’s closest O-BAS. We used the patient’s postal code at diagnosis.

advanced-stage breast cancer at diagnosis than screened patients; 8166 (29.1%) of symptomatic patients had stage 1 breast cancer at diagnosis, compared with 4519 (46.5%) of non-OBSP-screened patients and 8523 (62.6%) of OBSP-screened patients (Table 2). Symptomatic patients were more likely to have biologically more aggressive disease; 4319 (15.4%) had tumours negative for estrogen receptor (v. 1337 [9.8%] for OBSP-screened patients) and 4072 (14.5%) had tumours negative for human epidermal growth factor receptor 2 (v. 1429 [10.5%] for OBSP-screened patients).

**Diagnostic interval**

The diagnostic interval (i.e., time from suspicion of breast cancer until diagnosis) was a median 35 (interquartile range [IQR] 19 to 82) days. Diagnosis at an O-BAS did not meaningfully reduce the diagnostic interval (β = -2.0 d, 95% CI = -3.6 to -0.3 d) (Table 3) or shorter subintervals (Appendix 1, eTable S6).

Compared with patients with stage 1 cancer, the diagnostic interval was 10, 13, 21 and 9 days shorter for patients with stage 2, 3, 4 and unknown stage, respectively (p < 0.0001). Patients with bilateral breast cancer had a shorter diagnostic interval (β = -9.7 d, 95% CI = -16.3 to -3.0 d) than those with unilateral disease, as did male patients (β = -12.6 d, 95% CI = -19.3 to -5.9 d) compared with female patients. Compared with symptomatic patients, the diagnostic interval was 25 days shorter (β = -24.8 d, 95% CI = -26.2 to -23.3 d) for OBSP-screened patients and 5 days longer (β = 4.7 d, 95% CI = 3.3 to 6.3 d) for non-OBSP-screened patients. No other demographic and clinical factors were meaningfully associated with the length of the diagnostic interval.

**Pretreatment interval**

The first intervention provided was surgery for 40 652 (79.0%) patients and systemic therapy for 9296 (18.1%) patients. The pretreatment interval (i.e., time from diagnosis to start of treatment) was a median 34 (IQR 23 to 47) days. After adjustment, no factors were associated with a meaningful delay (Table 3).

**Health care use**

Patients referred to an O-BAS were more likely to have received various diagnostic tests before treatment than those who were not referred, including diagnostic mammography (90.9% v. 78.2%), screening mammography (43.7% v. 30.3%), breast biopsy (96.6% v. 85.1%), breast ultrasonography (94.3% v. 82.1%) and breast MRI (22.6% v. 13.2%) (Table 4). However, patients referred to an O-BAS were less likely to have had abdominal or thoracic computed tomography (24.5% v. 38.0%) and chest radiography (39.3% v. 48.5%). Patients referred to an O-BAS were more likely than those who were not referred to have a consultation with a general surgeon or general thoracic surgeon (97.0% v. 86.8%), but were less likely to visit their primary care provider (40.0% v. 48.9%), have a consultation with an internist (17.7% v. 24.0%) or medical oncologist (14.5% v. 26.0%).

Patients referred to an O-BAS had a consultation or visit with a general surgeon or general thoracic surgeon later than those who were not referred (median 8 d v. 1 d after diagnosis) (Table 4). However, the time from diagnosis until consultation with a medical oncologist or radiation oncologist was longer, with a median 20 (IQR 11 to 32) days and 21 (IQR 10 to 34) days overall, respectively.
Overall survival

Patients were followed for an average of 42 (SD 21.5) months after diagnosis. After adjustment, patients referred to an O-BAS for diagnosis had better overall survival than those who were not (HR 0.72, 95% CI 0.68 to 0.76) (Table 5). Overall survival was also better for patients who were either OBSP-screened (HR 0.72, 95% CI 0.66 to 0.79) or non-OBSP-screened (HR 0.67, 95% CI 0.62 to 0.72), compared with symptomatic patients.

Without adjustment, O-BAS had a larger impact on survival among symptomatic patients (HR 0.43, 95% CI 0.41 to 0.45), and non-OBSP-screened patients (HR 0.48, 95% CI 0.41 to 0.56) than OBSP-screened patients (HR 0.69, 95% CI 0.55 to 0.88) ($p_{interaction} = 0.0003$) (Figure 3). In the adjusted
Table 2 (part 1 of 3): Sociodemographic, clinical and cancer characteristics of patients whose breast cancer was detected by screening or by symptoms

| Characteristic | No. (%) of patients | OR (95% CI)* | p value* |
|---------------|---------------------|--------------|----------|
| **O-BAS**     |                     |              |          |
| Yes           | 12 138 (89.2)       | 1.74 (1.62 to 1.86) | < 0.0001 |
| No            | 1477 (10.8)         | Ref.         |          |
| **Sociodemographic** |                   |              |          |
| Sex           |                     |              |          |
| Female        | 13 615 (100.0)      | NA           | 0.18 (0.12 to 0.28) |
| Male          | 0 (0.0)             | Ref.         |          |
| Age, yr, mean ± SD (OR per 10-yr increment) | | 1.09 (0.07 to 1.11) | < 0.0001 |
| Neighbourhood income quintile† | | 0.84 (0.78 to 0.91) | 0.07 |
| Highest       | 3042 (22.6)         | Ref.         |          |
| Mid-high      | 2727 (20.3)         | 1.03 (0.96 to 1.11) | 0.99 (0.92 to 1.06) |
| Middle        | 2707 (20.1)         | 1.02 (0.95 to 1.10) | 0.95 (0.88 to 1.03) |
| Mid to low    | 2703 (20.1)         | 0.97 (0.90 to 1.04) | 0.94 (0.87 to 1.02) |
| Lowest        | 2275 (16.9)         | 0.84 (0.78 to 0.91) | 0.85 (0.78 to 0.92) |
| Neighbourhood immigrant density† | | 0.95 (0.89 to 1.01) | 0.07 |
| Least dense   | 8368 (61.9)         | Ref.         |          |
| Mid-dense     | 3124 (23.1)         | 1.04 (0.98 to 1.11) | 1.04 (0.94 to 1.15) |
| Most dense    | 2018 (14.9)         | 1.01 (0.93 to 1.10) | 1.09 (1.00 to 1.19) |
| Rurality†     | 1693 (12.6)         | Ref.         |          |
| Urban         | 11 765 (87.4)       | Ref.         |          |
| Rural         | 1693 (12.6)         | Ref.         |          |
| Distance to closest O-BAS, km, mean ± SD (OR per 100-km increment)‡ | | 0.96 (0.83 to 1.11) | 0.01 |
| Cognitive Comorbidity Index | | 0.71 (0.59 to 0.86) | 0.32 |
| Missing       | 5328 (39.1)         | 1.08 (1.03 to 1.13) | < 0.0001 |
| 0             | 6738 (49.5)         | 1.04 (0.99 to 1.10) |          |
| 1             | 1095 (8.0)          | 0.83 (0.76 to 0.91) | 0.91 (0.83 to 0.99) |
| 2             | 277 (2.0)           | 0.65 (0.56 to 0.76) | 0.65 (0.55 to 0.76) |
| ≥ 3           | 177 (1.3)           | 0.52 (0.43 to 0.63) | 0.71 (0.59 to 0.86) |
| Previous breast cancer relative to diagnosis, yr | | 0.03 (0.02 to 0.05) | < 0.0001 |
| Never         | 13 576 (99.7)       | Ref.         |          |
| ≤ 5           | < 6                 | 0.03 (0.01 to 0.08) | 0.90 (0.69 to 1.18) |
| 5–10          | 17 (0.1)            | 0.03 (0.02 to 0.05) | 1.01 (0.87 to 1.17) |
| ≥ 10          | 22 (0.2)            | 0.02 (0.01 to 0.03) | 1.05 (0.95 to 1.16) |
| Previous other cancer relative to diagnosis, yr | | 0.63 (0.54 to 0.72) | < 0.0001 |
| Never         | 12 718 (93.4)       | Ref.         |          |
| ≤ 5           | 313 (2.3)           | 0.63 (0.54 to 0.72) | 0.96 (0.83 to 1.11) |
| 5–10          | 221 (1.6)           | 0.87 (0.73 to 1.04) | 1.03 (0.85 to 1.25) |
| ≥ 10          | 363 (2.7)           | 0.71 (0.63 to 0.82) | 0.81 (0.69 to 0.95) |
Table 2 (part 2 of 3): Sociodemographic, clinical and cancer characteristics of patients whose breast cancer was detected by screening or by symptoms

| Characteristic                                      | No. (%) of patients | OR (95% CI)* | p value* |
|-----------------------------------------------------|---------------------|--------------|----------|
|                                                     | OBSP-screened n = 13615 | Non-OBSP-screened n = 9738 | Symptomatic n = 28107 | OBSP-screened v. symptomatic | Non-OBSP-screened v. symptomatic |       |
| **Cancer**                                          |                     |              |          |                      |                          |       |
| Laterality                                          |                     |              |          |                      |                          |       |
| Right                                               | 6660 (48.9)         | 4735 (48.8)  | 13594 (48.7) | Ref.                 | Ref.                     | 0.007 |
| Left                                                | 6881 (50.6)         | 4909 (50.6)  | 14055 (50.4) | 0.99 (0.95 to 1.04)  | 1.00 (0.95 to 1.05)       |       |
| Bilateral                                           | 71 (0.5)            | 61 (0.6)     | 252 (0.9)   | 0.59 (0.43 to 0.79)  | 0.75 (0.56 to 1.01)       |       |
| Cancer stage                                        |                     |              |          |                      |                          | < 0.0001 |
| 0                                                   | 32 (0.2)            | 62 (0.6)     | 105 (0.4)   | 0.52 (0.34 to 0.79)  | 0.89 (0.64 to 1.25)       |       |
| 1                                                   | 8523 (63.5)         | 4529 (47.4)  | 8166 (29.6) | Ref.                 | Ref.                     |       |
| 2                                                   | 3859 (28.7)         | 3235 (33.8)  | 11474 (41.6) | 0.31 (0.29 to 0.32)  | 0.50 (0.47 to 0.53)       |       |
| 3                                                   | 731 (5.4)           | 1057 (11.1)  | 4369 (15.8) | 0.16 (0.14 to 0.17)  | 0.42 (0.39 to 0.46)       |       |
| 4                                                   | 97 (0.7)            | 269 (2.8)    | 2062 (7.5)  | 0.06 (0.05 to 0.07)  | 0.25 (0.22 to 0.29)       |       |
| Unknown                                             | 185 (1.4)           | 405 (4.2)    | 1409 (5.1)  | 0.27 (0.22 to 0.32)  | 0.55 (0.48 to 0.64)       |       |
| **Histology**                                       |                     |              |          |                      |                          | < 0.0001 |
| Ductal                                              | 10837 (79.6)        | 7124 (73.2)  | 20954 (74.6) | Ref.                 | Ref.                     |       |
| Lobular                                             | 1213 (8.9)          | 926 (9.5)    | 2350 (8.4)  | 1.16 (1.07 to 1.26)  | 1.28 (1.18 to 1.40)       |       |
| Ductal and lobular                                  | 604 (4.4)           | 441 (4.5)    | 1147 (4.1)  | 1.06 (0.95 to 1.19)  | 1.16 (1.03 to 1.30)       |       |
| Adenocarcinoma                                      | 292 (2.1)           | 264 (2.7)    | 740 (2.6)   | 1.01 (0.86 to 1.18)  | 1.22 (1.04 to 1.43)       |       |
| Mucinous                                            | 224 (1.6)           | 188 (1.9)    | 542 (1.9)   | 0.56 (0.47 to 0.66)  | 0.90 (0.76 to 1.08)       |       |
| Other                                               | 445 (3.3)           | 795 (8.2)    | 2374 (8.4)  | 0.59 (0.53 to 0.67)  | 1.18 (1.07 to 1.30)       |       |
| **Hormone receptor profile**                        |                     |              |          |                      |                          | < 0.0001 |
| ER–, PR–, HER2–                                     | 895 (6.6)           | 822 (8.4)    | 2776 (9.9)  | Ref.                 | Ref.                     |       |
| ER–, PR–, HER2+                                     | 402 (3.0)           | 394 (4.0)    | 1336 (4.8)  | 0.98 (0.85 to 1.13)  | 1.02 (0.88 to 1.17)       |       |
| ER–, PR+, HER2–                                     | 29 (0.2)            | 45 (0.5)     | 144 (0.5)   | 0.63 (0.41 to 0.98)  | 1.08 (0.76 to 1.54)       |       |
| ER–, PR+, HER2+                                     | 11 (0.1)            | 15 (0.2)     | 63 (0.2)    | 0.78 (0.40 to 1.53)  | 0.98 (0.55 to 1.75)       |       |
| ER+, PR–, HER2–                                     | 923 (6.8)           | 625 (6.4)    | 1764 (6.3)  | 1.47 (1.30 to 1.66)  | 1.14 (1.01 to 1.29)       |       |
| ER+, PR+, HER2+                                     | 274 (2.0)           | 222 (2.3)    | 744 (2.6)   | 1.16 (0.98 to 1.37)  | 1.03 (0.86 to 1.22)       |       |
| ER+, PR+, HER2+                                     | 8736 (64.2)         | 5347 (54.9)  | 14412 (51.3) | 1.45 (1.33 to 1.59)  | 1.11 (1.02 to 1.21)       |       |
| Missing                                             | 1603 (11.8)         | 1693 (17.4)  | 4939 (17.6) | 1.18 (1.05 to 1.31)  | 1.16 (1.04 to 1.29)       |       |
| **Topography**                                      |                     |              |          |                      |                          | < 0.0001 |
| Upper–outer quadrant                                | 5462 (40.1)         | 3497 (35.9)  | 9467 (33.7) | Ref.                 | Ref.                     |       |
| Overlapping lesion                                  | 2578 (18.9)         | 1742 (17.9)  | 5018 (17.9) | 0.92 (0.86 to 0.98)  | 0.97 (0.91 to 1.04)       |       |
| Breast NOS                                          | 811 (6.0)           | 876 (9.0)    | 3176 (11.3) | 0.63 (0.57 to 0.69)  | 0.85 (0.77 to 0.93)       |       |
| Lower–outer quadrant                                | 1227 (9.0)          | 948 (9.7)    | 2602 (9.3)  | 0.82 (0.75 to 0.88)  | 0.99 (0.90 to 1.08)       |       |
| Upper–inner quadrant                                | 1986 (14.6)         | 1260 (12.9)  | 3567 (12.7) | 0.85 (0.79 to 0.91)  | 0.91 (0.84 to 0.98)       |       |
| Lower–inner quadrant                                | 820 (6.0)           | 578 (5.9)    | 1630 (5.8)  | 0.84 (0.76 to 0.93)  | 0.93 (0.84 to 1.04)       |       |
| Central portion                                     | 477 (3.5)           | 539 (5.5)    | 1692 (6.0)  | 0.63 (0.56 to 0.71)  | 1.00 (0.90 to 1.12)       |       |
| Nipple                                              | 202 (1.5)           | 233 (2.4)    | 723 (2.6)   | 0.58 (0.49 to 0.69)  | 0.88 (0.75 to 1.04)       |       |
| Axillary tail                                       | 52 (0.4)            | 65 (0.7)     | 232 (0.8)   | 0.55 (0.39 to 0.76)  | 0.87 (0.65 to 1.16)       |       |
model, the difference of the effect of O-BAS on overall survival was similar across patient types ($p_{interaction} = 0.85$): HR 0.73 (95% CI 0.69 to 0.78) among symptomatic patients; HR 0.74 (95% CI 0.62 to 0.87) among non-OBSP-screened patients; and HR 0.73 (95% CI 0.57 to 0.93) among OBSP-screened patients.

Patients also had worse overall survival if they were older, lived in a lower-income neighbourhood, had more comorbidities or previous cancer, cancer of a more advanced stage or had triple-negative disease (i.e., negative for the estrogen receptor, progesterone receptor and human epidermal growth factor receptor 2) ($p < 0.0001$ for all, Table 5).

### Interpretation

Patients whose breast cancer was screened through the OBSP had a faster time to diagnosis and were more likely to be referred to an O-BAS than symptomatic patients. Attendance at an O-BAS was associated with improved overall survival.

As of 1998, the OBSP implemented a process whereby screened patients can be directly referred for diagnostic follow-up (at an O-BAS or other assessment site) by the OBSP screening site responsible for that patient’s work-up. Our results show that similar improvements are needed for symptomatic patients (Appendix 1, eFigure S3). Symptomatic patients exhibit features associated with worse prognosis, including older age at diagnosis, more advanced stage at diagnosis and more biologically aggressive tumours. The OBSP are high-volume centres that are equipped to manage complex patients and efficiently render a diagnosis. Despite this, symptomatic patients were less likely to be given their diagnosis at an O-BAS (Appendix 1, eFigure S3a-c). A shorter time to treatment may be more important for patients with more aggressive tumours, which appear to be more common among symptomatic patients. However, we observed that symptomatic patients had a longer time until diagnosis (Appendix 1, eFigure S3d-e). Anxiety during the diagnostic interval is high, and may be higher for patients with symptoms. Thus, symptomatic patients may again derive greater benefit from a shorter diagnostic interval. In addition, since there is comprehensive data collection for the OBSP-screened population, patients who are screened through OBSP can learn about their risk of having cancer, given an abnormal screen. There is no parallel data collection for asymptomatic patients (Appendix 1, eFigure S3c-g).

The OBSP requires that O-BAS adhere to requirements outlined in its standard operating procedures. In addition, O-BAS are required to develop mechanisms for ongoing evaluation and quality improvement, and to implement processes to notify the referring physician of abnormal test results, recommendations for biopsy and the diagnosis. However, about 74% of all breast cancer cases are diagnosed outside the OBSP and are therefore not subject to those same standards, reporting and performance management requirements. Funnelling symptomatic patients through an organized system is therefore expected to improve clinical and patient-reported outcomes, and to provide data necessary to inform quality improvement.
Table 3 (part 1 of 2): Factors associated with wait times

| Characteristic                        | Diagnostic interval | Pretreatment interval |
|---------------------------------------|---------------------|-----------------------|
|                                       | Adjusted β (95% CI)* | p value              | Adjusted β (95% CI)* | p value              |
| O-BAS                                 |                     |                       |
| No                                    | Ref.                |                       |
| Yes                                   | −2.0 (−3.6 to −0.3)  | < 0.0001              | −3.9 (−4.7 to −3.2)  | < 0.0001              |
| Screening                             |                     |                       |
| Symptomatic                           | Ref.                |                       |
| OBSP-screened                         | −24.8 (−26.2 to −23.3) | 0.3 (0.1 to 0.5)      |
| Non-OBSP-screened                     | 4.7 (3.3 to 6.3)    |                       | −1.2 (−1.9 to −0.5)  |
| Sociodemographic                      |                     |                       |
| Age (per 10-yr increment)             | −3.3 (−3.7 to −2.8)  |                       |
| Sex                                   |                     |                       |
| Female                                | Ref.                |                       |
| Male                                  | −12.6 (−19.3 to −5.9) | 0.3 (0.1 to 0.5)      |
| Neighbourhood income quintile‡        | 0.97 (0.97 to 0.97)  | 0.004                 |
| Highest                               |                     |                       |
| Mid-high                              | −0.4 (−2.2 to 1.4)  | 0.3 (−0.5 to 1.1)     |
| Middle                                | −0.1 (−2.0 to 1.7)  | 0.6 (−0.2 to 1.4)     |
| Mid-low                               | 0.2 (−1.7 to 2.0)   | 1.1 (0.3 to 1.9)      |
| Lowest                                | 0.2 (−1.7 to 2.2)   | 1.6 (0.7 to 2.4)      |
| Neighbourhood immigrant density‡      | < 0.0001            | 0.18                  |
| Least dense                           |                     |                       |
| Mid-dense                             | 3.7 (2.1 to 5.3)    | 0.4 (−0.3 to 1.1)     |
| Most dense                            | 6.3 (4.2 to 8.4)    | 0.9 (−0.1 to 1.9)     |
| Rurality‡                             |                     |                       |
| Urban                                 | Ref.                |                       |
| Rural                                 | −0.1 (−2.3 to 2.1)  | −1.0 (−1.9 to 0.0)    |
| Distance to closest O-BAS (per 100-km increment)§ | 0.9 (−3.0 to 4.7) | 0.6 (−1.2 to 2.3) |
| Clinical                              |                     |                       |
| Charlson Comorbidity Index            | < 0.0001            | < 0.0001              |
| Missing                               | −7.8 (−9.1 to −6.5)  | 1.0 (0.4 to 1.5)      |
| 0                                     | Ref.                |                       |
| 1                                     | 1.8 (−0.9 to 3.3)   | 0.4 (−0.5 to 1.4)     |
| 2                                     | −0.5 (−4.2 to 3.1)  | 1.6 (−0.0 to 3.2)     |
| ≥ 3                                   | −1.8 (−6.0 to 2.4)  | 5.5 (3.6 to 7.4)      |
| Previous breast cancer relative to diagnosis, yr | < 0.0001            | < 0.0001              |
| Never                                 | Ref.                |                       |
| ≤ 5                                   | 79.5 (72.4 to 86.6) | −8.2 (−11.5 to −5.0)  |
| 5–10                                  | 34.9 (30.9 to 38.9) | 0.6 (−1.2 to 2.4)     |
| ≥ 10                                  | 12.5 (9.8 to 15.3)  | 0.5 (−0.8 to 1.7)     |
| Cancer                                |                     |                       |
| Laterality                            | 0.01 (0.01 to 0.01) | 0.22                  |
| Right                                 | Ref.                |                       |
| Left                                  | 0.3 (−0.9 to 1.5)   | −0.3 (−0.9 to 0.2)    |
| Bilateral                             | −9.7 (−16.3 to −3.0) | 1.6 (−1.4 to 4.6)    |
Table 3 (part 2 of 2): Factors associated with wait times

| Characteristic                  | Diagnostic interval | Pretreatment interval |
|--------------------------------|---------------------|-----------------------|
|                                | Adjusted β (95% CI)* | p value               | Adjusted β (95% CI)* | p value               |
| Cancer stage                   | < 0.0001            | 0.0002                |
| 0                              | 11.4 (1.8 to 21.0)  | < 0.0001              | 7.0 (2.7 to 11.2)    | 0.0002                |
| 1                              | Ref.                |                       | Ref.                |                       |
| 2                              | –9.8 (–11.2 to –8.5)| 0.1 (–0.5 to 0.7)     |                     |                       |
| 3                              | –12.7 (–14.7 to –10.8) | –1.2 (–2.0 to –0.3) |                     |                       |
| 4                              | –21.1 (–24.3 to –17.9)| 1.0 (–0.3 to 2.4)    |                     |                       |
| Unknown                        | 8.7 (5.1 to 12.4)   | 1.5 (–0.2 to 3.2)     |                     |                       |
| Histology                      | < 0.0001            | < 0.0001              |
| Ductal                         | Ref.                |                       | Ref.                |                       |
| Lobular                        | 5.4 (3.3 to 7.5)    | 4.2 (3.3 to 5.1)      |                     |                       |
| Ductal and lobular             | 0.9 (–2.0 to 3.7)   | 4.9 (3.6 to 6.2)      |                     |                       |
| Adenocarcinoma                 | 6.0 (2.1 to 9.9)    | –0.1 (–1.8 to 1.6)    |                     |                       |
| Mucinous                       | 7.7 (3.4 to 11.9)   | –3.8 (–5.7 to –1.9)   |                     |                       |
| Other                          | 3.8 (1.4 to 6.4)    | 1.0 (–0.1 to 2.1)     |                     |                       |
| Hormone receptor profile       | 0.0007              | 0.004                 |
| ER–, PR–, HER2–                | Ref.                |                       | Ref.                |                       |
| ER–, PR–, HER2+                | 1.4 (–2.0 to 4.8)   | –0.7 (–2.2 to 0.8)    |                     |                       |
| ER–, PR+, HER2–                | –1.8 (–10.8 to 7.1) | –1.6 (–5.7 to 2.4)    |                     |                       |
| ER–, PR+, HER2+                | 2.3 (–11.6 to 16.3) | 0.6 (–5.5 to 6.6)     |                     |                       |
| ER+, PR–, HER2–                | 2.7 (–0.3 to 5.7)   | –0.3 (–1.6 to 1.1)    |                     |                       |
| ER+, PR+, HER2–                | –1.9 (–6.0 to 2.2)  | 0.7 (–1.1 to 2.6)     |                     |                       |
| ER+, PR+, HER2+                | –0.1 (–2.3 to 2.0)  | 1.3 (0.3 to 2.2)      |                     |                       |
| ER+, PR+, HER+                 | –1.1 (–4.1 to 1.9)  | 0.6 (–0.7 to 1.9)     |                     |                       |
| Missing                        | 3.4 (0.8 to 6.1)    | 1.4 (0.2 to 2.6)      |                     |                       |
| Topography                     | < 0.0001            | < 0.0001              |
| Upper-outter quadrant          | Ref.                |                       | Ref.                |                       |
| Overlapping lesion             | 1.9 (0.2 to 3.6)    | 0.1 (–0.6 to 0.9)     |                     |                       |
| Breast NOS                     | 9.3 (7.1 to 11.6)   | –3.0 (–4.1 to –2.0)   |                     |                       |
| Lower-outter quadrant          | 1.0 (–1.1 to 3.1)   | 0.2 (–0.7 to 1.2)     |                     |                       |
| Upper-inner quadrant           | –0.0 (–1.8 to 1.9)  | –0.0 (–0.8 to 0.8)    |                     |                       |
| Lower-inner quadrant           | 0.4 (–2.1 to 3.0)   | 0.2 (–0.7 to 1.2)     |                     |                       |
| Central portion                | 3.7 (1.0 to 6.4)    | –1.3 (–2.5 to –0.1)   |                     |                       |
| Nipple                         | 10.6 (6.5 to 14.7)  | 1.2 (–1.6 to 2.0)     |                     |                       |
| Axillary tail                  | 1.0 (–6.1 to 8.1)   | 1.9 (–1.2 to 5.1)     |                     |                       |
| **Other**                      | **< 0.0001**        | **< 0.0001**          |
| Year of diagnosis              | Ref.                |                       | Ref.                |                       |
| 2014                           | –1.6 (–3.4 to 0.3)  | –1.3 (–2.2 to –0.5)   |                     |                       |
| 2015                           | –3.3 (–5.2 to –1.5) | –2.0 (–2.8 to –1.1)   |                     |                       |
| 2016                           | –4.2 (–6.0 to –2.3) | –2.2 (–3.0 to –1.4)   |                     |                       |
| 2017                           | –2.6 (–4.4 to –0.8) | –2.1 (–2.9 to –1.3)   |                     |                       |

Note: CI = confidence interval, ER = estrogen receptor, HER2 = human epidermal growth factor receptor-2, NOS = not otherwise specified, O-BAS = OBSP-affiliated breast assessment site, OBSP = Ontario Breast Screening Program, OR = odds ratio, PR = progesterone receptor, Ref. = reference category.

*Diagnostic interval is the time from suspicion of breast cancer until diagnosis (overall mean 62 d, standard deviation [SD] 65.6 d; median 35 d, interquartile range [IQR] 19–82 d). Pre-treatment interval is the time from diagnosis of breast cancer until first treatment (overall mean 38 d, SD 29.5 d; median 34 d, IQR 23–47 d).
†Adjusted for O-BAS status, screening status, age, neighbourhood income quintile, neighbourhood immigrant density, rurality, distance to the closest O-BAS, Charlson Comorbidity Index, previous breast cancer, laterality, cancer stage, hormone receptor profile, topography, year of diagnosis and level of geography (Local Health Integration Network). β coefficients reflect the effect of a 1-unit change in the patient or tumour characteristic on the duration of the time interval, in days.
‡Adapted from Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017), which is based on data licensed from Canada Post Corporation. We used the patient’s postal code at diagnosis.
§β coefficients reflect the effect of a 100-km change in Euclidean distance to the patient’s closest O-BAS. We used the patient’s postal code at diagnosis.
We suspect the existing O-BAS likely have the capacity to evaluate additional patients because most (79%) symptomatic patients in the province were given their diagnoses at an O-BAS (this has increased since the time of writing as more centres have become O-BAS). Although it remains unknown how many symptomatic patients have cancer ruled out at an O-BAS, we suspect this frequency reflects most symptomatic patients in the province because the likelihood of a cancer diagnosis is higher if symptoms are present; the need for a diagnostic biopsy is more likely for symptomatic patients; and O-BAS are more likely to have the ability to perform a biopsy than non-O-BAS.8,43

### Table 4: Health care use among patients with breast cancer who were or were not referred to a Breast Assessment Site affiliated with the Ontario Breast Screening Program

| Type of encounter* | Non-O-BAS | O-BAS |
|-------------------|-----------|-------|
|                   | No. (%) of patients | Days from encounter to diagnosis, median (IQR)† | No. (%) of patients | Days from encounter to diagnosis, median (IQR)† |
| Mammography       | n = 8862 |                               | n = 42 598 |                               |
| Screening mammography | 2683 (30.3) | 25 (14 to 41) | 18 614 (43.7) | 23 (14 to 39) |
| Diagnostic mammography (first) | 6929 (78.2) | 14 (3 to 28) | 38 708 (90.9) | 11 (0 to 23) |
| Diagnostic mammography (second) | 3726 (42.0) | 6 (–2 to 20) | 25 585 (60.1) | 0 (0 to 14) |
| Diagnostic mammography (third) | 1360 (15.3) | 0 (–32 to 0) | 12 509 (29.4) | 0 (–30 to 0) |
| Any mammography | 7386 (83.3) | 17 (7 to 34) | 40 858 (95.9) | 17 (7 to 32) |
| Other imaging     |           |                               |           |                               |
| Breast ultrasonography (first) | 7278 (82.1) | 8 (0 to 20) | 40 155 (94.3) | 5 (0 to 17) |
| Breast ultrasonography (second) | 7114 (80.3) | 12 (1 to 23) | 39 736 (93.3) | 9 (0 to 21) |
| Breast ultrasonography (third) | 3900 (44.0) | 0 (0 to 1) | 22 379 (52.5) | 0 (0) |
| Abdominal or thoracic ultrasonography | 1832 (20.7) | 0 (–22 to 43) | 8129 (19.1) | –9 (–22 to 47) |
| Abdominal or thoracic computed tomography | 3368 (38.0) | –6 (–22 to 9.5) | 10 547 (24.8) | –14 (–25 to 0) |
| Breast magnetic resonance imaging | 1168 (13.2) | –20 (–31 to –9) | 9635 (22.6) | –14 (–24 to –5) |
| Abdominal or thoracic magnetic resonance imaging | 1739 (19.6) | –15 (–27 to 2) | 11 250 (26.4) | –13 (–23 to 0) |
| Chest radiography | 4300 (48.5) | 0 (–21 to 40) | 16 738 (39.3) | –11 (–26 to 35) |
| Biopsy            |           |                               |           |                               |
| Breast biopsy     | 7543 (85.1) | 0 (0 to 0) | 41 160 (96.6) | 0 (0) |
| Lymph node biopsy | 789 (8.9) | 0 (–11 to 0) | 3711 (8.7) | 0 (–5 to 0) |
| Any biopsy        | 7723 (87.1) | 0 (0) | 41 804 (98.1) | 0 (0) |
| Consultations and visits |           |                               |           |                               |
| General or general thoracic surgeon | 7690 (86.8) | –1 (–14 to 9) | 41 300 (97.0) | –8 (–16 to 3) |
| Cardiac surgery consult | 52 (0.6) | 53 (–9 to 121) | 149 (0.3) | 87 (7 to 149) |
| Dermatology consult | 556 (6.3) | 86 (22 to 138) | 3088 (72) | 84 (27 to 140) |
| Cardiology consult | 632 (7.1) | 55 (0.5 to 128) | 2619 (6.1) | 63 (–2 to 127) |
| Primary care provider visit | 4337 (48.9) | 44 (3 to 115) | 17 059 (40.0) | 59 (12 to 123) |
| Medical oncology consult | 2310 (26.1) | –22 (–36 to –11) | 6180 (14.5) | –19 (–30 to –11) |
| Internal medicine consult | 2131 (24.0) | 0 (–18 to 81) | 7529 (17.7) | 10 (–21 to 104) |
| Radiation oncology consult | 1443 (16.3) | –22 (–36 to –10) | 4117 (9.7) | –20 (–33 to –10) |
| First visit        |           |                               |           |                               |
| Earliest of any of the above until diagnosis | 8056 (90.9) | 53 (20 to 128) | 39 822 (93.5) | 49 (19 to 125) |
| Earliest of any of the above until diagnosis (including diagnosis date) | 8862 (100.0) | 42 (14 to 121) | 42 598 (100.0) | 42 (15 to 119) |
| Suscepption until diagnosis | 7788 (87.9) | 39 (20 to 92) | 40 052 (94.0) | 35 (18 to 79) |

Note: IQR = interquartile range, O-BAS = OBSP-affiliated breast assessment site, OBSP = Ontario Breast Screening Program, *We collected health care encounter and timing of health care encounter relative to the diagnosis date from the Ontario Cancer Registry. We included encounters if they occurred within 6 months before diagnosis until the start of treatment (or 60 days after diagnosis, if no treatment). We identified encounters using billing codes from the Ontario Health Insurance Program, or procedural codes from the Discharge Abstract Database (inpatient) and the National Ambulatory Care Reporting System (outpatient). †Positive values indicate the encounter occurred before diagnosis; negative values indicate the encounter occurred after diagnosis.
### Table 5 (part 1 of 2): Factors associated with all-cause mortality

| Factor                                      | Crude HR (95% CI) | p value | Adjusted HR (95% CI)* | p value |
|---------------------------------------------|-------------------|---------|-----------------------|---------|
| **O-BAS**                                   |                   |         |                       |         |
| No                                          | Ref.              |         | Ref.                  |         |
| Yes                                         | 0.41 (0.39 to 0.43) | < 0.0001 | 0.72 (0.68 to 0.76) | < 0.0001 |
| Screening status                            |                   |         |                       |         |
| Symptomatic                                 | Ref.              |         | Ref.                  |         |
| OBSP-screened                               | 0.30 (0.27 to 0.33) | 0.72 (0.66 to 0.79) |
| Non-OBSP-screened                           | 0.43 (0.40 to 0.46) | 0.67 (0.62 to 0.72) |
| **Sociodemographic**                        |                   |         |                       |         |
| Age (per 10-yr increment)                   | 1.62 (1.59 to 1.65) | 1.49 (1.46 to 1.51) |
| Sex                                         |                   |         |                       |         |
| Female                                      | Ref.              |         | Ref.                  |         |
| Male                                        | 2.29 (1.91 to 2.74) | 1.43 (1.18 to 1.74) |
| Neighbourhood income quintile†              |                   | < 0.0001 | < 0.0001              |         |
| Highest                                     | Ref.              |         | Ref.                  |         |
| Mid-high                                    | 1.18 (1.09 to 1.28) | 1.13 (1.04 to 1.23) |
| Middle                                      | 1.29 (1.19 to 1.40) | 1.15 (1.06 to 1.25) |
| Mid-low                                     | 1.45 (1.34 to 1.56) | 1.18 (1.09 to 1.28) |
| Lowest                                      | 1.71 (1.58 to 1.84) | 1.29 (1.19 to 1.40) |
| Neighbourhood immigrant density†            |                   | < 0.0001 | < 0.0001              |         |
| Least dense                                 | Ref.              |         | Ref.                  |         |
| Mid-dense                                   | 0.88 (0.83 to 0.93) | 0.97 (0.91 to 1.04) |
| Most dense                                  | 0.84 (0.79 to 0.90) | 0.93 (0.85 to 1.03) |
| Rurality†                                   |                   |         |                       |         |
| Urban                                       | Ref.              |         | Ref.                  |         |
| Rural                                       | 1.09 (1.00 to 1.16) | 0.94 (0.86 to 1.03) |
| Distance to closest O-BAS (per 100-km increment)† | 1.17 (1.04 to 1.30) | 0.90 (0.77 to 1.05) |
| **Clinical**                                |                   |         |                       |         |
| Charlson Comorbidity Index                  |                   | < 0.0001 | < 0.0001              |         |
| Missing                                     | 0.73 (0.69 to 0.77) | 0.87 (0.82 to 0.92) |
| 0                                           | Ref.              |         | Ref.                  |         |
| 1                                           | 1.75 (1.63 to 1.88) | 1.33 (1.23 to 1.44) |
| 2                                           | 2.79 (2.52 to 3.08) | 1.66 (1.50 to 1.85) |
| ≥ 3                                         | 4.56 (4.15 to 5.02) | 2.55 (2.31 to 2.82) |
| Previous breast cancer relative to diagnosis, yr |                   | < 0.0001 | < 0.0001              |         |
| Never                                       | Ref.              |         | Ref.                  |         |
| ≤ 5                                         | 2.06 (1.68 to 2.52) | 1.65 (1.34 to 2.03) |
| 5–10                                        | 1.55 (1.36 to 1.77) | 1.10 (0.95 to 1.26) |
| ≥ 10                                        | 1.39 (1.26 to 1.53) | 0.98 (0.88 to 1.08) |
| Previous other cancer relative to diagnosis, yr |                   | < 0.0001 | < 0.0001              |         |
| Never                                       | Ref.              |         | Ref.                  |         |
| ≤ 5                                         | 2.26 (2.04 to 2.50) | 1.63 (1.46 to 1.82) |
| 5–10                                        | 1.72 (1.47 to 2.01) | 1.27 (1.08 to 1.49) |
| ≥ 10                                        | 1.74 (1.55 to 1.96) | 1.25 (1.11 to 1.42) |
Table 5 (part 2 of 2): Factors associated with all-cause mortality

| Factor                           | Crude HR (95% CI) | p value | Adjusted HR (95% CI)* | p value |
|----------------------------------|-------------------|---------|-----------------------|---------|
| **Cancer**                       |                   |         |                       |         |
| Laterality                       | < 0.0001          |         | < 0.0001              |         |
| Right                            | Ref.              |         | Ref.                  |         |
| Left                             | 1.00 (0.95 to 1.05) | < 0.0001 | 0.96 (0.91 to 1.01) | 0.01    |
| Bilateral                        | 1.84 (1.50 to 2.27) | < 0.0001 | 1.26 (1.02 to 1.56) |         |
| **Cancer stage**                 |                   |         |                       |         |
| 0                                | 1.31 (0.79 to 2.18) |         | 0.94 (0.55 to 1.61) | < 0.0001|
| 1                                | Ref.              |         | Ref.                  |         |
| 2                                | 2.12 (1.97 to 2.28) |         | 1.80 (1.66 to 1.94) |         |
| 3                                | 4.62 (4.27 to 5.01) |         | 4.10 (3.77 to 4.46) |         |
| 4                                | 18.4 (17.0 to 19.9) |         | 13.0 (11.9 to 14.2) |         |
| Unknown                          | 7.68 (6.96 to 8.46) |         | 3.72 (3.30 to 4.19) |         |
| **Histology**                    |                   |         |                       |         |
| Ductal                           | Ref.              |         | Ref.                  |         |
| Lobular                          | 1.13 (1.04 to 1.23) |         | 0.89 (0.82 to 0.98) |         |
| Ductal and lobular               | 1.03 (0.91 to 1.16) |         | 0.99 (0.88 to 1.13) |         |
| Adenocarcinoma                   | 2.07 (1.84 to 2.33) |         | 0.99 (0.86 to 1.06) |         |
| Mucinous                         | 0.79 (0.64 to 0.97) |         | 0.88 (0.72 to 1.09) |         |
| Other                            | 2.53 (2.26 to 2.71) |         | 1.22 (1.12 to 1.31) |         |
| **Hormone receptor profile**     |                   |         |                       |         |
| ER–, PR–, HER2–                  | Ref.              |         | Ref.                  |         |
| ER–, PR–, HER2+                  | 0.62 (0.55 to 0.70) |         | 0.50 (0.44 to 0.57) |         |
| ER–, PR+, HER2–                  | 1.07 (0.81 to 1.42) |         | 1.23 (0.93 to 1.63) |         |
| ER+, PR–, HER2–                  | 0.76 (0.47 to 1.23) |         | 0.47 (0.29 to 0.75) |         |
| ER+, PR+ , HER2+                 | 0.76 (0.69 to 0.85) |         | 0.62 (0.55 to 0.69) |         |
| ER+, PR+, HER2+                  | 0.64 (0.55 to 0.75) |         | 0.52 (0.44 to 0.61) |         |
| ER+, PR+, HER2–                  | 0.40 (0.37 to 0.43) |         | 0.37 (0.34 to 0.40) |         |
| Missing                          | 0.95 (0.88 to 1.03) |         | 0.53 (0.48 to 0.58) |         |
| **Topography**                   |                   |         |                       |         |
| Overlapping lesion               | 1.26 (1.18 to 1.36) |         | 1.09 (1.02 to 1.17) |         |
| Breast NOS                       | 2.80 (2.61 to 3.01) |         | 1.41 (1.30 to 1.52) |         |
| Lower–outer quadrant             | 1.03 (0.94 to 1.14) |         | 1.05 (0.95 to 1.15) |         |
| Upper–inner quadrant             | 0.90 (0.83 to 0.98) |         | 0.97 (0.89 to 1.06) |         |
| Lower–inner quadrant             | 1.05 (0.93 to 1.17) |         | 1.02 (0.91 to 1.14) |         |
| Central portion                  | 1.40 (1.26 to 1.55) |         | 1.05 (0.94 to 1.17) |         |
| Nipple                           | 1.28 (1.09 to 1.50) |         | 0.90 (0.76 to 1.06) |         |
| Axillary tail                    | 2.37 (1.91 to 2.93) |         | 1.48 (1.18 to 1.84) |         |

Note: CI = confidence interval, ER = estrogen receptor, HER2 = human epidermal growth factor receptor-2, HR = hazard ratio, NOS = not otherwise specified, O-BAS = OBSP-affiliated breast assessment site, OBSP = Ontario Breast Screening Program, PR = progesterone receptor, Ref. = reference category.

* = n = 49,383 patients and 6402 events; all estimates are adjusted for O-BAS status, screening status, age, neighbourhood income quintile, neighbourhood immigrant density, rurality, distance to the closest O-BAS, Charlson Comorbidity Index, previous breast cancer, laterality, cancer stage, hormone receptor profile, topography, year of diagnosis and level of geography (Local Health Integration Network).

†Adapted from Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017), which is based on data licensed from Canada Post Corporation.16 We used the patient’s postal code at diagnosis.

‡Hazard ratios reflect the risk of death for every 100-km increase in Euclidean distance to the patient’s closest O-BAS. We used the patient’s postal code at diagnosis.
It remains possible that increased referrals to O-BAS will result in capacity constraints and prolonged wait times. This should be considered when designing system-level changes to the diagnostic process for symptomatic patients. However, a more standardized diagnostic assessment pathway may also reduce repeated imaging and unnecessary testing, which is also expected to reduce costs. A 2018 environmental scan of national and regional cancer diagnostic improvement initiatives described cost savings, but formal cost effectiveness analyses were not available and are warranted.

**Limitations**

One limitation of this study is the risk of misclassification of non-OBSP-screened cancers (e.g., some may have been symptomatic) and symptomatic cancers (e.g., some may have been incidental, although this is likely uncommon). Also, the definition of O-BAS we used is imperfect; it reflects the institution that renders the diagnosis, which may differ from the institution conducting the remainder of the diagnostic work-up. Moreover, some institutions function like an O-BAS (e.g., have all the necessary equipment and personnel), but do not have patient navigation or a funding agreement with the OBSP. These centres were classified as non-O-BAS, despite having some O-BAS features.

Patients with previous breast cancers had a significantly longer diagnostic interval than those who did not. However, because the methodology used to identify the suspicion date was developed in a cohort of patients with first-ever breast cancer, it may not be valid in this subgroup of patients. Nevertheless, findings from a recent systematic review suggested that patients with a history of breast cancer be included in screening programs (even if not high risk), a conclusion that is supported by our findings.

Hazard ratio estimates of the OBSP-screened group, for which we corrected lead-time bias, assume that the sojourn time (i.e., time for an asymptomatic patient to become symptomatic) of 24 months is accurate. Our results may not generalize to certain patient groups, like men (who are not eligible for OBSP screening) or those with diagnoses of ductal carcinoma in situ (stage 0), which we did not include because it is generally asymptomatic (the few patients classified in our study as stage 0 are likely misclassified).

Finally, our results may not generalize to jurisdictions that do not have organized screening programs or a designated referral stream for symptomatic patients. Although other provinces in Canada have organized screening programs, we are unaware of any provincial-level assessment programs designated for symptomatic patients. Reviews of the literature related to symptomatic presentation often focus only on wait times as a measure of performance.

**Conclusion**

Patients whose breast cancer was first detected by the OBSP received their diagnoses earlier than symptomatic patients and were more likely to be referred to O-BAS, which was associated with better survival. Our findings suggest that all individuals with signs and symptoms of breast cancer would benefit from organized, high-quality diagnostic assessment processes and standards like those used by the OBSP.
References

1. Bray F, Ferlay J, Soerjomataram I, et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2018;68:439-84.

2. Ontario Cancer Statistics 2020: Chapter 1 – Estimated current cancer incidence. Toronto: Cancer Care Ontario; 2020. Available: https://www.cancercareontario.ca/en/statistics-reports/ontario-cancer-statistics-2020/ch-1-estimated-current-cancer-incidence (accessed 2020 Nov. 11).

3. Hendrick RE, Helvie MA. Mammography screening: a new estimate of number needed to screen to prevent one breast cancer death. AJR Am J Roentgenol 2012;198:723-8.

4. Hendrick RE, Helvie MA. United States Preventive Services Task Force screening mammography recommendations: science ignored. AJR Am J Roentgenol 2011;196:W112-6.

5. Webber C, Whitehead M, Eisen A, et al. Breast cancer diagnosis and treatment wait times in specialized diagnostic units compared with usual care: a Government-based study. Can Oncol 2020;27:e377-85.

6. Chiarelli AM, Muradali D, Blackmore KM, et al. Evaluating wait times from screening to breast cancer diagnosis among women undergoing organised assessment vs usual care. Br J Cancer 2017;116:1254-63.

7. Quan ML, Shumak RS, Majmudar V, et al. Improving work-up of the abnormal mammogram through organized assessment: results from the Ontario breast screening program. J Oncol Pract 2012;8:107-12.

8. Koo MM, von Wagner C, Abel GA, et al. RECORD Working Committee. The RECORD statement: standardizing Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS Med 2012;12:e1001885.

9. Chiarelli AM, Blackmore KM, Mirea L, et al. Annual vs biennial screening: diagnostic accuracy among concurrent cohorts within the Ontario breast screening program. J Natl Cancer Inst 2020;112:400-9.

10. Chiarelli AM, Blackmore KM, Muradali D, et al. Performance measures of magnetic resonance imaging plus mammography in the high risk Ontario breast screening program. J Natl Cancer Inst 2020;112:136-44.

11. Ontario Health Insurance Plan. OHIP schedule of benefits and fees. Toronto: Government of Ontario Ministry of Health and Long-Term Care. Available: https://www.health.gov.on.ca/en/pro/programs/ohip/schedule_of_benefits_and_fees (accessed 2021 Oct. 18).

12. Canadian Institute for Health Information [home page]. Available: https://www.cihi.ca/en (accessed 2021 Oct. 18).

13. Collaborative State data collection system [home page]. Available: http://cancerstaging.org/cstage/Pages/default.aspx (accessed 2021 Oct. 18).

14. Postal Code Conversion File Plus (PCCF+). Geographic files and documentation 82F0086X. Ottawa: Statistics Canada. Available: https://www150.statcan.gc.ca/t11/en/id/82F0086X20191219 (accessed 2021 Oct. 19).

15. Data catalogue. Toronto: Government of Ontario. Available: https://data.ontario.ca/dataset (accessed 2021 Oct. 18).

16. Jiang L, Gilbert J, Langley H, et al. Breast cancer detection method, diagnostic interval and use of specialized diagnostic assessment units across Ontario, Canada. Health Promot Chronic Dis Prev Can 2018;38:358-67.

17. Benchmol EI, Smeeth L, Gottmann A, et al., RECORD Working Committee. The RECORD statement: standardizing Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS Med 2012;12:e1001885.

18. Drukker CA, Schmidt MK, Rutgers EJT, et al. Mammographic screening detects low-risk tumor biology breast cancers. Breast Cancer Res Treat 2014;144:103-11.

19. Pollock M, Craig R, Chojecki D, et al. Initiatives to accelerate the diagnostic phase of cancer care: an environmental scan. Initiatives to accelerate the diagnostic phase of cancer care: an environmental scan. J Cancer Economics; 2018. Available: https://www.ihe.ca/publications/initiatives-to-accelerate-the-diagnostic-phase-of-cancer-care-an-environmental-scan (accessed 2021 Aug. 28).

20. Healey TT, Agarwal S, Patel R, et al. Cancer yield of incidental breast lesions detected on chest computed tomography. J Comput Assist Tomogr 2018;42:451-6.

21. Benveniste AP, Marlow LAV, Waller J, et al. What is it about a cancer diagnosis that would worry people? A population-based survey of adults in England. BMC Cancer 2018;18:86.

22. Prabhuv, Chhor CM, Ego-Osuala IO, et al. Frequency and outcomes of incidental primary breast cancers. Breast Cancer Res Treat 2014;151:261-8.

23. Koo MM, von Wagner C, Abel GA, et al. Annual vs biennial screening: diagnostic accuracy among concurrent cohorts within the Ontario breast screening program. J Natl Cancer Inst 2020;112:400-9.

24. Lawrence G, Wallis M, Allgood P, et al. Population estimates of survival in breast cancer: a multinational analysis. Southampton (UK): NIHR Journals Library; 2016.

25. S, Byrd DR, Compton CC, et al., editors. New York: Springer New York; 2017. p. 160-3.

26. Dobbins TA, Creighton N, Barratt H, et al., editors. Challenges, Solutions and Future Directions in the Evaluation of Service Innovations in Health Care and Public Health. Southampton (UK): NIHR Journals Library, 2016.

27. Dukker CA, Schmidt MK, Rutgers EJT, et al. Mammographic screening detects low-risk tumor biology breast cancers. Breast Cancer Res Treat 2014;144:103-11.

28. Fornvik D, Lång K, Anderson L, et al. Estimates of breast cancer growth rate from mammograms and its relation to tumour characteristics. Radiat Prot Dosimetry 2016;169:131-7.

29. Murphy PJ, Marlow LAV, Walle J, et al. What is it about a cancer diagnosis that would worry people? A population-based survey of adults in England. BMC Cancer 2018;18:86.

30. Balasaoversiya-Smeekens C, Walter FM, Scott S. The role of emotions in time to diagnosis for symptoms suggestive of cancer: a systematic literature review of quantitative studies. Psychoneuroendocrinology 2015:24:194-604.

31. Lawrence G, Wallis M, Allgood P, et al. Population estimates of survival in breast cancer: a multinational analysis. Southampton (UK): NIHR Journals Library; 2016.

32. Pollock M, Craig R, Chojecki D, et al. Initiatives to accelerate the diagnostic phase of cancer care: an environmental scan. J Cancer Economics; 2018. Available: https://www.ihe.ca/publications/initiatives-to-accelerate-the-diagnostic-phase-of-cancer-care-an-environmental-scan (accessed 2021 Aug. 28).

33. Ensen A, Blackmore KM, Meschino WS, et al. Genetic assessment wait time indicators in the High Risk Ontario Breast Screening Program. Mol Genet Genomic Med 2018;6:213-23.

34. Gilmore ML, Smith W, Curtis JR, et al. Evaluating comorbidty scores based on Medicare service expenditures. Med Care Med Res 2012;2:mmn.02.003.05.

35. Dobbins TA, Creighton N, Carrow DC, et al. Look back for the Charlson Index did not improve risk adjustment of cancer surgical outcomes. J Clin Epidemiol 2015;68:379-86.

36. Jiang L, Gilbert J, Langley H, et al. Is being diagnosed at a dedicated breast assessment unit associated with a reduction in the time to diagnosis for symptomatic breast cancer patients? Eur J Cancer Care (Engag) 2018;27:e12864.

37. American Joint Committee on Cancer. AJCC Cancer Staging Handbook. Edition 8, Byrd DR, Compton CC, et al., editors. New York: Springer New York; 2010.XIX, 718. Available: http://www.springer.com/us/book/9780387884424 (accessed 2021 Oct. 18).

38. Kilgore ML, Smith W, Curtis JR, et al. Evaluating comorbidity scores based on Medicare service expenditures. Med Care Med Res 2012;2:mmn.02.003.05.

39. Dobbs TA, Creighton N, Carrow DC, et al. Look back for the Charlson Index did not improve risk adjustment of cancer surgical outcomes. J Clin Epidemiol 2015;68:379-86.

40. Jiang L, Gilbert J, Langley H, et al. Effect of specialized diagnostic assessment units on the time to diagnosis in screen-detected breast cancer patients. Br J Cancer 2015;112:1744-50.

41. Groome PA, Webber C, Whitehead M, et al. Determining the cancer diagnostic interval using administrative health care data in a breast cancer cohort. JCO Clin Cancer Inform 2019;3:1-10.

42. Duffy SW, Nagtegaal ID, Wallis M, et al. Correcting for lead time and length bias in estimating the effect of screen detection on cancer survival. Am J Epidemiol 2008;168:98-104.

43. Land LH, Dalton SO, Jorgensen TL, et al. Comorbidity and survival after early breast cancer. A review. Crit Rev Oncol Hematol 2012;81:196-205.

44. Desai AA, Hoskin TL, Day CN, et al. Effect of primary breast tumor location on axillary nodal positivity. Ann Surg Oncol 2018;25:3011-8.
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Data sharing: Ontario Health is prohibited from making the data used in this research publicly accessible if they include potentially identifiable personal health information or personal information as defined in Ontario law, specifically the Personal Health Information Protection Act (PHIPA) and the Freedom of Information and Protection of Privacy Act (FIPPA).

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