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Spatial inequalities in colorectal and breast cancer survival: Premature deaths and associated factors

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ABSTRACT

This study examines the influence of cancer stage, distance to treatment facilities and area disadvantage on breast and colorectal cancer spatial survival inequalities. We also estimate the number of premature deaths after adjusting for cancer stage to quantify the impact of spatial survival inequalities. Population-based descriptive study of residents aged <90 years in Queensland, Australia diagnosed with primary invasive breast (25,202 females) or colorectal (14,690 males, 11,700 females) cancers during 1996–2007. Bayesian hierarchical models explored relative survival inequalities across 478 regions. Cancer stage and disadvantage explained the spatial inequalities in breast cancer survival, however spatial inequalities in colorectal cancer survival persisted after adjustment. Of the 6,019 colorectal cancer deaths within 5 years of diagnosis, 470 (8%) were associated with spatial inequalities in non-diagnostic factors, i.e. factors beyond cancer stage at diagnosis. For breast cancers, of 2,412 deaths, 170 (7%) were related to spatial inequalities in non-diagnostic factors. Quantifying premature deaths can increase incentive for action to reduce these spatial inequalities.

1. Background

Worldwide, breast cancer is the most common cancer in women, while colorectal cancer is the second most commonly diagnosed among women, and third most common among men (Ferlay et al., 2010). In developed nations, including Australia, survival for both these cancers has improved over recent decades (Australian Institute of Health and Welfare and Cancer Australia & Australasian Association of Cancer Registries, 2008), with Australia having one of the highest survival rates in the world (Coleman et al., 2011).

However, the improvement in survival has not been observed equally across all population subgroups. Inequalities for both breast and colorectal cancer survival have been reported by deprivation and differences in health care access (Du et al., 2011; McKenzie et al., 2011). Within Australia, poorer survival has been observed for those in areas of greater socio-economic disadvantage, geographic remoteness and, for rectal cancer, further distance to radiotherapy facilities (Australian Institute of Health and Welfare and Cancer Australia & Australasian Association of Cancer Registries, 2008; Baade et al., 2011b; Cramb et al., 2011).

The quality of patient management can be gauged by survival (Yu et al., 2004). The prognosis for breast and colorectal cancer depends in large part on the stage of disease at diagnosis (Schottenfeld and Fraumeni Jr, 2006), which may vary geographically (Tian et al., 2012; Tian et al., 2011). Beyond that, the outcome depends on other non-diagnostic factors such as treatment, rehabilitation, environmental factors such as area disadvantage, and patient characteristics including comorbidities (Yu et al., 2005a), all of which could potentially contribute to geographical variation in cancer survival. Throughout this paper we use the term "non-diagnostic" to encompass these other factors.

Since only a few population-based cancer registries collect stage information, not many studies have been able to separate the effect of diagnostic from other factors on geographic inequalities in cancer survival on a population basis. In New South Wales (NSW), Australia, it was found that adjusting for stage did not reduce the survival differential for colorectal cancer (Yu et al., 2005a). However, in Italy, stage at diagnosis explained most of the colorectal cancer survival inequalities between Northern and Southern areas, while treatment had a minimal role (Fusco et al., 2010). In England, stage at diagnosis and deprivation were important causes of breast cancer survival inequalities (Davies et al., 2010).

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However these previous studies have used relatively large geographical regions, which reduce the ability to measure spatial variation and can limit interpretation because of the greater heterogeneity within those regions. In contrast, inequalities in cancer survival at the small-area level have rarely been examined, typically due to difficulties associated with sparse data in small geographical areas and in accounting for the spatial correlation between neighboring areas (Wakefield and Elliott, 1999). Bayesian hierarchical methods overcome both problems by incorporating information from neighboring areas for each estimate, producing more reliable small-area estimates (Carlin and Xia, 1999).

Spatial survival analysis is an emerging field. Most analyses have focused on cause-specific survival (Henry et al., 2009; Huang et al., 2007; Wan et al., 2012). We chose to instead use Bayesian hierarchical methods to model relative survival (Fairley et al., 2008; Saez et al., 2012), where cancer patient mortality is compared against mortality in the population of similar age, sex and time period. Our focus was on comparing survival up to 5-years after diagnosis.

To quantify the impact of spatial inequalities in cancer survival, previous studies have calculated the number of deaths that could have been prevented within a given timeframe if there was no systematic regional variation in survival (Dickman et al., 1997; Yu et al., 2004). These estimates of avoidable premature deaths provide an objective measure by which to advocate for resource allocation and establish health priorities (Yu et al., 2004).

This study has two aims:

(1) To examine the influence of cancer stage at diagnosis, distance to treatment facilities and area-disadvantage on spatial survival inequalities for breast and colorectal cancer, and
(2) To estimate the number of premature deaths due to non-diagnostic-related spatial survival inequalities after adjusting for cancer stage at diagnosis.

2. Methods

2.1. Data

2.1.1. Study cohort

Data on colorectal (ICD-O3 C18-C20,C218) and breast (ICD-O3 C50) cancers diagnosed in Queensland during 1996 to 2007 were obtained from the Queensland Cancer Registry (QCR) following approval from Queensland Health (Ethics approval number: HREC/09/QHC/25). Due to small numbers, male breast cancers were excluded from analysis. The QCR is a population-based registry which has been in operation since 1982 (Queensland Cancer Registry, 2010), and covers a population of 4.2 million (in 2007) (Australian Bureau of Statistics, 2008b). Notification of cancer (excluding non-melanoma skin cancer) to the QCR is required by law (Queensland Cancer Registry, 2010). Data quality is high, as evidenced by the high percentage of cases diagnosed with histological verification (92.1%) and low percentage of cases diagnosed by death certificate only (1.4%) in 2007.

The survival analysis included the first occurrence of a primary colorectal or breast cancer in individuals aged less than 90 years at diagnosis. Cases were excluded if they lacked age or SLA of residence information, were identified at autopsy, notified via death certificate only or had a survival time of less than one day. All cases were followed until 31st December 2007.

2.1.2. Stage at diagnosis

Colorectal cancer stage was extracted from pathology records held by the QCR (Krnjacki et al., 2008) and then classified based on the Dukes staging system (Haq et al., 2009). To increase accuracy (Krnjacki et al., 2008) and reduce problems with sparse data, stage was grouped into three categories: early (localized/non-localized), advanced (regional/distant) and unknown.

The QCR does not collect detailed information about breast cancer stage at diagnosis. However, consistent with recent reports (Baade et al., 2011c; Krnjacki et al., 2008; Youlden et al., 2009), "Early" breast cancer was defined as ≤ 20 mm diameter with no evidence of lymph node involvement or distant metastases (stage I). Although it was unlikely these cases had metastasized, this could not be established. There was insufficient detail to distinguish between stages II, III or IV, so these were collectively categorized as "Advanced" breast cancers. Cancers diagnosed as a result of metastatic disease were included in this category. The "Unknown" category included those with unknown tumor size or unknown lymph node status if the tumor size was ≤ 20 mm.

2.1.3. Geographical location

Statistical Local Areas (SLAs) were used as the region of analysis. Cancer incidence data across all years were mapped to the 2006 SLA boundaries based on suburb and postcode of residence prior to data extraction. In 2006 Queensland had 478 SLAs, which covered the State without gap or overlap, with a median population of 5,810 (range: 7–77,523).

Based on their SLA of residence, each patient was assigned to a quintile of area disadvantage based on the Australian Bureau of Statistics (ABS) Socioeconomic Indexes for Areas Index of Relative Disadvantage (SEIFA-IRSD) (Australian Bureau of Statistics, 2008a).

2.1.4. Distance to treatment

The distance to the closest radiation facility was calculated by geocoding the location of all radiation facilities in Queensland, and the centroid of each SLA at diagnosis. A custom GIS application was used to calculate the shortest traveling time by road from each SLA centroid to the closest radiation facility by each year to account for increasing coverage of the radiation facilities over time. Radiotherapy facilities are only located in larger cities. By the end of 2007 there were a total of 4 public and 5 private radiotherapy facilities in Queensland. Five (3 public and 2 private) were located in Brisbane, three additional private facilities were located within a 125 km radius of Brisbane, and another public facility in Townsville (1,360 km north of Brisbane).

Distance was classified into three categories based on practical considerations to improve the interpretation of estimates: <2 h (return travel within one day), 2–6 h (one full day of traveling) and >6 h (more than one day of travel with overnight accommodation required).

2.2. Survival estimates

Unadjusted relative survival estimates were calculated using actuarial (life table) methods. Expected survival was estimated using the Ederer II method (Ederer and Heise, 1959) with the Stata macro strs, based on Queensland life tables generated from mortality data obtained from the ABS. The population mortality was calculated by each SLA, gender and 5-year age group (to ages 90+). Estimates were calculated for two aggregated time periods for greater stability; 1997–2002 and 2003–2007, and then applied to each year within the appropriate time period.

Survival estimates were derived using period analysis, in which survival is calculated using patients alive during the time period of interest (Brenner and Hakulinen, 2009). Since the focus was on estimating survival inequalities up to 5 years after diagnosis,