Cancer mortality around the Bradwell Nuclear Power Station, Essex
COMARE Statement

Abstract

Two groups (Green Audit and the Small Area Health Statistics Unit (SAHSU)) have produced reports drawing conflicting conclusions about deaths from cancer, particularly breast and prostate cancer, around Bradwell nuclear power station in Essex. Both groups used mortality data from the same source (the Office for National Statistics (ONS)). There were large differences in the figures presented in the first two reports from the two groups. COMARE asked the ONS to investigate these differences and report back to the Committee. COMARE has subsequently made a detailed study of 3 reports from Green Audit and 2 from SAHSU. All 3 Green Audit reports contained errors in the actual numbers of deaths and erroneous or inappropriate figures for the expected numbers of deaths which, together with inappropriate comparisons of various areas, resulted in over-estimation of the risks. Errors in the first SAHSU report, which underestimated the cancer risks, were corrected in the second. Analyses using correct mortality figures and the most appropriate expected values do not indicate any significant excess of cancer mortality around Bradwell, nor do they indicate any substantial or statistically significant risk of breast cancer mortality in groups of wards bordering the Blackwater estuary, or in Maldon compared with Burnham-on-Crouch.

SUMMARY OF COMARE INVESTIGATION

1. In December 2001 COMARE was asked by the Department of Health to comment on a document produced by Green Audit dated March of that year which concluded that there was a substantial excess of deaths from breast cancer and prostate cancer in the immediate area around the Bradwell nuclear power station. COMARE was also aware of a RIF (Rapid Inquiry Facility) report from the Small Area Health Statistics Unit (SAHSU) to the North Essex Health Authority in May 2001 which was intended to cover the same study population and same time scale as the Green Audit report. There were noticeable differences between some of the figures in the two reports.

2. As both groups had obtained their mortality data from the Office for National Statistics (ONS), we asked our assessor from ONS to investigate the figures and the possible sources of error which must have been present in one or both of these reports. The details of this and further investigations are given in the annex to this statement.

3. In summary, the Green Audit study, based on the simple addition of five sets of annual numbers of the registrations of deaths already aggregated at the electoral ward level, had a *net* excess of deaths from all malignant cancers of 100 (around 10%) compared with ONS data: results for 39 (three quarters) of the 52 ward totals were incorrect - positive errors totalled 149 deaths, negative errors 49. The total number of breast cancer deaths was only 1 higher than the ONS figure, but results for half of the wards were incorrect: this erroneous redistribution of deaths among the wards contributed to an exaggeration of the risk in four of the seven wards with the alleged largest excess mortality. The total number of deaths from prostate cancer was only 2 below the ONS figure (results for two wards each had a deficit of 1 death). Taking the numbers of deaths from all malignancies in males and in females, breast cancer and prostate cancer together, figures for more than half the ward totals were in error.

4. Green Audit produced a more extensive report on breast cancer mortality around Bradwell in July 2001. Compared with their first report, two of the 13 incorrect observed numbers of deaths had been corrected; and the expected numbers of deaths were higher overall, and consistently across all wards, by around 10%. These expected numbers (unlike the earlier ones) had been adjusted for socio-economic deprivation, but this did not account for the differences from their first report.

5. Checks made against expected numbers of deaths based on updated population figures for the late 1990s and published death rates for England and Wales, indicated that the expected numbers in Green Audit's first report for all malignancies, breast cancer and prostate cancer, and in Green Audit's second report for breast cancer, appear to be low by 12-14% as a result of them using out of date 1991 census populations. The expected numbers of breast cancer deaths in Green Audit's first report appear to be low by a further 10% for reasons unknown, ie by around 25% in total. All Green Audit's standardised mortality ratios (SMRs) are inflated by corresponding amounts, ie by around 14-16% and 30%, respectively.

6. The figures in the SAHSU RIF report to the North Essex Health Authority would not be expected to match the ONS ward data exactly, as they were for actual occurrences, rather than registrations, of deaths (not every death occurring in any one year is registered in that year); and because they were not derived directly from the ward codes, but through the postcode on each individual death record, using various postcode directories. However, the SAHSU totals all had deficits of around 10%: 105 deaths for all malignancies, 11 for breast cancer, and 6 for prostate cancer. The pattern in the deficits at the ward level was quite different from that in the discrepancies in the first Green Audit report: they were concentrated in just five wards where postcodes had been terminated in 1995. COMARE noted that given the rapid turnaround of a few working days, the RIF reports are necessarily based only on data held routinely on the SAHSU database, without any scope for further checking of the data.

7. SAHSU produced a further report for the North Essex Health Authority in March 2002 which satisfactorily explained the reasons for the inaccuracies in its original report. Using corrected figures, the report also demonstrated that that there was no significant excess mortality from all malignancies, breast cancer in females, or prostate cancer, in the area around the Bradwell nuclear power station. In April 2002 the Chairman of COMARE wrote to Dr Chris Busby of Green Audit asking him to comment on the discrepancies between the figures in their first report and ONS figures (which were supplied). Dr Busby was dismissive of COMARE's concerns and unwilling at that time to check the results in the Green Audit report.

8. Green Audit released a third report in December 2002 to the Committee Examining Radiation Risks of Internal Emitters (CERRIE, a working group of COMARE). In it, they explained most of the errors in their first report, and apologised for them. In extending their analysis for breast cancer by two years to 2001, they introduced five further errors resulting in a net deficit of 9 - positive errors totalled 2, negative errors 11 - in the total observed number of deaths; there were several other minor errors in the report. The expected numbers of deaths from breast cancer for 1995-1999 were again the apparently erroneously low figures given in their first report, not the 10% higher figures adjusted for socio-economic deprivation given in their second report. The expected numbers for 1995-2001 were those for 1995-1999 multiplied by 7/5; those for 1995-2001 were therefore also low by around 25% and the SMRs correspondingly inflated by around 30%.

9. In their second and third reports, Green Audit compared breast cancer mortality in various groups of wards around the Blackwater estuary, and in Maldon and Burnham-on-Crouch. There does not seem to be any consistent rationale behind Green Audit's inclusion of wards in these groups. Neither is it clear why Green Audit in their third report, used the expected numbers of breast cancer deaths from their first report, that were not adjusted for socio-economic deprivation, and which were lower than those in their second report. The consequences were to increase the apparent risks. Analyses using correct mortality data and the most appropriate population data indicated no substantial or statistically significant risks of breast cancer mortality in (overlapping) groups of wards bordering the Blackwater estuary, or in Maldon compared with Burnham-on-Crouch.

COMARE is concerned that independent reports using mortality data from the Office for National Statistics could be produced with such noticeably different numbers of deaths. These differences have inevitably led to confusion, on top of the concern among residents in the Bradwell area which was generated by the first Green Audit report. SAHSU subsequently addressed the problem that existed in their first RIF (Rapid Inquiry Facility) report to the North Essex Health Authority and produced an accurate report to the health authority which shows no evidence for excess cancer mortality.

Green Audit has now admitted the errors in the observed numbers of deaths in its first report, most of which were also in its second report. The third report corrects most of these errors but some new errors have been introduced. In addition, all the expected values in these reports are low by 12-14% as a result of the use of out of date 1991 census populations; and there also appear to be errors in the expected numbers of deaths from breast cancer in both the first and third reports (but not the second) which result in them being low by a further 10%, ie by around 25% in total.

COMARE has serious concerns about studies such as those of Green Audit that are published without formal peer review in the standard way that would be carried out by a reputable scientific journal. Such publications often raise a considerable amount of public concern, which is subsequently very difficult to allay if the results are unsubstantiated, as is the case here. Moreover, COMARE wishes to emphasise that any organisation or individual dealing with epidemiological data has a responsibility to ensure that the data are correct before publication.

SAHSU has taken steps to remedy the deficiencies in the postcode directories that led to under-reporting of deaths in its first report to the North Essex Health Authority (which it withdrew). Notwithstanding, the termination and allocation of post-codes is an ongoing process and we recommend that SAHSU ensures that systems are in place to incorporate such changes in their data base at the earliest moment so that their analyses are not compromised.

COMARE notes that the public health officials at the North Essex Health Authority had access to the ONS mortality data and could have checked the figures in the first Green Audit report. Had they done so, the errors in Green Audit's numbers of deaths would have been readily apparent. We recommend that public health officials should, when possible, make their own check on the figures quoted against an authoritative source when allegations of this nature are made.

While recognising that SAHSU's RIF reports to health authorities are produced extremely quickly, COMARE also recommends that should it be decided to give them widespread dissemination, detailed checking of the results should be undertaken and reports should be subjected to peer review. We accept that public concern can cause considerable pressure on public health officials to release unchecked data and also that hindsight makes it easy to criticise such action. Nevertheless, trust is not enhanced by the dissemination of data that later have to be amended.

COMARE also notes that any excess cancer mortality risks at the ward level - whether statistically significant or not - were very small. Owing to i) the small numbers of deaths involved, ii) geographical variation in cancer survival, and iii) particularly for breast cancer, the large number of known risk factors for incidence (on which there was no information at either the individual or aggregate levels), it would not be justifiable, even on the inflated SMRs in Green Audit's reports, to assign causality to any one external agent such as environmental radiation.

ANNEX 1

Details of COMARE/ONS investigation

Introduction

A report [A] released by Green Audit in March 2001 alleged that there were statistically significantly high rates of deaths from breast cancer (in women), prostate cancer, and all malignancies combined, over the five year period 1995-1999, in the area around the Bradwell nuclear power station which is situated on the south side of the Blackwater estuary in Essex. Green Audit released a more extensive report on breast cancer mortality in July 2001 [B].

The Small Area Health Statistics Unit (SAHSU) at Imperial College, London, reported in May 2001 to the North Essex Health Authority, the results of a standard "point source" analysis (which ignores administrative boundaries); and in further reports to the Health Authority in September 2001 [C,D] they attempted to replicate (using a different methodology) the analyses in the Green Audit report which was based on the numbers of deaths in each (electoral) ward.

At the COMARE meeting in December 2001, it was noted that there were differences between the Green Audit [A] and the SAHSU reports [C,D] in the numbers of deaths given for many of the individual wards and the overall totals. COMARE asked the assessor from the Office for National Statistics (ONS) to investigate these differences and report back to the Committee. A revised report [E] was issued by SAHSU in March 2002.

A third report [F], dealing principally with breast cancer mortality, was released by Green Audit in December 2002. This included explanations of the errors in the observed numbers of deaths in the first report [A], an apology for those errors, and corrected numbers; and extended the coverage of the data on breast cancer mortality by two years to 2001.

Summary

The numbers of deaths given in the Green Audit [A,B] and SAHSU reports [C,D,E] for the 26 wards concerned (none of which was affected by boundary changes in 1995-1999) were compared with the official ONS figures [G]. There were discrepancies in both the Green Audit [A,B] and the first of the SAHSU ward level reports [D]. Comparisons of the figures in the Green Audit and SAHSU reports with those from ONS are given in summary in Table 1 below (a detailed breakdown of the results from the first Green Audit and the first SAHSU reports by ward and by year is given in Table A in Appendix A). Most of these errors in the Green Audit report have now been explained, and Green Audit has apologised for them. In extending their analysis on breast cancer by two years to 2001 in their third report [F], Green Audit introduced new errors in the observed numbers of deaths for five of the 26 wards. There were several other minor errors in that report.

Checks using 1991 census populations indicate that the expected numbers of deaths from breast cancer - but not those from all malignancies in either males or females, or for prostate cancer - in the first Green Audit report [A] were erroneously low by 10%, for reasons unknown. Those in the second Green Audit report [B], which were adjusted for socio-economic deprivation, were around 10% higher than in their first report [A]; the adjustment does not explain the differences. Checks made against expected numbers of deaths based on updated population figures for the late 1990s and published death rates for England and Wales [J] indicated that the expected numbers of deaths in Green Audit's first report [A] for all malignancies, breast cancer and prostate cancer, and in Green Audit's second and third reports [B,F] for breast cancer, appear to be low by 12-14% as a result of them using out of date 1991 census populations. The expected numbers of deaths for breast cancer in Green Audit's third report [F] were the same as (or based on) those in their first [A] and therefore all of these appear to be low by around 25% in total. All Green Audit's standardised mortality ratios (SMRs) are inflated by corresponding amounts, ie by around

14-16% and 30%, respectively. Green Audit's assertion that Burnham-on-Crouch is an appropriate control area, because the Crouch estuary is not contaminated by radioactivity from Bradwell, is a hypothesis which appears to lack any actual evidence. In their second and third reports, Green Audit compared breast cancer mortality in various groups of wards around the Blackwater estuary, and in Maldon and Burnham-on-Crouch. There does not seem to be any consistent rationale behind Green Audit's inclusion of wards in these groups, nor is it clear why Green Audit in their third report used the expected numbers of breast cancer deaths from their first report that were not adjusted for socio-economic deprivation and which were lower than those in their second report. The consequences were to increase the apparent risks.

Investigations by SAHSU showed that the discrepancies in their report [D] were concentrated in just five wards where postcodes had been terminated in 1995. The results in the second SAHSU ward level report [E], using a new postcode directory, were all very close to the official figures and do not substantiate the allegations in the Green Audit report that there was substantial excess mortality from breast cancer (in women), prostate cancer and all malignancies combined, around the Bradwell nuclear power station. Further analyses of the ward level data in the SAHSU report [E] show that there were no statistically significant risks of breast cancer mortality in (overlapping) groups of wards bordering the Blackwater estuary, or in Maldon compared with Burnham-on-Crouch.

Table 1 Comparisons of figures for cancer mortality[1] in 26 wards in Essex, 1995-1999: ONS, Green Audit, and SAHSU

Cancer site(s)	Sex	ONS[G]	Green Audit[A]			SAHSU			
			No.	Diff	No. wards incorrect	May 2001[D]		March 2002[E]	
						No.	Diff[3]	No.	Diff[4]
All malignancies[2]	M	588	675	+87	*20*	530	-58	591	+3
	F	532	545	+13	*19*	485	-47	537	+5
	Total	1,120	1,220	+100		1,015	-105	1,128	+8
Breast cancer	F	104	105	+1	*13*	93	-11	104	0
Prostate cancer	M	84	82	-2	*2*	78	-6	85	+1

1 The ONS figures and - we assume (see text) - those of Green Audit, relate to deaths for which the registration was made in 1995-1999.

2 All malignant neoplasms, ie codes 140-208 inclusive in the Ninth Revision of the WHO Classification of Diseases [H].

3 The principal differences were concentrated in just five wards (see text).

4 These small discrepancies arose because the ONS figures are for deaths registered in 1995-1999 while the SAHSU figures are for deaths actually occurring in that period; and because the new Gridlink directory used by SAHSU differs slightly from the postcode directories used by ONS in the late 1990s (see text).

Findings

Green Audit report March 2001 [A]

The Green Audit report is not explicit about the source of the mortality data used. However,

- the report says that "the research was made possible by the recent release of small area cancer mortality data by the Office of National Statistics" (Discussion and Recommendations, page 6);
- Dr Busby has purchased from ONS the VS4D tables [G] which give the annual total numbers of deaths by sex, but not by age group, for all causes of death and for 12 (sometimes grouped and/or overlapping) causes of death including all malignancies, breast cancer and prostate cancer; and
- ONS has no record of any data extract or tabulations specially prepared for Dr Busby or either of the other co-authors of the Green Audit report.

It must therefore be assumed that the Green Audit report [A] was based on the (electronic) VS4D tables.

Compared with these, the numbers of deaths for all malignancies in the Green Audit report were in error by a net total of 100 (positive errors totalled 149, negative errors 49). For the individual wards, there were errors in 20 of the 26 for males and 19 for females (some below the ONS figures, most above). The large positive errors for males in the last five wards in the list (Birch/Messing and Copford, Pyefleet, Tiptree, West Mersea, and Winstree - all in Colchester local government area) may have arisen from double counting of data for some of the years. The overall total for breast cancer was wrong by only 1 death, but there were (compensating) errors in the figures for half (13) of the 26 wards. This erroneous redistribution of deaths among the wards contributed to an exaggeration of the risk in four of the seven wards with the alleged largest excess mortality. For prostate cancer, the figures for only two wards were wrong (both low by 1 death).

In April 2002 the Chairman of COMARE wrote to Dr Busby asking him to explain the discrepancies between the numbers of deaths given in the Green Audit report [A] and the official ONS figures [G] (Table 1 and Table A in Appendix A). Dr Busby replied that he would look again at the Bradwell report when he had the time.

Green Audit report July 2001 - Breast cancer [B]

Green Audit produced a more extensive report on breast cancer mortality around Bradwell in July 2001 [B], covering 80 wards in Essex, including the 26 in their March report [A]. The observed numbers of breast cancer deaths for two of the wards (both in Colchester local authority) which were wrong in the March report were corrected: Birch/Messing and Copford, from 0 to 2; and Tiptree, from 9 to 7 - the overall total was unaffected. The observed numbers of deaths for all the other 24 wards, 11 of which were wrong, were unchanged from the earlier report.

Green Audit report December 2002 [F]

Green Audit released a third report, principally about breast cancer mortality, in December 2002 [F]. In it, Green Audit admitted that there had been errors in some of the observed numbers of deaths their first report. They apologised for these errors. They also gave explanations of how they arose. They say that:

(i) numbers of deaths for 1997 were accidentally dislocated (by one row in their tables) resulting in the deaths for any particular ward being included (instead) in the five year total for the ward below it in their list [the order is that in Table A in Appendix A]. This explanation appears to apply to 17 of the 26 wards, the 5th to 21st (inclusive) in their list, for all malignancies in both males and females, and for breast cancer. It does not, however, appear to apply (for these cancers) to the first four wards in their list (which were almost entirely correct), or to the last five (see (ii) below); and it does not appear to apply at all to the numbers of deaths from prostate cancer (where, as noted above, there were only two small errors). For breast cancer, the error resulted in the increase or decrease in the five year totals of deaths of 1 in nine wards, 2 in three wards, and 4 in one ward.

(ii) The large errors in the numbers of deaths from all malignancies in males for the last five wards in their list arose from "a [implied single] typing error" which "increased the number of [such] deaths by 100". Inspection of the figures in Table A in Appendix A suggests that (as already noted above) the error involved the double counting of 3 of the 5 years of data - but not always the same years in the five wards. The overall error in these five wards was an excess of 91 deaths from all malignancies in males; there was also an unexplained excess in these five wards of 9 such deaths in females.

For breast cancer, Green Audit extended the period covered by two years by adding to the corrected numbers of deaths for 1995-1999 the numbers of deaths from the VS4D tables for 2000 and 2001. This resulted in errors in the new seven year totals for five of the 26 wards, with a net deficit of 9 deaths, 144 instead of 153: Little Baddow, Danbury and Sandon 9 instead of 16 (-7); Birch Messing and Copford 4 instead of 3 (+1); Tiptree 8 instead of 11 (-3); West Mersea 18 instead of 17 (+1); and Winstree 1 instead of 2 (-1).

Other errors in the third Green Audit report [F] include:

- some of the results quoted from their second report [B] do not correspond with the values given in that report: the "concentric rings" approach did show no effect, but the SMR (their Table 3) was 1.06 in the second report (c.f., 1.01 in the third report); and the "estuary versus inland" analysis showed a raised level of breast cancer mortality but the relative risk was 1.32 and the "P" value quoted was 0.07 (c.f., 1.34 and 0.003, respectively, in the third report);
- it is not true that none of the "computer" errors which led to the incorrect observed numbers of breast cancer deaths in the first Green Audit report [A] had any effect on the second study [B]: as noted above, only 2 of the 13 errors had been corrected;
- it is also not true that "although the Busby et al 2001a [A] errors make no difference to their result, the same is not true for SAHSU" {with respect to their revised report [E]}. In fact, SAHSU's revised results [E], like their first report [D], showed no significant overall excesses for all malignancies in males and females, breast cancer in females, or prostate cancer [see below];
- the closely similar Poisson probabilities quoted in Table 2 for The Maylands and Tollesbury wards, where the former has a lower SMR than the latter and is based on fewer observed deaths, obviously cannot both be correct; and most of the P values given are in fact incorrect;

  [the more general question of statistical significance of ward level SMRs is discussed below]
- the total (1991 census female) population of the two Burnham wards (North and South) (Table 7) is 3,605 (not 3,364); and
- in the Discussion (section 4) although it is true that there were "more than twice as many breast cancer deaths" in the Blackwater wards [than the Crouch wards] (Table 6) and for Maldon compared with Burnham (Table 7), this is principally because the populations of the first areas in each comparison are much larger than those of the second. Presumably what was meant is that the relative risks were greater than 2.

It should be noted that deaths in 2001 were coded to the ICD10 classification [K]. This incorporates changes to the rules for selecting the underlying cause of death from the information on the death certificate which have resulted in large falls in the numbers of deaths coded to pneumonia and similar causes, and small increases in the numbers of deaths coded to a wide range of other causes, including cancers [L]. Any observed numbers of deaths for 2001 are therefore not strictly comparable with their expected values.

<u>Expected numbers of deaths in the Green Audit reports</u> [A,B,F]

The COMARE meeting in December 2001 had noted that the "expected" numbers of deaths in the Green Audit report [A] might not be accurate for three reasons:

(i) the figures were based on out of date ward level population data from the 1991 census;

(ii) the results were not adjusted for socio-economic deprivation; and

(iii) the calculations, which involve multiplying several age specific national mortality rates by the relevant ward populations and summing the results, are more complicated than those for the observed numbers of deaths - in which Green Audit had made a large number of errors.

[Two values had been mis-typed: those for Woodham Ferrers and Bicknacre, and for Tiptree, should have read 2.176 (not 20176) and 7.151 (not 70151), respectively.]

Further investigations have shown that compared with expected numbers of deaths based on 1991 census populations for the 26 wards and death rates in eight age bands (0-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and 85 and over) for England and Wales published by ONS [J], the overall expected numbers of deaths in the Green Audit report of March 2001 [A] for all malignancies were within 5 deaths in over 500 for both males and females (less than 1% difference), while for prostate cancer there was virtually no difference. For breast cancer, however, the Green Audit total figure was low by almost 8 deaths, just under 10%; the expected value for every ward was low by around this percentage.

The expected numbers of deaths in the second Green Audit report [B] were adjusted for socio-economic deprivation using the Carstairs index. Compared with the expected values in the March report [A], the figures were around 10% higher; increases in the 26 individual wards ranged from 8.4% to 11.6%. They were in total less than 1 death different from the census/ONS mortality estimates, and the values for over 20 of the wards differed by less than 0.1 death. Although the incidence of breast cancer is higher in women living in more affluent areas [M], survival from breast cancer is better in those groups [N], and so breast cancer mortality varies little with socio-economic deprivation [M]. It is therefore, as noted in the first Green Audit report [A], unlikely that (overall) adjustment for socio-economic deprivation would make any appreciable difference to the expected figures. {The same is true for prostate cancer, as the patterns of incidence, mortality and survival with socio-economic deprivation are closely similar to those for breast cancer [M]. For all malignancies, however, adjustment for socio-economic deprivation could have noticeable effects, because for all the smoking related cancers, incidence and mortality are considerably higher in the more deprived groups than in the affluent [M]}.

The expected numbers of deaths from breast cancer in Green Audit's third report [F] for the period 1995-1999 (their Table 1) are those used in their first report [A], ie are not adjusted for socio-economic deprivation. The value for Woodham Ferrers and Bicknacre was mis-typed as 2.017 instead of 2.176. The expected numbers of breast cancer deaths for the period 1995-2001 (their Table 2) have not been based on England and Wales mortality rates including those for 2000 and 2001, but are the previously calculated values for 1995-1999 multiplied by 7/5. The value for Woodham Ferrers and Bicknacre is based on 2.176 for 1995-1999; the value for West Mersea should be 12.86 (not 12.87). As breast cancer mortality has been falling steadily in England and Wales during the 1990s [P], calculating expected values for the seven years 1995-2001 based on rates for 1995-1999 would tend to give slight overestimates, with corresponding slight underestimates of the SMRs.

The population estimates for the 26 wards for 1997 (the mid-point of the period covered by the mortality data) based on the "Estimating With Confidence" (EWC) project [Q] are some 6% higher than those from the 1991 census for males, and around 4% higher for females. The differences varied across the age groups and were generally smaller for young people and larger in middle aged and elderly people, ranging up to around 25% in those aged 45-54, and 32% and 48% in men and women, respectively, aged 85 and over. As cancer - particularly prostate cancer - is a disease predominantly of elderly people [J], it is likely that, because of the large demographic changes in the area concerned, there would be proportionally larger effects than the overall differences of 4-6% on any expected figures of deaths calculated using population estimates based on the EWC figures.

Comparisons of the expected values from the second SAHSU report [E], and those using ONS mortality rates and 1997 EWC populations, with those using the 1991 census populations (Table 2) indicate that the effect of using out of date 1991 census populations is an underestimation of around 14% for breast cancer.

Similar comparisons for all malignancies in males and in females and for prostate cancer indicated underestimation of 12-13%.

It therefore appears that in the first Green Audit report [A], not only were the observed numbers of deaths from breast cancer wrong in half of the 26 wards, but the expected numbers of deaths were erroneously low by around 10% and low by around 25% in total because of the use of out of date population figures. In the second Green Audit report [B], eleven of the observed numbers of deaths were still wrong, but its expected figures appear to be in line with those from the ONS calculations based on 1991 census populations (although some 14% lower than if up to date population figures had been used). In the third Green Audit report [F] the observed numbers of breast cancer deaths for 1995-1999 were correct, but the expected values were the same as in their first report [A], ie low by around 25%; there were errors in the numbers of observed deaths for five wards for 1995-2001, and the expected numbers, being simply a constant multiple of those for 1995-1999, were also low by around 25%.

The SMRs in Green Audit's reports [A,B,F] are all inflated by amounts corresponding to the underestimation of the expected values. For example, if an SMR {ie (observed deaths) / (expected deaths), or O/E} is based on an expected value which is erroneously low by 12%, the calculation gives $O/(E \times 0.88) = 1.14$ O/E, ie the apparent SMR is therefore 14% higher than the true value.

Thus the SMRs for all malignancies, breast cancer and prostate cancer in the first Green Audit report [A] and for breast cancer in the second [B] and third [F] appear to be inflated by 14-16%, as a result of them using out of date 1991 census populations. The SMRs for breast cancer in the first and third Green Audit reports [A,F] appear to be inflated by a further 10% for reasons unknown, ie by around 30% in total. [See also "Mudflats and other groups of wards" below.]

There does not seem to be any clear rationale behind Green Audit's use in their third report [F] of the expected numbers of breast cancer deaths from their first report [A], rather than those from their second report [B] (which were 10% higher and adjusted for socio-economic deprivation). It does, of course, have the effect of increasing the apparent risk.

The validity of Green Audit's assessment of the statistical significance of ward level SMRs is discussed below.

It should be noted that the recently issued population figures from the 2001 census were overall some 1 million lower than the previously published population estimates for 2001; the differences were concentrated largely in the younger age groups, particularly for males [see the National Statistics website: www.statistics.gov.uk]. As noted above, cancer is a disease predominantly of older people, and checks have shown that the effects on overall cancer incidence and mortality rates of using populations for the late 1990s which have been revised in the light of the results of the 2001 census are very small. As the local population figures on which any expected numbers of deaths would be based would also be revised, and hence be lower than those used previously, the effects on the expected values and the corresponding SMRs is likely to be negligible.

<u>SAHSU reports</u> [C,D,E]

The ward level figures from SAHSU's Rapid Enquiry Facility (RIF) in their reports to the North Essex HA [C,D] would not be expected to match the ONS VS4D figures [G] exactly, as they were for actual occurrences of deaths rather than registrations (and not every death occurring in any one year is registered in that year); and because they were not derived directly from the ward codes, but through the postcode on each individual death record, using various postcode directories. However, the total numbers of deaths in the first SAHSU ward level report [C] all had deficits of around 10%: 105 deaths for all malignancies, 11 for breast cancer, and 6 for prostate cancer, compared with the ONS figures. The principal differences were concentrated in just five of the 26 wards: Heybridge East, Heybridge West, Maldon East, Maldon North West, and Maldon South.

SAHSU's RIF reports, which are made available to local health authorities to inform their own investigations, stress the limitations of the data - which includes potential problems with the postcodes - and are not themselves published as SAHSU studies, but are intended to provide health authorities with a rapid initial screen of the health statistics related to a particular point source. They use the postcode to give information on the geographic location of cases and links to the underlying socio-demographic population statistics (which allows, for example, analyses to be carried out based on distance from a point source). Given the rapid turnaround of a few working days, the RIF reports are necessarily based only on data held routinely on the database, without any scope for further checking of the data.

Investigations have shown that over the country as a whole, the SAHSU Rapid Inquiry Facility correctly allocates 98.9% of death records and 99.3% of death records with a valid postcode to a ward. At the time of the study presented in their first report, SAHSU did not have access to the Gridlink Postcode Directory currently used by ONS. The postcode directories used by SAHSU were only able to provide an estimate for postcode termination dates and SAHSU did not allocate deaths records to wards if the postcode had ceased to be used more than a year previously. In the area covered by the study, the Post Office had terminated all postcodes beginning "CM9 7" in April 1995 (and re-allocated the addresses to postcodes beginning CM9 4, CM9 5, and CM9 6). These addresses were all in the Heybridge and Maldon areas. When a postcode is formally terminated, it does not go out of use immediately: the Post Office will continue to deliver mail with the former postcodes for the following eighteen months to two years. Postcodes that have been terminated are frequently given by the "informant" when registering a death and hence appear in the deaths database at ONS [J]. On average, approximately 50,000 postcodes, around 3% of the UK total of 1.6 million, are terminated each year, although the numbers fluctuate greatly from year to year.

ONS subsequently supplied SAHSU with the Gridlink directory, which contains all terminated postcodes. A revised SAHSU RIF report [E], using the Gridlink directory, was prepared for the North Essex Health Authority. The numbers of deaths for all malignancies (males and females), breast cancer, and prostate cancer in the 26 wards were very close to the official figures (Table 1). The remaining small discrepancies arose because the ONS VS4D figures [G] are for deaths registered in 1995-1999 while the SAHSU figures are for deaths actually occurring in that period; and because the new Gridlink directory differs slightly from the postcode directories used by ONS in the late 1990s.

In all SAHSU's formally published peer reviewed studies, in contrast to their RIF reports, detailed (and time-consuming) checking of the data is carried out. This may include a specific postcoding exercise carried out by ONS to obtain valid postcodes for virtually all the cases in the inquiry, and a mapping exercise to compare case incidence in the ward(s) concerned with that in other wards in the region [see, for example, reference R].

Using the reliable expected numbers of deaths in the second SAHSU report [E], which are based on numbers of deaths adjusted for socio-economic deprivation and updated ward level population estimates (based on the "Estimating With Confidence" project [Q] combined with annual births, deaths and a district migration factor), the SMRs for all malignancies in males and females, breast cancer and prostate cancer were 1.01, 0.98, 0.95 and 1.04, respectively; none of these was statistically significant. For the individual wards, none of the standardised mortality ratios (SMRs) for either breast cancer in females or prostate cancer was significantly raised. For all malignancies, for males one ward had a significantly high SMR of 1.67; and for females one ward had a significantly low SMR of 0.54 and two others had significantly high SMRs of 1.34 and 1.72 (neither was the ward with the raised SMR for males). This is about what would be expected by chance if there were no real differences in mortality between the wards.

It is quite clear that in their report of March 2002 [E], SAHSU had <u>not</u>, as alleged in Green Audit's third report [F] "set out to remove the significance of disease clusters" or "changed its method and invoked Bayesian smoothing to deny the existence of the breast [cancer mortality] cluster in Maldon North West" or "changed their methodology to sustain their original finding". As explained above, their analysis was a straight re-run of their first, but using the new Gridlink postcode directory which allowed correctly for terminated postcodes. All the tables in their second report [E] - for breast cancer, prostate cancer and for all

malignancies in males and females separately - include the (correct) observed numbers of deaths, expected values (based on updated population estimates and adjusted for socio-economic deprivation) and their unsmoothed ratios or SMRs. The smoothed SMRs have been added, but both the "Results" and "Comments" sections of their report [E] refer only to the unsmoothed values.

Green Audit also assert that Bayesian smoothing "does not seem appropriate for high incidence diseases" - but, as noted below, both breast and prostate cancer deaths in any one ward in any one year are rare events, with expected numbers of less than 1. Green Audit themselves used Poisson probabilities in their Tables 1 and 2 [F] (to assess the statistical significance of SMRs for breast cancer) which are only appropriate for rare events [S].

The difficulties of assessing the patterns of rare diseases in small areas have been well documented. The variance of an estimate, for example of mortality such as an SMR, is proportional to 1/{expected number of deaths} and so for areas with small populations the rates are dominated by sampling variability [T]. In these circumstances, Bayesian smoothing is entirely justified, and Green Audit's allegations [F] that reputable, independent scientists such as those at SAHSU, or Smans and Estève [U], have developed the technique deliberately in response to putative raised risks of various diseases around sources of environmental pollution in order to reduce the (apparently) high risks in some areas, is quite ludicrous.

Statistical significance of ward level standardised mortality ratios (SMRs)

The use of Poisson probabilities by Green Audit [F] may not indicate correctly the statistical significance of ward level SMRs. There are four main approaches to calculating confidence intervals for the observed number of deaths so as to assess whether it is significantly different from the number expected [S]:

(i) based on the simple (with or without continuity correction) chi-square statistic {but when the number of deaths is small, the Poisson distribution is rather skewed, and the "normal" approximation in the use of $\chi^2 = (O - E)^2 / E$ will be inadequate [S]};

(ii) the square root approximation;

(iii) Byar's approximation; this is in fact so accurate that it can be used instead of

(iv) the "exact" method, which involves iterative calculations.

Results for all those wards in Tables 1 and 2 of Green Audit's third report [F] which have a Poisson probability given for the SMR are given in Table 2, along with 95% confidence intervals (CIs) calculated using the exact method. The table also contains results using

(a) the correct number of observed deaths for West Mersea 1995-2001; and

(b) expected numbers of deaths based on up to date population data for 1995-1999 [E]; such expected numbers were not given for the period 1995-2001, so the expected values for 1995-1999 have - as in Green Audit's third report [F] - been multiplied by 7/5.

Green Audit [F] quote P values for SMRs based on data for the five years 1995-1999 (their Table 1) and for the seven years 1995-2001 (their Table 2). These sets of P values together are not valid, because the fundamental underlying assumption in the statistical tests is that they are independent - and they clearly are not, as five years of data are common to both sets of SMRs. If an SMR based on five years of data were high, then the SMR based on having added just two more years of data is also likely to be high. Thus, given that statistical tests on SMRs for 1995-1999 have already been carried out, the quoted P values for the second tests on the SMR for 1995-2001 are erroneously low. {The same applies to the tests on the SMRs in Green Audit's Tables 4 and 5 [F].} Nevertheless, for the five SMRs - which, as noted above, are inflated by around 30% - where the Poisson probability quoted is either 0.07 or 0.08, the 95% CIs all include 1, ie none of the five is statistically significant. With the reliable expected numbers of deaths (and hence also reliable SMRs), rather than those based on out of date 1991 census populations, all of the 95% CIs include 1, ie none of the eight SMRs was statistically significant.

Mudflats and other groups of wards

Green Audit's first report [A] alleged that there was "a substantial excess of deaths from breast cancer concentrated around the [Blackwater] river valley". As noted above, this was based on SMRs that appear to be inflated by around 30% owing to expected numbers of deaths which were both erroneously low and based on out of date 1991 census populations.

Green Audit's second report [B] included (their Table 2) comparisons with other groups of wards of a group (labelled "D") of 13 wards which were all "adjacent to and mostly within 4km of the R[iver] Blackwater". The figures given were observed deaths 62, expected 44.9 and female population 19,326. The report [B] does not say which the 13 wards are, but from the figures quoted above, they appear to be those marked in blue in the map at Figure 1. These do not include two wards on the north side of the estuary directly opposite the Bradwell nuclear power station and which have long inland creeks: Pyefleet, which includes the eastern half of Mersea Island (the remainder forms West Mersea ward); and Winstree. These two wards have SMRs of 0.99 (3 observed, 3.022 expected) and 0.48 (1 observed, 2.103 expected), respectively [B], both below the overall SMR for the 15 wards together. The effect of not including these wards is to increase the overall SMR.

Green Audit's third report [F] includes relative risks (ratios of SMRs) based on 9 wards which are "proximal to the [Blackwater] estuary" (labelled "mudsand" in their Table 3) compared with 17 "non-Blackwater" wards. Of the 13 Blackwater wards in the second report [B], four: Goldhanger, Heybridge West, Purleigh and Tolleshunt D'Arcy, have been removed. Of these, Heybridge West is no further from the estuary than much of Maldon North West and Maldon South, and the other three wards border the estuary. The first three of these wards have SMRs below the overall SMR for the 13 wards: 1.14 (2 observed, 1.76 expected), 1.07 (3 observed, 2.80 expected), and 0.71 (1 observed, 1.42 expected), respectively; the SMR in the fourth is 2.00 (4 observed, 2.00 expected). As can be seen from Table 3, the effect of removing these four wards, in total SMR 1.00 (8 observed, 7.98 expected), is to slightly increase the SMRs.

There does not seem to be any consistent rationale behind Green Audit's initial selection of 13 wards and their subsequent selection of 9 of these wards bordering the estuary, except to increase the apparent risk.

As noted above, the SMRs for breast cancer from Green Audit's second report [B] are inflated by 16%; and those from their third reports [F] by around 30%.

In addition, as a result of the errors in Green Audit's third report [F] in the numbers of breast cancer deaths in 1995-2001, the "mudsand" analysis (in their Table 5) should read Blackwater estuary deaths 72 (not 73), Non-Blackwater deaths 81 (not 71) and the relative risk should be 1.46 (not 1.7); and the Blackwater-Crouch comparison (their Table 6) should again read Blackwater estuary deaths 72, and relative risk 2.09 (instead of 2.12).

Ward level results provided in the second SAHSU report [E], which are based on the correct observed numbers of breast cancer deaths and updated populations, allow estimation of the SMRs for the group of 15 wards bordering the Blackwater estuary, ie the 13 wards selected by Green Audit [B] together with both Pyefleet and Winstree: SMR 1.13 (65 observed, 57.61 expected; 95% CI 0.87 to 1.44). For the group of 13 wards selected by Green Audit [B], the SMR was slightly higher: 1.18 (61 observed, 51.64 expected; 95% CI 0.90 to 1.52). These are not substantial excesses, nor are they statistically significant.

In addition, for both the groups of 13 and of 9 wards selected by Green Audit [B,F], there is no evidence of raised risks of mortality from all malignancies in either males or females, or for prostate cancer {analyses by ONS based on results in [E]}.

SMRs for breast cancer were given in Green Audit's second report [B] for various groups of wards in addition to "Blackwater" (the 13 wards marked on the map in Figure 1), including "non-Blackwater" (26 wards excluding, and 46 wards including, Colchester), and "Crouch" (5 wards - all those adjacent to the

Crouch estuary). Relative risks (ratios of SMRs) for breast cancer were given in Green Audit's third report [F] for various groups of wards in addition to "Blackwater estuary" (the 9 wards mentioned above), including "Crouch estuary" (3 wards, all on the north side of the river, rather than the 5 wards included in the "Crouch" group in their second report [B]; and "Maldon" (3 wards) and "Burnham" [-on-Crouch] (2 wards). This is a valid procedure, if there are good a priori reasons for selecting these groups, although as noted above, the SMRs for breast cancer in Green Audit's second and third reports [B,F] are inflated by around 16% and 30%, respectively. The statistical tests on the *ratios* of the SMRs for Blackwater and non-Blackwater, and of the SMRs for Blackwater and Crouch [B], and similar ratios of SMRs in Tables 4 to 7 of Green Audit's third report [F], however, may not be valid. SMRs are comparisons against the standard (here England and Wales) and it may not be valid to compare them against each other because the age distributions of the populations in the areas may be different [S]. In general, the most reliable way of comparing mortality in different areas is the ratio of the directly (rather than indirectly, as with SMRs) age standardised rates [S]. The information needed to do this (age specific numbers of deaths) was, however, not available to Green Audit.

In addition:

(i) Green Audit assert that Burnham-on-Crouch is an appropriate "control" area [F] because "the large area of the Buxey sand and the Maplin and Foulness offshore banks largely prevents radioactivity from Bradwell contaminating the Crouch" [B]. We have not seen measurements of radioactivity in the two estuaries to support this assertion. And

(ii) if the two urban areas at the head of the Blackwater and on the Crouch are to be compared on the grounds that they are "both yachting-centre towns on muddy estuaries" [F], it would seem more appropriate to include both Heybridge East and Heybridge West (which together have an SMR of 1.34) with the three Maldon wards (which together have an SMR of 1.79), and to compare them only with the built up area of Burnham-on-Crouch itself, using only Burnham-on-Crouch South ward, rather than including the much larger and predominately rural ward of Burnham-on-Crouch North where the 1991 census female population was only just over half that of Burnham-on-Crouch South - and which has a low SMR of 0.50. This more valid comparison gives a relative risk of 1.52, which although raised, is not statistically significant.

As with the selection of 13 and subsequently 9 "Blackwater" wards there does not seem to be any clear rationale behind Green Audit's choice of Maldon and Burnham-on-Crouch wards, except to increase the apparent risk.

Cancer and environmental epidemiology

Although over 220,000 new cases of malignant cancer (other than non-melanoma skin cancer) are diagnosed each year in England [V], the incidence of any one type of cancer in any particular small area in any fairly short time period is relatively rare. For example, as there are around 10,000 wards, even for the two most common cancers, breast cancer in females (over 34,000 cases in 1999) and prostate cancer (21,000 cases), there would be on average only just over 3 cases of breast cancer and 2 of prostate cancer in each ward in a year. In addition, overall, one quarter of cancer patients do not die from cancer. For breast and prostate cancers, where survival is quite good (five year relative survival is around 75% and 60%, respectively [W]) much higher proportions of patients do not die from their cancer. In the 26 wards in North Essex around the Bradwell nuclear power station, there were in total 105 breast cancer deaths and 84 prostate cancer deaths in the five year period 1995-1999, or on average 0.8 breast cancer deaths and 0.65 prostate cancer deaths per ward per year. In addition, wards vary considerably in size, and in North Essex over the five years there were 2 or fewer breast cancer deaths in 10 of the 26 wards (including one ward with none) and 2 or fewer prostate cancer deaths in 13 of the 26 wards (again including one with none - not the same ward as had no breast cancer deaths).

If SMRs or relative risks are less than about 1.5, ie the excess risk is less than 50%, it is probably not feasible using even the current sophisticated methods of environmental epidemiology on small area data to assign causation to any single external agent, for the following reasons.

First, as noted above, the annual numbers of cancer cases and deaths in small areas such as wards, even for the most common cancers, are very small: this results in very wide confidence intervals around estimates of expected numbers of cases or deaths, and hence also of the SMRs or relative risks. Second, it is known that there is wide geographical variation in cancer survival [X,Y]. And third, even where aggregation of areas or time periods gives more precise estimates of SMRs or relative risks, and even where adjustment is made for socio-economic deprivation, there are often many other risk factors for the incidence of cancer on which there is no information at either the individual or aggregate levels. For breast cancer, for example, these factors include family history of breast and/or ovarian cancer, overweight and obesity, ages at menarche and menopause, pattern of childbearing, use of oral contraceptives and hormone replacement therapy, and diet including alcohol consumption [Z]. Without knowledge of these factors, an SMR or relative risk of less than about 1.5, even if it were statistically significant, would likely be uninterpretable.

Conclusions

1 There was a large number of serious errors in the actual numbers of deaths given in the first Green Audit report. Green Audit has now explained most of these, and has apologised for the errors. Most of those for breast cancer were also incorrect in their second report. Further errors were introduced in their third report. In addition, the "expected" numbers of deaths in the first report for all malignancies, breast cancer and prostate cancer, and for breast cancer in the second and third, appear to be low by 12-14% as a result of them using out of date 1991 census populations; and those for breast cancer in the first and third reports appear to be low by a further 10% for reasons unknown, ie around 25% in total. The SMRs are all inflated by corresponding amounts, ie by around 14-16% and 30%, respectively. Green Audit's assertion that Burnham-on-Crouch is an appropriate control areas a hypothesis which seems to lack any actual evidence. In their second and third reports, Green Audit compared breast cancer mortality in various groups of wards around the Blackwater estuary, and in Maldon and Burnham-on-Crouch. There does not seem to be any consistent rationale behind Green Audit's inclusion of wards in these groups, nor is it clear why Green Audit in their third report used the expected numbers of breast cancer deaths from their first report (that were not adjusted for socio-economic deprivation) and which were lower than those in their second report. The consequences were to increase the apparent risks.

2 The discrepancies in the first SAHSU report were concentrated in just five wards where postcodes had been terminated in 1995. The official ONS numbers of deaths and the analysis in the revised SAHSU report (March 2002) do not substantiate the allegations in the Green Audit reports that there was substantial excess mortality from breast cancer (in women), prostate cancer, and all malignancies combined, around the Bradwell nuclear power station. Further analyses of the ward level data in the revised SAHSU report show that there were no statistically significant risks of breast cancer mortality in (overlapping) groups of wards bordering the Blackwater estuary, or in Maldon compared with Burnham-on Crouch.

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(a) re-creating the Green Audit analysis (summary only - see D below)
(b) of mortality from the same and some additional cancers over the period 1982-1997; and
(c) as (b) but on "affected" EDs selected by North Essex Health Authority.]

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Table 2 Statistical significance of ward level SMRs for breast cancer

Period	Ward	Green Audit[F]							SAHSU[E]				
		Obs	Expected	SMR	Poisson*	Poisson£	95% CI$	Sig	ONS obs	Expected#	SMR	95% CI	Sig
1995-1999	Maldon NW	13	5.836	2.227	0.007	0.007	1.19 - 3.81	sig	13	7.61	1.71	0.91 - 2.92	ns
	The Maylands	5	2.335	2.122	0.08	0.090	0.69 - 4.95	ns	5	2.81	1.78	0.58 - 4.15	ns
	West Mersea	14	9.186	1.524	0.08	0.084	0.83 - 2.56	ns	14	11.47	1.22	0.67 - 2.05	ns
1995-2001	Maldon NW	16	8.17	1.96	0.008	0.010	1.12 -3.18	sig	16	*10.65*	1.50	0.86 - 2.44	ns
	Maldon South	11	5.12	2.15	0.008	0.016	1.07 - 3.84	sig	11	*6.58*	1.67	0.83 - 2.99	ns
	The Maylands	5	3.30	1.52	0.08	0.237	0.49 -3.54	ns	5	*3.93*	1.27	0.41 - 2.97	ns
	Tollesbury	7	3.68	1.90	0.07	0.080	0.76 - 3.92	ns	7	*4.51*	1.55	0.62 - 3.20	ns
	West Mersea	18	12.87	1.40	0.08	0.103	0.83 - 2.21	ns	17	*16.06*	1.06	0.62 - 1.77	ns

CI Confidence interval
* P values given by Green Audit
£ Correct Poisson probabilities, ie of the observed numbers of deaths occurring if the underlying (Poisson) rate was the expected number
$ Not given in the Green Audit report [F] - see text for explanation of the calculation
\# The expected values for 1995-2001 - in italics - have been derived from the SAHSU report
by multiplying the expected values for 1995-1999 by 7/5 (as were those by Green Audit [F])

Table 3 Summary of "Mudflats" analyses - Breast cancer

	Ref	From	To	Total 26 wards			13 Blackwater wards* - GA July 2001			9 Blackwater wards* - GA Dec 2002		
				Obs	Expected	O/E	Obs	Expected	O/E	Obs	Expected	O/E
ONS-1991Census		1995	1999	104	94.99	1.09	61	44.48	1.37	51	35.97	1.42
ONS-EWC 1991		1995	1999	104	95.93	1.08	61	44.84	1.36	51	36.27	1.41
Green Audit Mar 2001	A	1995	1999	105	87.35	1.20	62	41.04	1.51	51	33.06	1.54
Green Audit July 2001£	B	1995	1999	105	95.80	1.10	**62**	**44.96**	**1.38** $	51	36.26	1.41
Green Audit Dec 2002	F	1995	1999	104	87.35	1.19	61	41.04	1.49	**51**	**33.06**	**1.54**
SAHSU Mar 2002#	E	1995	1999	104	110.02	0.95	61	51.64	1.18	52	41.55	1.25
ONS-EWC 1997		1995	1999	104	107.89	0.96	61	50.95	1.20	51	41.00	1.24
Green Audit Dec 2002	F	1995	2001	144	122.29	[1.18]	90	57.46	1.57	**73**	**46.29**	**1.58**
ONS-1991 Census (Expected x 7/5)		1995	2001	153	132.08	1.15	89	62.27	1.43	72	50.36	1.43
ONS-EWC 1997 (Expected x 7/5)		1995	2001	153	151.05	1.09	89	71.33	1.25	72	57.40	1.25

EWC Estimating With Confidence populations [Q]

* The figures in bold were given in the two Green Audit reports; all others are derived from ward level data provided in the various reports [A,B,E,F] or by ONS
£ Expected values adjusted for socio-economic deprivation
$ Green Audit report [B] gives expected deaths 44.9 (truncated) and O/E (incorrectly) 1.34
# Expected values based on EWC 1995-1999 populations, adjusted for socio-economic deprivation
[ ] O/E with correct (ONS) observed deaths of 153 is 1.25

Appendix A

Table A Numbers of deaths from all malignancies, breast cancer (females) and prostate cancer, 1995-1999, for 26 wards in Essex, by ward and year: figures from ONS[G], Green Audit[A], and SAHSU[D]

Note

The totals of deaths for each ward *registered* in 1995 to 1999 published in the first Green Audit report [A] were obtained by adding together the figures from the ONS VS4D tables [G] for each of the five years 1995, 1996, 1997, 1998 and 1999. There should therefore be absolutely no differences between these and the ONS totals given in Table A. Compared with the first Green Audit report [A], the numbers of breast cancer deaths for two of the wards (both in Colchester local authority) in Green Audit's second report [B] were amended: Birch/Messing and Copford, from 0 to 2; and Tiptree, from 9 to 7 - the overall total was unaffected; all the other 24 wards were unchanged.

The totals of deaths for each ward actually *occurring* in 1995 to 1999 given in the SAHSU report to the North Essex Health Authority [D] were based on aggregations of individual records using postcode directories. There will therefore inevitably be some small differences between the ONS figures for *registrations* of deaths given in Table A and the SAHSU figures of *occurrences* of deaths at the small area level, because not every death occurring in any one year is registered in that year; and because there may also have been differences between the postcode directories used by SAHSU in preparing their report in May 2001 and those used by ONS during the period that the death records for 1995 to 1999 were processed.

ONS usually publishes figures for the *registrations* of deaths within three months or so of the end of the year concerned. Figures for the actual *occurrences* of deaths are inevitably published somewhat later, but usually before the end of the year following the year in which the deaths occurred [J].

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Table A

Code	Ward		All Cancers M	diff	All Cancers F	diff	Breast F	diff	Prostate M	diff
N22UKFA	Althorne	1995	6		5		1		1	
		1996	6		1		0		1	
		1997	7		5		0		1	
		1998	4		1		0		1	
		1999	3		2		0		1	
		ONS total	26		14		1		5	
		Green Audit	26	0	14	0	1	0	5	0
		SAHSU	21	-5	13	-1	1	0	4	-1
N22UKFB	Burnham-on-Crouch North	1995	5		4		0		1	
		1996	6		6		1		2	
		1997	3		4		1		1	
		1998	3		1		0		0	
		1999	7		1		0		1	
		ONS total	24		16		2		5	
		Green Audit	24	0	16	0	2	0	5	0
		SAHSU	22	-2	13	-3	2	0	4	-1
N22UKFC	Burnham-on-Crouch South	1995	7		4		1		2	
		1996	6		5		1		1	
		1997	2		7		2		2	
		1998	5		10		1		0	
		1999	4		6		1		1	
		ONS total	24		32		6		6	
		Green Audit	24	0	32	0	6	0	6	0
		SAHSU	24	0	35	3	6	0	6	0

N22UKFE Goldhanger	1995	1		2		1		0	
	1996	1		2		1		0	
	1997	1		2		0		0	
	1998	3		1		0		1	
	1999	4		0		0		1	
	ONS total	10		7		2		2	
	Green Audit	10	0	8	1	3	1	2	0
	SAHSU	10	0	7	0	2	0	2	0
N22UKFF Great Totham	1995	4		4		3		0	
	1996	3		4		0		0	
	1997	5		1		0		1	
	1998	4		3		0		2	
	1999	3		4		0		0	
	ONS total	19		16		3		3	
	Green Audit	15	-4	17	1	3	0	3	0
	SAHSU	16	-3	15	-1	3	0	3	0
N22UKFG Heybridge East	1995	5		4		0		1	
	1996	4		5		1		0	
	1997	4		2		0		0	
	1998	2		3		1		0	
	1999	1		5		0		1	
	ONS total	16		19		2		2	
	Green Audit	17	1	18	-1	2	0	2	0
	SAHSU	5	-11	7	-12	2	0	0	-2
N22UKFH Heybridge West	1995	3		3		1		0	
	1996	2		4		0		0	
	1997	3		3		1		1	
	1998	2		4		1		0	
	1999	6		3		0		1	
	ONS total	16		17		3		2	
	Green Audit	17	1	16	-1	2	-1	2	0
	SAHSU	2	-14	5	-12	0	-3	0	-2

N22UFFL Little Baddow, Danbury and San	1995	10		9		1		2	
	1996	12		9		2		1	
	1997	15		7		0		2	
	1998	9		10		2		3	
	1999	11		15		4		1	
	ONS total	57		50		9		9	
	Green Audit	45	-12	46	-4	10	1	9	0
	SAHSU	59	2	50	0	9	0	9	0
N22UKFJ Maldon East	1995	2		3		1		0	
	1996	5		2		0		0	
	1997	10		9		4		1	
	1998	2		3		0		1	
	1999	4		4		0		0	
	ONS total	23		21		5		2	
	Green Audit	28	5	19	-2	1	-4	2	0
	SAHSU	6	-17	5	-16	0	-5	1	-1
N22UKFK Maldon North West	1995	10		13		4		0	
	1996	9		11		3		0	
	1997	10		5		2		2	
	1998	9		11		3		0	
	1999	5		8		1		2	
	ONS total	43		48		13		4	
	Green Audit	43	0	52	4	15	2	4	0
	SAHSU	37	-6	44	-4	10	-3	4	0
N22UKFL Maldon South	1995	8		5		1		2	
	1996	8		5		1		1	
	1997	9		9		1		1	
	1998	4		4		0		0	
	1999	4		8		2		1	
	ONS total	33		31		5		5	
	Green Audit	34	1	27	-4	6	1	5	0
	SAHSU	28	-5	25	-6	5	0	3	-2

N22UKFM Purleigh	1995	0		3		1		0	
	1996	2		2		0		1	
	1997	1		0		0		0	
	1998	1		1		0		0	
	1999	1		0		0		0	
	ONS total	5		6		1		1	
	Green Audit	13	8	15	9	2	1	1	0
	SAHSU	5	0	6	0	1	0	1	0
N22UKFN St. Lawrence	1995	5		1		1		0	
	1996	2		1		0		0	
	1997	1		0		0		0	
	1998	5		4		1		1	
	1999	4		3		0		1	
	ONS total	17		9		2		2	
	Green Audit	17	0	9	0	2	0	2	0
	SAHSU	16	-1	9	0	2	0	2	0
N22UKFP Southminster	1995	1		2		0		0	
	1996	7		4		0		2	
	1997	2		6		1		0	
	1998	1		4		1		0	
	1999	4		4		1		1	
	ONS total	15		20		3		3	
	Green Audit	14	-1	14	-6	2	-1	3	0
	SAHSU	15	0	20	0	3	0	3	0
N22UKFQ The Maylands	1995	1		6		3		0	
	1996	3		1		0		0	
	1997	5		2		1		1	
	1998	5		3		1		0	
	1999	1		1		0		0	
	ONS total	15		13		5		1	
	Green Audit	12	-3	17	4	5	0	1	0
	SAHSU	18	3	14	1	5	0	2	1

N22UKFR Tillingham	1995	3		3		0		0	
	1996	2		2		0		0	
	1997	1		5		0		0	
	1998	3		3		1		1	
	1999	1		2		1		1	
	ONS total	10		15		2		2	
	Green Audit	14	4	12	-3	3	1	2	0
	SAHSU	10	0	15	0	2	0	2	0
N22UKFS Tollesbury	1995	7		2		1		0	
	1996	3		3		0		0	
	1997	3		5		0		0	
	1998	2		4		1		0	
	1999	1		1		1		0	
	ONS total	16		15		3		0	
	Green Audit	14	-2	15	0	3	0	0	0
	SAHSU	16	0	15	0	3	0	0	0
N22UKFT Tolleshunt D'arcy	1995	8		2		2		0	
	1996	4		2		1		0	
	1997	4		4		0		1	
	1998	2		3		0		1	
	1999	1		4		1		0	
	ONS total	19		15		4		2	
	Green Audit	18	-1	16	1	4	0	2	0
	SAHSU	20	1	15	0	4	0	2	0
N22UKFU Wickham Bishops	1995	3		3		1		2	
	1996	2		0		0		1	
	1997	5		4		1		1	
	1998	1		5		1		0	
	1999	3		0		0		1	
	ONS total	14		12		3		5	
	Green Audit	13	-1	12	0	2	-1	5	0
	SAHSU	15	1	12	0	3	0	5	0

N22UKFW Woodham	1995	4		2		2		0	
	1996	2		5		1		0	
	1997	1		2		0		1	
	1998	1		5		0		0	
	1999	2		1		0		0	
	ONS total	10		15		3		1	
	Green Audit	14	4	17	2	4	1	1	0
	SAHSU	8	-2	15	0	3	0	1	0
N22UFGC Woodham Ferrers and Bicknacre	1995	2		3		0		0	
	1996	1		2		0		0	
	1997	5		1		0		1	
	1998	5		1		0		0	
	1999	6		3		0		0	
	ONS total	19		10		0		1	
	Green Audit	15	-4	11	1	0	0	1	0
	SAHSU	19	0	10	0	0	0	2	1
N22UGFB Birch/Messing and Copford	1995	7		2		2		2	
	1996	4		2		0		0	
	1997	5		1		0		2	
	1998	2		2		0		0	
	1999	5		4		0		0	
	ONS total	23		11		2		4	
	Green Audit	36	13	16	5	0	-2	4	0
	SAHSU	24	1	13	2	2	0	5	1
N22UGFR Pyefleet	1995	4		1		0		1	
	1996	3		4		1		0	
	1997	2		3		0		0	
	1998	3		2		0		1	
	1999	3		6		2		1	
	ONS total	15		16		3		3	
	Green Audit	24	9	19	3	3	0	2	-1
	SAHSU	15	0	18	2	3	0	3	0

N22UGFZ Tiptree	1995	7		6		0		0	
	1996	10		13		6		3	
	1997	10		5		0		0	
	1998	10		8		1		0	
	1999	9		8		0		0	
	ONS total	46		40		7		3	
	Green Audit	73	27	41	1	9	2	3	0
	SAHSU	46	0	40	0	7	0	3	0
N22UGGB West Mersea	1995	9		9		1		2	
	1996	13		9		4		0	
	1997	12		12		2		2	
	1998	12		12		4		3	
	1999	16		10		3		2	
	ONS total	62		52		14		9	
	Green Audit	95	33	52	0	14	0	8	-1
	SAHSU	62	0	52	0	14	0	9	0
N22UGGC Winstree	1995	2		0		0		0	
	1996	0		5		0		0	
	1997	3		1		0		0	
	1998	1		5		1		0	
	1999	5		1		0		2	
	ONS total	11		12		1		2	
	Green Audit	20	9	14	2	1	0	2	0
	SAHSU	11	0	12	0	1	0	2	0
Totals for the 26 wards	1995	124		101		28		16	
	1996	120		109		23		13	
	1997	129		105		16		21	
	1998	101		113		20		15	
	1999	114		104		17		19	
	ONS total	**588**		**532**		**104**		**84**	
	Green Audit	**675**	**87**	**545**	**13**	**105**	**1**	**82**	**-2**
	SAHSU	**530**	**-58**	**485**	**-47**	**93**	**-11**	**78**	**-6**

Map of Bradwell area