

## RESEARCH ARTICLE

# Influence of Mammographic Screening on Breast Cancer Incidence Trends in South Australia

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## Abstract

**Purpose:** To examine breast cancer (BC) incidence trends in relation to mammographic screening and risk factor prevalence in South Australia (SA). **Materials and Methods:** Trends in annual BC incidence rates were calculated using direct standardisation and compared with projected incidence derived from Poisson regression analysis of pre-screening rates. Annual percentage change and change time points were estimated using Joinpoint software. Biennial mammography screening participation rates were calculated using data from BreastScreen SA. Trends in overweight/obesity, alcohol use and hormone replacement therapy (HRT) use were examined using 1991-2009 Health Omnibus Survey data. Trends in total fertility were examined using data from the Australian Bureau of Statistics. **Results:** BC incidence increased around the time BreastScreen commenced and then stabilised in the mid-1990s. However rates have remained higher than projected, even though the proportion and age distribution of first time screening attendees stabilised around 1998. A decrease in BC incidence was observed among women aged 50-59yrs from the late-1990's but not among older women. Obesity and alcohol use have increased steadily in all age groups, while HRT use declined sharply from the late-1990s. **Conclusions:** BC incidence has remained higher than projected since mammography screening began. The sustained elevation is likely to be due to lead time effects, though over-diagnosis cannot be excluded. Declining HRT use has also impacted incidence trends. **Implications:** Studies using individual level data, which can account for changes in risk factor prevalence and lead time effects, are required to evaluate 'over-diagnosis' due to screening.

**Keywords:** Breast cancer - incidence trends - mammographic screening

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## Introduction

Breast cancer is the leading cancer among women world-wide (International Agency for Research on Cancer, 2008). BC incidence has been increasing in both developed and developing countries (Bray et al., 2004) but over the past decade incidence has stabilised or decreased in many developed countries (Canfell et al., 2008; De Prithwish et al., 2010; Krieger et al., 2010; Daubisse-Marliac et al., 2011; Hofvind et al., 2012). Changes in reproductive practices (e.g. fewer children, older age at first birth) and lifestyle factors (e.g. increasing body weight, decreasing physical activity, alcohol use, hormone use) and improved health and nutrition (leading to taller stature, younger age at menarche, older age at menopause) may have contributed to the increasing incidence globally (Bray et al., 2004). In addition, the availability of mammography screening, and more specifically the introduction of organised screening programs, is believed to have led to more pronounced increases in higher-income countries

(Holford et al., 2006). Reasons for the recent stabilisation or decline in some countries are still being debated. Possible explanations include the maturation of screening programs (Jemal et al., 2007; Gompel and Plu-Bureau, 2010) (i.e. once the proportion and age of first-time screeners stabilises incidence effects of screening should also stabilise), declining participation in mammography screening (Gompel and Plu-Bureau, 2010), and, or the sudden decline in hormone therapy use (Glass et al., 2007; Zbuk and Anand, 2012) following results of the Women Health Initiative (WHI) trial (Chlebowski et al., 2003).

The potential for mammography screening to lead to 'over-diagnosis' of BC has been intensely debated in the recent literature. Over-diagnosis refers to the detection of BC cases through screening that would not have become clinically evident during a woman's life had she not participated in screening (Paci and Duffy, 2005). To the extent that this occurs, some cancers would be treated unnecessarily. However estimates of the level of over-diagnosis vary widely, with reports ranging from 0-54%

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of cancers depending on methodologies used and ways these estimates have been reported, including choice of denominator (de Gelder, 2011; Puliti et al., 2012).

To interpret secular trends in BC incidence and to make relevant policy decisions about population-based screening, it is important to understand the local context, including risk factor trends that may affect BC incidence. For example, the impact of screening may depend on the specifics of local programs (e.g. screening interval, target age, number of views, number of readers, and participation rates), while changes in population-wide risk profiles (e.g. reproductive patterns, HRT use, BMI, and alcohol consumption and physical activity levels) may also influence BC incidence trends.

Breast Screen SA (BSSA), which is the South Australian chapter of Australia's national mammography screening program, began as a pilot program in 1989 and became fully operational from 1992. It has provided population-based screening to eligible women in SA without charge. Women aged 40 years or older with no symptoms of BC are eligible for biennial screening, with specific targeting of women aged 50-69 years through written invitation (now 50-74 years due to policy change in 2013). Women with a strong family history of BC are eligible for annual screening. Up until 2010, the program used analogue screen-film technology with two views independently read by two radiologists with a third reading if results were discordant.

Cancer registration has been mandatory in SA since 1977. In addition, BSSA has collected data on screening participation and outcomes, for accreditation purposes, since its inception in 1989 (BreastScreen SA, 2010). Data from these sources provide an important opportunity to examine the influence of organised mammography screening on incidence trends (Luke et al., 2006).

While considerable emphasis has been placed on evaluating breast cancer outcomes in Australia in recent publications (Roder et al., 2012; 2013), less attention has been given to describing trends in breast cancer incidence in relation to screening and other associated risk factors. In this descriptive study we examine trends in BC incidence over the past three decades among SA women in the eligible age range for publicly funded mammography screening. We also describe changing patterns of participation in mammography screening, as well as changes in the prevalence of HRT use and other BC risk factors in the population. Our study specifically addresses the following questions: Have BC incidence rates increased beyond projected rates based on pre-screening incidence trends?; At what time points did BC incidence trends increase, stabilise or decrease?; Do any of these changes coincide with the commencement of the organised screening and or stabilisation of screening participation; and were there any significant changes in risk factor prevalence that might also have influenced incidence trends?

## Materials and Methods

### *Breast cancer incidence*

Annual age-standardised breast cancer incidence

rates for the period 1977-2009 were calculated for all breast cancers (invasive breast cancer (IBC) and Ductal Carcinoma *in situ* (DCIS) and for IBC alone, using the direct standardised method (by single year of age), with the mid-year 2001 Australian female population distribution as the reference. The number of cases diagnosed for each year of age and calendar year was derived from the South Australian Cancer Registry. The estimated residential population for SA females at June 30 for each year of age and calendar year, sourced from the Australian Bureau of Statistics (ABS) (Australian Bureau of Statistics, 2012), was used as the denominator for calculating rates. Age-standardised rates (ASRs) were calculated within specific age groups 40-49yrs, 50-59yrs, 60-69yrs and 70-84yrs, for all ages (40-84yrs) and for those within the screening target age range (50-69yrs).

Breast cancer incidence rates were projected using Poisson regression of the observed ASRs for the period 1977-1988 (prior to the introduction of population-based mammography screening in SA). More detailed projection modelling, including use of age-period-cohort modelling, was appropriate due to the relatively short time period of data availability preceding introduction of screening (i.e. 12 years). Projected incidence rates were regarded as the rates that would have been expected had organised screening not been introduced in South Australia and had there not been a change in trends for BC risk factors. The projected and observed BC incidence rates are presented graphically, for all ages and for each of the specific age groups. Interested readers may request detailed data from the authors.

Trends in observed ASRs were analysed using Joinpoint Regression Software version 3.5.4 (National Cancer Institute, 2012) to indicate periods of increasing, decreasing or stable incidence, the annual per cent change (APC) over these periods and the time points at which trends changed. Details are provided in the footnote of Table 1. Analyses of trends are reported for all BC (IBC and DCIS combined), as well as for IBC alone.

### *Screening participation*

Data on the number of individual women participating in screening were derived from BSSA records for each year of age and calendar year, separately for attendance at the first round and subsequent screening rounds. Biennial screening participation was defined as the number of women screened over a two year period as a percentage of the average annual estimated residential population for that period, for each specified age group.

### *Breast cancer risk factors*

Trends in body weight, alcohol consumption and HRT use among SA women were based on Health Omnibus Survey data collected between 1991 and 2009. The Health Omnibus is an annual face-to-face interview-based health survey which uses random stratified cluster sampling to recruit a representative sample of 3000 South Australian men and women from SA households (Wilson et al., 1992). Participation rates have ranged from 61% to 82% with a trend toward decreasing participation over time. Data on self-reported height and weight were available for all

survey years except 1999, 2000 and 2002. 'Overweight' was defined as a body mass index (BMI) of 25.0-30kg/m<sup>2</sup> and 'obese' was defined as a BMI of ≥30kg/m<sup>2</sup>. Data on alcohol consumption were available for all years except 1999, 2003, 2005 and 2007. 'At-risk consumption' was defined as >14 standard alcoholic drinks per week, based on self-reported frequency of alcohol consumption (i.e. number of times/week and usual number of drinks/day when alcohol was consumed). Since response categories changed over time, it was necessary to collapse categories in later surveys to be consistent with the broader categories used in earlier surveys. Data relating to current HRT use were available for 1991, 1994, 1995, 1997, 1998, 2000, 2003, 2004, and 2008. Consistent data on type and duration of HRT use were not available. To estimate the prevalence of these risk factors, data were weighted by the inverse probability of selection into their respective survey samples, then reweighted to reflect the age distribution of the SA female population (40-84yrs) for each specific year, based on population estimates from the ABS (Australian Bureau of Statistics, 2012).

Trends in fertility were derived from the ABS births data which were periodically reported for SA from 1947 onwards (Australian Bureau of Statistics, 2008). These data were used to indicate complete fertility (i.e. number of births per women over her life time), which is an important risk factor for BC. Trends in mean age at first birth, also an important risk factor, were only reported for Australia for the period 1975 onwards, while trends in mean age for all births were available for 1921 onwards (Australian Bureau of Statistics, 2008).

This study was approved by the Human Research Ethic Committees of the University of Adelaide and South Australian Department of Health.

## Results

### Incidence trends

Figure 1 shows the observed compared with projected IBC incidence rates, using projections from the pre-screening period, for various age categories from

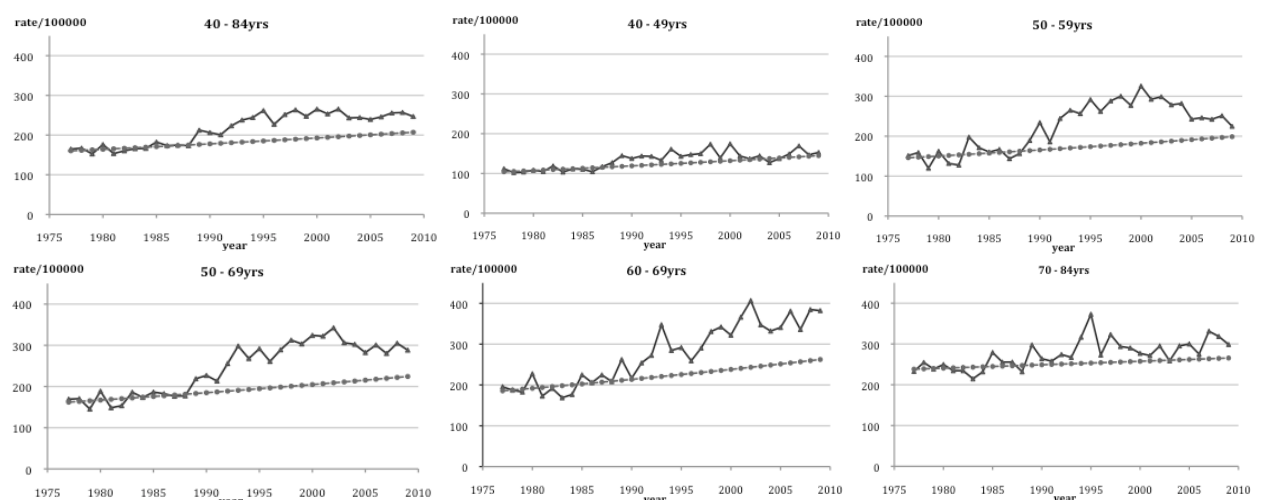
1977-2009. Observed incidence rates are higher than the projected rates since 1990 for all age groups, except for those aged 40-49, in which incidence rates began to increase before screening was introduced. The largest difference was seen for women aged 50-69yrs (i.e. the target age range for screening). The visual pattern shows declining incidence among 50-59yr olds over the past decade (i.e. circa 1998-2009) but increasing incidence among 60-69yr olds during that same period. These differences were also evident when considering IBC and DCIS combined.

Figure 2 and Table 1 show the results of Joinpoint analyses of incidence trends from 1977-2009. For IBC across all ages combined (40-84years) join-points occurred around 1987/88 and 1994/95. In the initial period, IBC incidence increased at around +0.9% per year. In the following period (1988-1994) incidence increased more

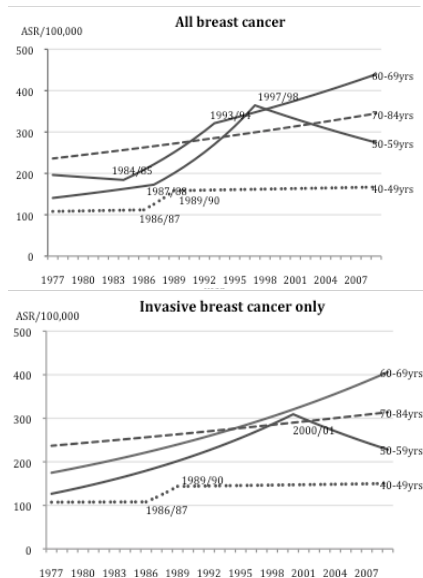
**Table 1. Trend Change Points and Annual Per Cent Change (APC) in Breast Cancer Incidence, Derived from Joinpoint Analysis<sup>a</sup> (South Australian Females 1997-2009)**

	All breast cancer (invasive and <i>in situ</i> )			Invasive breast cancer only		
	Segment	Period	APC (95%CI)	Segment	Period	APC (95%CI)
40-84	1	1977-1987	1.3 0.1, 2.6	1	1977-1987	0.9 -0.3, 2.0
	2	1988-1995	5.8 3.6, 8.0	2	1988-1994	5.3 2.6, 8.0
	3	1996-2009	-0.1 -0.8, 0.6	3	1995-2009	0.0 -0.6, 0.7
50-69	1	1977-1982	-1.4 -6.7, 4.2	1	1977-1982	-1.0 -6.1, 4.4
	2	1983-1998	5.4 4.3, 6.5	2	1983-2000	4.2 3.3, 5.0
	3	1999-2009	-0.8 -2.5, 0.8	3	2001-2009	-1.8 -3.9, 0.4
40-49	1	1977-1986	0.4 -1.8, 2.6	1	1977-1986	0.1 -2.0, 2.2
	2	1987-1989	12.3-11.9, 43.0	2	1987-1989	10.0 -12.5, 38.2
	3	1990-2009	0.3 -0.4, 0.9	3	1990-2009	0.2 -0.4, 0.9
50-59	1	1977-1987	2.1 -0.5, 4.7	1	1977-2000	4.0 3.1, 4.8
	2	1988-1997	7.8 4.6, 11.0	2	2001-2009	-3.3 -6.4, -0.1
	3	1998-2009	-2.3 -4.2, -0.4	-	-	-
60-69	1	1977-1984	-0.9 -4.1, 2.4	1	1977-2009	2.7 2.3, 3.1
	2	1985-1993	6.4 3.5, 9.3	-	-	-
	3	1994-2009	2.0 1.0, 3.0	-	-	-
70-84	1	1977-2009	1.2 0.8, 1.5	1	1977-2009	0.9 0.5, 1.2

<sup>a</sup>Log-linear modelling using Joinpoint software<sup>21</sup> to identify change points and to estimate APC for identified time periods. The optimal number of join-points was determined using the permutation method, with a minimum of 3 observations between join-points and 4 observations to either end of the observation period; Change points occur at the end of each period reported; Where only one period is listed, no change point was identified, i.e. constant rate of increase/decrease in incidence over the entire period; %CI=% confidence intervals



**Figure 1. Observed and Projected Invasive Breast Cancer Incidence Rates for Specified Age Groups, South Australian Females 1977-2009.** Circles/dashed line=projected breast cancer incidence rates. Triangles/solid line=observed breast cancer incidence rates. All rates are age standardised (per 100,000 per year) within respective age groups



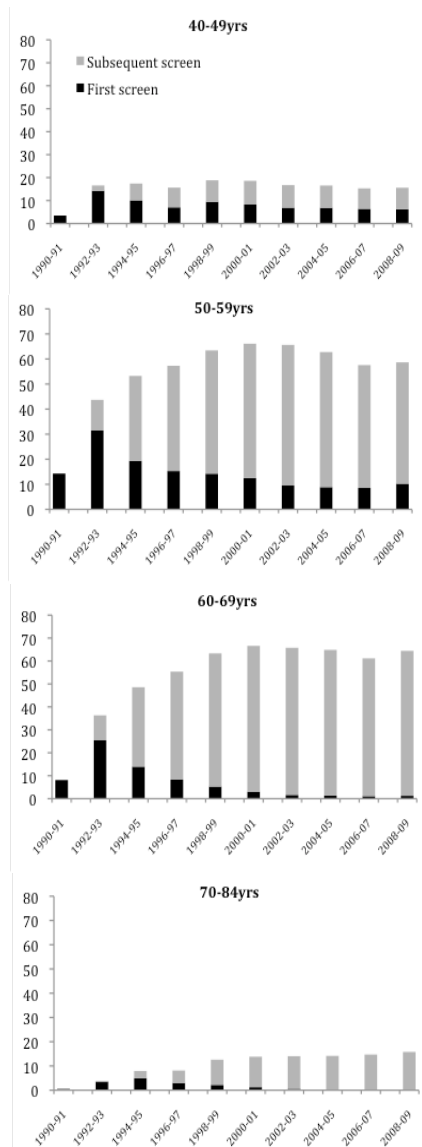
**Figure 2. Graphical Presentation of Results from Joinpoint Analysis of Female Breast Cancer Incidence Trends by Age Group (SA Females, 1977-2009)**

rapidly, at around +5.3% per year. From 1995-2009 rates were stable. The pattern for all BC, for all ages combined, was similar, except that the second change point occurred slightly later (1995/1996). Among the screening target age range (50-69yrs) incidence rates for both IBC and all BC began to increase from 1983 and continued to increase for a longer period of time (i.e. until 2000 for IBC and 1998 for all BC).

Age-stratified analysis of incidence trends indicates considerable variation in patterns across different age groups. For women aged 40-49yrs a rapid (though not statistically significant) increase in IBC incidence was observed between 1987 and 1989 (+10% per year) with relatively stable incidence either side of this period. Among women aged 50-59yrs, IBC incidence rose steadily between 1977 and 2000 at a rate of +4.0 % per year and then decreased by -3.3% per year from this point on. By contrast, no change points were evident for women aged 60-69 or 70-84yrs, with IBC incidence increasing steadily at +0.9% per annum over the 33 year period. Trends in incidence of all breast cancer generally followed similar patterns as for IBC, but with more distinct time points identified for women aged in their 50s and 60s.

*Screening participation*

Figure 3 depicts trends in biennial mammography screening participation for different age groups, for both first and subsequent screening rounds. Total participation among the target population (50-69yrs) increased steadily from the inception of screening to peak at 66% in 2000-2001. Between 2002 and 2007 there was a slight decline in participation which appears to have halted in 2008-09. A substantial proportion of women outside the target age range had also participated in screening. From 2000, biennial participation was 15-18% among women aged 40-49yrs and 12-15% among women aged 70-84yrs. Participation after 70yrs of age continued to increase steadily over time.

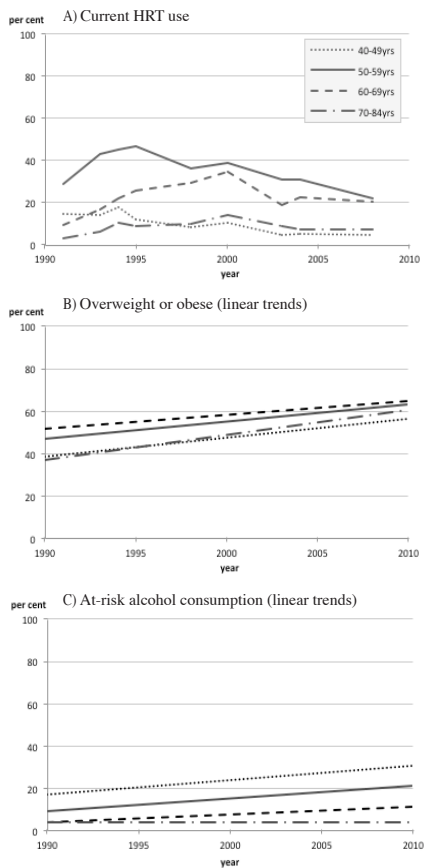


**Figure 3. Trends in Participation in Biennial Mammography Screening at BreastScreen SA, by Age Group (Percent of SA Estimated Residential Population)**

First-time participation in the screening appeared to reach a steady state around 1998-99. First round screening accounted for over 75% of all screening events in 1992/93, but only around 15% from 1998 onwards. Since the program stabilised, around 50% of participants began screening when aged 50-59yrs. However a substantial proportion (40%) had begun screening at a younger age. There has been a continual decline in first time screening among older women, to negligible proportions, as the program has matured.

*Trends in selected breast cancer risk factors*

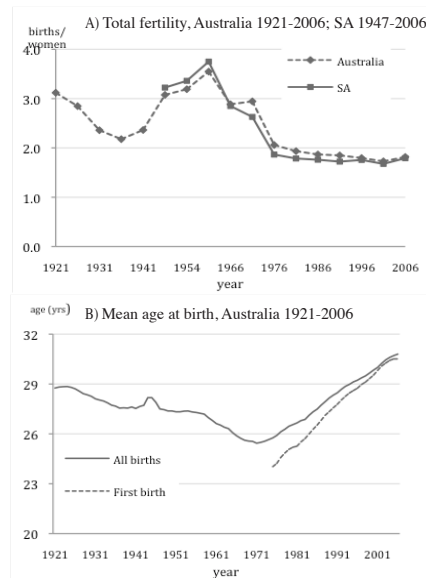
Figure 4 shows age specific trends in the prevalence of HRT use, overweight and obesity, and at-risk alcohol consumption among SA women since 1991. The prevalence of overweight and obesity has increased steadily in all age groups over the past two decades. Likewise, at-risk alcohol consumption has increased slightly across all age groups, with the exception of women age 70-84yrs, which was stable over the period. Prevalence



**Figure 4. Trends in Breast Cancer Risk Factors for South Australian Women, by Age Group.** Source: South Australian Health Omnibus Surveys 1991-2009

of HRT use however decreased after a period of high use during the early 1990s. The point at which the decline began differs across age groups. While prevalence among women aged 60-69yrs declined after 2000, the decline began earlier among women aged 50-59yrs (around 1995). Among women <50yrs, HRT use was declining over the entire study period. Population trends are consistent with data from BSSA reporting HRT use among screening participants (results not shown).

Figure 5 shows trends in total fertility among Australian women since 1921 and SA women since 1947, and mean age at birth (all births from 1921 and first births from 1975) for Australian women. The number of births per woman increased from comparatively low levels in the 1930's (during the economic depression) to peak in the early 1960s. Total births then declined rapidly over the next 15 years, and then more slowly during the 1980s. Data are limited with regard to maternal age at first birth. However, historical records indicate that the mean maternal age for all births in Australia was declining between 1921 and 1971 and only began increasing after this time. Given that total fertility was increasing between 1930 and 1960 while the mean age at birth was decreasing, age at first birth was unlikely to have begun increasing until after 1960. However, both decreasing fertility and increasing maternal age at first birth from the mid-1960s, are likely to have led to increased BC incidence among women in the target age range at the time the screening program commenced.



**Figure 5. Trends in Fertility Patterns for Australian and South Australian Women (Where Available).** Source: Australian Bureau of Statistics

## Discussion

Our results indicate that BC incidence increased substantially around the time organised mammography screening was introduced in SA, suggesting a strong screening effect. However, patterns differed quite markedly across age groups suggesting that other factors may have also influenced BC incidence trends. Patterns in incidence trends were similar for all BC (IBC and DCIS combined) and for IBC alone.

Overall, the observed incidence trends are consistent with expected patterns following the introduction of population-wide mammography screening (Holford et al., 2006). Since screening, by design, brings cancer diagnoses forward several years, a higher incidence rate would be expected immediately after the introduction organised population-based screening, due to the detection of cancers that would not have become clinically apparent until several years later. This lead time effect would continue to elevate BC incidence rates as screening continued, though to a lesser extent since many future cancers have already been detected. The large number of women in their 60s commencing screening during the implementation phase would further contribute to the higher incidence. Once the screening program stabilised (i.e. reached maximum capacity and the proportion/age of first round attendees reached a steady state) the overall effect on population incidence rates would be toward stable incidence. This rate may be slightly higher than the projected rate, given ongoing lead time effects as new cohorts commenced screening.

Examination of trends within specific age groups suggests that factors other than the introduction of mammography screening may also have impacted on BC incidence trends. Among women aged 50-59yrs, IBC incidence declined significantly after reaching a peak around 2000, whereas rates continued to increase over the entire period among the women aged 60-69yrs. The changing prevalence of HRT use is the most likely factor

affecting BC incidence trends. The sudden fall in HRT use, which occurred in response to release of WHI trial results of combined oestrogen-progestin HRT in 2002 (Chlebowski et al., 2003), may explain the decline in rates among women aged 50-59yrs. Since the effects of HRT are relatively short lived in that they are not apparent 5 years after ceasing use (Chlebowski et al., 2009) the impact of declining HRT use should be evident relatively quickly. Our results suggest that the decline in BC incidence among women in their 50's preceded the publicity surrounding the WHI trial findings. However, an earlier systematic review published in 1997 which showed elevated risk of BC with long term use of combined oestrogen-progestin formulas (Collaborative Group on Hormonal Factors in Breast Cancer, 1997), may have influenced prescribing patterns in more subtle ways, for example general practitioners may have encouraged shorter duration of use. Our data on HRT use show a gradual decline among women in their 50's well before 2002.

The increasing incidence among 60-69yr olds may also be consistent with HRT effects. HRT may act by promoting tumour growth rather than initiating nascent breast cancers (Dietel, 2010). If so, then breast cancers would be found at an earlier age among HRT users compared with non-users. Hence tumours that might have been detected at a younger age would instead be detected at an older age among women who stopped using HRT. Thus, there is likely to have been a shift from detection of cancers among women in their 50's when HRT prevalence was high, to detection in their 60's when HRT use decreased. Consequently incidence rates would have declined among women aged 50-59yrs but simultaneously increased among women aged 60-69yrs.

Changes in reproductive histories across successive cohorts may also have influenced BC incidence trends. Lower parity and older age at first birth are both independently associated with increased risk of BC (Ewertz et al., 1990; Kelsey et al., 1993). Based on South Australian fertility patterns, other factors aside, incidence among women in their 50's should have been increasing continuously over the 20 year period since breast screening began, due to declining fertility from the 1960's. However incidence in older women (60-69yrs and 70+yrs) would have been decreasing in 1990s, due to the increasing fertility rate when these women were in their childbearing years. The subsequent decline in fertility rates would have led to increased BC incidence in more recent years among women aged over 60yrs. Changes in fertility patterns, therefore, do not explain the declining incidence among women aged 50-59yrs from the late 1990s, but may provide an explanation for increasing incidence among older cohorts.

Changes in the prevalence of risk factors are unlikely to translate directly into changes in BC incidence due to the lag time between tumour initiation and eventual detection and, or cumulative risk over a lifetime. However there is considerable uncertainty about the biological pathways and temporal relationships for many of these risk factors. Some have suggested that alcohol may act as a tumour promoter (Brooks and Zakhari, 2013). If so, changing patterns of alcohol consumption may result in

more immediate changes in incidence rates. Similarly, weight loss during menopause has been found to be associated with reduced BC risk (Eliassen et al., 2006), which suggests adiposity may also have a transient effect. Since both risk factors are thought to act through hormonal pathways (Cleary and Grossmann, 2009; Brooks and Zakhari, 2013), it is highly plausible they promote tumour growth. What is clear is that the prevalence of both risk factors has increased steadily in the SA population with no dramatic changes that would account for a downward trend in incidence for women aged 50-59yrs if effects were transient. The most likely net impact of the observed trends in alcohol consumption and obesity is toward higher BC incidence over time.

The reason for the apparent increase in incidence among 40-49yr olds (around 1983) prior to the introduction of the screening program in SA is unclear. Since very few women under 50yrs participated in the pilot program (1989-1991), the effect of organised screening in this age group should not be evident until 1992 onwards. However, diagnostic mammography has been available as a reimbursable item through Medicare since 1984. Increasing uptake of 'opportunistic' mammography before the implementation of organised screening may account for an earlier increase in incidence among women aged 40-49yrs.

Also, we found no evidence of a compensatory drop in BC incidence, among women aged 70-84yrs, which would be expected due to the 'removal', through early detection, of cancers that would have become clinically evident at this age. One explanation may be that the follow-up period is still too short for the effect to be observable at a population level. Another explanation may be that the increasing trend toward continued screening beyond 70 years has negated the anticipated drop in incidence in this age group. Alternatively the underlying risk of BC may have increased over successive cohorts, due to the increasing prevalence of risk factors, to the extent that the expected drop has not been evident.

Our data indicate that BC incidence rates have remained higher than the projected rates across most age groups some twenty years after the introduction of population-based screening. While higher incidence could indicate some level of over-diagnosis due to screening, it may also reflect the sustained effect of lead time. Duffy and Parmar have recently demonstrated that lead time effects are considerably larger and persist for much longer periods than previously recognised (Duffy and Parmar, 2013). Their findings indicate that lead time alone would result in increased incidence more than 20 years after screening commenced. Also, one of the major assumptions in projecting incidence in the absence of screening is that underlying trends have not changed substantially from those observed prior to the implementation of screening. While BC incidence was increasing at around 1% per annum during the pre-screening period, it is possible that the collective effects of multiple risk factors have caused underlying BC rates to increase at a higher rate than predicted based on projections. In addition, changes in the medico-legal environment may also have influenced rates to increase to a greater extent than expected through driving changes in pathology practice that have increased

BC diagnosis (Nassar, 2011).

Reliance on self-reported risk factor measures is a limitation of this study. However it is unlikely that response bias has changed to the extent that would explain increasing BMI and alcohol use or decreasing HRT use. Furthermore, the increase in body weight is broadly consistent with national survey data using measured height and weight (Australian Institute of Health and Welfare: Dixon and Walters, 2003). Likewise, the increase in alcohol consumption is consistent national data on 'risky' alcohol consumption (Australian Bureau of Statistics, 2009) and the changing pattern of HRT use is consistent with data collected by Breast Screen. Our measures of breast cancer incidence and participation in screening, on the other hand, are likely to be highly reliable, given the statutory requirement to notify newly diagnosed cancers and BSSA's reporting requirements for accreditation purposes.

Finally, it is not possible to draw any causal inferences from this study given the ecologic design and lack of individual level data on BC risk factors, screening history and BC incidence for the population. However our findings are indicative of the multiple factors influencing BC trends in South Australia. We consider it likely that multiple factors would also affect BC trends in other populations, although their respective contributions probably would vary.

In conclusion, our analysis indicates that, since the introduction of population based mammography screening in South Australia, BC incidence rates have been higher than projected. The largest increases were observed among women in the target age range for breast screening, suggesting that population-based screening has been the major factor influencing BC incidence. Lead time effects are likely to be the main reason for the sustained elevation in incidence, though over-diagnosis cannot be excluded as a potential factor. The increasing prevalence of BC risk factors (e.g. BMI, alcohol use) and changing fertility patterns may have also contributed to higher than expected incidence. Furthermore, the distinctly different incidence trends for women aged 50-59yrs and 60-69yrs may be explained by the changing prevalence of HRT use among South Australian women, suggesting patterns of HRT use have had a major impact on BC incidence in SA.

To determine the extent of over-diagnosis that may be attributed to mammography screening, individual person level studies that take account of changes in risk factor patterns and adequately adjust for lead time effects are required. In Australia, the ideal study would require linkage of breast screening, cancer registry, census, health survey and pharmaceutical benefits datasets to provide individual level data on BC incidence, screening attendance (within and outside public screening programs), reproductive histories, HRT use and other risk factor measures. Currently such studies are difficult to undertake in Australia given the limited data collection, access and infrastructure. The feasibility of such studies is likely to vary across populations depending on their data infrastructure and data access policies.

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