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Introduction

A recent report (Pringle, 2003) has again raised the question of whether there is an increased cancer risk in the north-east of Ireland, and in county Louth in particular. Pringle has drawn attention to an apparently high incidence of cancer in Drogheda.

A previous report on childhood leukaemia (Daly et al, 1988, Herity et al, 1992) found no increased risk on the east coast, but some subsequent reports have questioned this finding, and have suggested that the reprocessing plant at Sellafield might have a role in increasing cancer risk in Co Louth (Radioactive Times, 1999). Concern continues with regard to the possible effects of Sellafield on health on this side of the Irish Sea. A recent search of the "Irish Times" archives produced 68 articles mentioning Sellafield in 2003 and 29 up to August 1st, 2004.

The purpose of this report is to analyse all available data on cancer in Co. Louth, to assess if there is an increased cancer risk to the residents of the county, or any part of it, and to examine the reasons for any unexpected findings.

Methods

Data used

The data used here comes from two sources: cancer registrations for 1994 to 2000 and death registrations from 1994 to 2001. Since January 1st, 1994 all newly diagnosed cancers in Ireland have been registered by the National Cancer Registry. The process is highly effective, with over 96% of cancers being identified (National Cancer Registry, 2001). Prior to 1994, there was no national cancer registration in Ireland and therefore no reliable information on cancer incidence is available for this period.

The incidence data for Co. Louth comprise all cancers diagnosed from January 1st, 1994 to December 31st, 2000. Incidence data for areas smaller than county level consist of all cancers diagnosed from January 1st 1994 and to the end of 1997. The reason for the shorter period used for local data is explained on the next page under "Geocoding".

All deaths in Ireland must be registered by law with the General Registry Office within one year of death. Copies of all death certificates have been made available to the National Cancer Registry since 1994. Most of the information on the death certificate, including cause of death and the normal residence of the deceased, is recorded by the Registry. All deaths due to cancer are matched to known registrations, and, if previously unknown to the Registry, are confirmed and registered as new cancer cases.

Unless specifically mentioned, the cases analysed here are "invasive" or "malignant" cancers only. The Registry also records a number of early or pre-cancerous conditions which are not included here. In some tables and figures, skin cancers other than melanoma are also omitted. Where this is done, it is noted and the cancer numbers are described as "excluding non-melanoma skin cancers". Non-melanoma skin cancers are the commonest of all cancers, but it is likely that their registration is less complete and more variable than that of other cancers (Stefoski Mikeljevic J et al, 2003). These cancers are often small and not obvious, they rarely spread or cause significant illness and may not be recognized by the patient as cancer. Similar considerations apply to the early and pre-cancerous conditions mentioned above. A high rate of non-melanoma skin cancer in an area may therefore be due to increased awareness of cancer, rather than a true difference in risk. As these cancers are so common, an apparent increase in the rate of non-melanoma skin cancer will usually cause an increase in overall cancer rates. For these reasons, international comparisons of cancer rates rarely include non-melanoma skin cancers or non-invasive conditions (Black RJ et al, 1997).

Geocoding

The address of each cancer patient at the time of cancer diagnosis is recorded by the Registry. The county of residence can be easily determined in the majority of cases from the address given. However, for detailed geographical analysis, each case must be assigned to an area much smaller than a county. In this way, areas of high cancer incidence can be more precisely defined and information on cancer incidence can be linked to known characteristics of an area, such as geographical location, population density and deprivation. The smallest useful area for this purpose in Ireland is the electoral division (ED)–formerly known as district electoral division–as this is the smallest area for which census data can be obtained. There are just over 3,500 EDs in Ireland, with an average population of 1050 at the 1996 census. However, EDs vary widely in population, with a range from 23 to 25,000. The two largest ED populations in Ireland at the 1996 census were those of Dundalk (25,762 persons) and Drogheda (24,460 persons).

In theory, each cancer patient can be assigned to an ED, using the address given. In all European countries other than Ireland, this is easily done, by using the postcode. In Ireland, however, addresses have no postcodes and so must be assigned to EDs by matching the address given to those in a table which links known addresses to EDs. Databases matching EDs to addresses are available from An Post/OSI (GeoDirectory) and from the Central Statistics Office. The Registry also has copies of all electoral registers, which contain both ED and address information. With these it is theoretically possible to match all addresses to EDs. In practice, however, many addresses collected by the Registry or recorded on death certificates are incomplete, non-standard or inaccurate. In addition, none of the available databases lists every address and some have errors. At best, only 70% to 80% of addresses have a close match in any of the databases and the remaining 20-30% have to be matched by inspection of individual records with reference to large-scale maps. The match rate is lower for death certificates than for registrations, as the quality of address data is poorer. As the registry records over 20,000 new cases and 7,500 deaths each year, assigning an ED to each case or death is a time-consuming process. In 1999, the Registry had all registrations from 1994 mid-1998 coded to ED by a contractor, but no further coding was carried out due to lack of resources.

The data in this report are those cases diagnosed in 1994 to 1997 which were allocated to an ED. Cases from 1998, which were not completely geocoded, have been excluded. Of the 1722 new cancers diagnosed in Louth residents in 1994-1997, 1633 (95%) could be assigned to a definite ED of residence and only these cases are included in the analysis by small area. Because we were not satisfied with the quality of the geocoding for death certificates, no small area data is presented here for cancer deaths.

In 2003 funds were made available by the Department of Health and Children and the health boards to bring this geocoding up to date. A program of automated and manual matching is now taking place and we intend to have EDs allocated to all cancer cases by the end of 2005.

Apart from its obvious use in allocating cancer cases to specific areas and studying geographical patterns, geocoding can give some general information on the socioeconomic status of patients through area-based deprivation indices (Kelly and Sinclair, 1997). Information on income, employment or other indicators of socio-economic status is not available at an individual level to the Registry, as this information is rarely available from medical records, and linkage to other sources of information on individuals (e.g. census or income tax data) is not permitted. Area-based indices of socio-economic status are not as sensitive as individual-based measures, especially in rural areas, but show a reasonable correlation with other measures.

Calculations

(Examples of the calculations described below are given in Appendix 1).

Results are presented here in a number of forms:

Counts of cases or deaths

The period for which these are recorded is given.

Incidence and mortality rates

In comparing cancer numbers or deaths between areas or over time, two main factors must be considered—the number of people at risk, and their ages. The correction for number at risk is obvious. Cancer numbers or deaths are divided by the number of people resident in the area, as given by the census, to give an incidence or mortality rate. For intercensal years, the CSO and Department of Health and Children have prepared annual mid-year population estimates to county level, which are used here (Department of Health and Children, 2004). Rates calculated in this way (usually described as the "crude" rate) only consider the overall population size and do not allow for the age distribution of the population.

Age is a major risk factor for cancer, with risk doubling for every eight or nine years of life. An area with an older population can be expected, all else being equal, to have more cases. We have corrected for age in two ways:

1. Use of a "standard" population.

Using the incidence or mortality rate for each five-year age-group, an overall rate is calculated using a population of standard age composition. The population used here is the "European" standard (World Health Organisation, 1991). The rate is referred to as the **age-standardised incidence (or mortality)** rate.

2. Calculation of expected rates.

This is the more common method for small areas. The previous method can be used only if the area has some residents in each age group, which is not always the case for EDs, particularly those with small populations. It also allows direct comparison of rates between a larger area (country or county) and the smaller areas making it up. Using the national incidence or mortality rates for each age group and the number of people in each age group in the area of interest, we can calculate the total expected number of cancers in an area. This can be compared to the number actually found, and the ratio of observed to expected cases (or deaths) is given, as a percentage or a ratio. This is called the **standardised incidence (or mortality) ratio,** abbreviated as SIR or SMR. The value of SIR/SMR for Ireland as a whole is always 1 (or 100%).

The difference between observed and expected cases will also show an "excess" or "deficit" of cases/deaths in an area compared to the number that would have been expected from national rates.

3. Confidence limits/intervals

For both types of rate calculation, and for case or death numbers, we can show calculated "confidence limits (or intervals)". In normal statistical interpretation, this means that there is a specified probability (usually 95%) that the confidence interval contains the true value of the quantity being measured. The usual interpretation of the confidence interval is when we use a sample to make an estimate of the true value. For instance, if we try to estimate the average height of women in Ireland we would usually measure only a sample of women and get their average height. The confidence limits describe a range around this sample average that we are fairly sure contains the average for the whole country. It has been questioned (Pringle, 2003) if these limits have any meaning when the quantity being measured is not a sample, but the entire set of cancer cases registered in a particular area. However it is noticeable in cancer epidemiology that the number of cases in an area varies from year to year in a random way, and, in the case of small areas, the variation can be quite large relative to the number of cases or deaths. The underlying risk of cancer, on the other hand, is unlikely to vary much from year to year. The risk for some cancers may have occurred only a short time before the cancer was diagnosed, while the risk for others may have occurred many years previously, and so the number of cancers seen in a year will depend on a number of different risk factors averaged out over a long period of time. For this reason we consider the risk of cancer to be fairly stable from year to year (although subject, of course, to long-term upwards or downwards trends), even though the number of cases or deaths may fluctuate.

From this perspective, the number of cases observed in a period of a few years can be viewed as an estimate of the underlying risk of cancer to the population. The longer we collect data, the closer we would come to a "true" estimate of risk, assuming that this does not change, or changes only gradually, with time. Conversely, a small number of cases registered in a short period of time will give us only a very rough estimate of risk. A confidence limit, although not to be strictly interpreted as a sampling statistic, nevertheless gives a good estimate of the accuracy of an estimate of cancer risk based on these case numbers. Rates or figures with wide confidence intervals, therefore, need to be interpreted with caution when drawing conclusions and may not give a good indication of the true population risk. For almost all the data presented here, the confidence intervals depend on the number of cases or deaths observed.

Interpretation of differences in rate

In interpreting the finding that there appears to be a higher incidence of cancer in a particular area, we need to ask a number of questions

- Is there actually a higher incidence of cancer?
- If so, does this mean that there is a higher risk?
- If there is a higher risk, is living in the area a cause or an effect of this risk?

Bradford Hill, in one of the fundamental papers on the relation of environment to disease (Bradford Hill, 1965) said *"the decisive question is whether the frequency of the undesirable event B will be influenced by a change in the environmental feature A"*. In other words, the question to be asked in this case is whether there is an environmental feature associated with residence in Co. Louth which **alters** the risk of developing cancer. While it may be unquestionable that the number of cancer cases in an area is greater than would be expected, we cannot immediately draw the conclusion that living in the area is in itself a risk factor for cancer. It is common to observe apparent relationships between sets of events which are clearly unconnected, and the accepted practice in the study of disease in populations is to apply a series of tests to distinguish those sets of circumstances that suggest A is caused by B from those which suggest that the relationship between them is only accidental. Absolute proof is usually impossible in these situations, but there will be an accumulation of evidence in one direction or the other.

Associations may be found between two unrelated sets of events through three main mechanisms: chance, confounding and bias.

Chance: Cancer occurs more or less at random, and it is impossible to predict exactly how many cases will occur at a particular place and time, but there are statistical techniques which allow us to say that, based on past experience, we are fairly certain that there will be between, for instance, 15 and 20 cases in the following year. The narrower the range of prediction, the less sure we can be that our prediction will be correct. If there are 20 cancer cases this year, and we predict that there will be between 10 and 30 cases next year, we can be more confident that this will be true than if we predict that there will be between 19 and 21 cases. This idea is often expressed in "confidence limits", as mentioned previously, which can be interpreted as saying that we are 95% (or any other number) confident that the number of new cases will fall between the confidence limits. The narrower the limits, the less confident we can be that the true figure will fall between them.

Obviously our degree of confidence in a prediction depends on the amount of evidence there is to support it. In the case of cancer cases or deaths, the most important evidence is the number of cases or deaths we have been able to count in previous periods. As a result, the more events we observe, the narrower will be the confidence limits of any estimate based on the counts. We all understand intuitively that the more often an event occurs the less likely it is that this has happened by chance. We can accept that for it to rain for the last four weekends is bad luck, but for it to rain for the last forty would suggest a change in the climate. Similarly, if one person gets a stomach upset after a meal, we are less likely to attribute this to the meal than if nine out of ten people do. In the same way, if we count 100 cancer cases in an area X this year, the 95% confidence limits can be calculated by standard statistical methods to be about 80 to 120 (±20% of the expected numbers)—that is, we can predict with 95% confidence that we will observe between 80 and 120 cases next year. On the other hand, if we observe only 10 cases in area Y, then the confidence limits are calculated to be between 4 and 16 (±60% of the expected value)—so we can make much less precise predictions when there are fewer cases. One consequence is that, if the number of cases in both area X and area Y increased by 50% in the following year, we could be quite confident that this was not due to chance in area X, but it could have been due to chance in area Y. The smaller the area or the shorter the time period, the fewer events we observe, and the more difficult it is to draw any firm conclusions about differences in cancer rates.

In comparing cancer rates between areas, we often use the confidence intervals to indicate if the difference is "statistically significant"—not if it is real, which it quite obviously is—but to test how strongly this difference supports the idea that people in the area have a different risk of developing cancer and how well we can predict, given what we already know, what rates will be like in future years. A difference which could have come about by chance gives much less support to the idea that there is a connection between cancer risk and where you live. However, statistical testing like this does not constitute proof, but just gives an idea of how strong the evidence is for a difference in risk between areas or times. In interpreting a difference, other aspects of the situation need to be considered .

Confounding: This is the commonest and most difficult problem in comparing areas. In its simplest form it means that the relationship between A and B only exists because they are both caused by some third factor. For instance, we might find that the rate of lung cancer was higher in people who take less exercise. This may be because exercise protects against lung cancer, but an equally likely explanation is that both lung cancer and lack of exercise are to be expected in people who smoke. We need to know which explanation is true, because if it is the second, then encouraging smokers to exercise is not necessarily going to reduce their chances of developing lung cancer. In the present study, we need to distinguish between the statements "people who live in Louth are at higher risk of cancer" and "people are at higher risk of cancer because they live in Louth". In the first case, moving from or into Louth is not, in itself, going to change your cancer risk; in the second case, it is. In the second case we also need to know why living there affects cancer risk, and if anything can be done to reduce this.

Confounding is difficult to deal with because we can never know with certainty all the possible factors which might link a disease and a suspected risk. We can measure some of these—for instance, smoking habits—and conclude that others, such as genetic differences, are unlikely to apply. However, before concluding that living in Louth is in itself a cause of increased cancer risk we need to eliminate as many other possibilities as we can.

Bias: There may also be some systematic error in the way in which the information has been collected or analysed—for instance that you are more likely to be registered as having, or dying of, a cancer because of where you live. This is called "bias". The use of cancer registration and death registration, which should detect every cancer case or death in an area, will eliminate some bias of this type, but no method is foolproof. Some cancers are more likely to be missed by registration. They may not be recognised by the patient as cancer[1], may never develop into full-blown cancer,[2] or may occur late in life in people who die of other causes before the cancer becomes obvious.[3] Where screening services are developed, where there is higher "cancer awareness" or an active programme of case-finding, the rates of occurrence of these cancers may seem higher just because more of them are being picked up.

[1] Some types of non-melanoma skin cancer may appear as small ulcers and not be recognised as cancer.
[2] Some early and pre-cancerous conditions such as "carcinoma in situ" of cervix and breast, may disappear without progressing to cancer.
[3] Cancers of the prostate are commonly found at post-mortem in elderly men who had no symptoms of cancer.

The methods of calculating cancer rates may also lead to bias. The number of cases or deaths in an area is usually divided by the number of people living in the area, so we can describe the rate as for instance, 36 cases per 100,000 people per year. This assumes that the people living in the area developed the cancer in the area. It can be ten to twenty years from the time a cancer first occurs to the time it becomes apparent and the patient will have been exposed to the causes of the cancer for years before it occurs. During this long period, after the important exposure has happened, it is possible that the patient will move home. Where there has been substantial immigration to an area, therefore, a proportion of the cancers will have arisen while patients were living elsewhere, but will become apparent some time after the move. If people move from a high risk area to a lower risk area, then the apparent risk of cancer will be increased in the area to which they move.

Bearing the problems of chance, confounding and bias in mind, Bradford Hill (1965) suggested the following criteria which would lead us to believe that there was a connection between some factor and the occurrence of disease. In this case, the question is "Does living in Co. Louth (or any part of it) increase the risk of developing cancer?".

(1) *How strong is the association?* Is living in the area associated with a high risk (2, 5, 10 times that expected) of cancer, or is the increased risk small, of the order of 20% or 30%? It is important to note, as Bradford Hill did, that the association should be "perfectly clear-cut and beyond what we would attribute to the play of chance".

(2) *How consistent is the association?* Do we find it in every study, for both incidence and mortality, in all of the cancers in which we would expect it? If the proposed risk factor is environmental, do we find an increased risk in both men and women?

(3) *How specific is this relationship?* Is it confined to cancer? Are there high rates of other diseases in the area? Conversely, do we see similar patterns of cancer in other parts of the country? If so we might conclude that some other (confounding) factor is at work.

(4) *Does the effect follow the cause?* This is difficult to establish in this case, but it seems likely that most of the cancers originated while the patients were already living in Louth. However, Louth, and Drogheda in particular, has had one of the highest rates of population growth in the country (Central Statistics Office, 1996 and 2002), so at least some cancers may have arisen before the patients moved to Louth.

(5) *Does greater exposure bring higher risk?* This does not really apply here, except for those who have moved to the area. For these individuals, length of residence may be a useful measure of exposure. If risk is related, for instance, to exposure to the Irish Sea, then risk might fall off with distance from the coast (see, for instance, www.llrc.org for a detailed discussion of this hypothesis).

(6) *Is there a plausible explanation for the link?* This obviously depends on our knowledge of the causes of cancer, which are very complex and not yet fully understood. However, we need to be able to identify exposures shared by the population of Louth which are a result of living in the area, and not due to personal or life-style choices. The only plausible agents for this are air and/or water pollution. Soil pollution may also be a factor but only if the population eats a substantial quantity of locally produced food.

(7) *Is the finding consistent with what is already known about the disease*?. Some causes of the common cancers are well known, and two findings are of particular importance:

- The common cancers do not share any important risk factors.(Schottenfeld and Fraumeni, 1996) The main cause of skin cancer is sunlight; of lung cancer, smoking; of breast cancer, lifetime hormone levels; and of bowel cancer, diet.
- External factors (pollution, radiation) contribute very little to overall cancer risk (of the order of a few percent) (Doll and Peto, 1981) and are very unlikely to be the reason for 20-30% differences in cancer risk, either overall or for individual cancer.

(8) *Does removal of the cause reduce the cancer rate?* To establish this we would have to compare cancer risk in those living in Louth to an identical group who had left. This would require setting up a special study and is beyond the scope of this investigation.

(9) *Have there been other situations in which a definite link has been established between residence in an area and cancer risk?* A large number of studies have tried to link place of residence to cancer risk, and have sometimes shown a strong link, usually with an obvious source of a high level of carcinogens.

(10) *Have we allowed for the effects of chance?* Are the effects of chance likely to be greater than the effects we observe? This has been dealt with on pages 4-5.

Approach

In compiling this report, we have attempted to answer the questions in the following order:

1. Are there more cancer cases and/or deaths in Louth than we would expect?
2. If yes, is this true of the whole county or only some parts?
3. If so, does this apply to all cancers, sexes and age groups?
4. Do the higher rates suggest an increased risk to the population of the area?
5. If there is a higher risk, can we explain this using what we know about risk factors for these cancers?

In taking such a broad approach, without any specific hypothesis, it is likely that some of the areas studied will appear to have an abnormally high or low cancer rate purely by chance. There are about 20 fairly common cancers. If we look at all of these for each of the 37 EDs in Louth, for both sexes separately, this will give almost 1500 values for cancer incidence rates, and the same number for mortality. Given such a large number of measurements of rate it would be surprising if we did not find some very extreme values purely by chance. Because of this, we need to look not only at the incidence or mortality rate itself, but at supporting evidence for cancer risk, and to consider how plausible it is that a high (or low) rate is due to a real difference in the underlying risk of cancer.

Results

New cancer cases

All invasive cancers, 1994 to 2000

The number of new cancers diagnosed in residents of Co. Louth was 7% higher than would have been expected from the national rate, 8% higher for women and 6% higher for men (Table 1). This represents an average of 34 extra new cancer cases each year. Louth ranked second highest in cancer rates for women (after Dublin) and 3rd highest for men (after Dublin and Westmeath). From these 1994—2000 figures the chances seem to be greater than 95% that the cancer risk in Louth is higher than the national average. The fact that we find this for both men and women adds consistency to the finding that cancer incidence in Louth is higher than in Ireland overall.

Counties where the differences in rate from the national average were larger than could be plausibly attributed to chance (statistically significant; see page 5) are shown in bold. This is the case for both males and females in Louth.

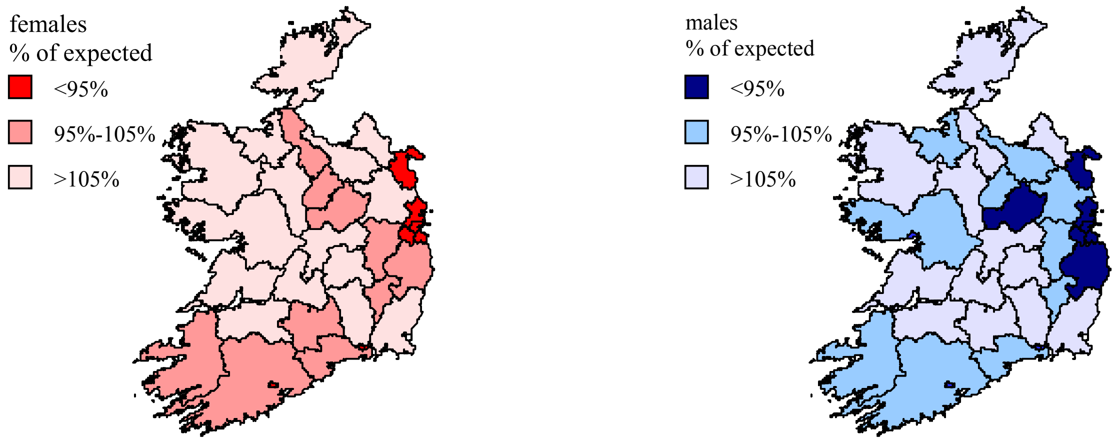
Table 1. New invasive cancer cases, 1994-2000, by county of residence

	females		***males***	
county	***new cancers 1994-2000***	***observed/ expected (95% confidence limits)***	***new cancers 1994-2000***	***observed/ expected (95% confidence limits)***
Clare	1207	77% (72%; 81%)	1576	82% (78%; 86%)
Cork	**7171**	**102% (100%; 105%)**	**7826**	**104% (101%; 106%)**
Cavan	883	93% (87%; 99%)	1178	96% (91%; 102%)
Carlow	657	103% (95%; 111%)	747	100% (93%; 107%)
Donegal	2013	90% (86%; 94%)	2578	93% (90%; 97%)
Dublin	**19226**	**114% (112%; 116%)**	**18096**	**114% (113%; 116%)**
Galway	2838	91% (88%; 95%)	3624	97% (94%; 100%)
Kildare	1708	102% (97%; 107%)	1779	100% (96%; 105%)
Kilkenny	994	80% (75%; 85%)	1183	80% (76%; 85%)
Kerry	2332	101% (97%; 105%)	2789	100% (96%; 103%)
Longford	523	97% (88%; 105%)	644	99% (91%; 106%)
Louth	**1605**	**108% (103%; 113%)**	**1618**	**106% (101%; 111%)**
Limerick	2425	92% (88%; 96%)	2549	89% (85%; 92%)
Leitrim	485	95% (87%; 104%)	599	87% (80%; 94%)
Laois	770	91% (85%; 98%)	901	86% (80%; 91%)
Meath	1500	92% (88%; 97%)	1739	96% (91%; 100%)
Monaghan	689	81% (75%; 87%)	898	89% (83%; 94%)
Mayo	1909	88% (84%; 92%)	2383	89% (85%; 92%)
Offaly	866	92% (86%; 98%)	960	84% (79%; 90%)
Roscommon	874	85% (80%; 91%)	1154	87% (82%; 92%)
Sligo	961	94% (88%; 100%)	1184	98% (92%; 103%)
Tipperary N	862	84% (78%; 89%)	1077	90% (84%; 95%)
Tipperary S	1238	95% (90%; 101%)	1410	93% (88%; 98%)
Waterford	1591	101% (96%; 106%)	1784	101% (97%; 106%)
Westmeath	1069	104% (97%; 110%)	1257	**107% (101%; 113%)**
Wicklow	1602	99% (94%; 104%)	1774	**105% (100%; 110%)**
Wexford	1559	90% (85%; 94%)	1809	92% (87%; 96%)

Figures shown in **bold** are significantly higher than expected

The geographical distribution of cancer risk in Ireland is not uniform (Figure 1). The areas of high risk for both men and women are in the east, and those of low risk in the west and the south midlands. The clustering of risk is more pronounced for men than for women, but the overall pattern is quite similar.

Figure 1. Standardised incidence ratios, all invasive cancers, 1994-2000



All invasive cancers excluding non-melanoma skin cancer, 1994 to 2000

As already mentioned, the inclusion of non-melanoma skin cancer cases, which make up almost ⅓ of all cases, can distort the picture considerably, and geographical comparisons of cancer rates normally exclude non-melanoma skin cancers.

The exclusion of non-melanoma skin cancer cases reduces the difference between the rates in Louth and the country as a whole from 7% to 4% (Table 2). Counties where the differences in rate from the national average were larger than could be plausibly attributed to chance (statistically significant; see page 5) are shown in bold. It should be noted that this is not the case for Louth.

The number of extra cancer cases in Louth, after excluding non-melanoma skin cancer, is reduced from 34 to 13 per year. Using formal statistical testing, there is insufficient evidence to conclude that cancer risk in Louth, excluding non-melanoma skin cancer, is truly different from the country as a whole. For the period under study there was clearly a small excess number of cancer cases in Co. Louth for both men and women, but we cannot tell if this was due to chance or increased cancer risk.

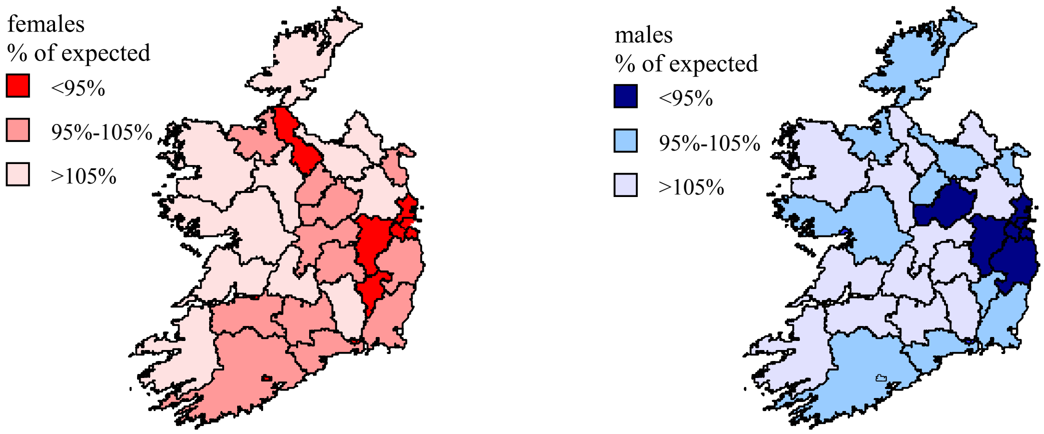
Table 2. New invasive cancer cases (excluding non-melanoma skin cancer), 1994-2000, by county of residence

	females		***males***	
county	***new cancers 1994-2000***	***observed/ expected (95% confidence limits)***	***new cancers 1994-2000***	***observed/ expected (95% confidence limits)***
Clare	891	79% (74%; 84%)	1091	81% (76%; 86%)
Cork	5134	102% (99%; 105%)	5379	102% (99%; 104%)
Cavan	636	94% (86%; 101%)	836	98% (91%; 104%)
Carlow	512	111% (102%; 121%)	537	103% (94%; 111%)
Donegal	1512	95% (90%; 99%)	1833	95% (91%; 99%)
Dublin	**13313**	**109% (107%; 111%)**	**12552**	**113% (111%; 115%)**
Galway	2021	91% (87%; 94%)	2503	96% (92%; 99%)
Kildare	**1319**	**108% (102%; 113%)**	1302	105% (99%; 110%)
Kilkenny	754	84% (78%; 90%)	878	85% (80%; 91%)
Kerry	1524	92% (88%; 97%)	1817	93% (89%; 97%)
Longford	392	101% (91%; 111%)	471	103% (94%; 113%)
Louth	1116	104% (98%; 110%)	1120	104% (98%; 110%)
Limerick	1889	99% (95%; 104%)	1866	93% (89%; 97%)
Leitrim	379	105% (94%; 116%)	448	94% (85%; 103%)
Laois	580	96% (88%; 103%)	630	86% (79%; 92%)
Meath	1101	94% (88%; 99%)	1181	93% (88%; 98%)
Monaghan	510	84% (76%; 91%)	646	91% (84%; 98%)
Mayo	1364	88% (83%; 93%)	1648	88% (84%; 92%)
Offaly	667	98% (91%; 106%)	689	86% (80%; 93%)
Roscommon	648	89% (82%; 96%)	798	86% (80%; 92%)
Sligo	726	100% (93%; 107%)	841	100% (93%; 106%)
Tipperary N	677	92% (85%; 99%)	765	91% (85%; 97%)
Tipperary S	937	101% (94%; 107%)	991	94% (88%; 100%)
Waterford	1131	100% (94%; 105%)	1266	103% (97%; 109%)
Westmeath	774	104% (97%; 112%)	865	105% (98%; 112%)
Wicklow	1156	99% (93%; 105%)	**1257**	**106% (100%; 112%)**
Wexford	1212	97% (91%; 102%)	1381	100% (95%; 105%)

Figures shown in bold are significantly higher than expected

Looking at overall geographical patterns (Figure 2), it can be seen that the difference in risk between the eastern and western parts of the country persists when non-melanoma skin cancers are excluded, although there are some differences in the counties involved.

Figure 2. Standardised incidence ratios, all invasive cancers except non-melanoma skin, 1994-2000



Cancer deaths

In 1994-2001, cancer deaths in Louth were 3% higher than expected, a total of 5.5 extra deaths per year (Table 3). As with cancer cases, this higher than expected rate was found for both men and women. Louth ranked fifth highest in death rate for women and seventh for men.

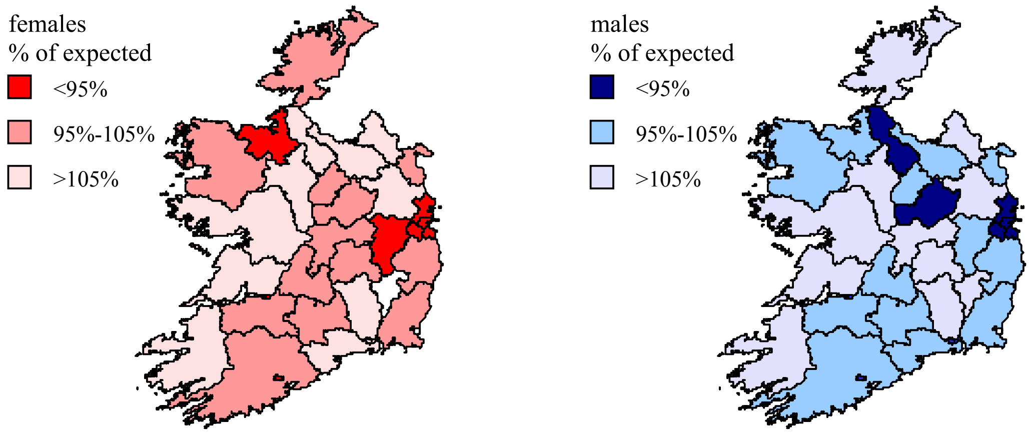
Counties where the differences in rate from the national average were larger than could be plausibly attributed to chance (statistically significant; see page 5) are shown in bold. It should be noted that this is not the case for Louth.

Table 3. Cancer deaths, 1994-2000, by county of residence

	females		***males***	
county	***cancer deaths 1994-2000***	***observed/ expected (95% confidence limits)***	***cancer deaths 1994-2000***	***observed/ expected (95% confidence limits)***
Clare	647	86% (80%; 93%)	811	84% (78%; 89%)
Cork	3349	101% (98%; 105%)	3799	101% (98%; 105%)
Cavan	423	91% (83%; 100%)	641	103% (95%; 111%)
Carlow	369	124% (111%; 137%)	349	94% (85%; 104%)
Donegal	1043	97% (91%; 102%)	1321	94% (88%; 99%)
Dublin	**8321**	**106% (104%; 108%)**	**8605**	**112% (109%; 114%)**
Galway	1306	88% (83%; 93%)	1713	90% (86%; 95%)
Kildare	**799**	**107% (100%; 114%)**	884	103% (96%; 110%)
Kilkenny	522	89% (81%; 97%)	620	84% (78%; 91%)
Kerry	1043	93% (88%; 99%)	1305	92% (87%; 97%)
Longford	265	101% (89%; 113%)	323	98% (87%; 109%)
Louth	719	103% (95%; 111%)	775	103% (96%; 110%)
Limerick	1275	103% (97%; 108%)	1417	100% (95%; 105%)
Leitrim	233	93% (81%; 105%)	372	106% (95%; 117%)
Laois	385	97% (87%; 107%)	495	94% (86%; 102%)
Meath	677	90% (83%; 97%)	783	87% (81%; 93%)
Monaghan	341	84% (75%; 93%)	450	88% (80%; 97%)
Mayo	1032	96% (90%; 102%)	1346	98% (93%; 103%)
Offaly	429	97% (88%; 106%)	509	90% (82%; 97%)
Roscommon	443	88% (80%; 97%)	552	81% (75%; 88%)
Sligo	517	105% (96%; 114%)	621	101% (93%; 109%)
Tipperary	1133	102% (96%; 108%)	1316	97% (92%; 102%)
Waterford	700	94% (87%; 101%)	902	103% (97%; 110%)
Westmeath	493	101% (92%; 110%)	619	106% (97%; 114%)
Wicklow	728	96% (89%; 103%)	818	98% (91%; 105%)
Wexford	828	101% (94%; 107%)	951	97% (90%; 103%)
Figures shown in bold are significantly higher than expected				

The geographical pattern for cancer mortality was not as clear-cut as it was for incidence; however the areas of highest incidence for both men and women tended to be in the east, and the lowest in the west (Figure 3). As with cancer incidence, the highest rates were found in Dublin.

Figure 3. Standardised mortality ratios, all cancers, 1994-2000



Time trends

Cancer cases

The age-standardised incidence rate for males for all invasive cancers combined was above the expected value in Louth for all but one of the seven years studied (although the gap between Louth and Ireland as a whole seemed to be closing), while for females there was no consistent trend (Figure 4). When non-melanoma skin cancers are excluded, male rates were slightly above expected in four of the seven years shown, but female rates were essentially the same as those for Ireland as a whole (Figure 5) for the entire period.

Figure 4. Time trends in age-standardised cancer incidence rate, all invasive cancers, 1994-2000

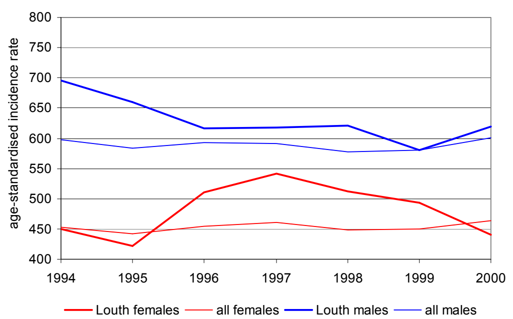
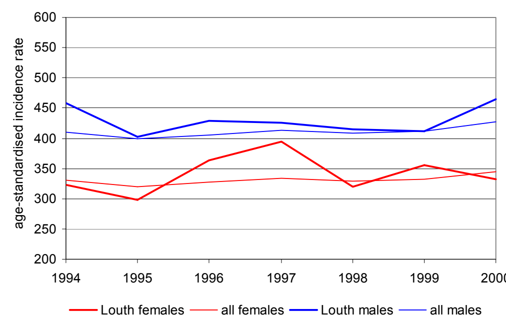


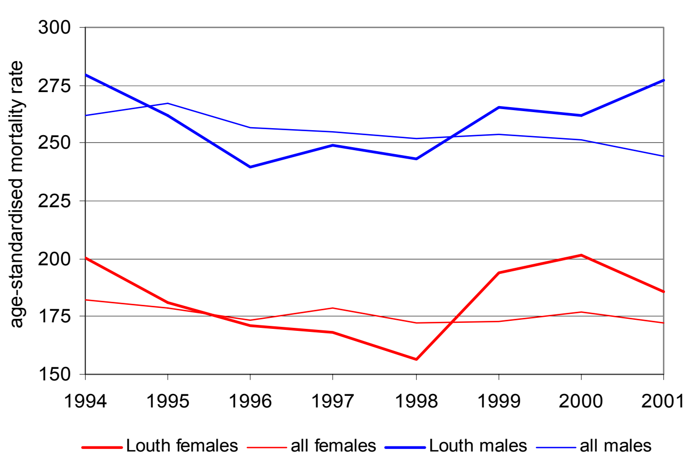
Figure 5. Time trends in age-standardised cancer incidence rate, all invasive cancers excluding non-melanoma skin, 1994-2000



Cancer deaths

Over the period 1994 to 2001, cancer death rates in Louth fluctuated around the national average, being higher than average in some years and lower in others (Figure 6). The rates were higher than average in the period 1999 to 2001, but this seems to be due to random variation, and there was no overall trend or consistent difference from the national average. The overall similarity between the trends for men and women in Louth suggests that at least some of this variation was due to inaccuracies in the estimation of population between census dates and that the apparent rise in death rate from 1998 onwards for both sexes may have been due to consistent under-estimation of population growth in the county (possibly due to migration from other areas).

Figure 6. Trends in cancer death rates, 1994-2001



Individual cancer sites

The common cancers do not have any important known shared risk factors, so it is very unlikely that any single factor can be responsible for the higher incidence in Louth. To understand why the overall rate is higher than average, we need to look at individual cancer types and their risk factors.

Cancer incidence

The 13 common cancers listed below (Table 4) made up 85% of all cancers diagnosed in Ireland from 1994 to 2000. Rates in Louth for women were higher than expected for six of these (skin cancer—both melanoma and non-melanoma—lung, stomach, leukaemia and pancreas cancers) and lower for seven. Rates were higher than expected for eight cancers in men (non-melanoma skin cancer, colorectal, lung, lymphoma, stomach, oesophagus, pancreas and leukaemia) and lower for five. Most of these differences were small and could be attributed to chance. However, rates were more than 20% higher than the rest of Ireland (even if this difference was not always statistically significant) for both men and women for skin, lung and stomach cancer and leukaemia, for cancer of the oesophagus in men and melanoma in women. Cancers for which the differences in rate from the national average were larger than could be plausibly attributed to chance (statistically significant; see pages 6-7) are shown in bold. These were: stomach cancer for both sexes, non-melanoma skin cancer for women and lung, and oesophageal cancer for men.

Table 4. Standardised incidence ratios (SIR) by cancer site, Louth 1994-2000

	females		***males***	
cancer type	***cases***	***SIR (95% confidence limits)***	***cases***	***SIR (95% confidence limits)***
non-melanoma skin	489	**1.18 (1.08 ;1.28)**	498	1.09 (0.99 ;1.19)
colorectal	124	0.90 (0.74 ;1.06)	171	1.02 (0.87 ;1.17)
breast	286	0.97 (0.86 ;1.08)	—	—
lung	113	1.16 (0.95 ;1.37)	207	**1.25 (1.08 ;1.42)**
prostate	—	—	192	0.92 (0.79 ;1.05)
lymphoma	34	0.84 (0.56 ;1.12)	46	1.01 (0.72 ;1.30)
stomach	46	**1.44 (1.02 ;1.86)**	65	**1.33 (1.01 ;1.65)**
bladder	20	0.88 (0.49 ;1.27)	48	0.88 (0.63 ;1.13)
melanoma	54	1.26 (0.92 ;1.60)	20	0.80 (0.45 ;1.15)
leukaemia	34	1.32 (0.88 ;1.76)	43	1.23 (0.86 ;1.60)
pancreas	33	1.09 (0.72 ;1.46)	29	1.03 (0.65 ;1.41)
oesophagus	17	0.82 (0.43 ;1.21)	45	**1.52 (1.08 ;1.96)**

Figures shown in bold are significantly higher than expected

The same cancers—non-melanoma skin cancer, lung cancer and leukaemia, melanoma for women and cancer of the oesophagus for men—were those for which Louth ranked highest among the counties in incidence rate (Table 5).

Table 5. Rank among counties of standardised incidence ratios by cancer site, Louth 1994-2000 (1=highest rate)

cancer type	***females***	***males***
non-melanoma skin	3	2
colorectal	21	6
breast	13	—
lung	3	2
prostate	—	19
lymphoma	21	11
stomach	2	2
bladder	17	15
melanoma	2	20
ovary	21	—
leukaemia	3	4
pancreas	6	13
oesophagus	16	1

Cancer mortality

The 13 commonest causes of cancer death, shown in Table 6, made up 75% of all cancer deaths in Ireland between 1994 and 2000. Rates in Co. Louth were higher than expected for eight of these thirteen cancers in women (lung, breast, stomach, brain, leukaemia, kidney, bladder and melanoma) and lower for five. Rates were higher for seven of the thirteen cancers in men (lung, colorectal, stomach, oesophagus, brain, leukaemia and kidney) and lower for six.

Cancers where the differences in rate from the national average were larger than could be plausibly attributed to chance (statistically significant; see page 5) are shown in bold. Most of the differences from expected rates were small, and only one cancer—lung cancer in men—had a significantly raised mortality rate. Cancer of the stomach for both men and women had a death rate more than 20% above the national rate, although this was not statistically significant. Other differences from national rates were not consistent between the sexes.

Table 6. Standardised mortality ratios(SMR) by cancer site, Louth 1994-2000

	females		***males***	
	cases	***SMR (95% confidence limits)***	***cases***	***SMR (95% confidence limits)***
lung	114	1.05 (0.85; 1.24)	**220**	**1.24 (1.08; 1.40)**
colorectal	71	0.92 (0.71; 1.13)	110	1.14 (0.93; 1.35)
breast	148	1.16 (0.97; 1.34)	—	—
stomach	37	1.23 (0.84; 1.63)	55	1.31 (0.96; 1.66)
prostate		—	77	0.85 (0.66; 1.04)
oesophagus	23	0.97 (0.57; 1.36)	40	1.08 (0.75; 1.41)
pancreas	34	0.99 (0.66; 1.32)	27	0.77 (0.48; 1.06)
brain	20	1.12 (0.63; 1.61)	32	1.25 (0.82; 1.69)
leukaemia	21	1.21 (0.69; 1.73)	28	1.16 (0.73; 1.59)
all lymphomas	21	0.81 (0.47; 1.16)	23	0.86 (0.51; 1.21)
kidney	14	1.20 (0.57; 1.83)	18	1.03 (0.56; 1.51)
bladder	15	1.40 (0.69; 2.11)	11	0.60 (0.25; 0.96)
melanoma skin	9	1.41 (0.49; 2.34)	5	0.81 (0.10; 1.51)

Figures shown in bold are significantly higher than expected

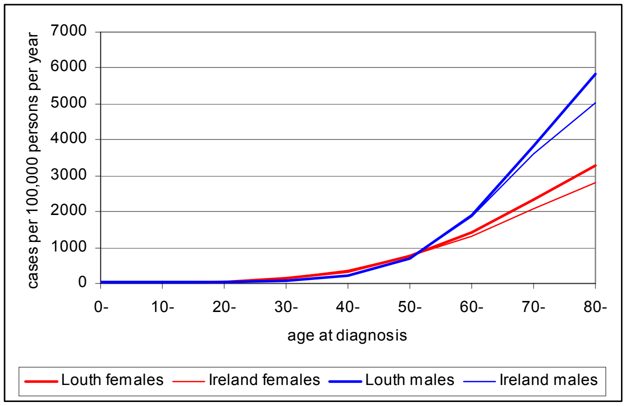
To a large extent the cancers with high mortality rates were those which we have already noted to have a high incidence rate. Exceptions to this were bladder cancer in women, which had a high mortality rate, although incidence was less than expected, and cancer of the oesophagus in men, which had a high incidence rate but a mortality rate that was not very different from the national rates.

Age profile of cancer cases

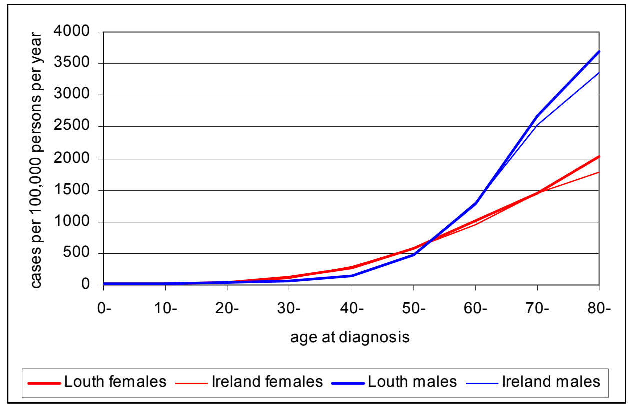
All invasive cancers

Figure 7. Age-specific incidence rates, Louth and Ireland 1994-2000

all invasive cancers



all invasive cancers, excluding non-melanoma skin cancer



The age profile of cancer cases in Louth was very similar to that for Ireland as a whole (Figure 7). The age-specific rates in Louth were higher than those for Ireland for the older age groups, but this difference was apparent only for the oldest age group when non-melanoma skin cancers were excluded.

Individual cancer sites

There was very little consistency between individual cancer sites in the pattern of rate with age (Table 7). For many cancers, there were no cases in the 0-19 age group and some of the high rates in this age group are based on very few cases. The apparently high rates for lymphoma in the under 20s, for instance, are based on two female and five male cases, and rates for kidney cancer were based on only two cases. With numbers of this size, no reliable conclusions can be drawn about relative risk for this age-group.

Table 7. Standardised incidence ratios for some common cancers by age group, Louth 1994-2000

	age at diagnosis					
	0-19		***20-64***		***65+***	
cancer type	***females***	***males***	***females***	***males***	***females***	***males***
non-melanoma skin	0.00	0.00	1.02	0.96	1.25	1.20
lung	0.00	0.00	1.29	1.40	1.09	1.18
colorectal	0.00	—	0.85	0.90	0.92	1.13
breast	—		0.91		1.08	
prostate		—	—	0.61	—	0.99
lymphoma	1.29	1.57	0.70	0.86	0.91	1.24
stomach	—	0.00	1.04	1.04	1.43	1.49
bladder	0.00	—	0.90	0.78	0.87	1.04
melanoma	3.00	0.00	1.21	1.11	1.10	0.29
leukaemia	1.13	1.37	1.14	1.25	1.45	1.21
pancreas	0.00	—	1.30	0.69	1.07	1.23
oesophagus	—	—	0.64	1.99	0.85	1.11
brain	1.43	1.15	1.34	1.03	1.31	0.96
kidney	1.45	2.49	0.74	0.53	1.21	1.29

— indicates that no cases were registered for this group.

Overall, 13 of 28 rates for those aged 20-64 were higher than expected, and 19 of 28 for the over 65s. The largest differences from expected rates were for non-melanoma skin and stomach cancer for both sexes in the oldest age group, and for lung cancer in men aged 20 to 64 years old.

Small area variation in cancer cases

All invasive cancers

A map of the electoral divisions in Louth and a table showing their populations is given in Appendix 2.

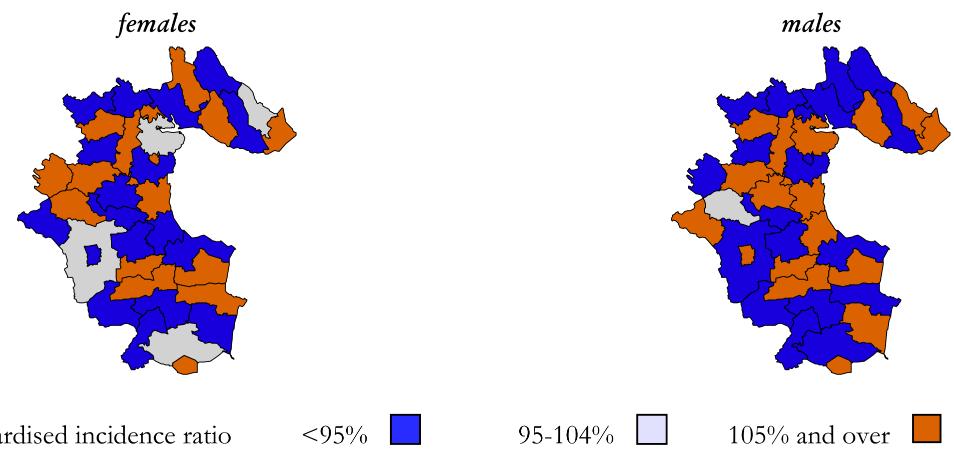
Small area variation was studied for cancer incidence only, and for the period 1994 to 1997, for the reasons given above (see "Geocoding", page 2).

Of the 1722 new cancers diagnosed in residents of Louth between 1994 and 1997, 1630 (95%) could be allocated with confidence to an electoral division (ED). Of these, 941 (58%) were in residents of either Dundalk Urban District or Drogheda Borough (Table 8).

For the 37 electoral divisions in Louth, 16 (43%) had cancer rates higher than expected, 21 (57%) for women, and 16 (43%) for men. If cancer incidence rates were distributed randomly among EDs around the country, we would expect roughly 50% of EDs to have rates below average and 50% to have rates above average, so, despite the higher than expected cancer rates in Louth as a whole, fewer EDs had higher rates than would have been expected from the national rates. This is because the high rates in Louth were found in the EDs with the largest populations and these predominate in the figures for Louth as a whole. For only one ED (Drogheda) were rates high enough to be statistically significant for both men and women. The overall cancer incidence rate was also significantly high for men in Dundalk, Dunleer and Clogher. Rates significantly below the national average were found in Ballymascanlon for both sexes, for women in Ardee Rural, Drumcar, Creggan Upper and Mansfieldstown, and for men in Monasterboice and Mullary.

There was no clear overall geographical pattern to the low and high incidence rates within Louth (Figure 7), and the distribution of EDs with high rates was different for women and men.

Figure 8. Standardised incidence ratio by ED, all invasive cancers, including non-melanoma skin, 1994-1997



All invasive cancers excluding non-melanoma skin cancer

The exclusion of non-melanoma skin cancers from the analysis made essentially no difference to the findings, although the number of EDs for which the rate was greater than expected changed to 14 (38%) for both sexes. The increased rates for men in Dunleer were no longer statistically significant but the rate in Clogher remained significantly high, at over 200% of the expected value (Table 9). EDs where differences from the national average were larger than could be plausibly attributed to chance (statistically significant; see page 5) are shown in bold.

Table 8. Standardised incidence ratio by ED, all invasive cancers, Louth 1994-1997

		females		***males***	
urban/rural district	***electoral division (ED)***	***cases***	***% of expected (95% CI)***	***cases***	***% of expected (95% CI)***
Drogheda M.B.	Drogheda M.B.	267	**139% (122%; 155%)**	241	**136% (119%; 153%)**
Dundalk U.D.	Dundalk Urban	213	102% (88%; 115%)	220	108% (93%; 122%)
Ardee R.D.	Ardee Rural	10	60% (23%; 98%)	18	89% (48%; 131%)
	Ardee Urban	39	121% (83%; 159%)	32	98% (64%; 131%)
	Castlebellingham	16	115% (59%; 171%)	12	75% (33%; 117%)
	Clonkeen	5	162% (20%; 304%)	5	95% (12%; 178%)
	Collon	5	66% (8%; 124%)	7	69% (18%; 120%)
	Dromin	4	100% (2%; 199%)	7	187% (48%; 325%)
	Dromiskin	11	106% (43%; 168%)	10	82% (31%; 133%)
	Drumcar	2	**25% (0%; 60%)**	12	103% (45%; 161%)
	Dunleer	17	140% (73%; 206%)	27	**176% (109%; 242%)**
	Stabannan	2	49% (0%; 117%)	6	129% (26%; 232%)
	Tallanstown	5	84% (10%; 159%)	7	103% (27%; 180%)
Dundalk R.D.	Ballymascanlan	7	43% (11%; 74%)	8	52% (16%; 88%)
	Barronstown	9	183% (64%; 303%)	5	94% (12%; 175%)
	Carlingford	16	128% (65%; 191%)	18	147% (79%; 214%)
	Castlering	3	54% (0%; 114%)	5	67% (8%; 126%)
	Castletown (part)	10	112% (43%; 182%)	13	130% (59%; 201%)
	Creggan Upper	1	23% (0%; 68%)	4	66% (1%; 130%)
	Darver	5	121% (15%; 227%)	5	85% (10%; 159%)
	Drummullagh	8	97% (30%; 164%)	7	81% (21%; 140%)
	Dundalk Rural (part)	5	110% (14%; 206%)	6	116% (23%; 208%)
	Faughart	7	111% (29%; 194%)	4	57% (1%; 112%)
	Greenore	10	123% (47%; 200%)	12	126% (55%; 197%)
	Haggardstown (part)	30	91% (58%; 123%)	29	82% (52%; 111%)
	Jenkinstown	7	105% (27%; 183%)	8	92% (28%; 155%)
	Killanny	4	91% (2%; 180%)	4	72% (1%; 143%)
	Louth	10	130% (50%; 211%)	12	131% (57%; 205%)
	Mansfieldstown	1	28% (0%; 84%)	4	96% (2%; 190%)
	Rathcor	11	141% (58%; 224%)	8	71% (22%; 119%)
	Ravensdale	7	116% (30%; 202%)	9	131% (45%; 217%)
Louth R.D.	Clogher	12	99% (43%; 155%)	25	**196% (119%; 273%)**
	Dysart	5	102% (13%; 192%)	8	118% (36%; 200%)
	Monasterboice	3	53% (0%; 114%)	3	42% (0%; 90%)
	Mullary	3	53% (0%; 113%)	2	28% (0%; 67%)
	St. Peter's (part)	9	72% (25%; 120%)	13	93% (42%; 144%)
	Termonfeckin	18	138% (74%; 202%)	17	115% (60%; 170%)

Figures shown in bold are significantly higher than expected

Table 9. Standardised incidence ratio by ED, all invasive cancers excluding non-melanoma skin cancer, Louth 1994-1997					
		females		***males***	
urban/rural district	***electoral division***	***cases***	***% of expected (95% CI)***	***cases***	***% of expected (95% CI)***
Drogheda M.B.	Drogheda M.B.	177	**130% (111%; 149%)**	**159**	**131% (110%; 151%)**
Dundalk U.D.	Dundalk Urban No. 1	156	105% (89%; 122%)	146	104% (87%; 121%)
Ardee R.D.	Ardee Rural	9	76% (26%; 125%)	14	101% (48%; 154%)
	Ardee Urban	25	111% (68%; 155%)	20	89% (50%; 128%)
	Castlebellingham	12	124% (54%; 194%)	10	92% (35%; 149%)
	Clonkeen	3	138% (0%; 294%)	3	85% (-11%; 181%)
	Collon	4	75% (1%; 148%)	4	58% (1%; 114%)
	Dromin	3	108% (0%; 229%)	5	194% (24%; 365%)
	Dromiskin	8	106% (33%; 180%)	9	108% (38%; 179%)
	Drumcar	1	**18% (0%; 52%)**	7	88% (23%; 153%)
	Dunleer	13	150% (68%; 231%)	15	143% (70%; 215%)
	Stabannan	2	69% (0%; 164%)	3	94% (0%; 201%)
	Tallanstown	4	96% (2%; 190%)	7	152% (39%; 264%)
Dundalk R.D.	Ballymascanlan	7	61% (16%; 106%)	5	**47% (6%; 89%)**
	Barronstown	8	229% (70%; 388%)	4	110% (2%; 217%)
	Carlingford	10	115% (44%; 186%)	8	96% (29%; 162%)
	Castlering	3	75% (0%; 159%)	3	59% (0%; 127%)
	Castletown (pt.)	9	140% (49%; 232%)	11	160% (66%; 255%)
	Creggan Upper	1	**32% (0%; 96%)**	2	48% (0%; 115%)
	Darver	4	139% (3%; 275%)	2	50% (0%; 119%)
	Drummullagh	5	87% (11%; 163%)	5	84% (10%; 158%)
	Dundalk Rural (pt.)	1	**31% (0%; 92%)**	5	141% (17%; 265%)
	Faughart	4	89% (2%; 176%)	3	62% (0%; 132%)
	Greenore	8	142% (44%; 240%)	7	108% (28%; 187%)
	Haggardstown (pt.)	20	84% (47%; 121%)	16	**66% (33%; 98%)**
	Jenkinstown	6	127% (25%; 228%)	7	117% (30%; 204%)
	Killanny	2	64% (0%; 154%)	4	106% (2%; 210%)
	Louth	8	146% (45%; 247%)	12	193% (84%; 302%)
	Mansfieldstown	1	40% (0%; 120%)	2	71% (0%; 169%)
	Rathcor	4	72% (1%; 143%)	4	52% (1%; 103%)
	Ravensdale	3	69% (0%; 147%)	8	170% (52%; 288%)
Louth R.D.	Clogher	6	70% (14%; 126%)	20	228% (128%; 328%)
	Dysart	5	144% (18%; 270%)	5	108% (13%; 202%)
	Monasterboice	2	48% (0%; 116%)	3	62% (0%; 132%)
	Mullary	3	73% (0%; 155%)	2	**41% (0%; 97%)**
	St. Peter's (pt.)	5	56% (7%; 106%)	9	95% (33%; 156%)
	Termonfeckin	15	161% (80%; 243%)	8	79% (24%; 134%)
Figures shown in bold are significantly higher than expected					

Individual cancer sites

Analysis of variation at ED level for the commoner cancers showed no consistent geographical pattern (Figures 9 to 13). There was no clear geographical pattern for non-melanoma skin cancer in women (Figure 9) or for lung cancer (Figure 10). Non-melanoma skin cancer in men seemed higher in the southern coastal area, while female stomach cancer seemed to be more frequent along the central coastal area (Figure 11). Oesophageal cancer in women (Figure 12) had a higher incidence than the national average over almost all of the county, as had leukaemia (Figure 13).

Figure 9. Standardised incidence ratio by ED, non-melanoma skin cancer, 1994-1997

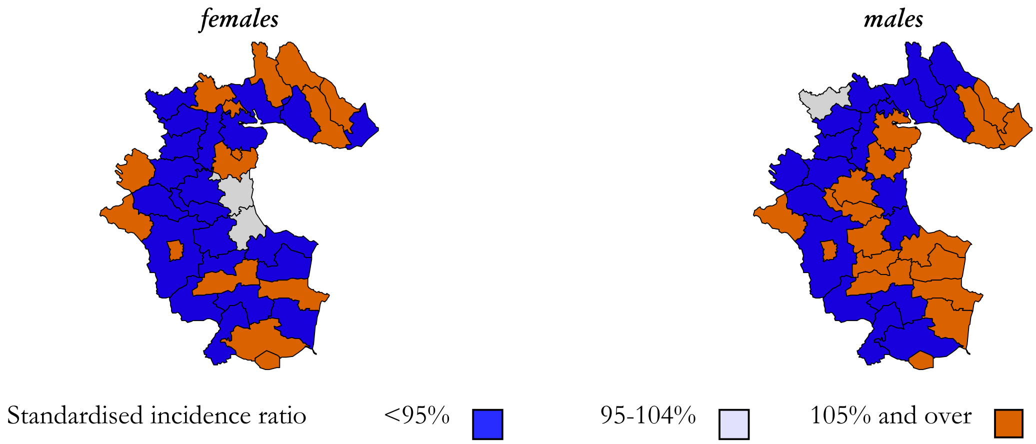


Figure 10 Standardised incidence ratio by ED, lung cancer, 1994-1997

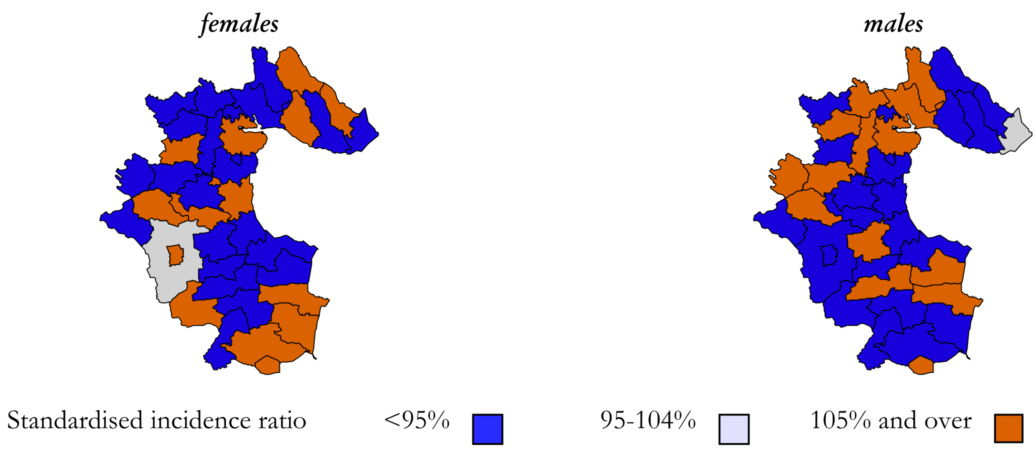
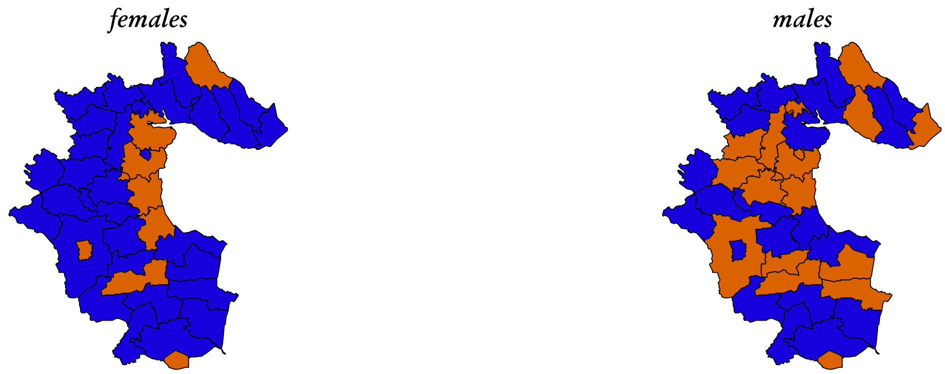


Figure 11. Standardised incidence ratio by ED, stomach cancer, 1994-1997

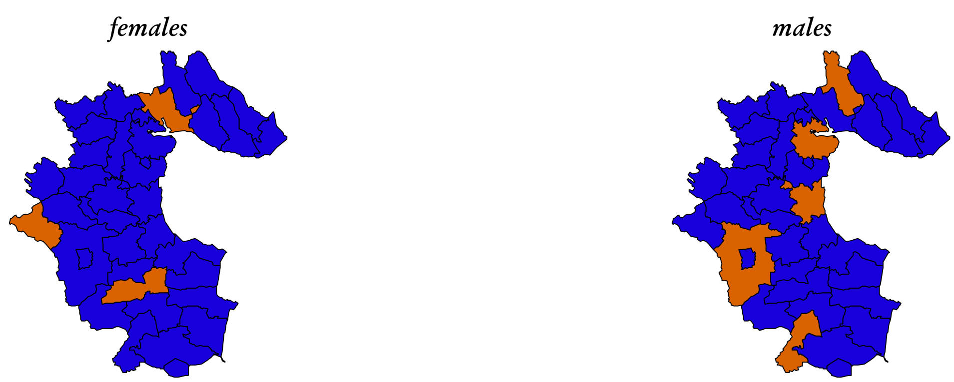


Standardised incidence ratio <95% 95-104% 105% and over

Figure 12. Standardised incidence ratio by ED, oesophageal cancer, 1994-1997

Standardised incidence ratio <95% 95-104% 105% and over

Figure 13. Standardised incidence ratio by ED, leukaemia, 1994-1997



Standardised incidence ratio <95% 95-104% 105% and over

Grouped EDs

All invasive cancers

Because of the small number of cases observed in EDs other than Dundalk and Drogheda, analysis at ED level by individual cancer sites is not usually meaningful, and the data are too limited to allow for accurate interpretation of the results. Therefore, EDs in Louth need to be grouped for analysis for cancer type. As the mapping described above shows no obvious grouping of EDs by cancer risk, we need to use some pre-existing groups. The accepted official grouping is of adjacent EDs into urban and rural districts, giving a total of five areas: Ardee Rural District, Drogheda Borough, Dundalk Rural District, Dundalk Urban District and Louth Rural District. Pringle (2003) suggests another geographical grouping, based partly on his need to specifically address cancer rates in the Cooley peninsula (see Table 11). EDs can also be grouped into “coastal” and “inland”. The coastal EDs are Dundalk, Castlebellingham, Dromiskin, Drumcar, Ballymascanlan, Carlingford, Drummullagh, Greenore, Haggardstown, Jenkinstown, Rathcor, Clogher, Dysart and Termonfeckin. Drogheda, although not, strictly speaking, on the coast, is also included, being estuarial. None of these groupings takes into consideration anything other than the geographical location of the areas.

Two other area-based groupings can be made—one based on a census-derived deprivation index, as described by Kelly (1999)—and one based on population density alone. The census-based deprivation index takes a number of characteristics of an ED, as recorded in the census, and uses these to ascribe an index of deprivation to the ED, ranging from 1 (most affluent) to 5 (most deprived). The population and area of each EDs is available from the census, allowing a population density to be calculated.

Ardee Urban District, Drogheda and Dundalk form a group of relatively high population density compared to the rest of the county, with Haggardstown (which surrounds Dundalk to the south) in an intermediate position (Table 10). Ardee, Drogheda, Stanbannan and Termonfeckin form a group of high deprivation. St Peter’s ED, which is included by Pringle in “Greater Drogheda”, can be seen to be quite different in population density and deprivation level from Drogheda urban area (as is St. Mary’s ED, which surrounds Drogheda to the south and is in Co. Meath). Ardee Urban District and Drogheda Borough, alone in Louth, combine relatively high deprivation and high population density.

However EDs are grouped, it is clear that the majority of the population of the county lives in the Dundalk and Drogheda urban areas, both of which are on the coast and have a high population density. Population density in Drogheda is almost twice that in Dundalk, as is its deprivation score. Cancer rates in these two Eds will, because of their size, dominate any group of which they form part.

Table 10. Louth EDs grouped by deprivation index and population density (1996 census)			
ED	***deprivation***	***ED***	***population density (person/ha)***
Dysart	1	Clonkeen	0.2
Greenore		Darver	0.2
Ballymascanlan	2	Dysart	0.2
Carlingford		Stabannan	0.2
Castlebellingham		Mansfieldstown	0.3
Castlering		Killanny	0.3
Clonkeen		Dromin	0.3
Collon		Barronstown	0.3
Drummullagh		Drummullagh	0.3
Dundalk Urban		Creggan Upper	0.3
Dunleer		Ravensdale	0.3
Haggardstown		Collon	0.4
Killanny		Ardee Rural	0.4
Mansfieldstown		Tallanstown	0.4
Monasterboice		Jenkinstown	0.4
Tallanstown		Castlering	0.4
Mullary		Mullary	0.4
St. Peter's		Rathcor	0.4
St. Mary's (Co. Meath)		Monasterboice	0.4
Barronstown	3	Louth	0.5
Castletown		Faughart	0.5
Clogher		Drumcar	0.5
Creggan Upper		St. Peter's	0.5
Darver		Greenore	0.6
Dromin		Clogher	0.6
Dromiskin		Termonfeckin	0.6
Drumcar		Dunleer	0.7
Dundalk Rural		Castletown	0.7
Faughart		Dromiskin	0.7
Jenkinstown		Castlebellingham	0.7
Louth		Ballymascanlan	0.8
Rathcor		Carlingford	0.8
Ravensdale		Dundalk Rural	0.9
Ardee Rural	4	St Mary's (Co. Meath)	1.0
Ardee Urban		Haggardstown	2.0
Drogheda M.B.		Ardee Urban	7.2
Stabannan		Dundalk Urban No. 1	10.5
Termonfeckin		Drogheda M.B.	18.3

The most basic grouping is into three areas—Drogheda Municipal Borough, Dundalk Urban District and the rest of Louth (Table 11). As already noted, the areas surrounding both Drogheda and Dundalk are quite different in their characteristics from the two towns, and simple geographical closeness cannot be used as a criterion for amalgamating them into "Greater" Dundalk and Drogheda. Using this grouping, and that into urban and rural districts, only Drogheda has rates significantly above what would be expected, 39% higher than the national rates for women and 36% higher for men. The grouping suggested by Pringle (2003) gives similar findings.

Coastal areas had significantly higher rates for both women and men, 14% above the national rates. There was also a clear relationship between deprivation, population density and cancer incidence, with rates well above average for the areas of highest population density and greatest deprivation.

Table 11. Standardised incidence ratio by aggregate area, all invasive cancers, Louth 1994-1997

	females		***males***	
	cases	***% expected (95% CI)***	***cases***	***% expected (95% CI)***
Drogheda, Dundalk and the rest of Louth				
Drogheda M.B.	**267**	**139%(122%;155%)**	**241**	**136%(119%;153%)**
Dundalk U.D..	213	102%(88%;115%)	220	108%(93%;122%)
rest of Louth	317	98% (87%; 109%)	372	99% (89%; 109%)
Urban/rural districts				
Ardee R.D.	116	98%(81%;116%)	143	103%(86%;120%)
Drogheda M.B.	**267**	**139%(122%;155%)**	**241**	**136%(119%;153%)**
Dundalk R.D.	151	99%(83%;114%)	161	92%(78%;107%)
Dundalk U.D.	213	102%(88%;115%)	220	108%(93%;122%)
Louth R.D.	50	93%(67%;119%)	68	109%(83%;135%)
Areas suggested by Pringle (2003)				
Cooley	66	100% (76%; 125%)	70	96% (74%; 119%)
Gtr Dundalk	258	101% (88%; 113%)	268	105% (93%; 118%)
Mid Louth	57	95% (70%; 120%)	81	110% (86%; 134%)
South Louth	41	99% (69%; 130%)	55	113% (83%; 143%)
Gtr Drogheda	**276**	**135% (119%; 150%)**	**254**	**133% (117%; 149%)**
Gtr Ardee	49	101% (72%; 129%)	50	94% (68%; 121%)
NW Louth	50	100% (72%; 128%)	55	88% (65%; 111%)
Coastal/inland				
Inland	164	97% (82%; 111%)	198	99% (85%; 113%)
Coastal	**633**	**114% (105%; 122%)**	**635**	**114% (105%; 123%)**
Deprivation index				
1	15	115% (57%; 174%)	20	123% (69%; 176%)
2	345	96% (86%; 106%)	371	99% (89%; 109%)
3	101	105% (85%; 126%)	128	110% (91%; 129%)
4	336	**130% (116%; 144%)**	**314**	**126% (112%; 140%)**
Population density				
low (<5 persons/ha)	278	95% (84%; 106%)	340	99% (89%; 110%)
high (>5 persons/ha)	519	**119% (109%; 130%)**	**493**	**119% (109%; 130%)**

Figures shown in bold are significantly higher than expected

Individual cancer sites

Drogheda can be seen to have an exceptionally high incidence of non-melanoma skin cancer in both men and women (Table 12). The incidence in Dundalk is also greater than expected for men, but not for women. For men, also, lung cancer incidence in both Drogheda and Dundalk was greater than expected, while for women, breast cancer incidence in Dundalk was significantly raised.

Table 12. Standardised incidence ratio by ED, all invasive cancers excluding non-melanoma skin cancer, Louth 1994-1997

		females		***males***	
cancer type	***electoral division***	***cases***	***% of expected (95% CI)***	***cases***	***% of expected (95% CI)***
non-melanoma skin	Drogheda	90	**161% (127%; 194%)**	**82**	**147% (115%; 179%)**
	Dundalk	57	88% (65%; 111%)	**74**	**133% (103%; 163%)**
	rest of Louth	93	102% (81%; 123%)	120	94% (77%; 111%)
colorectal	Drogheda	15	85% (42%; 128%)	24	124% (75%; 174%)
	Dundalk	15	73% (36%; 110%)	17	88% (46%; 130%)
	rest of Louth	31	109% (71%; 147%)	45	102% (72%; 132%)
lung	Drogheda	16	134% (69%; 200%)	32	**167% (109%; 225%)**
	Dundalk	15	98% (48%; 148%)	30	**156% (100%; 212%)**
	rest of Louth	19	106% (58%; 153%)	37	84% (57%; 111%)
breast	Drogheda	51	137% (99%; 174%)	—	—
	Dundalk	33	**163% (107%; 218%)**	—	—
	rest of Louth	53	63% (46%; 80%)	—	—
prostate	Drogheda		—	28	134% (84%; 184%)
	Dundalk		—	16	77% (39%; 114%)
	rest of Louth		—	45	89% (63%; 115%)
stomach	Drogheda	9	223% (77%; 368%)	7	119% (31%; 207%)
	Dundalk	7	126% (33%; 219%)	6	102% (20%; 184%)
	rest of Louth	8	140% (43%; 237%)	19	142% (78%; 205%)
leukaemia	Drogheda	2	60% (0%; 143%)	5	127% (16%; 238%)
	Dundalk	3	79% (0%; 168%)	9	228% (79%; 378%)
	rest of Louth	12	226% (98%; 354%)	12	140% (61%; 219%)
melanoma	Drogheda	9	155% (54%; 256%)	4	141% (3%; 279%)
	Dundalk	6	129% (26%; 232%)	4	141% (3%; 279%)
	rest of Louth	15	135% (67%; 203%)	2	34% (0%; 80%)
bladder	Drogheda	4	126% (3%; 249%)	7	105% (27%; 183%)
	Dundalk	3	64% (0%; 137%)	10	150% (57%; 243%)
	rest of Louth	6	142% (28%; 256%)	10	65% (25%; 105%)
lymphoma	Drogheda	5	94% (12%; 176%)	3	59% (0%; 125%)
	Dundalk	6	93% (19%; 168%)	8	157% (48%; 265%)
	rest of Louth	6	74% (15%; 133%)	9	85% (29%; 140%)

Figures shown in bold are significantly higher than expected

Deprivation index and cancer risk

Because of the small number of cases, estimates of risk based on individual cancer sites are subject to a high degree of random variation. However for the three cancers found to have a high relative rate in Louth (non-melanoma skin cancer, lung cancer and stomach cancer), it is clear that risk was highest for areas of high deprivation (Table 13) and was significantly so for non-melanoma skin cancer and for lung and oesophageal cancer in men.

Table 13. Standardised incidence ratios by area deprivation index for specified invasive cancers, Louth 1994-1997

		females		*males*	
cancer type	***deprivation index***	***cases***	***% expected (95% CI)***	***cases***	***% expected (95% CI)***
non-melanoma skin cancer	**1+2**	97	89% (71%; 107%)	137	111% (92%; 129%)
	3+4	**143**	**139% (116%; 162%)**	**139**	**121% (101%; 141%)**
lung cancer	**1+2**	24	103% (62%; 145%)	45	105% (75%; 136%)
	3+4	26	118% (73%; 164%)	**54**	**136% (100%; 172%)**
stomach cancer	**1+2**	13	165% (75%; 254%)	14	108% (51%; 164%)
	3+4	11	148% (61%; 236%)	18	148% (80%; 217%)
leukaemia	**1+2**	9	141% (49%; 234%)	13	154% (70%; 237%)
	3+4	8	131% (40%; 222%)	13	162% (74%; 251%)
oesophageal cancer	**1+2**	3	59% (0%; 125%)	10	129% (49%; 208%)
	3+4	2	42% (0%; 99%)	**18**	**250% (134%; 365%)**

Figures shown in bold are significantly higher than expected

Similarly, cancer rates were consistently higher in the areas of high population density (Table 14). Significantly raised rates of non-melanoma skin cancer were found for both sexes, and for lung cancer in men, in densely populated areas.

Table 14. Standardised incidence ratios by population density for specified invasive cancers, Louth 1994-1997

		females		*males*	
cancer type	***population density***	***cases***	***% expected (95% CI)***	***cases***	***% expected (95% CI)***
non-melanoma skin cancer	**low**	79	93% (73%; 114%)	108	99% (81%; 118%)
	high	**161**	**126% (107%; 146%)**	**168**	**129% (110%; 149%)**
lung cancer	**low**	15	83% (41%; 125%)	34	91% (61%; 122%)
	high	35	129% (86%; 172%)	**65**	**144% (109%; 179%)**
stomach cancer	**low**	7	115% (30%; 200%)	18	158% (85%; 231%)
	high	17	184% (97%; 272%)	14	102% (49%; 155%)
leukaemia	**low**	3	125% (0%; 267%)	4	99% (2%; 195%)
	high	1	28% (0%; 82%)	7	140% (36%; 243%)
oesophageal cancer	**low**	0	--	12	177% (77%; 277%)
	high	5	84% (10%; 157%)	16	195% (100%; 291%)

Figures shown in bold are significantly higher than expected

Excess risk of cancer

In comparing risk in Louth with that in Ireland as a whole we have used the standardised incidence ratio. This gives an estimate of the increase or decrease in relative risk due to a cancer. However, a large change in relative risk for a rare cancer may have very little impact on overall cancer rates in an area, and the excess risk—the difference between observed and expected cases—may be more useful in understanding the differences in cancer burden between areas. For instance, if we expect to find 20 lung cancers and 2 stomach cancers in an area, and we find 25 lung cancers and 3 stomach cancers, the standardised incidence ratio for lung cancer is 125% and that for stomach cancer 167%. The risk seems, from these figures, to be higher for stomach cancer than for lung cancer, but the excess risk is of 5 lung cancers but only 1 stomach cancer. Using only the standardised incidence ratio alone can therefore give disproportionate emphasis to small differences in the numbers of the less common cancers, and so we also need to examine the differences in numbers as well as in rates.

Over the seven-year period 1994 to 2000, 206 more cancers were diagnosed in Co. Louth than would have been expected (Table 15).

Table 15. Cancers with more observed than expected cases, Louth 1994-2000

	observed minus expected cases[4]			
	females	***males***	***both sexes***	***% of excess***
all invasive cancers	118	87	206	
non-melanoma skin	75	41	116	56%
lung	15	41	56	27%
stomach	14	16	30	15%
leukaemia	8	8	16	8%
oesophagus	-4	15	12	6%
melanoma	11	-5	6	3%
pancreas	3	1	4	2%

Over half of this excess of cases (56%) was made up of non-melanoma skin cancer. Most of the remaining excess was due to cancers of the lung and stomach. (As there were fewer cases than expected for many of the cancers not shown, the totals for the cancers given in Table 15 come to more than 100%).

Almost all of the excess of cancer cases (199 of 206 cases, 97%) was in patients aged 65 or over (Table 16). The only significant excess of cases in patients under 65 was for lung cancer.

[4] Note: The case numbers in Tables 15-18 have been rounded to the nearest whole number, but totals have been calculated from the exact values, so figures may not be exactly consistent within or between tables.

Table 16. Cancers with more observed than expected cases, by age group, Louth 1994-2000				
	observed minus expected cases			
	age group	***females***	***males***	***both sexes***
all cancers	0-14	0	3	3
	15-64	6	-2	4
	65+	112	87	199
non-melanoma skin cancer	0-14	0	0	0
	15-64	1	-8	-7
	65+	74	49	122
lung	0-14	0	0	0
	15-64	8	21	29
	65+	7	20	28
stomach	0-14	0	0	0
	15-64	0	0	1
	65+	14	16	29
oesophagus	0-14	0	0	0
	15-64	-2	11	10
	65+	-2	4	2
leukaemia	0-14	0	2	2
	15-64	2	3	5
	65+	6	3	9

Small area variation in case differences

For the years 1994-1997, there were 146 more cancer cases in Co. Louth than would have been expected. This excess was completely accounted for by patients living in Drogheda (95% of the total) and Dundalk (Table 17). In the rest of Louth there were 11 cases fewer than expected. In Drogheda, 44% of the excess was due to non-melanoma skin cancer and 12% to lung cancer. In Dundalk almost half (9 cases of 19) of the excess was due to lung cancer.

Table 17. Difference between observed and expected cases by area of residence, Louth 1994-1997

	observed minus expected cases			
	ED of residence	***females***	***males***	***both sexes***
all cancers	Drogheda	74	64	138
	Dundalk	3	16	19
	rest of Louth	-8	-4	-11
non-melanoma skin	Drogheda	34	26	60
	Dundalk	-4	10	5
	rest of Louth	-1	1	0
lung	Drogheda	4	13	17
	Dundalk	2	8	9
	rest of Louth	-1	-4	-5
stomach	Drogheda	5	1	6
	Dundalk	3	-1	2
	rest of Louth	1	6	8
oesophagus	Drogheda	-1	6	5
	Dundalk	0	2	2
	rest of Louth	-4	6	1
leukaemia	Drogheda	-1	-2	-3
	Dundalk	-2	5	3
	rest of Louth	0	0	0

For patients under age 65, the contrast was marked between Drogheda and the rest of Louth. There were 66 excess cases of cancer in this age group in Drogheda, but there were 48 fewer cases than expected in the rest of the county (Table 18). Non-melanoma skin cancer and lung cancer together accounted for 56% of the Drogheda excess. Altogether, 48% of the excess cases in Drogheda were in patients aged under 65.

Table 18. Difference between observed and expected cases by area of residence, Louth 1994-1997

	observed minus expected cases			
patients under 65	***ED of residence***	***females***	***males***	***both sexes***
All cancers	Drogheda	46	20	66
	Dundalk	-8	3	-5
	rest of Louth	-17	-27	-43
non-melanoma skin	Drogheda	14	13	27
	Dundalk	-7	-4	-12
	rest of Louth	-7	-4	-11
lung	Drogheda	5	5	10
	Dundalk	2	5	6
	rest of Louth	3	-1	1
stomach	Drogheda	1	-1	0
	Dundalk	0	-2	-2
	rest of Louth	-1	-1	-1
oesophagus	Drogheda	-1	1	0
	Dundalk	0	3	3
	rest of Louth	-1	2	1
leukaemia	Drogheda	0	-1	-1
	Dundalk	-1	4	3
	rest of Louth	0	-1	-1

Cancer in Drogheda

As Drogheda has been identified as the only area in Louth with a consistently elevated cancer risk, this last section looks at the higher risk in Drogheda in some more detail. A number of questions need to be answered:

1. Is Drogheda exceptional in its cancer rates?
2. Is the high rate in Drogheda due to one particular cancer?
3. Is cancer risk high for any age group?
4. Are there known risk factors which might explain the high cancer rates in Drogheda?

1. Drogheda rates in the national context

Figure 14 shows the distribution of standardised incidence ratio for all invasive cancers by ED for Ireland as a whole. The blue line indicates the percentage of EDs with a standardised incidence ratio within each 10% range and the green line the cumulative total. Drogheda (SIR=137%) falls in the range 130-139%, and it can be seen that a large number of EDs, 18% of the total, with 30% of the cancer cases, have standardised incidence ratios greater than this. From Figure 15, it can be seen that this 18% of EDs are scattered randomly throughout the country, with no apparent geographical pattern or trend.

Figure 14. Distribution of standardised incidence ratio by ED in Ireland, 1994-1997

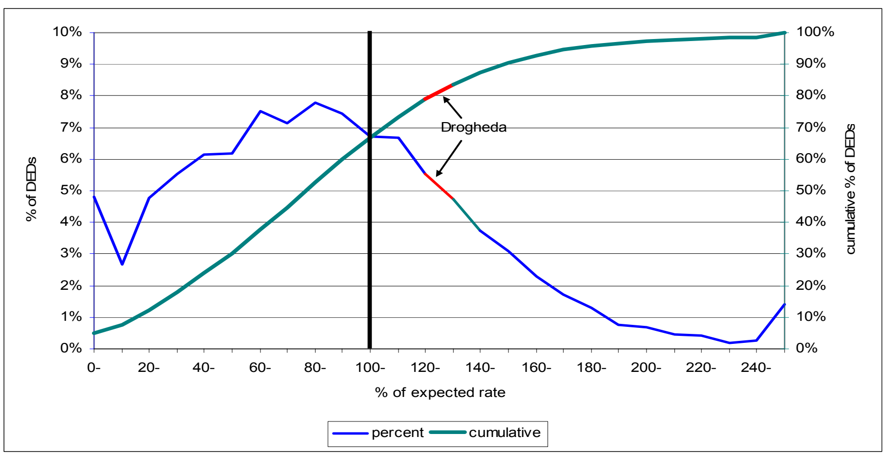
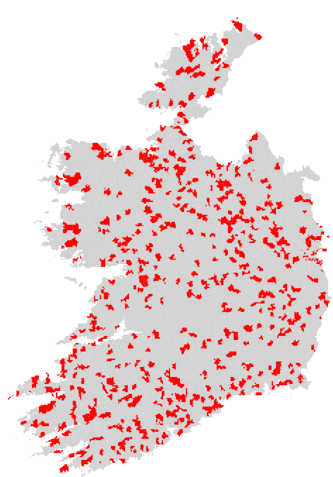


Figure 15. EDs with SIR for all invasive cancers greater than or equal to that in Drogheda, 1994-1997



2. Rates for individual cancer types in Drogheda

As mentioned earlier, overall cancer rates are of limited explanatory value, and we need to determine if the higher rate in Drogheda is due to an increased incidence for all cancers, or an excess of a relatively small number of cancer types. Table 19 shows that no cancer in Drogheda, other than non-melanoma skin cancer in both sexes and lung cancer in men, had a level significantly greater than expected. However, a number of other cancers had rates which were in the region of 20% or more higher than expected. These were melanoma in both sexes, cancer of the stomach in women and cancer of the lung and oesophagus in men. These cancers are those already identified as having a high incidence in Louth overall.

Table 19. Standardised incidence ratio for Drogheda ED, 1994-1997

	females		***males***	
	cases	***SIR (95% confidence limits)***	***cases***	***SIR (95% confidence limits)***
all invasive cancers	**267**	**139% (122%; 155%)**	**241**	**136% (119%; 153%)**
all invasive cancers excluding NMSC	**177**	**130% (111%; 149%)**	**159**	**131% (110%; 151%)**
non-melanoma skin	**90**	**161% (127%; 194%)**	**82**	**147% (115%; 179%)**
breast	51	137% (99%; 174%)		
lung	16	134% (69%; 200%)	**32**	**167% (109%; 225%)**
colorectal	15	85% (42%; 128%)	24	124% (75%; 174%)
prostate			28	134% (84%; 184%)
unknown primary site	14	178% (85%; 271%)	5	72% (9%; 135%)
stomach	9	223% (77%; 368%)	7	119% (31%; 207%)
melanoma skin	9	155% (54%; 256%)	4	141% (3%; 279%)
bladder	4	126% (3%; 249%)	7	105% (27%; 183%)
oesophagus	2	76% 0%; 182%)	9	258% (89%; 426%)
kidney	3	143% (0%; 305%)	7	223% (58%; 389%)
ovary	9	119% (41%; 197%)	0	
lymphoma	5	94% (12%; 176%)	3	59% (0%; 125%)
leukaemia	2	60% (0%; 143%)	5	127% (16%; 238%)
corpus uteri	6	120% (24%; 216%)	0	
cervix	6	143% (29%; 257%)	0	
brain	4	153% (3%; 304%)	2	63% (0%; 149%)
pancreas	3	80% (0%; 171%)	2	64% (0%153%)
multiple myeloma	2	110% 0%; 264%)	3	153% 0%; 327%)

Figures shown in bold are significantly higher than expected

3. Age-specific cancer risk in Drogheda

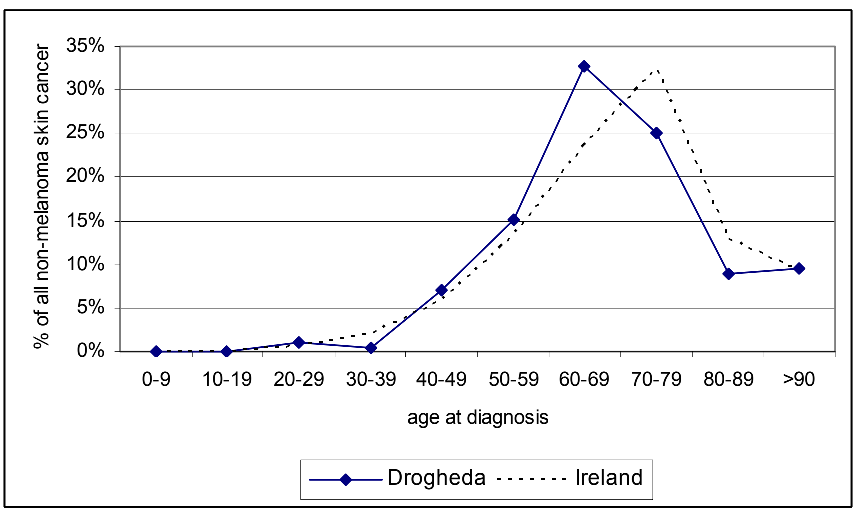
Table 20 shows the percentage of patients aged under 65 with some of the common cancers. The most striking finding is that half of the women with lung cancer in Drogheda, and 42% of those in Louth, were aged under 65, compared to 27% in Ireland as a whole. Other cancers in which the proportion of younger patients was high in Drogheda were melanoma and cancer of the bladder.

Table 20. Percentage of patients aged under 65 for the common cancers, Ireland, Louth and Drogheda 1994-1997

	Ireland		Louth		Drogheda	
	females	males	females	males	females	males
non-melanoma skin	31%	33%	28%	33%	36%	43%
lung	27%	31%	42%	36%	50%	38%
colorectal	31%	34%	34%	27%	33%	42%
breast	62%	35%	57%	—	69%	—
prostate	—	15%	—	9%	—	18%
stomach	23%	33%	13%	19%	22%	14%
leukaemia	45%	45%	35%	50%	50%	40%
melanoma	61%	57%	70%	90%	78%	100%
bladder	27%	30%	38%	37%	50%	71%
lymphoma	54%	61%	47%	50%	40%	33%

Risk for the commonest cancer, non-melanoma skin cancer was similarly distributed among age groups in Drogheda as it was in Ireland as a whole (Figure 16), although with a slightly lower average age at diagnosis.

Figure 16. Age distribution of non-melanoma skin cancer in Drogheda and Ireland 1994-1997

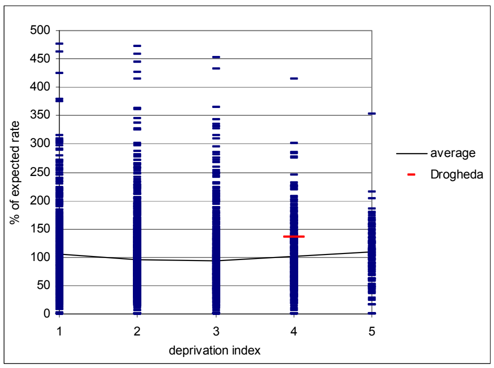


3. Known cancer risk factors in Drogheda

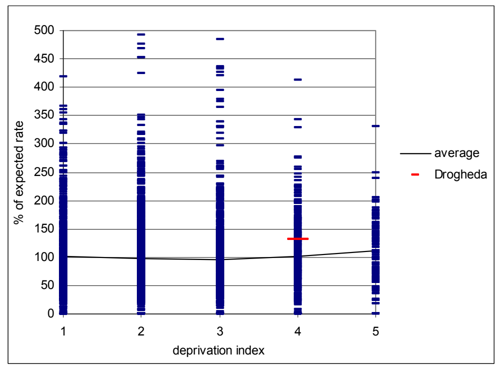
We have very little information on the known important cancer risk factors—smoking, diet, sun exposure, sexual and reproductive life (Doll and Peto, 1981)—for Drogheda, relative to the rest of Ireland. Deprivation has already been identified as an important factor in the high cancer incidence within Louth. In the national context, we can see from Figure 17 that Drogheda has cancer rates typical of its level of deprivation, although in most cases a little higher than the national average for its deprivation score.

Figure 17. Distribution of standardised incidence ratio by deprivation index of ED in Ireland, 1994-1997
(each horizontal bar represents one ED)

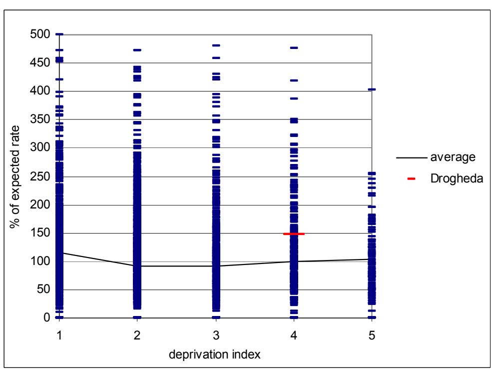
all invasive cancers



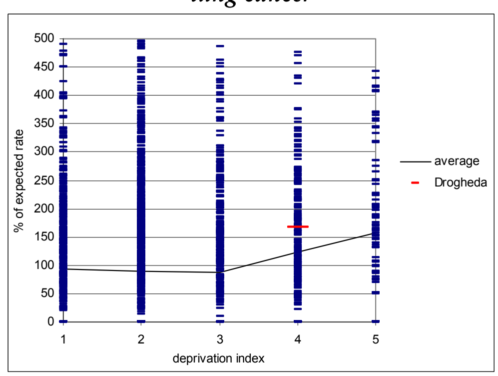
all invasive cancers excluding non-melanoma skin cancer



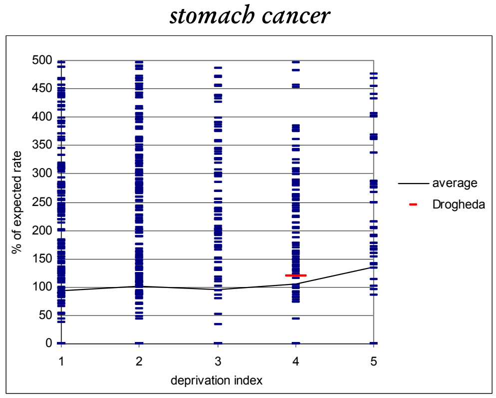
non-melanoma skin cancer



lung cancer



stomach cancer



Discussion

There is consistent evidence that the risk of cancer in Co. Louth is higher for both sexes than would be expected on the basis of national cancer incidence rates. The evidence in favour of a higher risk of cancer mortality is less strong. The high risk of cancer in Louth is consistent with what appears to be a general pattern of high cancer risk in the region including and surrounding Dublin. This excess risk, for Louth, is of the order of 29 extra new cancer cases per year, or 3 extra cases per 10,000 people per year.

The higher risk in Louth is mainly due to an increased risk of non-melanoma skin cancer in older patients. To a lesser extent, an increased risk of lung, stomach and oesophageal cancer, and possibly of melanoma and leukaemia, contributes to the higher risk found.

Within Louth, almost all of the excess risk is confined to Drogheda Borough. Analysis of the cancer patterns in Drogheda confirms the main increase in risk as being due to skin cancer, and to a lesser extent lung and stomach cancers. There is a significant excess risk of lung cancer to persons aged under 65 in Drogheda. Although the relative risk is also elevated for Dundalk and Ardee Urban District, these contribute much less to the excess of cases in Louth.

Risk factors for individual cancers in Co. Louth

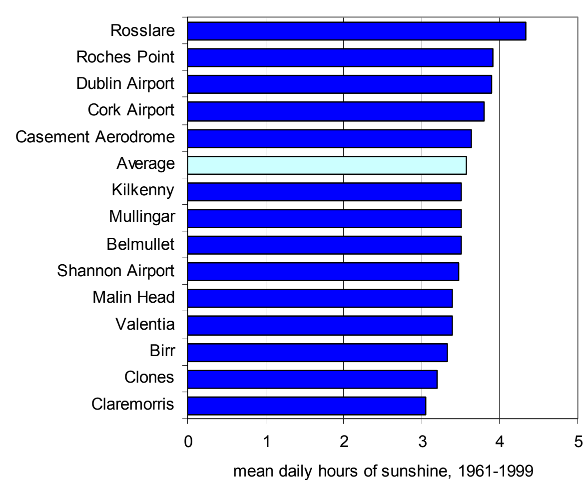
Skin cancer—melanoma and non-melanoma

The only important risk factor for both melanoma and non-melanoma skin cancer is ultraviolet (UV) light from sunlight and sunbeds, and the main predisposing factors are fair skin and outdoor occupation. Frequent sunburn is an independent risk factor for melanoma but probably not for non-melanoma skin cancer. We are not aware of any published data on sun (or sunbed) exposure or sunburn for the Louth population, nor do we have any information on skin type in Drogheda or Co. Louth in general.

Historic data on sunshine in Ireland (Figure 18) shows longer average mean annual sunshine on the east coast (Met Eireann, 2004), with mean daily sunshine in Rosslare being 42% greater than in Claremorris. Louth has no weather station, but as it is about equidistant between Dublin Airport and Clones, mean sunshine can be assumed to be close to average levels. Wexford and Cork, which have the highest levels of sun exposure, do not have exceptionally high levels of skin cancer (National Cancer Registry, 2002), so climate, in any case, is unlikely to be an important factor in Ireland.

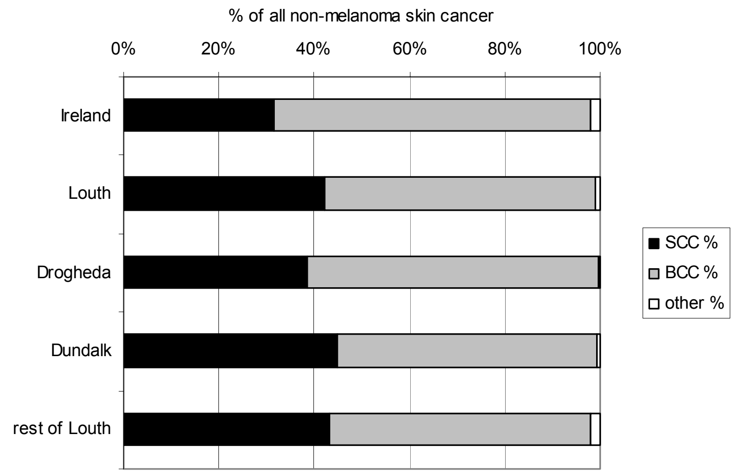
Lifetime UV exposure is highest for those in outdoor occupations. The percentage of the population engaged in outdoor occupations in Louth (farming, fishing, forestry and construction) was 11%, compared to 13% nationally, at the date of the last census (Central Statistics Office, 2004).

Figure 18. Mean daily sunshine at Irish weather stations, 1960-1991.



As the accepted risk factors for skin cancer do not seem to be particularly prevalent in Louth, a possible reason for the apparently higher rate is higher levels of detection and diagnosis. As noted previously, a significant fraction of non-melanoma skin cancers may escape detection by either patient or doctor, and increased awareness of these cancers, coupled with a thorough examination, may yield more skin cancers. This suggestion could only be verified by choosing a large number of Louth residents at random, matched with a similar group living elsewhere, and carrying out a thorough search for skin cancer in both groups.

Figure 19. Histological type of non-melanoma skin cancers, 1994-1997.



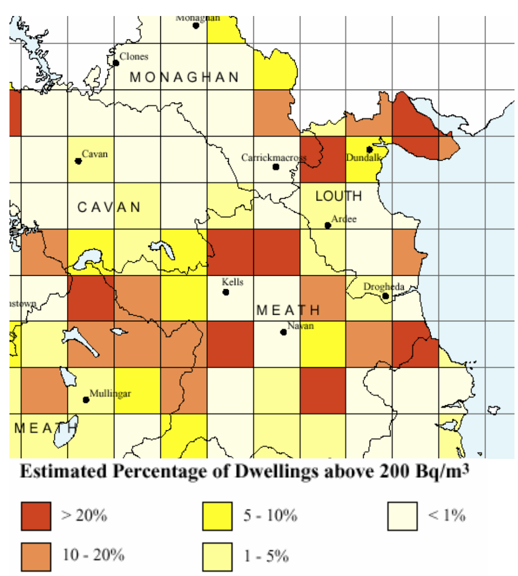
However, there is some indirect evidence against this hypothesis. The two main types of non-melanoma skin cancer, squamous cell (SCC) and basal cell carcinoma (BCC), make up 98% of all cases. Basal cell carcinoma is more common, but less aggressive, than squamous cell cancer, and therefore more likely to go unrecognised. If more thorough diagnosis were an explanation for the higher skin cancer rates in Louth, then we would expect a higher proportion of basal cell carcinoma, but in fact the proportion of basal cell carcinoma in Louth, and in Drogheda, is lower than in Ireland as a whole (Figure 19).

Lung cancer

The main risk factor for lung cancer is cigarette smoking. Radon may be an additional risk factor, but radon levels in Louth, and in Drogheda in particular, are not exceptional (Fennell et al, 2002) (Figure 20). However, individual radon exposure is poorly correlated with general levels within an area (Cohen, 1995) and radon cannot be ruled out as one possible factor in the high level of lung cancer. However, smoking levels in Louth appear to be high—the prevalence of smoking in the North Eastern Health Board area is second only to that in north Co. Dublin (Office of Tobacco Control, 2004). There is also a well recognised link between smoking, lung cancer and deprivation.

Lung cancer in Louth, and in Drogheda in particular, appears to affect a younger group of patients than in the country as a whole (Table 21). Half of the female lung cancer patients in Drogheda and 42% of those in Louth, excluding Dundalk and Drogheda, were under 65, compared to 29% in all of Ireland.

Figure 20. Radon levels in Louth and adjoining counties



Source: Radiological Protection Institute of Ireland, 2002

Table 21. Percentage of lung cancer patients aged under 65 years, by area of residence 1994-1997		
	% of patients under 65	
area	females	males
Ireland	29%	34%
Drogheda	50%	44%
Dundalk	37%	42%
rest of Louth	42%	38%

Stomach and oesophageal cancers

These share many of the same predisposing factors—diet, alcohol and socio-economic deprivation (Kogevinas et al, 1997). We are not aware of any published data on diet or alcohol consumption in Louth; however, as shown earlier (Figure 17) the incidence of stomach cancer in Drogheda is typical for its deprivation level.

Leukaemia

The commonest forms of leukaemia in residents of Louth were chronic lymphocytic leukaemia and acute and chronic myeloid leukaemia (Table 22). The numbers of individual types in Drogheda were small. The acute leukaemias, which can be caused by exposure to infection, chemicals or radiation, were slightly less frequent in Louth (29% of the total) compared to Ireland as a whole (34% of the total). Unlike acute lymphoid and myeloid leukaemias, the risk of chronic lymphocytic leukaemia is not thought to be increased by chemicals, infective radiation or any other environmental exposure.

Table 22. Percentage of leukaemias by type 1994-1997

type of leukaemia	Ireland		Louth		Drogheda	
	number of cases	% of all leukaemia	number of cases	% of all leukaemia	number of cases	% of all leukaemia
All leukaemia	**1381**		**52**		**7**	
chronic lymphoid	476	34%	10	19%	0	–
acute myeloid	279	20%	9	17%	1	14%
acute lymphoid	188	14%	6	12%	1	14%
chronic myeloid	108	8%	9	17%	1	14%
other	330	24%	17	33%	4	57%

Conclusions

This report confirms previous findings (National Cancer Registry, 2002, Pringle 2003) that there were more incident cancer cases than would be expected in the period since 1994 in Co. Louth. This excess, which seems to be largely confined to the town of Drogheda (but not the surrounding area) was found for both sexes and, for men at least, was seen in all years. There was no corresponding excess of cancer deaths.

The cancers found in higher numbers were those of the skin, lung and stomach, and to a lesser extent, cancers of the oesophagus and leukaemia. The only known shared risk factor for these is smoking, which increases the risk of lung, oesophagus, and possibly stomach, cancers. Two publications (Aubry and McGibbon, 1985; De Hertog, 2001) have suggested a link between smoking and squamous carcinoma of the skin, but this relationship is not widely accepted.

The relatively high number of skin cancers has no apparent explanation. There is no reason to expect that the population of Louth, or of Drogheda in particular, have skin types or ultraviolet exposures different from the national population or from neighbouring countries. More thorough diagnosis seems the most likely explanation.

The higher incidence of lung and stomach cancer is almost certainly related to the known risk factors of diet and smoking, both of which are, in turn, related to levels of deprivation (Kogevinas et al, 1997). The high incidence of lung cancer in the younger age groups in Drogheda is a particularly worrying finding.

The apparent excess of leukaemia is not due to any particular form of the disease, and acute leukaemia, the type associated with environmental exposures is no more common in Louth than elsewhere. The commonest leukaemia in Louth, as in the rest of Ireland, is chronic lymphoid leukaemia, a disease which affects mainly the elderly, and has no known cause in the majority of cases.

Radiation from the Irish Sea, derived ultimately from the nuclear re-processing plant at Sellafield, has been alleged to be responsible for a range of health effects in Co. Louth for many years. The mechanism by which this radiation could cause the effects suggested remains unknown, despite some interesting theories (Busby, 1994). The fraction of radiation in Irish Sea water due to artificially produced isotopes is a minute fraction of the background radiation in the water (Ryan et al, 2003). There is no proven way in which even this small extra radioactive burden could increase the radiation exposure of Louth residents in any significant quantities, nor is it plausible that any mechanism which could do this would affect the residents of Drogheda to such a disproportionate extent. In any case, none of the cancer types found to be in excess in Louth are known to be caused by radiation.

The excess risk of cancer in Louth appears to be due to a small number of well-known and remediable risk factors—sun exposure, smoking and diet—and attention needs to be focussed on these. There is no evidence that residence in Co. Louth is in itself an independent risk factor for cancer.

Appendix 1. Examples of calculation of incidence and mortality rates

Crude rate

1605 cancer cases were diagnosed in women Co. Louth during the period 1994 to 2000 and the female population in Louth during that time is shown in the table below (Table A1). The incidence rate ("crude" or unadjusted for age distribution) is the number of cases (1605) divided by the total population during the same period (331963).

Table A1.

	cases	*population*	*incidence rate (per 100,000)*
1994	203	46232	439
1995	194	46343	419
1996	235	46525	505
1997	251	47179	532
1998	255	47852	533
1999	243	48559	500
2000	224	49273	455
1994-2000	**1605**	**331963**	**483**

Note: incidence rates are usually calculated per 100,000 persons to avoid the need for decimals.

Age-standardised rate

If we do the same calculation for Leitrim, which had 485 female cases and a female population of 84644 during the same period, the crude incidence rate is found to be 573 per 100,000, 18% higher than that in Louth. However, we cannot conclude that the cancer risk is higher in Leitrim unless we allow for the fact that the population of Leitrim is older on average than that of Louth and that cancer is commoner in older people. The first step is to look at cancer rates at different ages. We usually group ages into five-year bands, giving 18 bands from 0-4 to 85 and over (Table A2). For each age band we calculate an incidence rate by dividing cases by population as before. These are shown as "age-specific rates" in Table A2. We can see that these age-specific rates are lower in Leitrim than in Louth for most age groups.

Table A2.

	Louth			***Leitrim***		
age	***cases***	***population***	***age-specific rate***	***cases***	***population***	***age-specific rate***
0-4	4	23517	17	1	5305	19
5-9	4	25169	16	0	6661	0
10-14	1	28546	4	1	7604	13
15-19	6	30249	20	2	6898	29
20-24	9	25732	35	1	4064	25
25-29	16	24274	66	1	4033	25
30-34	26	24486	106	2	4971	40
35-39	36	23391	154	8	5814	138
40-44	52	21116	246	27	5759	469
45-49	84	20318	413	30	5384	557
50-54	126	17657	714	15	4429	339
55-59	112	13972	802	38	4055	937
60-64	146	12023	1214	44	3655	1204
65-69	192	11508	1668	57	4020	1418
70-74	230	11190	2055	67	4147	1616
75-79	244	9183	2657	79	3595	2197
80-84	188	5763	3262	74	2538	2916
85+	129	3869	3334	38	1712	2220

We then calculate the number of cases that would be found in a population of standard size and age distribution which had the same age-specific rates as those in Louth and Leitrim. Two populations are commonly used for this calculation—the "European" and "World" standard populations. These are not the real European and World populations, but approximations which are designed to have a total population size of 100,000.

For each age group we multiply the age-specific rate, as calculated above, by the numbers in the standard population, giving the calculated number of cases for each age group (Table A3). These can then be added over all age groups to give the total number of cases that would be found in the standard population, based on age-specific rates in Louth and Leitrim.

Table A3

	Louth			***Leitrim***		
age	***age-specific rate***	***standard population***	***expected cases***	***age-specific rate***	***standard population***	***expected cases***
0-4	17	8000	1	19	8000	2
5-9	16	7000	1	0	7000	0
10-14	4	7000	0	13	7000	1
15-19	20	7000	1	29	7000	2
20-24	35	7000	2	25	7000	2
25-29	66	7000	5	25	7000	2
30-34	106	7000	7	40	7000	3
35-39	154	7000	11	138	7000	10
40-44	246	7000	17	469	7000	33
45-49	413	7000	29	557	7000	39
50-54	714	7000	50	339	7000	24
55-59	802	6000	48	937	6000	56
60-64	1214	5000	61	1204	5000	60
65-69	1668	4000	67	1418	4000	57
70-74	2055	3000	62	1616	3000	48
75-79	2657	2000	53	2197	2000	44
80-84	3262	1000	33	2916	1000	29
85 +	3334	1000	33	2220	1000	22
Total		**100000**	**482**		**100000**	**433**

From this we see that we would expect 482 cases based on Louth rates and 433 based on Leitrim rates. As the size of the standard population is 100,000, we conclude that the **age-standardised incidence rate** for Louth is 482 per 100,000 (quite close to the crude rate) but that for Leitrim has fallen to 433 per 100,000, as the population in that county is older on average than that of the European standard population. So, in fact, the higher rate in Leitrim is entirely due to the older population.

Standardised incidence rate

The second method of calculation is more commonly used for small areas, as it adjusts for the age distribution as does the previous method, but also allows us to relate the rates in individual areas to an overall rate for the whole area being studied, for instance to compare counties or EDs to Ireland as a whole.

The first step is to calculate age-specific incidence rates for Ireland in exactly the same way as we did for Louth and Leitrim above (Table A4).

Table A4

	Ireland		
age	***cases***	***population***	***age-specific rate***
0-4	146	870459	17
5-9	91	951611	10
10-14	114	1083306	11
15-19	185	1154182	16
20-24	280	1031113	27
25-29	485	936387	52
30-34	889	942990	94
35-39	1526	924833	165
40-44	2421	863184	280
45-49	3401	793784	428
50-54	4414	679428	650
55-59	4890	551097	887
60-64	5608	496549	1129
65-69	7027	464154	1514
70-74	8296	434820	1908
75-79	8091	349071	2318
80-84	6513	240594	2707
85+	5180	175398	2953

Multiplying these rates by the population in the corresponding age group in both counties (Table A5), we can calculate the number of cases that would have been found if the rates in the two counties were exactly the same as in Ireland as a whole. Adding all of these expected cases, we find that 1487 cases would have been found in Louth and 509 in Leitrim if the rates were the same as in all Ireland.

Table A5

	Louth		**Leitrim**	
age-specific rate for Ireland	**population**	**expected number of cases**	**population**	**expected number of cases**
17	23517	4	5305	1
10	25169	2	6661	1
11	28546	3	7604	1
16	30249	5	6898	1
27	25732	7	4064	1
52	24274	13	4033	2
94	24486	23	4971	5
165	23391	39	5814	10
280	21116	59	5759	16
428	20318	87	5384	23
650	17657	115	4429	29
887	13972	124	4055	36
1129	12023	136	3655	41
1514	11508	174	4020	61
1908	11190	213	4147	79
2318	9183	213	3595	83
2707	5763	156	2538	69
2953	3869	114	1712	51
Total for all ages		**1487**		**509**

However, we know that there were actually 1605 cases in Louth and 485 in Leitrim, so the ratio of "cases found" to "cases expected" (the standardised incidence ratio) is 1.08 (or 108%) for Louth and 0.95 (95%) for Leitrim (Table A6). This gives us two pieces of information:

1. As we found using the previous method, the cancer rate in Louth is higher than that for Leitrim when we allow for age;
2. The rate for Louth is greater than that for Ireland as a whole (more cases found than expected; standardised incidence ratio greater than 1, while that for Leitrim is less than that for Ireland (fewer cases found than expected).

Table A6

	cases expected	**cases found**	**standardised incidence ratio**
Louth	1487	1605	108%
Leitrim	509	485	95%

Appendix 2. Louth electoral districts

ED name	population (1996)
Ardee Rural	2390
Ardee Urban	3440
Ballymascanlan	1927
Barronstown	547
Carlingford	1282
Castlebellingham	1391
Castlering	745
Castletown	1305
Clogher	1548
Clonkeen	402
Collon	1029
Creggan Upper	638
arver	458
Drogheda (Fairgate)	24460
Dromin	429
Dromiskin	1561
Drumcar	1404
Drummullagh	815
Dundalk Rural	524
Dundalk Urban	25762
Dunleer	1677
Dysart	548
Faughart	872
Greenore	905
Haggardstown	4222
Jenkinstown	870
Killanny	563
Louth	1010
Mansfieldstown	424
Monasterboice	1017
Mullary	1014
Rathcor	1105
Ravensdale	892
St. Peter's	1809
Stabannan	535
Tallanstown	887
Termonfeckin	1759

Note: The area shown as "Dundalk Urban" consists of the area described as "Dundalk Urban District" in the 1996 and 2002 censuses and consists of Dundalk Urban electoral districts Nos.1 to 4, and parts of the electoral districts of Castletown, Dundalk Rural and Haggardstown.

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