CHAPTER 5

REGIONAL VARIATION AND SPATIAL CORRELATION

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Age standardised rates

The age standardised rates presented in the maps are calculated using the world standard population and are given by

$$ASR_i = \sum_j w_j r_{ij},$$

where r_{ij} is the age specific mortality rate for age group j in region i, and w_j is the world standard population weight for age group j.

Regional variation

We used two methods to assess the strength of the regional variation in the age-standardised rates. The first was a method developed by Pennello, Devesa & Gail (1999) based upon a Poisson model for the observed number of cases together with a random effect for the regional variation. The second used a hierarchical regression model to partition the variation in the mortality rates among countries, among regions and within regions. In all of this work we used data from age groups 30-34 to 80-84 as there were few deaths from cancer in people under 30 and death certification is less reliable in those aged 85 and over.

Poisson Gamma model

The number of deaths in region i and age group j, d_{ij}, is assumed to follow a Poisson distribution, with mean depending upon the person years at risk, y_{ij}.

$$d_{ij} \sim Poisson(y_{ij}\xi_j\gamma_i)$$

where ξ_j is the age effect for age group j and γ_i is the random effect for region i. The random effect is assumed to follow a Gamma distribution,

$$\gamma_i \sim \Gamma(\alpha, \alpha)$$

which has a mean of 1 and a variance of $\frac{1}{\alpha}$.

The parameter estimates of this model, ξ_j and α, were obtained by maximum likelihood using specially written functions in R (Ihaka & Gentleman, 1996) and S-PLUS (Insightful Corporation, 2005).

As the γ_i are the relative risks in region i the square root of $\frac{1}{\alpha}$ is known as the relative risk standard deviation (RRSD). If the age effects, ξ_j, are known then $\sum_j y_{ij}\xi_j = E_i$ is the expected number of deaths in region i. Initial estimates of γ_i can be obtained by estimating ξ_j using the sum over all regions $\hat{\xi}_j^0 = \frac{\sum_i d_{ij}}{\sum_i y_{ij}}$, then calculating the expected number of deaths $E_i^0 = \sum_j y_{ij}\hat{\xi}_j^0$ and estimating $\hat{\gamma}_i^0 = \frac{O_i}{E_i^0}$, where $O_i = \sum_j d_{ij}$ is the observed number of deaths in each region. The standard deviation of the $\hat{\gamma}_i^0$ is an initial estimate of the RRSD. Using these initial estimates, maximum likelihood estimates are obtained by successively re-estimating ξ_j and

α until convergence. This was usually achieved within a few iterations. The estimated standard error of the estimated RRSD is calculated from the information matrix for α using the delta method.

This model is closely related to the empirical Bayes smoothing method of Clayton & Kaldor (1987). Neither model takes into account the geographical or spatial structure of the data. Randomly interchanging the regions would give exactly the same value for the RRSD. The RRSD is not a measure of spatial structure or correlation.

The RRSD is a measure of the regional variation both in the age specific rates and in the age standardised rates, as there is a constant multiplier for all age groups in the same region. The magnitude of the RRSD can be used to rank the cancer sites with the ones with larger values having more relative regional variation. More attention should be paid to the interpretation of the geographical distribution for cancer sites with larger values of the RRSD. If the RRSD is low then the common scale map at the bottom right of the chart will tend to be of one colour indicating little geographic variation even although the main relative map may have strong geographic patterns.

The RRSD is a measure of the variability in the distribution of age standardised rates illustrated in the boxplot for all Europe presented at the top of the boxplots beside each map and denoted 'All'. These boxplots are plotted on a different scale for each cancer site so it is not possible to use the boxplots to compare cancer sites. This can only be achieved with the RRSD and other measures of regional variation.

The RRSDs were calculated for each cancer site for males and females separately. Furthermore, for each cancer site we calculated the RRSD separately for each of the European countries. Generally, we would expect the RRSD for all Europe to be greater than the RRSDs for the individual countries. It is possible that the RRSD for a particular country will be larger than the RRSD for all of Europe, implying that there is extreme regional variation in that country. If the separate RRSDs for each country are similar in magnitude to each other then this implies constant regional variation over the countries of Europe. For the smaller countries with few regions and small populations the RRSD was not estimated for the rarer cancer sites. Convergence difficulties were noted due to the log likelihood function increasing monotonically as α increases.

Hierarchical modelling

In this framework, a three level multilevel model is used where the levels are country, region within country, and age group within region within country. The mean number of cases in age group j, in region i of country h, μ_{hij}, is written as

$$\ln(\mu_{hij}) = \ln(y_{hij}) + \rho_j + v_h + u_{hi}$$

where ρ_j are the age group effects, v_h the random effects associated with country, and u_{hi} the random effects associated with region within country. The ρ_j are fixed effects and are the same as $\ln(\xi_j)$ in the Poisson Gamma model.

The random effects are assumed to follow normal distributions with mean zero and variances σ_v^2 and σ_u^2, respectively. Similar models are used by Langford et al (1999), Leyland et al (2000) Langford & Day (2001).

At the lowest (age group) level the number of deaths is assumed to follow a Poisson distribution

$$d_{hij} \sim Poisson(\mu_{hij})$$

which has expectation and variance $E[d_{hij}] = Var[d_{hij}] = \mu_{hij}$. This can be extended to include extra Poisson variation, Breslow (1984), through an over dispersion parameter, ϕ, where

$$Var[d_{hij}] = \phi\mu_{hij}.$$

The parameters are estimated using MLwiN, Rasbash et al (2000), using restricted iteratively reweighted least squares, partial quasi likelihood and a second order approximation. No major estimation problems were encountered other than for mesothelioma for males where a first order approximation was used.

If the parameter, μ_{hij}, of the Poisson distribution is assumed to follow a Gamma distribution, as in Pennello, Devesa & Gail (1999), then a Negative Binomial distribution for the deaths, d_{hij}, results. This is an extension to the hierarchical Poisson regression model and has exactly the same level 2 and 3 structure but at the age group level has

$$d_{hij} \sim NBD\left(\mu_{hij}, \frac{\mu_{hij}}{\mu_{hij} + \nu}\right)$$

which, with a parameter for over dispersion, ϕ, has variance $Var\left[d_{hij}\right] = \phi\mu_{hij} + \frac{1}{\nu}\left(\mu_{hij}\right)^2$.

If we have only a two level model with age group nested within region then the Poisson model without the over dispersion parameter should be equivalent to the Poisson Gamma model, Pennello, Devesa & Gail (1999). The models are not algebraically identical, as the two level Poisson model assumes a normal distribution for the regional effects and so a log normal distribution for the exponential of these random effects. The exponential of the random effects serve the same purpose as the γ_i in the Poisson Gamma model which are assumed to follow a Gamma distribution. The hierarchical Poisson and Negative Binomial models are extensions to the two level Poisson Gamma model in that both regional variation and over dispersion can be estimated simultaneously.

The sum of the parameters, σ_v^2 and σ_u^2 is an estimate of the total regional variance and so performs a similar function to the RRSD of the Poisson Gamma model. We anticipate that $\sqrt{\sigma_v^2 + \sigma_u^2}$ would be strongly associated with RRSD. In fact the correlation over all sites investigated is 0.95 for males and 0.93 females. Usually the RRSD is slightly smaller than $\sqrt{\sigma_v^2 + \sigma_u^2}$ and the median ratio is 0.86 for males and 0.93 for females.

Only the results for the negative binomial model with over dispersion are presented. The regional and country variance parameters are similar for the Poisson and Negative Binomial models.

The important parameters for the assessment of regional variation are σ_v^2 and σ_u^2. When the rates tend to be higher in one country compared with other countries we would expect to see larger values for the between country variance, σ_v^2. In most cases σ_v^2 will be larger than the within country variance, σ_u^2; however if they are approximately the same size we would conclude that there was little evidence of geographical pattern associated with countries. If σ_v^2 is very much larger than σ_u^2 this is indicative of a geographical pattern associated with countries.

The geographical pattern need not be specifically associated with isolated countries but if there is a band of high rates in Scandinavia and lower rates in the Mediterranean countries this would be expected to manifest itself as between country variance larger than within country variance (σ_v^2 larger than σ_u^2). If there were areas of high rates and very low rates within a country with the same pattern in all countries then this would result in σ_v^2 being similar in magnitude to, or smaller than, σ_u^2.

As with the Poisson Gamma model, this is not a true model of spatial structure. It has a spatial structure in so far as regions are located within countries. However the countries could be randomly distributed in space and the regions randomly reordered within countries with exactly the same results.

The between country variance, σ_v^2, is a measure of the variability of the differences among the medians for each country as illustrated in the boxplots presented with the maps. The average variability within each boxplot is measured by σ_u^2.

Spatial autocorrelation

The spatial autocorrelation or association may be defined as "the phenomenon where locational similarity (observations in spatial proximity) is matched by value similarity (attribute correlation)" (Anselin 1995). Note that this matching may be the result of a "true" interaction among the variables or as a sort of error due to the "artificial" administrative units such as provinces, counties, states etc. (Magalahes et al. 2002).

To quantify the strength of the autocorrelation of a given random variable in a given geographic map a number of statistics have been proposed (Gebhardt, 1998), including the Moran's I statistic (Cliff and Ord 1981):

$$I = \frac{r}{S_0} \frac{\sum_{ij} w_{ij} (z_i - \bar{z})(z_j - \bar{z})}{\sum_i (z_i - \bar{z})^2}$$

where there are r regions, with z_i denoting the age standardised rate in region i, and $\bar{z}$ is the average over all regions so that $\bar{z} = \frac{\sum_{i=1}^{r} z_i}{r}$. The neighbours of a particular region are denoted by a positive number w_{ij} if regions i and j share a common boundary, i.e. are neighbours, and $w_{ij} = 0$ if they are not neighbours, and $S_0 = \sum_{i=1}^{r} \sum_{j=1}^{r} w_{ij}$. Various forms have been used in the literature for w_{ij}, but the most important are $w_{ij} = 1$ and $w_{ij} = 1/v_i$, where v_i denotes the number of neighbours of region i. We chose the latter form, which allows a simple geometrical interpretation for the statistic.

In fact, Moran's I statistic, with $w_{ij} = 1/v_i$, has similarities to the correlation coefficient and indeed may be interpreted as the slope of the regression line obtained from the scatter plot of $\bar{z}_i^*$ against $z_i - \bar{z}$, where $\bar{z}_i^*$ is the average of the age standardised rates in the regions neighbouring region i. This scatter plot has been proposed for its usefulness in exploratory spatial data analysis since it gives a synthetic graphical idea of the degree of correlation of the analysed map. It is possible to use the scatterplot to identify potential groups of regions having high (or low) values of the variable in study (Anselin, Sybari & Smirnov, 2002).

Moran's I statistic measures the similarity in age standardised rates between geographically close areas. If there is no spatial dependence, I will be close to zero, while values close to one indicate spatial clustering. Note that even if in theory the I statistic should be used only with identically distributed stochastic variables, it is often used also when the variables are not so distributed. As we are interested in assessing the spatial autocorrelation among neighbouring regions, the "mono-province" islands were not included in the computation since they have no neighbours. This means that Cyprus, Iceland and Malta were excluded from this analysis which is why they do not appear in Table 5.3. Furthermore, any other island with just one level 3 nuts region was also excluded. This means that Corsica, Orkney and Shetland, for example, were excluded but that Sicily, Crete and Sardinia were included.

We also used a bivariate version of this statistic to calculate the spatial association between the rates for males and females, and also between certain cancer sites. This is achieved by calculating the correlation between $\bar{z}_i^*$ for males and $\bar{z}_i^*$ for females. We would expect this correlation to be positive. If it is close to zero then this implies that the spatial structure is not the same for males and females. If it is close to one then the spatial structure is the same for males as for females. In these bivariate analyses we included also the "mono-province" islands, since the comparisons make sense also for regions without neighbours. The scatter plots associated with these correlations show, in particular, regions where the geographic pattern is not the same for males as for females.

Results

Across the cancer sites the magnitude of the overall variability (RRSD) ranged in males from 0.144 (leukaemia) to 0.755 (pleura) and in females from 0.138 (leukaemia) to 0.758 (oesophagus) (Figure 5.1, Tables 5.1 and 5.2). Among males, pleura (mesothelioma) exhibits the greatest regional variation (among females it has the third largest regional variation). This cancer site has very low rates in most areas but, relatively, very high rates in a few areas. A similar pattern is observed in most countries.

For both males and females, the cancer sites which have low regional variability are leukaemia, brain and central nervous system, pancreas and multiple myeloma. There may still be a spatial structure but the relative spread of the age-standardised rates is small. Irrespective of the absolute level of the rates there is not much relative variation over all countries and NUTS regions in the maps for these cancers. There was also low variability for two major cancers – breast and prostate.

The cancer sites which have high regional variation are pleura, non-melanoma skin cancer, oesophagus, liver and larynx. These are sites where there is a relatively large range from the regions with low rates to the regions with high rates.

The model was fitted for each country for each cancer site. In some instances numerical problems were experienced when fitting the model as the log likelihood was monotonic in α and kept increasing while α tended to infinity. The reported value of the RRSD was consequently zero but no standard error could be calculated. This problem generally occurred among the cancer sites with fewer numbers of deaths and in the countries with fewer regions. Consistent results were obtained when using MLwiN in that the level 2 variance was estimated as zero. Individual countries with high regional variation are reported with the individual cancer sites in chapter 6. Results by country are given in Table 5.3 for males and females separately.

For the three level models, a negative binomial distribution was chosen, allowing for extra negative binomial dispersion: the addition of another component for the level 1 variation produced an extra negative binomial term which was smaller than the extra Poisson term. This happened in all sites, but such a reduction, although small, was present for both males and females. The estimates of the country variance and within country variance are not affected a great deal by the use of a Poisson or Negative Binomial level 1 structure.

The median variation associated with country is just over 80% in both males and females indicating substantial variation over large scale regions such as countries (Figure 5.2, Tables 5.1 and 5.2). This suggests that we should expect to see large scale regional patterns for most cancer sites. This may include high rates in just one country relative to all the others, or low rates in one country relative to the others. It may also manifest itself as lower rates in certain geographic areas, spanning more than one country. From the values of the statistic for the different cancer sites, such a large scale geographic pattern should be more evident for gallbladder, non-Hodgkin's lymphoma, large bowel, melanoma, liver, multiple myeloma and kidney. For males, the statistics is also high for prostate, oral cancer and larynx, while for females it is high for all uterus under 50, ovary, and all uterus. The sites where there may not be such a large scale pattern are bladder and Hodgkin's disease (in both males and females) and oral cancer in females, as these sites have the lowest percentages of variation associated with country.

For both males and females there is evidence of substantial extra Negative Binomial dispersion for lung cancer, where there are large numbers of deaths, and also for non-melanoma skin cancer. There is also over dispersion for pleura among males and all uterus among females. There is generally less over dispersion in rarer cancers such as melanoma, thyroid, testis and Hodgkin's disease. There is generally less over dispersion among females compared with males. For lung cancer, which has the greatest over dispersion for females, the estimate is 1.14 compared with 1.19 for males.

Moran's I statistic ranges from 0.18 (thyroid) to 0.82 (stomach) for males and from 0.16 (leukaemia) to 0.82 (oesophagus) in females (Figure 5.3, Table 5.4). The greatest spatial clustering is to be found in lung, liver, stomach, oesophagus and large bowel, for both males and females. There is also high spatial correlation in all uterus, breast and gallbladder for females, and in oral cancer and larynx for males. For these cancers we would expect to see areas of red clustered together on the maps and areas of green clustered together. Leukaemia, thyroid, brain, and Hodgkin's disease in both sexes, and testis all have very low spatial correlation and we should not find any spatial pattern.

For cancer sites which affect both males and females, the correlations between the smoothed rates for males and females are also presented in Table 5.4. The highest correlations are for stomach, large bowel and gallbladder, indicating that the geographic pattern for males and females is similar. The lowest correlations are for lung, bladder and larynx.

For cancer sites which affect both males and females the values of the variability and correlation statistics are plotted for males and females in Figure 5.4. Generally, the magnitude of the RRSD is the same in males and females for cancers affecting both (Figure 5.4 (a)). Over the 20 common sites the median of the ratio of the RRSD for males to females is 0.99 ranging from 0.53 to 1.99, with an inter quartile range from 0.87 to 1.14. The main differences are lung and oesophagus, especially, and gallbladder and skin, also, which have a larger RRSD in females, and oral cancer, which has a larger RRSD in males. With the exception of these five sites there is a very strong agreement between the relative risk standard deviations in males and females. The rates may be higher for males (larynx, for example) than in females, but the magnitude of the relative geographic variability is the same.

The variation between countries (Figure 5.4(b)) is not always the same for males and females and the biggest differences occur for oral cancer and larynx, which have greater between country variation for males, and lung, oesophagus, skin and gallbladder, which have greater between country variation for females. The variation within a country is virtually the same for males and females over all cancer sites (Figure 5.4(c)). The only minor exceptions are for gallbladder, lung, and larynx which have higher variation within a country for females compared with males. The pattern for total variability from the multilevel model (Figure 5.4(d)) is similar to that for the RRSD (Figure 5.4(a)).

There is general agreement between Moran's I for males and for females for many sites (Figure 5.4(e)), but not for larynx and oral cancer which have a low Moran's I for females but high for males, and, to a lesser extent, for gallbladder and oesophagus which have a slightly higher Moran I for females compared with males. Also, for Hodgkin's Disease there is low spatial correlation for females but slightly higher for males.

The correlation between the smoothed rates for males and the smoothed rates for females is high (over 0.8) for cancers of the stomach, large bowel, gallbladder and kidney, non-Hodgkin's Lymphoma and low (under 0.3) for larynx, lung and bladder (Figure 5.4(f)). This implies that the spatial pattern among males and females is similar in some of the digestive tract cancers but not in three of the sites associated with smoking.

The measures of spatial variation and correlation are plotted pairwise against each other in Figure 5.5 for males and females separately. The three measures provide complementary information. The RRSD is a measure of relative spatial variation, Moran's I is a measure of spatial correlation through a chain of local correlations, and the percentage of variation associated with country is a measure of large scale correlation. Generally they are all weakly positively associated. The correlation between the RRSD and the percentage of variation associated with country is 0.08 for males and 0.13 for females; the correlation between the RRSD and Moran's I is 0.26 for males and 0.35 for females; and the correlation between the percentage of variation associated with country and Moran's I is 0.36 for males and 0.49 for females.

It is possible to find low RRSD and a high percentage of variation due to country (Figures 5.5(a) and 5.5(b)). Among females, this occurs for ovary, large bowel, multiple myeloma and leukaemia; among males, there is a similar pattern for non-Hodgkin's lymphoma, large bowel, multiple myeloma, prostate and leukaemia. This occurs when the relative regional variation is small but there are some countries with consistently higher or lower rates across their regions. When there was a relatively low percentage of variation due to country, as in the case of oral cancer and bladder among females, there was also a low RRSD. Those sites with strong overall variability (high RRSD) tended to have a higher percentage of variation due to country.

The overall association between RRSD and Moran's I is low (Figures 5.5(c) and 5.5(d)). There is however some similarity in the pattern for males and females. Both measures are low for leukaemia, brain and multiple myeloma and both are high for liver. Pleura, skin and testis cancer (males only) have a high RRSD but low spatial correlation, while bowel, breast, prostate, lung (males), ovary, and uterus have relatively low RRSD but high spatial correlation.

If Moran's I is high, over 0.7, then the percentage of variation associated with country tends also to be high (Figures 5.5(e) and 5.5(f)). However it is possible to have a high percentage and a low Moran's I, for example for leukaemia. Also, we do not find a low percentage of variation explained by country differences and a very high Moran's I, as a strong local spatial correlation would imply differences between the countries. There are many sites where Moran's I is low but the country percentage is high. Often these are the same sites with RRSD low but the country percentage high such as leukaemia and multiple myeloma.

Summary

In this chapter we illustrate the use of summarising spatial variability and spatial correlation with a view to using these measures to assist in the interpretation of the maps. Throughout chapter 6 we discuss the interpretation of the maps in relation to these statistics. In the current chapter we have looked at the relationship among these statistics and have commented on the similarity between the maps for males and females for a number of, but not all, cancer sites.

If the RRSD is small then there is not a great deal of spatial variability in the rates even although the main map may have areas of red and green. In such cases it is prudent to pay attention to the absolute scale maps at the bottom right hand corner of the main maps. Furthermore, over-interpretation of the differences in rates between areas of the maps should be discouraged. If there is a large RRSD then there is a greater relative difference among the rates in the regions and for such maps the geographic differences are likely to be important.

Although we use a measure of the percentage of variation associated with country this has a broader interpretation of large scale correlation. When this percentage is low there is no large scale pattern in the rates. Moran's I statistic is high when there is high spatial correlation and this can occur even when the RRSD is low. Cancer sites with a high Moran's I and a high RRSD are the ones with the greatest geographic variation and pattern. Cancer sites with a low value for Moran's I and a low RRSD are the ones with little geographic variation and little geographic pattern.

Table 5.1: Spatial variation measures for males

Cancer site	Relative risk standard deviation		Countries		NUTS within countries		Extra Negative Binomial		%
	RRSD	SE	Var	SE	Var	SE	Var	SE	
Oral cavity and pharynx	0.552	0.011	0.375	0.107	0.0618	0.0038	1.083	0.018	85.9
Oesophagus	0.452	0.010	0.158	0.046	0.0643	0.0039	1.036	0.018	71.0
Stomach	0.395	0.008	0.194	0.055	0.0400	0.0022	1.004	0.016	82.9
Large bowel	0.251	0.006	0.082	0.023	0.0138	0.0009	1.025	0.016	85.7
Liver	0.602	0.012	0.328	0.093	0.0561	0.0034	1.075	0.015	85.4
Gallbladder	0.505	0.012	0.239	0.069	0.0218	0.0031	1.027	0.014	91.6
Pancreas	0.198	0.006	0.039	0.011	0.0148	0.0012	1.049	0.016	72.4
Larynx	0.617	0.013	0.573	0.163	0.0499	0.0038	1.050	0.016	92.0
Lung	0.294	0.006	0.111	0.032	0.0335	0.0017	1.188	0.026	76.8
Pleura	0.755	0.010	0.711	0.211	0.2327	0.0161	1.180	0.015	75.3
Melanoma	0.352	0.010	0.184	0.053	0.0312	0.0036	0.942	0.015	85.5
Non-melanoma skin cancer	0.555	0.010	0.185	0.064	0.0562	0.0101	1.161	0.015	76.7
Breast	..	..	..	..	..	..	..	..	..
All uterus	..	..	..	..	..	..	..	..	..
All uterus under 50	..	..	..	..	..	..	..	..	..
Ovary	..	..	..	..	..	..	..	..	..
Prostate	0.204	0.005	0.039	0.011	0.0068	0.0006	1.062	0.015	85.0
Testis	0.542	0.009	0.243	0.076	0.0711	0.0156	0.972	0.015	77.3
Urinary bladder	0.243	0.007	0.052	0.015	0.0256	0.0019	1.021	0.015	66.8
Kidney	0.334	0.008	0.127	0.036	0.0264	0.0021	1.062	0.016	82.8
Brain and CNS	0.183	0.007	0.026	0.008	0.0084	0.0012	1.019	0.016	75.7
Thyroid	0.365	0.008	0.083	0.028	0.0268	0.0086	1.019	0.013	75.6
Hodgkin's disease	0.475	0.010	0.153	0.047	0.0707	0.0097	0.920	0.015	68.4
Non-Hodgkin's lymphoma	0.273	0.008	0.118	0.034	0.0154	0.0017	0.991	0.015	88.4
Multiple myeloma	0.201	0.008	0.021	0.006	0.0036	0.0008	1.003	0.015	85.7
Leukaemia	0.144	0.006	0.047	0.014	0.0105	0.0019	0.988	0.014	81.7
All cancer (ICD-9 140-208)	0.174	0.004	0.042	0.012	0.0099	0.0005	1.284	0.032	80.8

Table 5.2: Spatial variation measures for females

Cancer site	Relative risk standard deviation		Countries		NUTS within countries		Extra Negative Binomial		%
	RRSD	SE	Var	SE	Var	SE	Var	SE	
Oral cavity and pharynx	0.278	0.009	0.049	0.016	0.0420	0.0049	0.945	0.015	54.0
Oesophagus	0.758	0.013	0.361	0.104	0.0672	0.0060	1.044	0.015	84.3
Stomach	0.384	0.008	0.156	0.045	0.0407	0.0024	1.037	0.016	79.3
Large bowel	0.236	0.006	0.051	0.015	0.0091	0.0007	1.038	0.016	84.8
Liver	0.538	0.012	0.249	0.072	0.0480	0.0036	1.079	0.015	83.8
Gallbladder	0.609	0.013	0.362	0.103	0.0517	0.0036	0.999	0.014	87.5
Pancreas	0.209	0.006	0.038	0.011	0.0144	0.0012	0.983	0.014	72.6
Larynx	0.503	0.008	0.236	0.074	0.0797	0.0136	0.874	0.013	74.7
Lung	0.554	0.011	0.252	0.072	0.0656	0.0035	1.144	0.020	79.3
Pleura	0.662	0.009	0.425	0.132	0.1873	0.0188	0.771	0.012	69.4
Melanoma	0.303	0.010	0.140	0.041	0.0265	0.0036	0.924	0.015	84.1
Non-melanoma skin cancer	0.667	0.009	0.297	0.092	0.0672	0.0136	1.099	0.015	81.6
Breast	0.201	0.005	0.035	0.010	0.0116	0.0007	1.067	0.018	75.1
All uterus	0.353	0.008	0.142	0.040	0.0224	0.0017	1.114	0.018	86.4
All uterus under 50	0.539	0.013	0.344	0.100	0.0410	0.0054	1.132	0.019	89.4
Ovary	0.257	0.006	0.067	0.019	0.0092	0.0010	1.043	0.017	87.9
Prostate	..	..	..	..	..	..	..	..	..
Testis	..	..	..	..	..	..	..	..	..
Urinary bladder	0.316	0.009	0.051	0.016	0.0348	0.0034	0.941	0.013	59.7
Kidney	0.361	0.009	0.146	0.042	0.0252	0.0025	0.996	0.015	85.2
Brain and CNS	0.202	0.007	0.037	0.011	0.0097	0.0015	1.035	0.016	79.1
Thyroid	0.319	0.010	0.063	0.020	0.0271	0.0057	1.002	0.014	69.9
Hodgkin's disease	0.415	0.010	0.113	0.037	0.0606	0.0109	0.928	0.014	65.1
Non-Hodgkin's lymphoma	0.307	0.009	0.160	0.046	0.0182	0.0019	1.020	0.015	89.8
Multiple myeloma	0.225	0.008	0.017	0.005	0.0036	0.0009	1.040	0.015	83.0
Leukaemia	0.138	0.006	0.066	0.020	0.0142	0.0022	1.046	0.015	82.3
All cancer (ICD-9 140-208)	0.166	0.003	0.026	0.008	0.0060	0.0003	1.264	0.024	81.6

Table 5.3: Relative risk standard deviation (RRSD) and standard errors (SE) for each cancer site by country

(a) Males

Country*	Oral cavity and pharynx		Oesophagus		Stomach		Large bowel		Liver		Gallbladder		Pancreas		Larynx		Lung		Pleura	
	140-149		150		151		153, 154 & 159.0		155		156		157		161		162		163	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.205	0.062	0.141	0.071	0.112	0.033	0.170	0.048	0.184	0.056	0.302	0.095	0.110	0.039	0.063	0.064	0.088	0.024	0.198	0.097
Belgium	0.321	0.072	0.119	0.038	0.216	0.056	0.059	0.018	0.242	0.058	0.104	0.075	0.102	0.031	0.222	0.056	0.097	0.022	0.423	0.105
Czech Republic	0.168	0.039	0.152	0.039	0.137	0.030	0.113	0.024	0.186	0.043	0.061	0.038	0.026	0.038	0.123	0.041	0.166	0.032	0.000	0.055
Denmark	0.380	0.078	0.226	0.053	0.136	0.041	0.097	0.025	0.528	0.125	NA	NA	0.088	0.039	0.364	0.085	0.106	0.023	0.499	0.127
Estonia	0.248	0.077	0.174	0.125	0.218	0.058	0.097	0.069	NA	NA	0.129	0.026	0.000	0.043	0.188	0.080	0.093	0.030	0.726	0.052
Finland	0.209	0.063	0.275	0.068	0.127	0.036	0.056	0.042	0.257	0.064	0.171	0.093	0.098	0.034	0.166	0.142	0.083	0.022	0.451	0.115
France	0.283	0.022	0.319	0.024	0.186	0.016	0.114	0.010	0.249	0.019	0.090	0.031	0.109	0.013	0.230	0.020	0.186	0.015	0.376	0.037
Germany	0.209	0.012	0.184	0.013	0.176	0.009	0.096	0.006	0.212	0.014	0.174	0.019	0.051	0.014	0.190	0.018	0.212	0.008	0.464	0.021
Greece	0.008	1.234	0.210	0.050	0.438	0.049	0.206	0.032	0.276	0.035	0.094	0.015	0.297	0.048	0.268	0.053	0.260	0.028	0.001	0.000
Hungary	0.180	0.032	0.205	0.037	0.132	0.025	0.075	0.016	0.137	0.029	0.049	0.059	0.091	0.024	0.234	0.042	0.111	0.019	0.000	0.000
Ireland	0.075	0.075	0.075	0.049	0.120	0.045	0.000	0.072	0.077	0.078	0.000	0.046	0.000	0.022	0.282	0.109	0.166	0.045	0.572	0.134
Italy	0.412	0.032	0.567	0.041	0.299	0.022	0.171	0.014	0.326	0.025	0.125	0.022	0.244	0.020	0.259	0.023	0.230	0.018	0.681	0.052
Latvia	0.161	0.057	0.172	0.080	0.111	0.042	0.164	0.050	0.224	0.069	0.268	0.032	0.000	0.035	0.203	0.063	0.139	0.029	0.000	0.000
Lithuania	0.160	0.058	0.202	0.053	0.116	0.037	0.157	0.039	0.208	0.052	0.505	0.038	0.165	0.056	0.195	0.053	0.142	0.023	0.000	0.000
Netherlands	0.146	0.037	0.082	0.024	0.144	0.026	0.059	0.017	0.179	0.049	NA	NA	0.082	0.027	0.000	0.001	0.094	0.013	0.533	0.067
Norway	0.236	0.065	0.183	0.068	0.125	0.045	0.093	0.025	0.161	0.113	0.242	0.110	0.134	0.048	0.389	0.117	0.130	0.027	0.490	0.096
Poland	0.191	0.026	0.162	0.027	0.132	0.016	0.159	0.020	0.209	0.028	0.274	0.043	0.084	0.018	0.130	0.020	0.141	0.015	0.418	0.062
Portugal	0.274	0.053	0.241	0.052	0.222	0.038	0.149	0.033	0.234	0.051	0.185	0.072	0.154	0.042	0.344	0.063	0.371	0.060	0.000	0.000
Slovakia	0.264	0.038	0.238	0.046	0.138	0.031	0.133	0.027	0.217	0.055	0.369	0.058	0.201	0.047	0.299	0.051	0.127	0.020	0.335	0.041
Slovenia	0.195	0.079	0.109	0.140	0.190	0.070	0.155	0.059	0.174	0.106	0.000	0.140	0.034	0.200	0.106	0.131	0.154	0.048	0.943	0.036
Spain	0.296	0.035	0.290	0.033	0.221	0.026	0.134	0.017	0.227	0.028	0.098	0.039	0.126	0.019	0.218	0.026	0.232	0.026	0.466	0.055
Sweden	0.260	0.067	0.154	0.045	0.127	0.035	0.056	0.021	0.225	0.048	0.000	0.064	0.121	0.034	0.204	0.113	0.158	0.030	0.373	0.106
Switzerland	0.234	0.052	0.261	0.055	0.161	0.036	0.080	0.027	0.324	0.057	0.128	0.030	NA	NA	0.366	0.071	0.111	0.026	0.414	0.062
United Kingdom	0.290	0.023	0.148	0.013	0.217	0.016	0.115	0.009	0.227	0.020	0.162	0.031	0.054	0.015	0.336	0.027	0.220	0.014	0.690	0.041

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions

NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

Country*	Melanoma		Skin (other)		Breast		All uterus		All uterus Under 50		Ovary		Prostate		Testis	
	172		173		174		179-182		179-182		183		185		186	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.000	0.026	0.000	0.070	..	..	..	..	..	..	..	..	0.084	0.027	0.475	0.119
Belgium	0.000	0.024	0.093	0.195	..	..	..	..	..	..	..	..	0.088	0.025	0.681	0.103
Czech Republic	0.085	0.065	0.085	0.134	..	..	..	..	..	..	..	..	0.059	0.024	0.000	0.052
Denmark	0.004	1.412	0.000	0.000	..	..	..	..	..	..	..	..	0.063	0.022	0.000	0.000
Estonia	0.174	0.042	0.000	0.000	..	..	..	..	..	..	..	..	0.122	0.070	0.000	0.000
Finland	0.107	0.077	0.454	0.060	..	..	..	..	..	..	..	..	0.098	0.034	0.356	0.051
France	0.116	0.032	0.233	0.037	..	..	..	..	..	..	..	..	0.112	0.010	0.197	0.020
Germany	0.142	0.023	0.487	0.014	..	..	..	..	..	..	..	..	0.069	0.008	0.369	0.012
Greece	0.312	0.031	0.431	0.045	..	..	..	..	..	..	..	..	0.156	0.028	0.453	0.025
Hungary	0.089	0.058	0.222	0.074	..	..	..	..	..	..	..	..	0.100	0.022	0.249	0.106
Ireland	0.103	0.136	0.000	0.112	..	..	..	..	..	..	..	..	0.011	0.079	0.371	0.114
Italy	0.288	0.033	0.188	0.046	..	..	..	..	..	..	..	..	0.102	0.011	0.189	0.016
Latvia	0.108	0.022	NA	NA	..	..	..	..	..	..	..	..	0.133	0.077	0.000	0.000
Lithuania	0.206	0.025	0.000	0.000	..	..	..	..	..	..	..	..	0.088	0.063	0.000	0.000
Netherlands	0.095	0.053	0.159	0.021	..	..	..	..	..	..	..	..	0.059	0.017	0.117	0.012
Norway	0.240	0.070	0.000	0.000	..	..	..	..	..	..	..	..	0.095	0.026	0.000	0.000
Poland	0.187	0.041	0.251	0.050	..	..	..	..	..	..	..	..	0.092	0.016	0.335	0.074
Portugal	0.296	0.105	0.151	0.079	..	..	..	..	..	..	..	..	0.151	0.030	0.000	0.000
Slovakia	0.000	0.000	0.334	0.048	..	..	..	..	..	..	..	..	0.056	0.057	0.230	0.026
Slovenia	0.000	0.081	0.335	0.108	..	..	..	..	..	..	..	..	0.000	0.051	0.476	0.100
Spain	0.169	0.043	0.336	0.049	..	..	..	..	..	..	..	..	0.100	0.014	0.263	0.031
Sweden	0.125	0.060	0.375	0.074	..	..	..	..	..	..	..	..	0.064	0.022	0.294	0.035
Switzerland	0.082	0.027	0.175	0.029	..	..	..	..	..	..	..	..	0.071	0.024	0.000	0.000
United Kingdom	0.230	0.025	0.176	0.024	..	..	..	..	..	..	..	..	0.063	0.008	0.216	0.021

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions
NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

Country*	Urinary bladder		Kidney		Brain and CNS		Thyroid		Hodgkin's disease		Non-Hodgkin's lymphoma		Multiple myeloma		Leukaemia	
	188		189		191 & 192		193		201		200 & 202		203		204	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.069	0.035	0.079	0.053	0.102	0.043	0.000	0.081	0.859	0.243	0.165	0.052	0.023	0.160	0.000	0.036
Belgium	0.090	0.029	0.122	0.041	0.000	0.009	0.097	0.191	0.000	0.092	0.033	0.045	0.028	0.105	0.113	0.038
Czech Republic	0.141	0.037	0.130	0.031	0.069	0.038	NA	NA	0.174	0.078	0.055	0.068	0.000	0.052	0.049	0.036
Denmark	0.160	0.043	0.082	0.053	0.036	0.094	NA	NA	0.171	0.165	NA	NA	NA	NA	0.050	0.062
Estonia	0.000	0.119	0.000	0.038	0.073	0.162	0.000	0.000	0.000	0.000	0.239	0.134	0.200	0.066	0.000	0.018
Finland	0.000	0.043	0.040	0.096	0.000	0.011	0.000	0.000	0.000	0.000	0.014	0.257	0.000	0.076	0.000	0.039
France	0.184	0.017	0.111	0.016	0.102	0.017	0.064	0.009	0.301	0.035	0.055	0.017	0.027	0.063	0.037	0.022
Germany	0.222	0.013	0.186	0.012	0.099	0.015	0.305	0.014	0.346	0.014	0.121	0.016	0.274	0.019	0.045	0.022
Greece	0.200	0.036	0.157	0.055	0.173	0.036	0.591	0.033	0.226	0.042	0.174	0.047	0.094	0.031	0.144	0.040
Hungary	0.058	0.029	0.125	0.033	0.000	0.022	0.182	0.100	0.295	0.100	0.106	0.039	0.100	0.084	0.074	0.033
Ireland	NA	NA	0.053	0.102	0.154	0.062	NA	NA	0.323	0.168	0.000	0.006	0.128	0.070	0.000	0.015
Italy	0.145	0.014	0.289	0.025	0.058	0.020	0.158	0.041	0.165	0.046	0.191	0.019	0.117	0.022	0.071	0.014
Latvia	0.080	0.165	0.116	0.098	0.000	0.001	0.762	0.039	0.522	0.048	0.000	0.050	0.000	0.000	0.000	0.039
Lithuania	NA	NA	0.190	0.062	0.000	0.052	0.000	0.000	0.000	0.000	0.287	0.052	0.147	0.019	0.000	0.049
Netherlands	0.066	0.030	0.000	0.038	0.000	0.022	0.000	0.000	0.000	0.000	0.046	0.040	0.000	0.032	0.000	0.030
Norway	NA	NA	0.000	0.031	0.173	0.059	0.437	0.087	0.000	0.000	0.092	0.053	0.125	0.073	0.029	0.166
Poland	0.107	0.020	0.154	0.024	0.117	0.023	0.000	0.000	0.165	0.044	0.197	0.032	0.116	0.039	0.068	0.027
Portugal	0.302	0.058	0.290	0.072	0.085	0.050	0.000	0.000	0.174	0.123	0.225	0.059	0.039	0.083	0.163	0.042
Slovakia	0.112	0.065	0.121	0.063	0.146	0.087	0.341	0.032	0.259	0.029	0.129	0.026	0.186	0.059	NA	NA
Slovenia	0.209	0.100	0.000	0.041	0.315	0.146	0.000	0.000	0.000	0.000	0.158	0.119	0.000	0.165	0.000	0.058
Spain	0.212	0.025	0.217	0.029	0.098	0.026	0.000	0.000	0.194	0.044	0.191	0.030	0.083	0.034	0.057	0.020
Sweden	0.093	0.038	0.041	0.046	0.058	0.053	0.034	0.008	0.320	0.070	0.043	0.043	0.000	0.023	0.108	0.034
Switzerland	0.089	0.044	0.000	0.063	0.000	0.239	0.332	0.047	0.000	0.000	0.022	0.008	0.054	0.099	0.145	0.053
United Kingdom	0.126	0.014	0.068	0.017	0.113	0.017	0.128	0.010	0.184	0.021	0.111	0.014	0.061	0.025	0.039	0.024

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions

NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

(b) Females

Country*	Oral cavity and pharynx		Oesophagus		Stomach		Large bowel		Liver		Gallbladder		Pancreas		Larynx		Lung		Pleura	
	140-149		150		151		153, 154 & 159.0		155		156		157		161		162		163	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.245	0.079	0.000	0.077	0.130	0.039	0.122	0.034	0.000	0.038	0.141	0.054	0.095	0.033	0.190	0.154	0.221	0.060	0.273	0.127
Belgium	0.321	0.083	0.194	0.071	0.149	0.040	0.063	0.020	0.173	0.052	0.045	0.083	0.052	0.030	0.178	0.098	0.221	0.049	0.460	0.109
Czech Republic	0.124	0.074	0.000	0.060	0.124	0.029	0.095	0.022	0.062	0.040	0.093	0.028	0.028	0.045	0.000	0.114	0.317	0.061	0.311	0.152
Denmark	0.166	0.071	0.082	0.087	0.085	0.051	0.062	0.026	0.158	0.092	NA	NA	0.080	0.034	0.000	0.000	0.126	0.027	0.000	0.000
Estonia	0.193	0.046	0.317	0.043	0.224	0.063	0.180	0.064	0.222	0.070	0.000	0.000	NA	NA	0.000	0.000	0.162	0.068	0.000	0.000
Finland	0.000	0.077	0.000	0.075	0.000	0.027	0.076	0.035	0.325	0.083	0.134	0.054	0.138	0.039	0.000	0.000	0.340	0.063	0.405	0.051
France	0.207	0.030	0.255	0.030	0.205	0.020	0.091	0.010	0.139	0.020	0.239	0.025	0.112	0.015	0.251	0.038	0.236	0.020	0.401	0.041
Germany	0.251	0.020	0.355	0.021	0.175	0.010	0.087	0.006	0.262	0.018	0.286	0.014	0.077	0.011	0.388	0.010	0.285	0.011	0.438	0.014
Greece	0.000	0.000	0.000	0.000	0.426	0.051	0.199	0.033	0.232	0.037	0.342	0.041	0.188	0.048	0.001	0.000	0.244	0.038	0.000	0.000
Hungary	0.236	0.053	0.290	0.076	0.071	0.020	0.069	0.017	0.140	0.038	0.118	0.027	0.137	0.031	0.265	0.077	0.210	0.052	0.000	0.000
Ireland	0.000	0.053	0.164	0.074	0.094	0.046	NA	NA	0.091	0.149	0.269	0.109	NA	NA	0.112	0.567	0.183	0.054	0.000	0.000
Italy	0.238	0.032	0.475	0.047	0.289	0.022	0.124	0.011	0.319	0.026	0.159	0.018	0.241	0.021	0.454	0.042	0.359	0.030	0.533	0.047
Latvia	0.305	0.044	0.471	0.041	0.247	0.056	0.149	0.044	0.522	0.101	0.363	0.047	0.160	0.073	0.513	0.039	0.326	0.075	0.754	0.033
Lithuania	0.370	0.039	0.000	0.000	0.172	0.043	0.154	0.033	0.000	0.147	0.140	0.032	0.073	0.088	0.000	0.000	0.278	0.061	0.401	0.022
Netherlands	0.234	0.064	0.149	0.051	0.125	0.028	0.072	0.018	0.019	0.296	0.085	0.058	0.074	0.024	0.369	0.045	0.195	0.028	0.294	0.041
Norway	0.285	0.092	0.188	0.060	0.079	0.047	0.116	0.028	0.065	0.307	0.228	0.089	0.098	0.045	0.000	0.000	0.215	0.044	0.082	0.020
Poland	0.159	0.046	0.155	0.044	0.120	0.018	0.136	0.018	0.155	0.023	0.239	0.030	0.117	0.020	0.261	0.064	0.346	0.038	0.151	0.030
Portugal	0.138	0.120	0.590	0.111	0.244	0.042	0.102	0.023	0.105	0.052	0.192	0.061	0.133	0.040	0.000	0.000	0.292	0.059	0.195	0.026
Slovakia	0.209	0.127	0.227	0.034	0.074	0.061	0.160	0.034	0.177	0.070	0.212	0.058	0.188	0.054	0.000	0.000	0.203	0.045	0.000	0.000
Slovenia	0.000	0.090	0.000	0.297	0.133	0.063	0.118	0.073	0.401	0.143	0.107	0.109	0.085	0.122	0.000	0.027	0.246	0.086	0.000	0.000
Spain	0.044	0.115	0.346	0.058	0.223	0.026	0.111	0.015	0.248	0.031	0.206	0.030	0.126	0.021	0.000	0.000	0.150	0.024	0.219	0.031
Sweden	0.192	0.075	0.035	0.012	0.131	0.042	0.052	0.023	0.165	0.051	0.091	0.036	0.065	0.029	0.250	0.032	0.190	0.038	0.136	0.046
Switzerland	0.224	0.040	0.204	0.037	0.124	0.045	0.014	0.099	0.217	0.049	0.197	0.060	0.070	0.039	0.555	0.049	0.204	0.043	0.578	0.052
United Kingdom	0.179	0.028	0.173	0.016	0.246	0.019	0.066	0.008	0.202	0.025	0.242	0.032	0.058	0.015	0.281	0.032	0.269	0.017	0.739	0.025

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions

NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

Country*	Melanoma		Skin (other)		Breast		All uterus		All uterus Under 50		Ovary		Prostate		Testis	
	172		173		174		179-182		179-182		183		185		186	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.099	0.055	0.124	0.158	0.066	0.020	NA	NA	0.147	0.083	0.000	0.025	..	..	..	..
Belgium	0.169	0.069	0.000	0.093	0.066	0.018	0.090	0.033	0.100	0.098	0.135	0.036	..	..	..	..
Czech Republic	0.131	0.065	0.000	0.056	0.064	0.016	0.149	0.033	0.168	0.054	0.095	0.026	..	..	..	..
Denmark	0.000	0.043	0.000	0.069	0.091	0.022	0.092	0.038	0.053	0.206	0.055	0.035	..	..	..	..
Estonia	0.000	0.000	0.000	0.000	0.128	0.050	0.000	0.097	0.115	0.375	0.078	0.058	..	..	..	..
Finland	0.092	0.177	0.364	0.048	0.135	0.028	0.000	0.049	NA	NA	0.000	0.000	..	..	..	..
France	0.171	0.028	0.150	0.018	0.100	0.009	0.137	0.015	0.232	0.036	0.126	0.014	..	..	..	..
Germany	0.100	0.016	0.681	0.013	0.098	0.006	0.200	0.011	0.336	0.020	0.081	0.010	..	..	..	..
Greece	0.000	0.000	0.318	0.036	0.156	0.025	0.176	0.054	0.319	0.028	0.166	0.046	..	..	..	..
Hungary	0.000	0.045	NA	NA	0.122	0.022	0.096	0.024	0.164	0.054	0.105	0.029	..	..	..	..
Ireland	0.218	0.111	0.000	0.000	NA	NA	0.082	0.057	0.201	0.151	0.116	0.050	..	..	..	..
Italy	0.221	0.033	0.137	0.019	0.167	0.014	0.163	0.016	0.240	0.042	0.183	0.018	..	..	..	..
Latvia	0.000	0.000	NA	NA	0.101	0.030	0.155	0.055	0.352	0.122	0.000	0.049	..	..	..	..
Lithuania	0.265	0.031	0.000	0.000	0.119	0.028	0.147	0.046	0.251	0.061	0.076	0.035	..	..	..	..
Netherlands	0.125	0.060	0.281	0.033	0.055	0.012	0.015	0.126	0.052	0.215	0.029	0.028	..	..	..	..
Norway	0.221	0.072	0.000	0.000	0.069	0.023	0.114	0.045	0.219	0.135	0.137	0.043	..	..	..	..
Poland	0.108	0.052	0.181	0.052	0.136	0.017	0.142	0.018	0.131	0.031	0.091	0.018	..	..	..	..
Portugal	0.162	0.097	0.283	0.074	0.231	0.042	0.202	0.043	0.086	0.105	0.245	0.053	..	..	..	..
Slovakia	0.114	0.151	0.651	0.082	0.194	0.034	0.140	0.039	0.128	0.107	0.161	0.052	..	..	..	..
Slovenia	0.356	0.145	0.510	0.103	0.132	0.050	0.067	0.174	0.308	0.217	0.046	0.167	..	..	..	..
Spain	0.109	0.030	0.449	0.059	0.134	0.016	0.203	0.028	0.209	0.039	0.090	0.020	..	..	..	..
Sweden	0.000	0.158	0.321	0.059	0.103	0.024	0.180	0.044	NA	NA	0.086	0.034	..	..	..	..
Switzerland	0.000	0.000	0.001	0.000	0.058	0.020	0.000	0.019	0.247	0.046	0.095	0.034	..	..	..	..
United Kingdom	0.214	0.022	0.198	0.017	0.041	0.007	0.124	0.013	0.233	0.029	0.051	0.011	..	..	..	..

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions
NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

Country*	Urinary bladder		Kidney		Brain and CNS		Thyroid		Hodgkin's disease		Non-Hodgkin's lymphoma		Multiple myeloma		Leukaemia	
	188		189		191 & 192		193		201		200 & 202		203		204	
	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE	RRSD	SE
Austria	0.287	0.093	0.092	0.066	0.088	0.042	0.248	0.086	0.811	0.223	0.164	0.049	0.000	0.027	0.000	0.029
Belgium	0.199	0.063	0.103	0.040	0.000	0.043	0.000	0.090	NA	NA	NA	NA	0.000	0.007	0.056	0.037
Czech Republic	0.273	0.076	0.177	0.041	0.126	0.038	0.184	0.092	NA	NA	0.073	0.052	0.096	0.055	0.029	0.052
Denmark	0.130	0.061	0.000	0.036	0.051	0.098	NA	NA	0.140	0.048	0.000	0.084	0.138	0.068	0.000	0.033
Estonia	0.000	0.000	0.000	0.000	NA	NA	0.526	0.061	0.000	0.000	0.267	0.063	0.000	0.000	0.000	0.067
Finland	0.215	0.088	NA	NA	0.000	0.027	0.270	0.131	0.393	0.050	0.000	0.041	0.089	0.115	0.094	0.082
France	0.122	0.025	0.138	0.022	0.098	0.021	0.143	0.056	0.198	0.029	0.054	0.020	0.055	0.029	0.061	0.018
Germany	0.263	0.017	0.169	0.015	0.230	0.019	0.230	0.019	0.230	0.019	0.103	0.017	0.311	0.018	0.044	0.028
Greece	0.194	0.050	0.000	0.000	0.166	0.047	0.268	0.027	0.071	0.009	0.000	0.000	0.149	0.036	0.056	0.019
Hungary	0.136	0.039	0.113	0.042	0.000	0.018	0.161	0.085	0.105	0.103	0.128	0.046	0.158	0.064	0.099	0.033
Ireland	0.000	0.057	NA	NA	NA	NA	0.000	0.074	0.000	0.223	0.046	0.136	0.000	0.263	0.123	0.072
Italy	0.154	0.024	0.305	0.029	0.101	0.022	0.066	0.050	0.124	0.029	0.232	0.022	0.141	0.023	0.061	0.017
Latvia	0.000	0.000	NA	NA	0.263	0.122	0.000	0.000	0.000	0.000	0.033	0.008	0.348	0.050	0.117	0.106
Lithuania	0.367	0.041	0.188	0.069	0.228	0.062	0.000	0.000	0.331	0.027	0.195	0.033	0.000	0.000	0.075	0.066
Netherlands	NA	NA	0.000	0.022	0.087	0.045	0.000	0.000	0.000	0.000	0.100	0.034	0.099	0.047	0.092	0.040
Norway	0.091	0.111	0.164	0.064	0.100	0.096	0.187	0.061	0.000	0.000	0.117	0.051	0.076	0.078	0.033	0.161
Poland	0.293	0.045	0.164	0.029	0.139	0.027	0.113	0.078	0.213	0.060	0.273	0.040	0.134	0.038	0.084	0.027
Portugal	0.210	0.067	0.181	0.069	0.165	0.063	0.375	0.083	0.122	0.145	0.207	0.054	0.205	0.060	0.057	0.040
Slovakia	0.119	0.163	0.139	0.070	0.000	0.000	0.000	0.000	0.048	0.008	0.280	0.072	0.346	0.077	0.000	0.082
Slovenia	0.000	NA	0.108	0.145	0.377	0.163	0.000	0.136	0.577	0.089	0.000	0.061	0.024	0.863	0.348	0.148
Spain	0.088	0.027	0.167	0.040	0.079	0.032	0.170	0.044	0.085	0.021	0.200	0.030	0.110	0.032	0.042	0.024
Sweden	0.122	0.084	0.091	0.042	0.000	0.003	0.000	0.000	0.189	0.061	0.050	0.065	0.112	0.054	0.087	0.063
Switzerland	0.000	0.056	0.157	0.036	0.067	0.065	0.132	0.021	0.273	0.032	0.156	0.050	NA	NA	0.080	0.067
United Kingdom	0.164	0.018	0.111	0.023	0.047	0.026	0.166	0.018	0.065	0.007	0.066	0.017	0.000	0.000	0.065	0.022

* RRSDs cannot be calculated for Cyprus, Iceland, Luxembourg and Malta as they have only 1 or 2 regions

NA denotes situations where it was not possible to estimate the RRSD because of numerical problems see Results paragraph 4

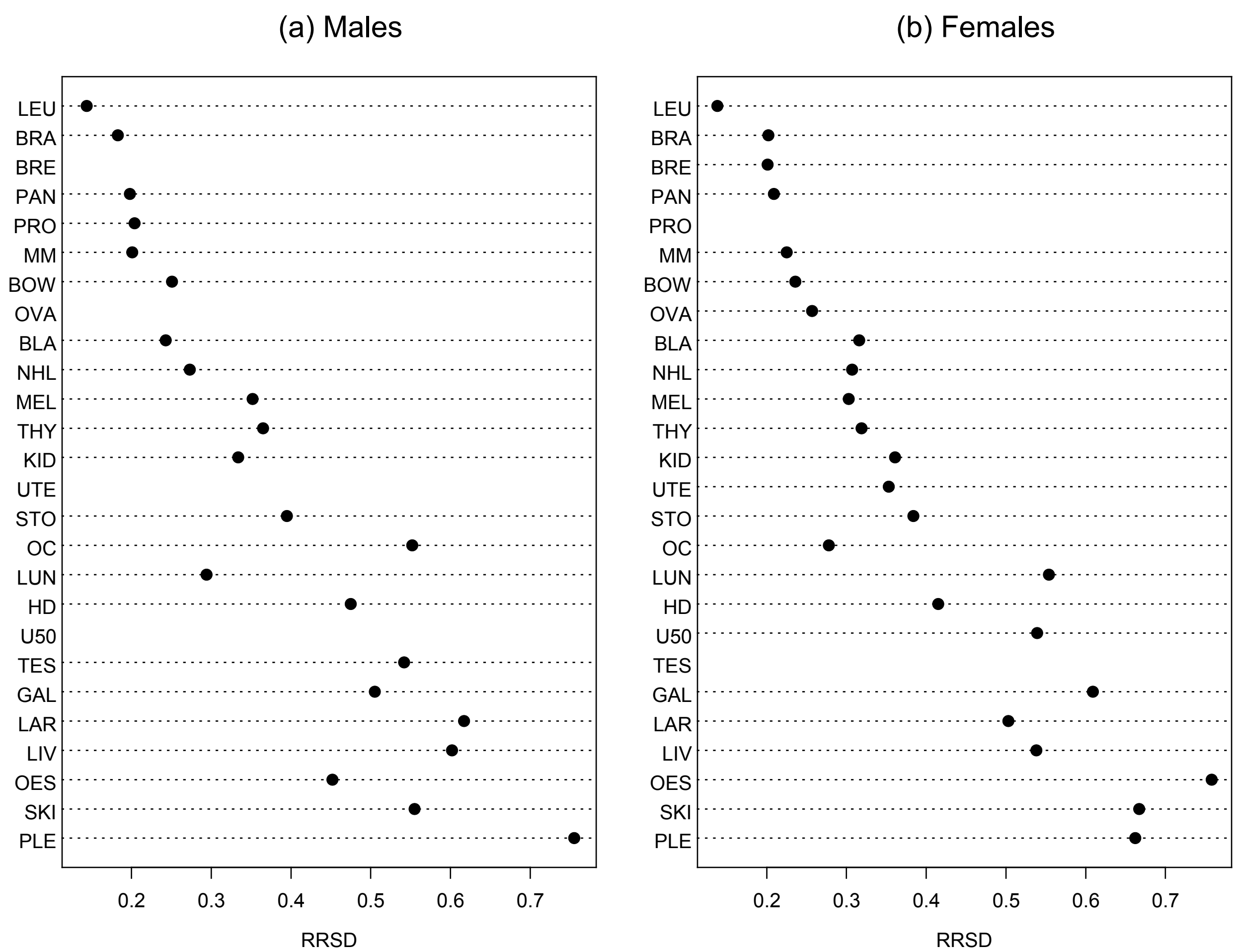
Table 5.4: Moran's I and correlations

Cancer site	Moran's I				Corr
	Males		Females		
	Value	Rank	Value	Rank	
Oral cavity and pharynx	0.794	3	0.236	19	0.407
Oesophagus	0.702	7	0.824	1	0.562
Stomach	0.816	1	0.715	6	0.897
Large bowel	0.736	6	0.700	8	0.830
Liver	0.802	2	0.736	5	0.730
Gallbladder	0.582	10	0.790	3	0.873
Pancreas	0.468	14	0.413	13	0.433
Larynx	0.756	5	0.206	21	0.289
Lung	0.761	4	0.793	2	0.187
Pleura	0.469	13	0.343	15	0.551
Melanoma	0.415	15	0.317	17	0.735
Skin (other)	0.401	16	0.387	14	0.737
Breast	..	..	0.700	7	..
All uterus	..	..	0.770	4	..
All uterus under 50	..	..	0.566	..	..
Ovary	..	..	0.573	9	..
Prostate	0.656	8	..	..	..
Testis	0.285	20	..	..	..
Urinary bladder	0.513	11	0.463	12	0.229
Kidney	0.630	9	0.537	10	0.838
Brain and CNS	0.287	22	0.251	22	0.683
Thyroid	0.184	19	0.203	18	0.526
Hodgkin's disease	0.351	17	0.213	20	0.559
Non-Hodgkin's lymphoma	0.508	12	0.507	11	0.808
Multiple myeloma	0.332	18	0.330	16	0.707
Leukaemia	0.195	21	0.163	23	0.520
All cancer (ICD-9 140-208)	0.773		0.776		0.439

Table 5.5: Cancer site codes for the Figures

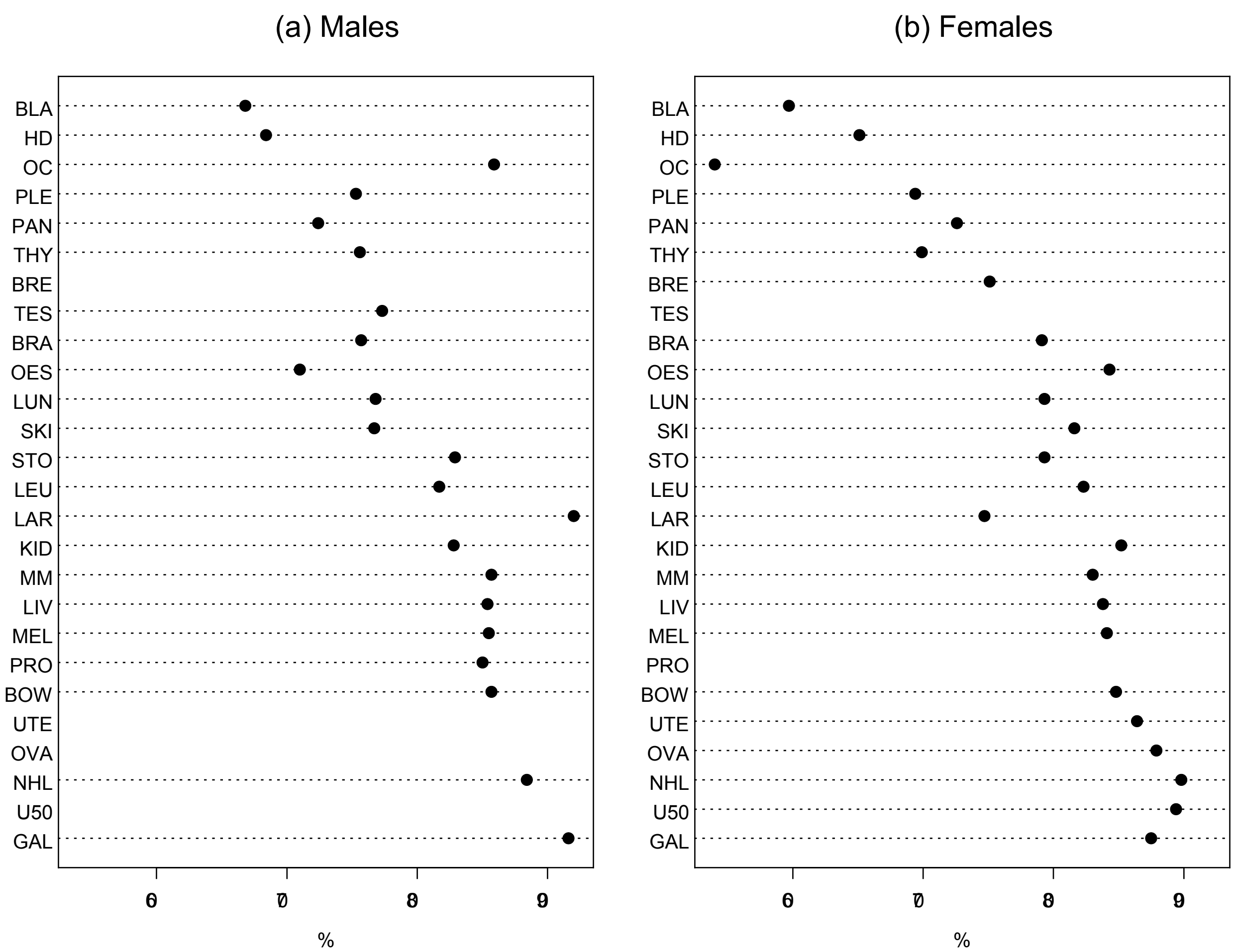
Cancer site	Figures 1 to 3	Figures 4 & 5
Oral cavity and pharynx	OC	OC
Oesophagus	OES	Oe
Stomach	STO	St
Large bowel	BOW	Bo
Liver	LIV	Li
Gallbladder	GAL	G
Pancreas	PAN	Pn
Larynx	LAR	La
Lung	LUN	Lu
Pleura	PLE	Pl
Melanoma	MEL	Ml
Skin (other)	SKI	Sk
Breast	BRE	Br
All uterus	UTE	U
All uterus under 50	U50	U50
Ovary	OVA	O
Prostate	PRO	Pr
Testis	TES	Ts
Urinary bladder	BLA	Bl
Kidney	KID	K
Thyroid	THY	Th
Brain and CNS	BRA	Bn
Hodgkin's disease	HD	HD
Non-Hodgkin's lymphoma	NHL	NHL
Multiple myeloma	MM	MM
Leukaemia	LEU	Le

Figure 5.1: Relative risk standard deviation (RRSD) for each cancer site*, ordered by the average value for males and females combined



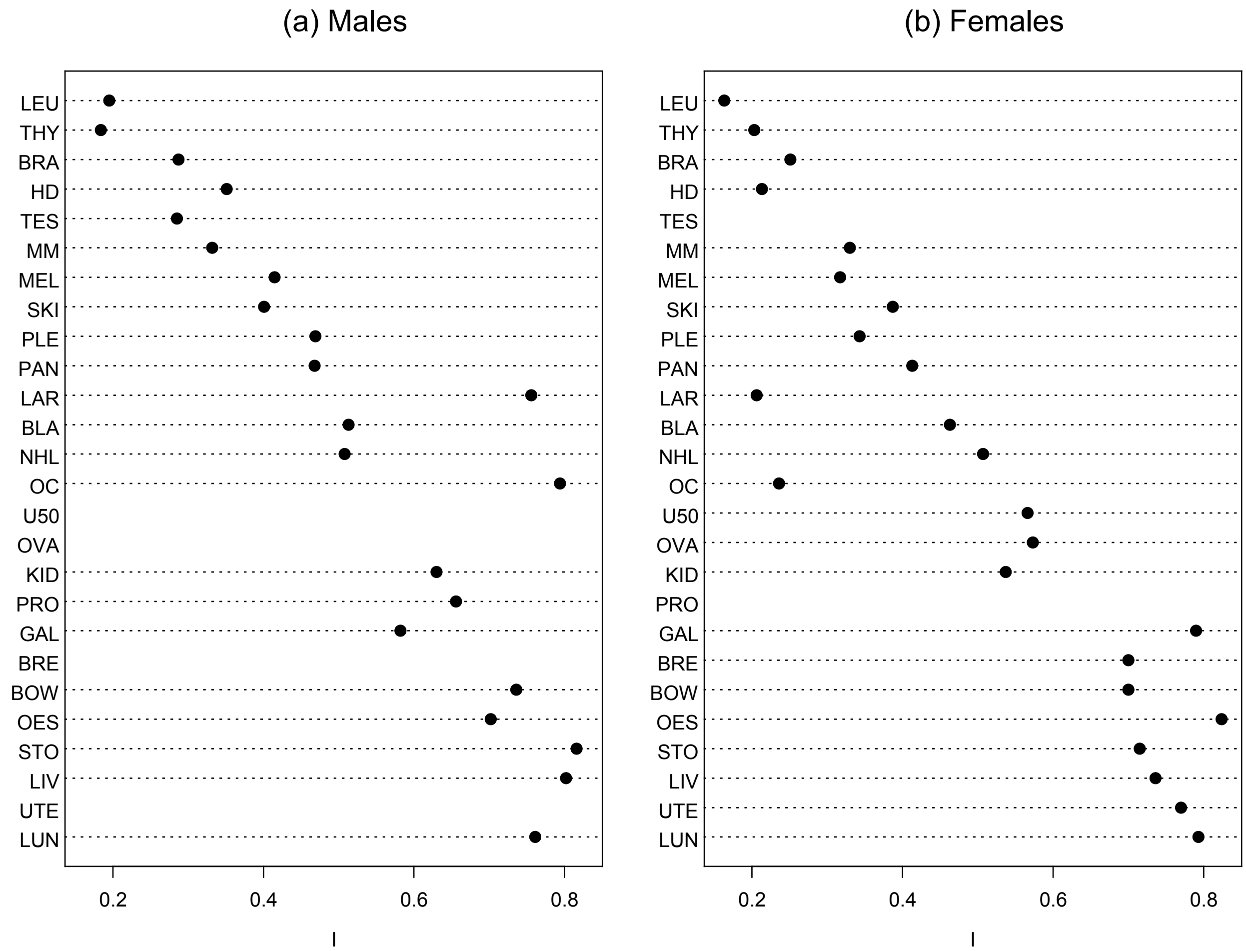
* See Table 5.5 for the cancer site codes

Figure 5.2: Percentage of variation associated with country for each cancer site*, ordered by the average value for males and females combined



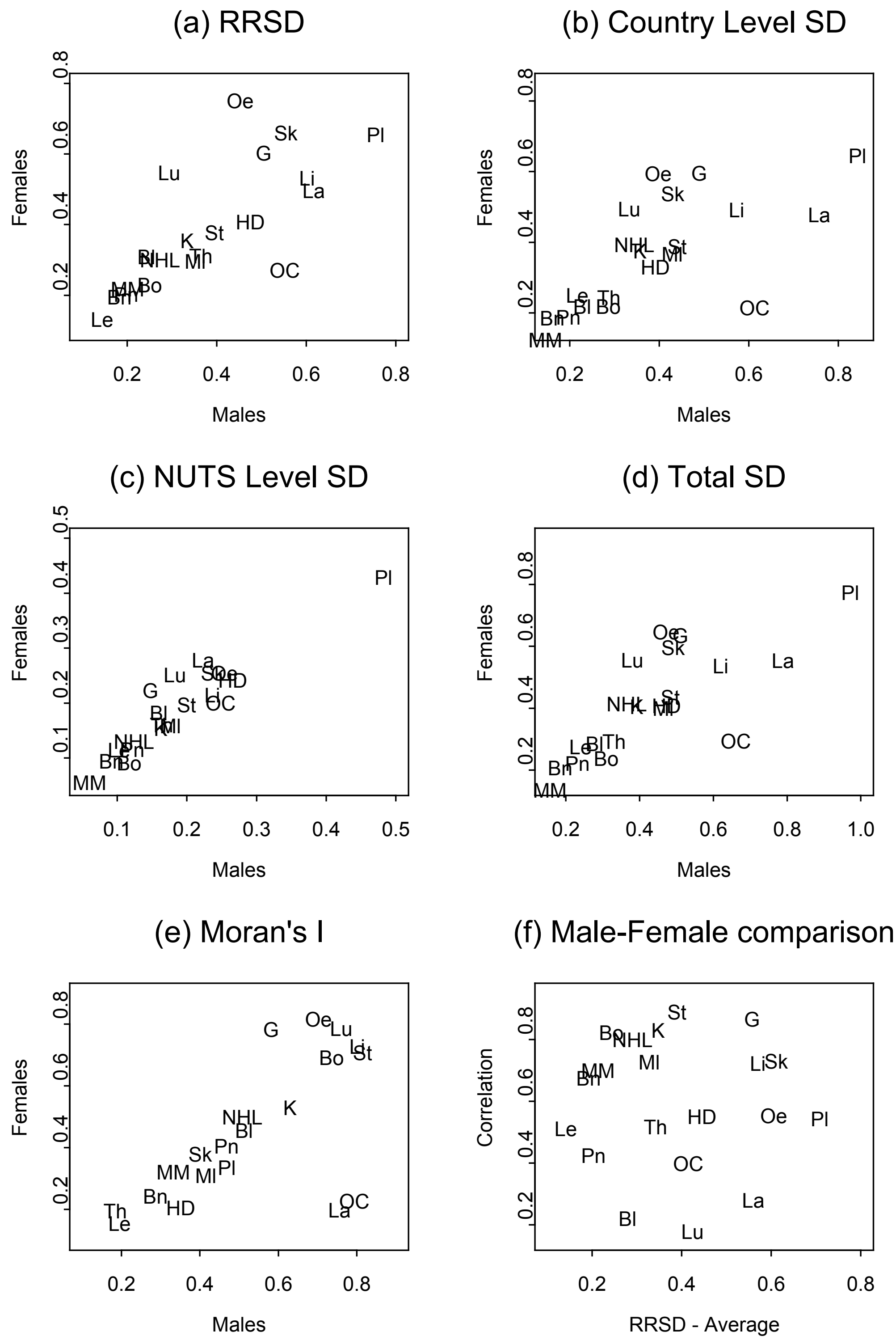
* See Table 5.5 for the cancer site codes

Figure 5.3: Spatial correlation – Moran's I – for each cancer site*, ordered by the average value for males and females combined



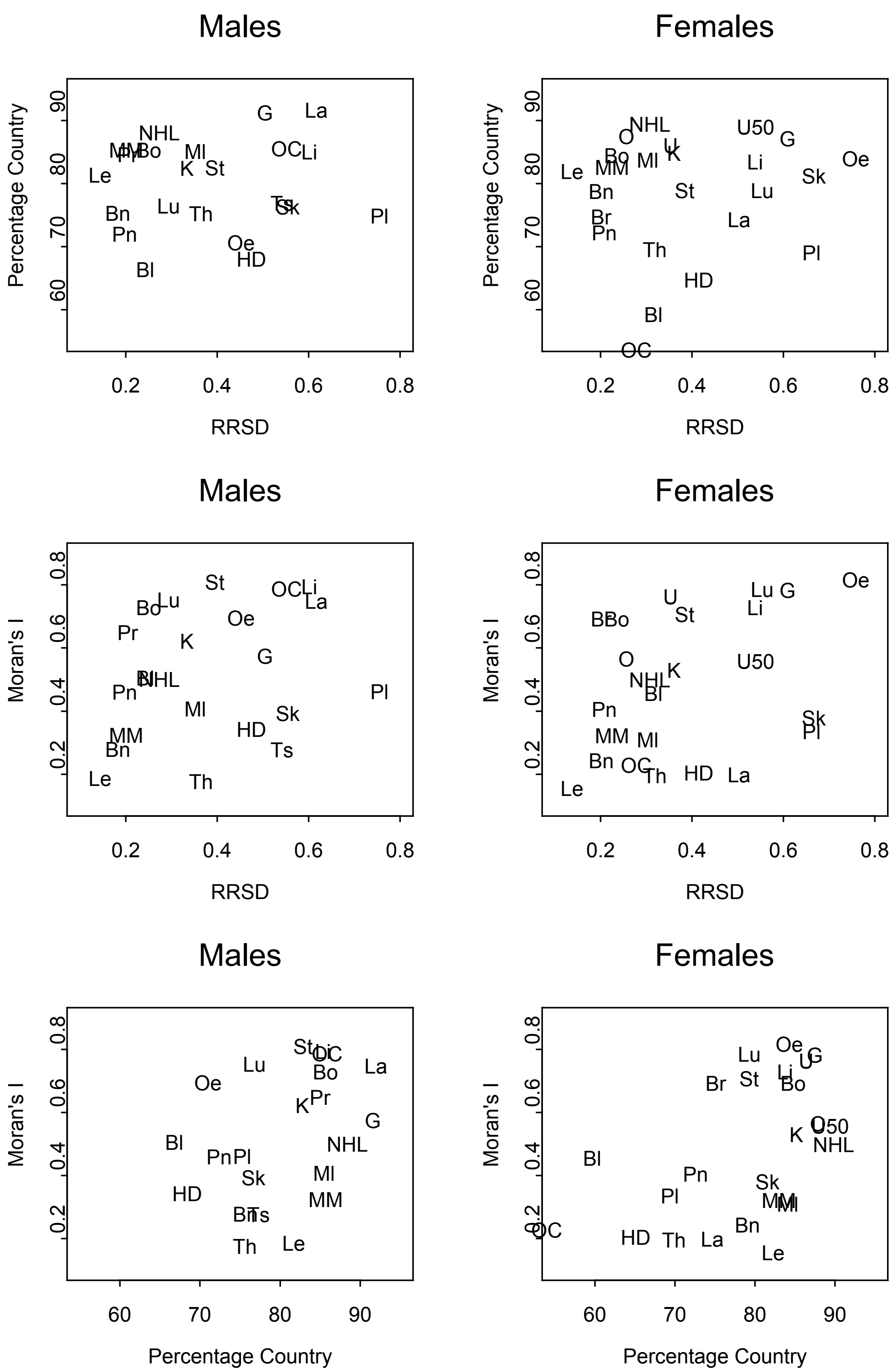
* See Table 5.5 for the cancer site codes

Figure 5.4: Comparisons between spatial statistics for males and females



See Table 5.5 for the cancer site codes

Figure 5.5: Comparisons of measures of variability and spatial correlation



See Table 5.5 for the cancer site codes

References

Anselin L (1995). Local indicators of spatial association – LISA. *Geographical Analysis*, 27 no. 2.

Anselin L, Syabri I & Smirnov O (2002). Visualizing Multivariate Spatial Correlation with Dynamically Linked Windows. (http://www.dpi.inpe.br/gilberto/csiss/contributors.htm)

Breslow N (1984). Extra Poisson variation in log linear models. *Applied Statistics*, 39:38-44.

Clayton D & Kaldor J (1987). Empirical Bayes estimates of age standardized relative risks for use in disease mapping. *Biometrics*, 43:671-681.

Cliff AD & Ord JK. *Spatial processes: models and applications*. London, Pion, 1981.

Gebhardt F (1998). Survey on cluster tests for spatial area data. GMD Report. GMD, Sankt Augustin, 52 pages. (http://www.gmd.de/People/Friedrich.Gebhardt/Survey.pdf)

Ihaka R & Gentleman R (1996). R: A Language for Data Analysis and Graphics. *Journal of Computational and Graphical Statistics*, 5:299-314. http://www.r-project.org/

Langford IH & Day RJ. Poisson Regression. In: Leyland AH & Goldstein H, eds. *Multilevel Modelling of Health Statistics*. Chichester, Wiley, 2001:45-58.

Langford IH, Leyland AH, Rasbash J & Goldstein H (1999). Multilevel modelling of the geographical distribution of rare diseases. *Applied Statistics*, 48:253-268.

Leyland AH, Langford IH, Rasbash J & Goldstein H (2000). Multivariate spatial models for event data. *Statistics in Medicine*, 19:2469-2478.

Magalhaes A, Hewings JD & Azzoni CA (2000). Spatial dependence and regional convergence in Brazil. REAL Tech Report 00-T 11.

Pennello GA, Devesa SS & Gail MH (1999). Using a Mixed Effects Model to Estimate Geographic Variation in Cancer Rates. *Biometrics*, 55:774-781.

Rasbash J, Browne W, Goldstein H et al. *A User's Guide to MLwiN*. London, Institute of Education Multilevel Models Project, 2000.

S-PLUS Version 7.0. Insightful Corporation, 2005.