Background

London has had a relatively low uptake of breast screening with only 61% of women accepting their invitations in 2008–09, compared with a national average of 74%. Several factors ranging from a diverse and mobile population, low awareness of screening, problems accessing services to the way these are delivered have been proposed as responsible. London includes contrasting areas of deprivation in inner city areas, and areas of affluence, mostly in outer areas. There are a number of private hospitals and clinics where women may choose to undergo screening outside of the National Health Service (NHS). In addition, the population is the most ethnically diverse area in England, with 6% of women in the screening age group being from Black ethnic groups and 7% from Asian groups, compared with 2001 national census estimates of 1.3 and 2.4%, respectively. Breast screening attendance among women from different ethnic groups is thought to vary in the UK, although lack of ethnicity data for all invited women prevents the calculation of accurate attendance rates. A recent study using an area-based method in London...
suggested that communities with large Black populations have low screening attendance. Other population-based studies in the Midlands and West Yorkshire, using surnames to identify Asian women, found that they had lower attendance than non-Asian women.

Breast cancer incidence and survival rates are strongly associated with socioeconomic deprivation, with women living in the most deprived areas having a lower incidence and worse survival than those in living in the more affluent areas. In South-East England the overall breast cancer incidence in women from Black and Asian ethnic groups was lower than that in White women but Black women were at higher risk of dying from their breast cancer than White women. One national analysis found that women from Black ethnic groups tended to present with larger tumours at a more advanced stage. A recent London study has confirmed US findings that women from Black ethnic groups have a higher incidence of disease that is negative for oestrogen, progesterone and HER-2 receptors (triple negative disease) and carries a worse prognosis.

Population-based breast screening is generally accepted to decrease population mortality from breast cancer by increasing the diagnosis and treatment of disease at an earlier stage. At the same time, for every woman that screening saves from a breast cancer death, it is estimated to diagnose three women with disease that would otherwise not presented symptomatically or lead to death. The information women receive about these benefits and harms is being reviewed. Rates of screen-detected breast cancer in different populations are of interest as an indicator of disease likely to carry a better prognosis. This study aimed to explore inequalities in the incidence of screen-detected breast cancer among London women to help plan London Breast Cancer Screening Services. Its objectives were to

(i) determine the incidence of screen-detected breast cancer and investigate its relationship to socioeconomic deprivation.
(ii) investigate the relationship between the relative survival of screen-detected breast cancers and socioeconomic deprivation.
(iii) explore variation in screen-detected breast cancer between different ethnic groups, taking into account age and socioeconomic deprivation.

Methods

During the study period 1998–2005, data on breast cancer diagnoses in the London population of 7.5 million were collected by the Thames Cancer Registry (TCR). Cancer registration was initiated by clinical and pathology information received from hospitals, and by information on deaths provided by the NHS Central Register via the Office for National Statistics. Trained data collection officers collected further information on demographic details and disease site from the medical records of individual patients. Data were continuously added to a central database, checked against cases already registered and quality assured.

The London Cancer Screening Quality Assurance Reference Centre (QARC) monitors the performance of the NHS Breast Screening Programme in 31 London Primary Care Trusts (PCTs), and uses data received on all screen-detected cancers to perform an annual audit. In 2005 we began a data exchange exercise to record screening status on the Registry database for all London women diagnosed from 1998 through the NHS Breast Screening Programme. Cases known to the QARC but not to the Registry were also added to the database and those known to the Registry and not to the London QARC were traced through NHS systems to determine their breast cancer screening status. Cases were then grouped as interval cancers (those diagnosed between two screening mammograms), and cancers diagnosed in women who had not attended for their last screening invitation, had never attended or had been found never to have been invited. Cancer registries in England have support to collect cancer data under Section 251 of the NHS Act 2006. The NHS Cancer Screening Programme has a confidentiality protocol covering the collection, processing and release of data. These approvals were reviewed annually by the National Information and Governance Board. This study used an anonymized data set and separate ethical approval was not required.

Assigning ethnicity

Historically ethnicity has not been well recorded by cancer registries and only 26.5% of breast cancer cases recorded by TCR as diagnosed between 1998 and 2005 initially had a valid ethnicity code. Recording of ethnicity within the NHS became mandatory for all inpatients from April 1995. The primary source of ethnicity data for this study was self-assigned ethnicity information held within Hospital Episodes Statistics (HES) data, and provided to registries by the NHS Information Centre. This was linked to TCR data at a patient level by combinations of the fields: sex, NHS number, postcode, date of birth and date of diagnosis. Seventy-nine per cent of breast cancer tumours in the TCR database matched to an HES record in the years
1998–2005. If no HES ethnicity code was available registry ethnicity data obtained from medical records were used. Individual ethnic groups were derived using a combination of 1991 and 2001 census ethnicity codes and aggregated into nine categories: White, Indian, Pakistani, Bangladeshi, Black Caribbean, Black African, Chinese, Other and Not known.

**Analysis**

We extracted data on 11,957 women resident in London and diagnosed with invasive breast cancer (C50) between 1998 and 2005 within the screening age range of 50–64 years. For comparative purposes we grouped the data into screen-detected cancers known to be diagnosed through the NHS Breast Screening Programme and those that were not, which we categorized as non-screen detected. We investigated the relationship between the incidence rates for each breast cancer group by socioeconomic deprivation for a 5-year period from 2001 to 2005. Using the postcode of residence, each woman was assigned to a lower layer super output area (LSOA)—a geographical area including around 1500 people based on the census. These areas were categorized to a quintile of deprivation using the income domain of the index of multiple deprivation 2004. We calculated the age-standardized incidence rates (ASRs) for screen-detected and non-screen-detected disease using the European standard population. ASRs were calculated per 100,000 women, using the sum of the female population in each LSOA. To explore whether each kind of breast cancer was significantly more common in affluent or deprived groups of women, we carried out a weighted linear regression analysis. Each observation was weighted by the number of cases in each group. We then explored variation across London by calculating the ASRs for all breast cancers and screen-detected breast cancers in each PCT. These rates were grouped into quintiles and displayed on maps, using the geographical information system software with high incidence rate quintiles coloured in darker shades and lower rates in lighter ones. These analyses were undertaken at a PCT level and do not take account of the sometimes wide range of deprivation and affluence of individual LSOAs within them.

We investigated 5-year relative survival for each cancer in the period 2001–05 by socioeconomic deprivation. Finally, we calculated the proportion of women with screen-detected breast cancer in each ethnic group for the period 1998–2005. Using logistic regression analysis, we calculated the odds ratios (ORs) for screen-detected breast cancer, conditional on having breast cancer, in each ethnic group compared with the White population, adjusting for age and socioeconomic deprivation.

**Results**

**Sample characteristics**

Table 1 shows the characteristics of the study women. A larger number of cancers were diagnosed in the youngest age group, reflecting the age distribution of London women. 40.5% of breast cancers were screen detected. 11.5% of women known to the cancer registry could not be found by the QARC using the NHS tracing systems for England and could not be assigned an NHS screening status category. Overall, the woman's ethnicity was not known in 22.8% of the sample. Of those recorded, the most common ethnicity was White (62.1%). The remainder were 0.7% Pakistani, 3.3% Indian, 0.2% Bangladeshi, 1.3% Black African, 2.6% Black Caribbean, 0.4% Chinese and 6.6% other.

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>62.1%</td>
</tr>
<tr>
<td>Pakistani</td>
<td>0.7%</td>
</tr>
<tr>
<td>Indian</td>
<td>3.3%</td>
</tr>
<tr>
<td>Bangladeshi</td>
<td>0.2%</td>
</tr>
<tr>
<td>Black African</td>
<td>1.3%</td>
</tr>
<tr>
<td>Black Caribbean</td>
<td>2.6%</td>
</tr>
<tr>
<td>Chinese</td>
<td>0.4%</td>
</tr>
<tr>
<td>Any other**</td>
<td>6.6%</td>
</tr>
<tr>
<td>Not known</td>
<td>22.8%</td>
</tr>
</tbody>
</table>

**Table 1** Characteristics of women diagnosed with breast cancer aged 50–64, London 1998–2005

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50–52</td>
<td>2622 (21.9)</td>
</tr>
<tr>
<td>53–55</td>
<td>2389 (20.0)</td>
</tr>
<tr>
<td>56–58</td>
<td>2448 (20.5)</td>
</tr>
<tr>
<td>59–61</td>
<td>2330 (19.5)</td>
</tr>
<tr>
<td>62–64</td>
<td>2168 (18.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Screening status</th>
<th>Number (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen detected</td>
<td>4842 (40.5)</td>
</tr>
<tr>
<td>Non-screen detected</td>
<td>7115 (59.5)</td>
</tr>
<tr>
<td>Cancer in lapsed attender</td>
<td>661 (5.5)</td>
</tr>
<tr>
<td>Cancer in non-attender</td>
<td>1754 (14.7)</td>
</tr>
<tr>
<td>Cancer in the uninvited</td>
<td>717 (6.0)</td>
</tr>
<tr>
<td>Interval cancer</td>
<td>2605 (21.8)</td>
</tr>
<tr>
<td>Not known/missing</td>
<td>1378 (11.5)</td>
</tr>
</tbody>
</table>

**Note:**

*Other includes Asian other, Black other, Mixed and any other ethnic group.
Incidence of screen-detected breast cancer and relation to socioeconomic deprivation

The overall age-standardized incidence rate for breast cancer in women aged 50–64 was relatively stable over the study period, between 267.6 and 277.4 per 100,000 population, although there was a gradual increase from 99.0 to 127.1 in screen-detected rates. Figure 1a shows that for all breast cancers there was a strong association between ASRs and socioeconomic deprivation (trend $P = 0.02$), with the most deprived groups having the lowest rates for both screen-detected and non-screen-detected cancer (trend for both $P < 0.05$). Rates of screen-detected disease in the two most affluent quintiles appeared to be equal.

Figure 2 shows the incidence rates mapped for each PCT, which reveal three distinct patterns. First, the incidence rates for all breast cancers were generally higher in outer London.
PCTs (e.g. Bromley, Harrow and Kingston), while lower rates were found in the more inner London areas (e.g. City and Hackney, Newham and Tower Hamlets). Secondly, the pattern for screen-detected breast cancer was generally similar with higher rates being observed in the same outer London PCTs and lower rates in the inner London PCTs. However, there were exceptions, for example, Westminster PCT had one of the higher incidence rates of breast cancer, but a lower incidence rate for screen-detected breast cancer. Thirdly, North East London in particular had lower rates for each type of breast cancer.

**Relationship between relative survival for screen-detected breast cancer and socioeconomic deprivation**

Figure 1b shows the relationship between 5-year period relative survival for all breast cancers, screen-detected and non screen-detected disease, and socioeconomic deprivation of area of residence. There was a tendency for higher survival in patients resident in the most affluent quintile. The difference was smallest for screen-detected cancer with a 5-year survival of 97.9%, 95% confidence interval (95.8–100.0%) for the most affluent women and 94.1% (91.9–96.4%) in the most deprived. The difference in the survival for non screen-detected disease was larger, 85.5% (82.6–88.4%) and 73.9% (71.1–76.8%), respectively. The difference in relative survival between high and low levels of deprivation was therefore substantially smaller among those women with screen-detected breast cancer than among those with non screen-detected cancer.

**Ethnicity and screen-detected breast cancer**

Women with screen-detected breast cancer tended to be older and living in more affluent areas (data not shown). Higher proportions of Indian (52.3%), Chinese (43.1%) and White (42.5%) women, and lower proportions of Black Caribbean (33.9%), Black African (28.1%) and Bangladeshi (27.8%) women had screen-detected disease (Fig. 3a). The results for Bangladeshi women and Chinese women are based on relatively low numbers as reflected by the large confidence intervals. Figure 3b shows that the ORs for screen-detected breast cancer were not materially influenced by adjustment for age and deprivation in any of the ethnic groups. The adjusted results showed Indian women were significantly more likely to be diagnosed with screen-detected disease than White women, while Black Caribbean and Black African women were significantly less likely to be diagnosed in this way. These results were not influenced by adjustment for age and socioeconomic deprivation. These findings confirm socioeconomic and ethnic inequalities in the incidence of screen-detected breast cancer and therefore in the early diagnosis of breast cancer across London.

**Discuss**

**Main findings of this study**

This study found that the incidence of screen-detected breast cancer in London women aged 50–64 had increased gradually between 1998 and 2005. The incidence was higher in women living in more affluent areas and tended to be higher in those living in outer London. In contrast, women living in more deprived areas, and generally those living in inner London tended to have lower incidence rates of screen-detected breast cancer. Women living in deprived areas had a worse 5-year relative survival from non screen-detected breast cancer than those in affluent areas. However, the difference in survival between women of different backgrounds was smaller for screen-detected breast cancers. The proportion of women with screen-detected breast cancer was higher for Indian women and lower for Black African and Black Caribbean women compared with White women. ORs showed that Indian women were significantly more likely to be diagnosed with screen-detected disease than White women, while Black Caribbean and Black African women were significantly less likely to be diagnosed in this way. These results were not influenced by adjustment for age and socioeconomic deprivation. These findings confirm socioeconomic and ethnic inequalities in the incidence of screen-detected breast cancer and therefore in the early diagnosis of breast cancer across London.

**What is already known on this topic**

It is well established that breast cancer incidence rates in the UK are higher in more affluent women, but the incidence of screen-detected breast cancer has less commonly been reported. Screening uptake is routinely reported across London PCTs and in 2004–05 varied in women aged 53–64 from 47% in Tower Hamlets (an inner city area) to 77% in Havering PCT (an outer London area). It is also lower among women living in deprived areas. One national analysis found that for patients diagnosed in 2001–02 there was a 12.2% difference in survival between the most deprived and the most affluent women for breast cancer detected symptomatically compared with only a 6.6% difference for screen-detected cancer. The same report found that a lower proportion of Black women had screen-detected breast cancer (19% compared with 33% of White women), and that Black women with breast cancer were...
more likely than White and Chinese women to live in deprived areas (81% compared with 33–34%). However, the analysis did not explore the possible independent influence of socioeconomic deprivation upon the odds of being diagnosed with screen-detected disease, or report results for more specific Black and Asian ethnic groups. We are not aware of a similar study reported in the international literature for any city as diverse as London. Data from the USA, however, does show that while access to mammography for African American women initially lagged behind White women, this has now improved and the rates of breast cancer among this group has leveled at a lower rate than for White women.15

**What this study adds**

This study confirms the need for London screening services to focus on decreasing socioeconomic and ethnic differences in screening uptake. Considering socioeconomic deprivation first, our study shows that women living in more deprived areas tend to have lower rates of screen-detected breast cancer as well as lower rates of breast cancer. The overall pattern we found for lower rates in inner London PCTs and higher rates in outer London PCTs very likely reflects the more affluent nature of outer London PCT populations where women are both at greater risk of breast cancer and more likely to attend the NHS Breast Screening Programme. However, while the PCT pattern is of interest

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**Fig. 3** (a) Proportion of women within each ethnic group that had screen-detected breast cancer aged 50–64, London 1998–2005, with 95% confidence intervals and average for the population. (b) OR for screen-detected breast cancer in women aged 50–64 in different ethnic groups, London 1998–2005 (results from the logistic regression analysis). White women as the reference group.
to local commissioners, this level of analyses does not take into account the varying pockets of affluence and deprivation contained within each PCT or the provision and location of services which might influence women’s receipt of invitations and access to screening services. We do not believe this variation can be explained by differences in the screening sensitivity of services and technical expertise of screening staff because services are provided across inner and outer London and the NHS Breast Screening Quality Assurance Standards would detect and iron out such differences. The mobility of London women has often been cited as a reason for variation. One study by Millet et al. suggests low mobility of only a few per cent each year among women aged over 45 years in the screening age group. A recent investigation in South East London, however, found much higher mobility among Black women who had not responded to their appointments. Finally, the difference in the relative survival between high and low levels of deprivation was substantially smaller among those women with screen-detected cancer than among those with non screen-detected cancer. This suggests that the screening service introduced some level of equity by detecting breast cancer and decreasing inequalities in early diagnosis.

The findings for differing odds for screen-detected breast cancer in women from different ethnic groups provide new information. The lower odds for screen-detected cancers in Black women are consistent with estimates of screening uptake by ethnicity made by Renshaw et al. for this London population, which suggested that women living in Black communities were less likely to attend appointments, even taking into account socioeconomic deprivation of area of residence. The current study therefore suggests that lower attendance for screening (or less frequent attendance) among Black women may translate into a lower proportion of screen-detected breast cancers in this group. Screening attendance may itself be influenced by perceptions of not being at risk of breast cancer, and low awareness of its signs and symptoms as well as increased mobility. The finding of lower proportions of screen-detected disease maybe part of the explanation for why Black African and Black Caribbean women in South East England diagnosed during 1998 and 2004 were more likely to present with advanced disease and to die from their disease than White women. However, this interpretation needs further corroboration. It is also possible that there may be a biological difference among different ethnic groups which could alter the ability to detect cancer from screening and explain the findings. For example, breast cancers in Black and South Asian women, are more likely to be triple negative tumours which grow more aggressively and could be less commonly detected by mammography.

The findings for the Asian women are also interesting. An earlier study of breast cancer and ethnicity in South-East England found that Asian women were also more likely to present with more advanced disease but were not more likely to die from their disease than White women. The finding of a higher odds of screen-detected disease for Asian women in the current study is consistent with an estimate from one previous London study showing that the screening attendance in Asian groups was higher than in Black women. This may relate to greater awareness of breast cancer and different behaviours within Asian communities on which screening uptake initiatives have initially focused. It may also be related to a lower breast density which one London study found in Asian women compared with White women. Although the study linked lower risk factors for breast cancer to lower breast density, it would also mean that cancers in Asian women were more likely to be detected at mammography.

A major issue for London services therefore is that many different groups of women need to be targeted and the messages and mechanisms to encourage uptake in each may differ and need testing. Effective interventions to increase screening uptake include invitation letters, mailed educational material, telephone calls and training plus direct reminders. A large number of such initiatives are now underway in London based on these methods. For example, Eilbert et al. report a ‘whole systems’ initiative in Tower Hamlers for Bangladeshi women between 2005 and 2009. This included (i) developing a community outreach programme to provide knowledge, information and peer support to women, (ii) appointing a Bangladeshi general practitioner screening lead, and providing incentives for practitioners and (iii) reorganizing the screening appointment telephone system and providing customer service training for the staff in the screening unit. The findings of this study suggest that similar sustained initiatives need to be focused on women living in deprived areas and in Black communities. Data on the ethnicity of women attending for screening in London have also now been collected for more recent years in all units. A major policy recommendation must be that the ethnicity of women invited for screening is routinely collected and reported by the NHS so that accurate uptake rates can be calculated and monitored routinely for different ethnic groups.

Limitations of the study
This is the first time that data on screen-detected breast cancer has been analysed and presented for London, but
more recent data would be informative. Further work will report data for 2006–12 to determine whether the range of initiatives within London aimed at reaching different ethnic groups with information about screening have had an effect on these baseline findings. The equal rate of screen-detected disease in the two most affluent groups (quintiles 1 and 2) is puzzling. It could be real or an artefact due to some of the most affluent women being diagnosed privately outside of the NHS Breast Screening Programme. Data on their screening status would not always be captured by NHS screening or the registry data collection systems. Lack of information on women diagnosed through non-NHS screening programmes could also lead to an underestimation of inequalities. Further work is underway with private health providers to improve capture of these diagnoses by the Registry.

Authors’ contributions

C.R. carried out the initial analyses and wrote the first draft of the paper. V.H.C. carried out the subsequent analyses and helped write the paper. S.D. helped interpret the findings and write the paper. H.M. helped to design the study, interpret the findings and commented on the paper. E.A.D. helped to design the study, interpret the results, redrafted all subsequent versions of the paper and is the guarantor.

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