Age differences in mammography screening reconsidered: life course trajectories in 13 European countries

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Background: Breast cancer is the most common cause of cancer mortality among European women. To reduce mortality risk, early detection through mammography screening is recommended from the age of 50 years onwards. Although timely initiation is crucial for cancer prognosis, the temporal dimension has largely been ignored in research. In cross-sectional research designs, it is not clear whether reported age differences reflect ‘true’ age effects and/or presumed period effects resulting from evolving knowledge and screening programmes. Methods: We use longitudinal data from the survey of Health, Ageing and Retirement (SHARELIFE, 2008), which enables to cast light on age differences by providing retrospective information on the age at which women commenced regular mammography screening. Moreover, the cross-national dimension of the SHARE permits framing the results within the context of nationally implemented screening programmes. By means of the Kaplan–Meier procedure, we examine age trajectories for five 10-year birth cohorts in 13 European countries (n = 13 324). Results: Birth cohorts show very similar age trajectories for each country. Along with the observation that large country differences and country-specific deviations coincide with screening programme characteristics, this suggests strong period effects related to implemented national screening programmes. Conclusion: Age differences in mammography screening generally reflect the period effects of national screening policies. This leaves little room for economic theories about human health capital that leave out the institutional context of preventive health care provision.

Introduction

Breast cancer is the most frequently diagnosed form of cancer among European women, accounting for 319 900 cases in 2006 (30.9% of all cancer diagnoses). It is the leading cause of death from cancer among women, with an estimated mortality rate of 16.7%. Breast cancer will remain an important public health issue, given that even more women are likely to be affected in the future due to the ageing population.1

Research has predominantly focused on the role of national programmes in reducing the well-documented socio-economic inequalities in mammography screening.2–4 In contrast, the timely initiation of screening has received much less attention,5 despite its crucial importance for cancer prognosis.6 After all, the stage at diagnosis (or tumour size) is strongly linked to survival.7 Since women aged 50–69 years are at the highest risk for breast cancer, both the World Health Organization (WHO) and the Council of the European Union8 recommend that national programmes target these women for regular check-ups.

In general, age is regarded as a control or a confounding variable, or is used as a proxy for ‘need’ for care, because ‘need’ factors are not always apparent.9,9 Occasionally, age differences are theoretically hypothesized based on the economic theory of human health capital.10 Good health is treated as both a consumption commodity (i.e. sick days being a source of disutility) and an investment commodity (i.e. the total amount of time available for market and non-market activities). In the case of medical screening, early detection and intervention of the illness does not only improve the disease prognosis as previously mentioned, but can also reduce treatment costs.11 As such, investments and the choice for mammography screening are made in order to optimize their utility.9 During these cost-benefit considerations, women are likely to consider factors other than just financial costs such as the fear of false positives,12 pain13 and overtreatment.14 With regard to age, different hypotheses can be formulated. On the one hand, the returns on investment from preventive screening are hypothesized as being reduced for older women, given that overall health deteriorates with increased age and the years that can potentially be saved also declines.15 On the other hand, greater returns on investment can be hypothesized for older women, since they face a higher risk of breast cancer.1

Empirical studies generally report lower engagement in screening among older women,6 but confusion remains high. One of the reasons for this is that studies still predominantly rely on cross-sectional designs, in which women are asked to report whether or not they engaged in screening during a prior period, usually 2 years. This design and question wording render it impossible to examine the extent to which age differences reflect ‘true’ age effects rather than age acting as a proxy for period effects, which are expected given the changing knowledge over time about breast cancer and screening programmes. Moreover, this snapshot perspective does not allow study of the long-term use of mammography screening at the recommended regular intervals of 2 years.16 The retrospective data from the Survey of Health, Ageing and Retirement (SHARE, 2008–9, known as SHARELIFE), provides information about the age at which women commenced regular mammography screening. This allows to discern largely age effects from broader period effects and includes the notion of regularity.

In addition, the cross-national dimension of the population-based data enables us to frame potential period effects within the context
of nationally implemented screening programmes. These programmes can reduce or eliminate financial and other costs and therefore change age-eligible women’s cost-benefit analysis. Despite general guidelines, European countries differ greatly in screening strategies (left-hand columns, table 1). Most have now organized national population-based programmes, in which women are personally offered screening on a regular basis, mostly every 2–3 years from the age of 50 years onwards. However, in Switzerland and Italy, programmes of this nature have only been implemented in some regions, and other countries, such as Austria and Greece, still rely completely on opportunistic screening, where individuals request screening themselves or are recommended to do so by health advisors. Further, large differences exist in the organizational characteristics of programmes, their implementation stage, the method of offering screening and the participation rate.

By comparing different institutional contexts, we highlight the supply side, which influences preventive healthcare use along with frequently cited individual factors such as socio-economic status.

To date, seven studies have addressed cross-national differences in mammography screening in Europe, using population-based data from the World Health Survey (2002), the Eurobarometer (66.2, 2006), the first two waves of the SHARE (2004/2006), and SHARELIFE. Except for the last studies, all have focused on socio-economic inequalities using cross-sectional data, rendering the study of age differences in regular screening problematic. Also using data from SHARELIFE, Sirven and Or very briefly mention age differences in the commencement of regular mammography screening for three large birth cohorts and four large European regions. This current article aims to provide a more in-depth discussion, paying explicit attention to country differences and their associations with the characteristics of national screening policies.

**Data**

SHARE is a multidisciplinary and cross-national panel database on health, socio-economic status and social and family networks. Details about the sampling procedure can be found elsewhere, but in general, it consists of probability samples, drawn from population registers or from multistage sampling. Respondents aged 50 years or above together with their partner (and other household members in wave 1, aged at least 50 years) were interviewed face-to-face using structured computerized questionnaires. This study uses data from the third wave (SHARELIFE, 2008–9), in which retrospective information was collected about preventive healthcare use during the life course, among other items. To improve recall of retrospective data, a life history calendar (LHC) was used. The respondent’s life is represented graphically by a grid that is completed during the interview. Special efforts were made to reduce attrition and attain high retention rates throughout the different waves. This has led to an overall retention rate of 71%. The household response rate in the first wave was on average 62% and country variation reflected patterns from other international surveys. Individual response rates amount to 85% on average (for country-specific figures see website: http://www.share-project.org/data-access-documentation/sample.html). Data were collected in six Western European countries (Belgium, France, The Netherlands, Germany, Switzerland and Austria), two Northern European countries (Denmark and Sweden), three Southern European countries (Spain, Greece and Italy) and two countries in Eastern Europe (Poland and The Czech Republic). Because of the focus on preventive mammography screening, a small number of women who were diagnosed with breast cancer during their lives are excluded from the sample (n = 285; 2.0%). This information was retrieved from wave 1 (2004) and wave 2 (2006). There is only a small amount of information missing for mammography screening practices (5.3%) and this is therefore deleted listwise.

**Measurements**

**Regular mammography screening initiation**

Our dependent variable, the commencement of regular mammography screening, is retrieved from the question ‘In which year did you start having mammograms regularly?’ given to all women who answered yes to the question ‘Have you ever had mammograms regularly over the course of several years?’

**Birth cohorts**

We construct five birth cohorts from 1910 to after 1949 in 10-year intervals. These cohorts act as proxy for period effects. Depending on their birth cohort, women were the recommended age for screening and/or the eligible age for population-based screening programmes in different time periods.

**Methods**

We apply event history analysis, to model the time until women commenced regular mammography screening. The end of the risk period is defined either by the time the event occurred (i.e. the age of commencing regular mammography screening) or by the time the individual is censored (i.e. those who did not experience the event during the observation period). Here, women who did not engage in mammography screening are censored at the time of the

### Table 1 Mammography screening in 13 European countries

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<th>Characteristics of breast cancer screening policies</th>
<th>Number and % of regular screeners, based on SHARELIFE data</th>
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retrospective data collection in SHARELIFE (2008 or 2009). Unlike standard statistical methods such as linear or logistic regression, event history analysis can adequately deal with censoring. The Nelson–Aalen method is used to calculate the cumulative hazard function, which assesses at each point in time the amount of accumulated risk between the beginning of the examined period and each observed event time. Exploring behaviour graphically over time allows us to retrieve information about the shape of the underlying hazard function. The graphs will thus show at each age, the accumulated risk factor for women of a specific birth cohort to commence regular screening. A log rank test is performed to assess whether these cumulative hazards differ significantly by birth cohorts. Also, simple descriptive statistics are calculated to give an overview of the proportion of women in each country that ever commenced regular screening. All analyses are carried out in Stata 11.

**Results**

First, we focus on the age trajectories. Figure 1 shows that the cumulative hazard increases at a similar rate across age in all countries, except for a large increase at the age of 50 years, which reflects the generally recommended age for commencing screening. A notable exception is found for Sweden, where the likelihood of screening increases sharply among 40-year-old women. This is not that remarkable, as about 65% of Swedish counties start offering screening for women at the age of 40 years.

To find out whether these age trajectories differ according to birth cohorts, we turn to the country-specific figures (figure 2A–M). For all countries, women in younger birth cohorts have a higher cumulative hazard and are thus more likely to commence regular screening at some age (log-rank, \( P < 0.001 \) for all countries). For the three youngest cohorts in particular, the hazard for screening increases at the same rate and a notable increase is observed at the age of 50 years, except for Austria, Greece, Germany and Poland. This suggests that there are no ‘true’ age effects, so that age is not a crucial factor that is taken into consideration when deciding about screening. Rather this points to broader period effects, especially because features of national screening programs can again be linked to these exceptions and also to a great extent to the large country variation in the overall take-up of screening.

In Austria and Greece, an organized programme is absent, while the implementation in Poland (2007) was too close to the data collection in 2008–9 to be reflected in the figures. Similarly, in Germany, the roll-out of the national screening programme started in 2005, but it was completed only in 2009. In Denmark, the national programme only commenced in December 2007, but here an increase at the age of 50 years is still notable. This can be explained by regional programmes, which have covered 20% of the national volume of opportunistic screening is notable (64.7%). In Italy, regional programmes have taken off since 1985, so that in 2007 at least one pilot population-based programme in all Italian regions has been realized. Accordingly, the share of women with regular screenings in Italy (62.4%) is similar to its neighbouring country Spain, where a national programme was launched in 1990 (66.5%). Although Germany and France both had their national programme only recently implemented in 2004, the number of regular screeners differs considerably (48.2% and 77.4%, respectively). This could be associated with the long-standing practice since 1971 to offer yearly gynaecological ‘cancer early detection exams’ to German women from the age of 30 years onwards. Breast self-examinations are free of charge for women from the age of 40 years. The sharp increase in screening at the age of 40 years for women born after 1949 in Austria is probably a reflection of this programme or the example it has set. An increase at 45 years of age is found for Spanish and Czech women born after 1949. Some Spanish regions start offering screening to women aged 45 years and the national programme in the Czech Republic includes women from the age of 45 years onwards.

Next, countries differ largely in how high the cumulative hazards are across age (figure 1). This indicates that at all ages, the take-up of regular mammography screening differs strongly between European countries, which is also reflected in the general figures in table 1. The lowest proportion is found in Denmark (29.3%), whereas Swedish women are the most likely to engage in regular screening (89.8%). It is remarkable that these extremes are both in the Northern European region, which is generally considered as universally the best performing with regard to health, due to relatively generous and universal welfare provision. However, this is not so surprising given the long-term implementation of a national screening programme in Sweden, in contrast to Denmark (table 1).

After Sweden, The Netherlands has the longest running programme and the second-highest proportion of regular screeners (84.9%). On the other hand, the least regular screeners are found in Denmark (29.3%), Poland (40.1%), Germany (48.2%), Greece (47.5%) and Switzerland (48.9%). A national programme was implemented too closely to the SHARELIFE data collection for reflection in the figures of Denmark and Poland, while it is absent in the two latter countries. However, the absence of a national programme does not necessarily entail that many women forgo mammography screenings as for example in Austria a large volume of opportunistic screening is notable (64.7%). In Italy, regional programmes have taken off since 1985, so that in 2007 at least one pilot population-based programme in all Italian regions has been realized. Accordingly, the share of women with regular screenings in Italy (62.4%) is similar to its neighbouring country Spain, where a national programme was launched in 1990 (66.5%). Although Germany and France both had their national programme only recently implemented in 2004, the number of regular screeners differs considerably (48.2% and 77.4%, respectively). This could be associated with the long-standing practice since 1971 to offer yearly gynaecological ‘cancer early detection exams’ to German women from the age of 30 years onwards. Breast self-examinations are free of charge for women from the age of 40 years. The sharp increase in screening at the age of 40 years for women born after 1949 in Austria is probably a reflection of this programme or the example it has set. An increase at 45 years of age is found for Spanish and Czech women born after 1949. Some Spanish regions start offering screening to women aged 45 years and the national programme in the Czech Republic includes women from the age of 45 years onwards.

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Figure 2 (A–M) Country-specific cumulative hazard function for mammography screening initiation per 10-year birth cohort (Nelson–Aalen estimates)
over the course of their lives is inextricably bound up with the evolution in knowledge about breast cancer and the discussion and implementation of screening policies. The crucial role of screening policies is also reflected in the large country variation in screening as well in the observation that exceptions can be linked to features of national screening programmes.

Even within the same European region, large country differences are notable in the take up of mammography screening. The World Health Survey (WHS) 2002 revealed similar results, although the ranking of prevalence rates shows some differences. For five countries (Belgium, Denmark, Sweden, Greece and the Czech Republic) proportions are lower in the WHS than in SHARELIFE, whereas for the other five countries with available data (France, Germany, Austria, Spain and Italy), higher proportions are noted. For France, this might be related to the introduction of a national programme (2004) between the data collections of the two surveys. However, in other countries such as Spain this might not be the case, given the early implementation of the programme there in 1990. Instead, as suggested by Braillon, cross-sectional data might overestimate the quality of the programmes. The one other cross-national study that did not use data from SHARE, only scrutinized determinants of screening for a dichotomous grouping of countries based on opportunistic vs. nationally organized programmes. Our results suggest that important country-specific characteristics are thereby overlooked.

The SHARELIFE also questioned the reasons for not taking up mammography. These reasons differ strongly between countries (for numbers see refs and can again been linked to screening policies. Respondents stated that information was lacking and that screening was not affordable or available in countries without a national programme (Austria and Greece) or only a recently implemented programme (Germany and Poland). In countries with only regional coverage (Italy and Switzerland), respondents stated that they did not engage in screening because of a lack of information and financial means. In the Netherlands and Sweden, the two countries with the highest screening rates, none of the aforementioned perceived barriers were indicated. Instead, only the belief that screening is not necessary was found to be significantly related to not participating.

The fact that age trajectories in screening appear relatively universal for all countries, despite the varying perceived ‘costs’ of screening, corroborates the contention that age differences are largely attributable to the period effects of national policies. These period effects are mirrored in cross-sectional studies that have reported lower screening rates above the age of 60 years or 65 years. Similarly, longitudinal studies such as that of Puddu and colleagues, report important period effects in terms of an increase in screening over a 3-year period among women aged 60–69 years.

Before turning to the conclusion, two limitations should be acknowledged. First, retrospective data may raise some concerns regarding recall bias. However, SHARE took this concern seriously. In addition to the measures to minimize bias at the time of data collection, quality checks were conducted on the respective data. Although more research is needed, strong consistency has already been found for personal events. The second limitation concerns the question wordings regarding mammography screening. It is impossible to discern fully whether women started mammography screening for preventive purposes only or for other reasons. Data limitations hinder us from discerning the motivations of women to commence screening. A family history of breast cancer is related to perceived risk of the disease, which in turn impacts on the commencement of mammography screening. However, the information on health history enables us to exclude women diagnosed with breast cancer.

This study illustrates the potential of applying a longitudinal perspective in cross-national comparative research on health. For both policy makers and researchers, timeliness deserves further attention, even more so for preventive services that require already starting routine check-ups in childhood, such as dental care. In sum, cross-sectional age differences in mammography screening generally reflect the period effects of national screening policies. This leaves little room for economic theories about human health capital that ignore the institutional context of preventive healthcare provision.

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Conflicts of interest: None declared.

Key points

What is already known on this subject?
- The uptake of mammography screenings differs largely between countries and socio-economic groups.
- Little is known about the age of commencement of regular screenings. In a cross-sectional design, it is impossible to discern age effects from period effects related to evolving knowledge and the implementation of national screening programmes.

What this study adds?
- By means of retrospective information of the SHARELIFE on the age of screening initiation, age trajectories are calculated for different birth cohorts in 13 European countries.
- In all 13 European countries, age trajectories seem very similar for all birth cohorts, which suggest strong period effects rather than ‘true’ age effects.
- Besides, strong period-effects are reflected in the large between-country variation in screening uptake as well as in country-specific deviations.

References

Breast cancer diagnosis and death in The Netherlands: a changing burden

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Background: Lifetime risks are often used in communications on cancer to the general public. The most-cited estimate for breast cancer risk (1 in 8 women), however, appears to be outdated. Here we describe the breast cancer burden in the Netherlands over time by means of lifetime and age-conditional risks. The aim is to identify changes in absolute risk of primary breast cancer diagnosis and death. Methods: Data on breast cancer incidence, mortality and size of the female population were retrieved from the Netherlands Cancer Registry and Statistics Netherlands. Lifetime and age-conditional risks were calculated for 1990, 2000 and 2010 using the life-table method (DevCan software). Results: The lifetime risk of developing breast cancer (ductal carcinoma in situ and invasive) in 1990, 2000 and 2010 was estimated at 10.8 (1 in 9.3 women), 13.5 (1 in 7.4) and 15.2% (1 in 6.6), respectively. Most women were still diagnosed after the age of 50, with the highest risk between 60 and 70 years of age in 2010. The lifetime risk of breast cancer death was 3.8% (1 in 27) in 2010, which is lower than in 1990 (4.5%; 1 in 22) and 2000 (4.2%; 1 in 24). Conclusion: Breast cancer risk has increased to 1 in 6.6 women being diagnosed during their lifetime (invasive cancer only: 1 in 7.4), whereas risk of breast cancer death has decreased from 1 in 22 to 1 in 27 women. To keep cancer management and prevention up-to-date, it remains important to closely monitor the ever-changing breast cancer burden.

Introduction

The international breast cancer burden has changed over time. Changing lifestyles and early detection have markedly influenced breast cancer incidence in recent years. Simultaneously, advances in breast cancer therapy and early detection have had a profound effect on breast cancer mortality. This includes the introduction of mammographic screening programmes in many countries. The effect of long-running screening programmes with both high coverage and attendance rates, like the Dutch programme, is becoming increasingly visible.

Researchers often refer to age-standardized incidence and mortality rates in studies on the burden of breast cancer. An alternative measure is the lifetime risk, which is calculated by converting the population-based rates into individual risks. The lifetime risk is a summary measure that combines different population characteristics, thereby also allowing for competing risk adjustments. The lifetime risk is often the preferred measure in public health communications, as it is perceived to be both informative and easily comprehensible. In addition, it corresponds to the more individual perspective that is increasingly applied in prevention, including personalized screening. Lifetime risks can be calculated for newborns, which give the probability of a breast cancer diagnosis or breast cancer death throughout an entire lifetime. Furthermore, both short- and long-term risks for women who have been cancer-free up until a certain age can be calculated. The 10-year breast cancer risk for a 50-year-old woman, for example, may be very helpful in the evaluation of the screening starting age.

Cancer registry data covering the whole country since 1989 are available from the Netherlands Cancer Registry (NCR). Because of the high-quality long-running cancer registry, long-term trends in cancer epidemiology can easily be studied in the Netherlands. These data have been used previously to calculate lifetime risks. The most-cited estimate, however, dates from 2003. The average lifetime risk for invasive tumours was estimated to be 1 in 8 (12.7%) at that time, whereas the estimate including in situ tumours was nearly 1% higher (13.6%). In this paper, we illustrate the breast cancer burden in the Netherlands by means of lifetime and age-conditional...