Public Health England

Protecting and improving the nation's health

National Cancer Registration and Analysis Service

Deprivation and cancer: in search of a common measure across England, Wales, Scotland, Northern Ireland and Ireland

Based on cancer incidence and mortality data, 2008-2012

About Public Health England

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Foreword

In this report we examine whether there is a common metric within the deprivation measures that can be applied across the five countries of England, Wales, Scotland, Northern Ireland and Ireland (*see footnote below). There are no consistent deprivation indices between the five countries, each of which currently uses a number of different metrics and methodologies. Many studies have examined cancer rates by deprivation in one or more of the countries of the UK and Ireland. However, because of differences in how deprivation indices are derived in these countries, none of these studies have directly compared the effect of deprivation on cancer incidence and mortality across the UK and Ireland. This report analyses three common metrics used to measure deprivation across the five countries. It examines the extent to which the relationship between deprivation and cancer is independent of the way deprivation is measured.

As a result this enables, for the first time, the variation of cancer incidence and mortality by socioeconomic deprivation to be examined across these countries. The report analyses incidence and mortality data for the period 2008-2012.

This report builds on existing work, the National Cancer Intelligence Network (NCIN) report *Cancer by deprivation in England*, on cancer and socioeconomic deprivation. Data were analysed for nine cancer sites, where previous studies across the five countries had found significant relationships between deprivation and either incidence or mortality. Similar analyses by cancer registries in the other countries have found similar relationships.

The aim of the analysis is to update and enhance our understanding of the variation in the incidence of new cancer cases and the number of deaths, and the association between the two, between the most and least deprived groups across the five countries. The rates for all five countries are analysed, and the association between deprivation and cancer incidence and mortality across the UK and Ireland explored.

This report also provides further insights into the factors that might underlie these ‘deprivation gaps’; to help develop and evaluate effective cancer prevention as part of other universal population health improvement action that is also targeted to reduce inequities, but without inadvertently widening them. In addition, our report could influence community and health service efforts aimed at achieving better and more equitable outcomes for everyone affected by cancer.

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* The order of presentation for countries in this report is based on the recommendations in the Office for National Statistics publication *Guide to Presenting Statistics - General Principle* (Nov 2015).

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This report was a collaborative piece of work with a significant contribution from our cancer colleagues in England, Wales, Scotland, Northern Ireland, and Ireland. Our co-authors on this report are Claudia Oehler[1], Luke Hounsome[1], Lucy Elliss-Brookes[1], Julia Verne[2], Ceri White[3], Dyfed Wyn Huws[3], Steven Hecht[4], Andy Deas[4], David Brewster[4], David Donnelly[5], Anna Gavin[5], Sandra Deady[6] and Harry Comber[6].

Organisations that have provided data, substantial content and expertise include National Cancer Registration and Analysis Service, Public Health England[1]; Public Health England[2]; Welsh Cancer Intelligence and Surveillance Unit, Public Health Wales[3]; Scottish Cancer Registry[4]; Northern Ireland Cancer Registry[5]; and National Cancer Registry, Ireland[6].

We would like to acknowledge the essential work of the National Cancer Registration Service, and the United Kingdom and Ireland Association of Cancer Registries (UKIACR), without which there would be no data. In addition, PHE colleagues from the National Cancer Registration and Analysis Service analytical team and the National Cancer Registration and Analysis Service coordinating team have provided invaluable contributions and helped with this publication.

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Executive summary

1. This report examines, for the first time, the variation in cancer incidence and mortality by socioeconomic deprivation across the countries of the UK and Ireland; and whether there is a common metric within the deprivation measures that can be applied across the five countries.

2. It shows that the relationship between deprivation and cancer is to a large extent independent of the way deprivation is measured in England, Wales, Scotland, Northern Ireland, and Ireland. The three deprivation metrics: (i) the Indices of Multiple Deprivation (IMD), (ii) education and, (iii) unemployment, produced very similar trends in age-standardised rates for cancer incidence and mortality. This comparability, between the deprivation metrics, shows that the IMD deprivation measure is robust, despite the differences in the methodologies across the five countries.

3. The unemployment metric may be a suitable measure of deprivation when comparing age-standardised rates across countries. The unemployment metric provides a better fit than the education metric (89% v 80%) compared with the IMD metric.

4. Across the deprivation quintiles, there were similarities in age-standardised rates, and trends in age-standardised rates, for incidence and mortality throughout the UK and Ireland, with similar results in most cases.

5. As expected, there were significant deprivation trends for most cancers that we choose to study. There was no significant trend across the deprivation quintiles in any of the countries, for the incidence rates of female colorectal cancer and the mortality rates of prostate cancer. For three cancers: breast, malignant melanoma of the skin and prostate, there were higher incidence rates associated with lower levels of deprivation; but this only translated into higher mortality rates among the least deprived for malignant melanoma of skin.

6. For the majority of cancers, there were no significant differences between incidence and mortality age-standardised rates (ASRs) in England, and those in Wales or Northern Ireland. Incidence and mortality ASRs were higher for most cancers in Scotland; incidence ASRs were higher for many sites in Ireland.

7. Colorectal cancer was the only cancer that had significantly higher incidence rates for males and females throughout the UK and Ireland, as well as in the

UK as a whole, compared with England; with mortality rates also significantly higher for males throughout the UK, compared with England.

Chapter 1: Introduction

Deprivation has long been known to have a significant detrimental impact on people's health. The Marmot Review *Fairer Society, Healthy Lives* highlighted that deprivation, measured variously by social class, income, employment status, educational attainment and area deprivation quintile, impacts on health in a wide variety of ways. Higher levels of deprivation were found to be associated with higher mortality rates, higher rates of mental illness, higher rates of limiting illness, higher rates of obesity[1] and lower life expectancy.[1,2] The review described the importance of measures to address the wider determinants of health as well as interventions to prevent ill health by improving health behaviours.

Cancer was the leading cause of death in England and Wales, Scotland and Northern Ireland in 2013.[3,4,5] In 2013, cancer was the second most common cause of death in Ireland.[6] Inequalities in cancer incidence and mortality rates have been observed, related to a number of factors, such as sex, age, ethnicity and by area deprivation.[7,8] Previous studies have shown a strong link between socioeconomic deprivation, and incidence and mortality rates, across many cancer sites. [9,10,11,12,13,14] The NCIN has previously shown that the number of excess cancer deaths that is related to deprivation is very large.[10]

In all five countries examined, a very strong link has been shown between incidence rates of lung cancer and deprivation, with the most deprived areas having the highest incidence and mortality rates. In Wales, lung cancer incidence shows the widest inequality of the four most common cancers by area deprivation quintile, and the gap is widening.[15] Overall one-year survival for lung cancer shows no relationship with area deprivation in Wales; however, for patients with stage 1 disease one-year survival does vary by area deprivation, with better survival rates in the least deprived areas of Wales.[16] The incidence of other smoking related cancers has also been shown to be highest among the most deprived areas in England and Scotland. Incidence rates of cervical cancer (England, Scotland, Northern Ireland and Ireland) and stomach cancer (England and Scotland) were found to be highest in the most deprived quintile (England, Scotland, Northern Ireland and Ireland). There is also evidence of higher incidence (England, Wales, Scotland and Northern Ireland) and mortality (England, Wales and Scotland) rates for colorectal cancer among the most deprived areas.

For breast and prostate cancer, as well as malignant melanoma of the skin, the inverse trend of lower incidence rates among the most deprived has been observed previously. But this inverse relationship does not necessarily hold for their mortality rates.[10]

A review of social inequalities and cancer was undertaken by the International Agency for Research on Cancer (IARC).[17] It included a wide range of studies, from a number of countries, examining differences in cancer incidence and mortality rates by social inequality. It considered social inequalities in a number of ways, including by social class, by occupational group, by income and by education level. It found that, for the majority of cancer sites, incidence and mortality rates increased for those of lower social class, lower occupational status, lower income and lower education levels. The study also investigated risk factors such as tobacco

smoking, alcohol consumption and diet, which could help explain the differences in cancer incidence and mortality rates observed across different social groups. Those with lower socioeconomic status were found to have higher rates of exposure to many risk factors, which could at least partially explain the higher incidence and mortality rates observed. The *Global Burden of Disease* study 2013[18] showed that behavioural risk factors made the greatest contribution to years lost to death and disability. Known risk factors operating together explained 40% of ill health in England; unhealthy diet and tobacco were the two largest contributors to disease burden.

In 2011, the Centre for Cancer Prevention and Cancer Research UK published a report on the fraction of cancer attributable to lifestyle and environment factors in the UK,[19] which explored the impact of many of the above factors (tobacco, alcohol, diet, and infection), as well as other factors such as obesity and solar radiation exposure, on the rates of cancer incidence. Such a project is also ongoing in Wales by a collaboration of Cancer Research UK and the Welsh Cancer Intelligence and Surveillance Unit. This analysis was not systematically linked to socioeconomic status or deprivation.

Cancer incidence and mortality rates in the countries of the UK and Ireland have been previously compared.[20] The effect of deprivation on cancer incidence and mortality also has been compared for one or more of these five countries.[20,21] However, a comparison of deprivation between all five countries has not yet been examined because of methodological differences in the creation of the deprivation indices in the five countries.

The aims of this report are:

- to analyse, for the first time, the impact of socioeconomic deprivation on incidence and mortality rates, for a number of cancer sites, across the five countries of England, Wales, Scotland, Northern Ireland and Ireland,[22] using a number of measures of deprivation

- to determine whether there is a common metric within the deprivation measures that can be applied across the five countries

- to summarise recent data and information regarding deprivation quintiles and risk factors known to be linked to cancer incidence and mortality

Chapter 2: Methods

2.1 Data

Incidence data were based on newly diagnosed cases of cancer during 2008-2012, registered by the following five population-based cancer registries: the National Cancer Registration Service, Public Health England (PHE); the Welsh Cancer Intelligence and Surveillance Unit (WCISU); the Information Services Division (ISD) of NHS National Services Scotland; the Northern Ireland Cancer Registry (NICR); and the National Cancer Registry of Ireland (NCRI). Incident cases of cancer are counted for each separate primary tumour. One person may be diagnosed with more than one tumour, and would then appear twice in the incidence data. Recurrences of a previous cancer are not counted as new incident cases.

Mortality data were those deaths registered with an underlying cause of cancer during 2008-2012, as supplied by the Office for National Statistics (ONS) for England and Wales; National Records of Scotland; and the General Register Office for Northern Ireland (GRONI). Mortality data were not available for Ireland at a small enough geographic area to analyse by deprivation quintiles; and so no mortality data for Ireland could be included in this analysis.

Population data for the period 2008-2012 were provided by ONS for England and Wales; National Records of Scotland; the Northern Ireland Statistics and Research Agency (NISRA); and the Central Statistics Office (CSO) in Ireland.

Incidence, mortality and population data were analysed by sex and five-year age group for nine selected cancers. These were the four cancers with the highest rates of incidence, and five additional cancers, where previous studies had found significant links between deprivation and either incidence or mortality rates.[7,10] These cancers were grouped using codes from the 10th revision of the International Classification of Diseases (ICD-10) across each of the five countries separately. The cancers examined were: female breast cancer (C50); cervical cancer (C53); colorectal cancer (C18-C20); laryngeal cancer (C32); lip, mouth and pharyngeal cancer (C00-C14); lung cancer (C33-C34); malignant melanoma of skin (C43); prostate cancer (C61); and stomach cancer (C16).

2.2 Measures of deprivation

In each country, counts for incidence, mortality and the underlying population were allocated to deprivation quintiles according to the:

1) Income domain scores of the Indices of Multiple Deprivation in England (English indices of deprivation 2010)[23], Wales (Welsh Index of Multiple Deprivation (WIMD) 2014)[24], Scotland (Scottish Index of Multiple Deprivation 2012)[25], Northern Ireland (Northern Ireland Multiple Deprivation Measure 2010)[26], and according to the relative score from

the 2011 Pobal HP Deprivation Index[27] for Small Areas in Ireland. For simplicity, and to differentiate them clearly from alternative deprivation metrics described subsequently, these measures of deprivation will be referred to as the IMD metric throughout this report.

Each country was split into small areas (see below), and an income score (in the cases of England, Wales, Scotland and Northern Ireland) or relative Pobal HP deprivation index score (in Ireland) was assigned to each area. The areas were then grouped into quintiles according to their deprivation score, with approximately 20% of the total population in each quintile (rather than 20% of the areas in each quintile). The quintiles were ordered from least deprived (1) to most deprived (5).

Calculations for the UK as a whole were undertaken by summing the incidence, mortality and population data, by sex and five-year age groups, for quintiles 1-5 separately for England, Wales, Scotland and Northern Ireland. This means that the least deprived quintile in the UK is made up of the least deprived 20% of the population in each of the constituent countries, rather than the 20% least deprived in the UK as a whole.

Although the methods behind calculating the IMD metrics in England, Wales, Scotland and Northern Ireland were quite similar, they were not identical, which brought the validity of comparisons across the countries into question. One of the aims of this report was to use measures of deprivation that were common to each of the countries of the UK, as well as to Ireland. The education and unemployment metrics which were selected were chosen from the censuses that took place in March and April 2011 in each of the five countries.

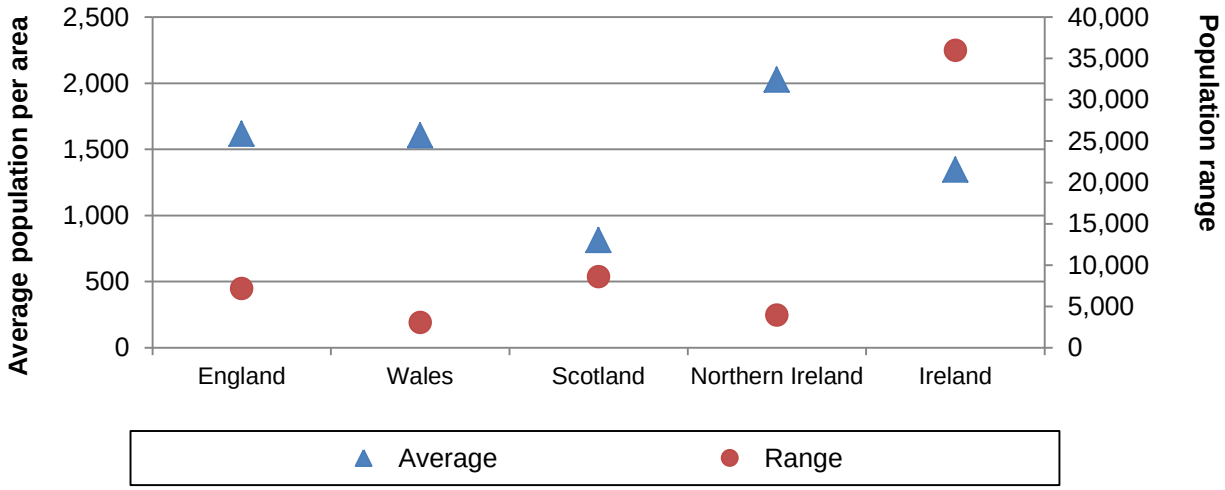
2) Education: The percentage of the population, aged 16 and over, with a third level qualification (degree or higher) at the time of the census in 2011. Lower rates of third level education were taken as an indicator of higher levels of deprivation.

3) Unemployment: The percentage of the population, aged 16-74, who were unemployed at the time of the census in 2011. Higher rates of unemployment were taken as an indicator of higher levels of deprivation.

2.3 Classifications of area

The five countries under consideration use the following classifications of area when considering deprivation: England and Wales, Lower Super Output Areas (LSOA); Scotland, Data Zones; Northern Ireland, Super Output Areas (SOA); Republic of Ireland, Electoral Divisions (ED). Figure A shows the average population and the range of population per output area for each country.

Figure A: Average population per area and population range by country



Differences in average population and population range will reduce the accuracy of the area based deprivation measure for larger populations. The population range in Ireland is larger and more variable than for the other countries, with between 75 and 36,000 people per electoral division; this means less homogenous areas with the range of deprivation levels could have similar average levels of deprivation across the electoral divisions. The deprivation gradient for incidence in Ireland could therefore be much less pronounced than the other countries. Area based deprivation measures are also affected by the rurality of the population; as rural areas are less homogeneous than urban areas in socioeconomic composition. So the rurality of the population in each country will tend to smooth out the deprivation gradients.

2.4 Incidence and mortality across cancer sites

The statistics used to measure the relationship between incidence and mortality, and socioeconomic deprivation were:

The age-standardised rate (ASR): the number of new cases of cancer, or deaths from cancer, per 100,000 persons in the population of interest; for example, females in the most deprived socioeconomic quintile. Differences in the age structure of the population in different deprivation quintiles can be controlled by using ASRs. The ASR in this report was calculated using the 2013 European Standard Population.[28]

The age-standardised rate ratio (rate ratio): the ratio of the ASR for quintile 1 to 5 compared with the ASR of quintile 1. For quintile 1 the rate ratio must equal 1. If the rate ratio is greater than 1, this indicates that the incidence or mortality rate in the quintile of interest is greater than the rate in the least deprived quintile. A rate ratio of less than 1 indicates that the incidence or mortality rate in the quintile of interest is less than the rate in the least deprived quintile.

2.5 Statistical tests

Regression analysis was used:

- First, to test whether there were linear trends in the age-standardised incidence and mortality rates, across deprivation quintiles, for each country separately.
- Second, to determine whether there were significant differences in the age-standardised rates across countries. Given the size of the population in England (approximately 78% of the total population of the UK and Ireland) the English ASRs were used as the base rate for these tests. Each of the countries ASRs were compared with the English rates to determine whether their ASRs differed significantly relative to the English rates, after controlling for the effects of quintiles.
- Third, to compare the three different methods of measuring deprivation within each country, and determine whether the ASRs differed according to which deprivation metric was used. Linear regression was used to test for interactions between ASRs and deprivation metric, to determine if the ASRs changed significantly when using either the Education or Unemployment deprivation metric, compared with the IMD deprivation metric. This was done after controlling for the effect of quintiles.
- Fourth, to determine how comparable the results of the analysis were when using alternative metrics, the level of concurrence between methods was measured. The results were deemed to have concurred if:
    a. The trends were both significant and trending in the same direction, or both not significant, when using the IMD metric, and using either of the new metrics.
    b. The comparison of ASRs across countries were found to be significant using both the IMD metric and the new metrics, or not significant when using both the IMD metric and the new metrics.

Chapter 3: Results

3.1 Incident cases and deaths

Table 1: Number of newly diagnosed cases of cancer, by site, sex and country, in the period 2008 to 2012

Cancer Site	Sex	England	Wales	Scotland	N. Ireland	UK	Ireland
Breast	**F**	205,954	12,926	22,431	6,198	247,509	12,465
Cervical	**F**	12,498	796	1,594	535	15,423	1,398
Colorectal	**M**	93,683	6,754	10,897	3,243	114,577	6,345
	F	74,177	4,995	8,956	2,543	90,671	4,538
Laryngeal	**M**	7,599	534	1,150	313	9,596	604
	F	1,635	124	303	73	2,135	96
Lip, mouth & pharynx	**M**	19,792	1,357	2,784	641	24,574	1,170
	F	10,601	673	1,467	352	13,093	556
Lung	**M**	95,904	6,617	13,107	3,168	118,796	5,823
	F	77,339	5,307	12,426	2,232	97,304	4,240
Malignant melanoma	**M**	25,793	1,777	2,718	647	30,935	1,656
	F	27,385	1,692	3,195	858	33,130	2,141
Prostate	**M**	175,914	12,220	15,026	5,144	208,304	14,321
Stomach	**M**	19,448	1,482	2,321	675	23,926	1,514
	F	10,369	785	1,386	423	12,963	890

Table 2: Number of cancer deaths, by site, sex and country, in the period 2008 to 2012

Cancer Site	Sex	England	Wales	Scotland	N. Ireland	UK
Breast	**F**	48,848	3,067	5,146	1,511	58,572
Cervical	**F**	3,808	288	526	117	4,739
Colorectal	**M**	35,196	2,565	4,084	1,154	42,999
	F	29,571	1,950	3,654	951	36,126
Laryngeal	**M**	2,552	150	393	95	3,190
	F	612	37	112	25	786
Lip, mouth & pharynx	**M**	5,969	431	978	205	7,583
	F	3,166	212	465	115	3,958
Lung	**M**	79,041	5,445	10,686	2,718	97,890
	F	61,787	4,152	9,906	1,894	77,739
Malignant melanoma	**M**	5,074	352	525	129	6,080
	F	3,855	257	389	123	4,624
Prostate	**M**	44,776	2,738	4,200	1,186	52,900
Stomach	**M**	12,670	876	1,537	403	15,486
	F	7,464	531	972	287	9,254

3.2 Age-standardised rates (ASR) analysis

These results are for the IMD deprivation metrics, using the income domain of the respective indices of multiple deprivation in England, Wales, Scotland and Northern Ireland, and the relative deprivation score from the Pobal HP deprivation index in Ireland.

Table 3a: Incidence ASR analysis of deprivation trends by cancer site, sex and country

Cancer Site	Sex	England	Wales	Scotland	N. Ireland	UK	Ireland
Breast	**F**	-	NS	-	NS	-	NS
Cervical	**F**	+	+	+	NS	+	+
Colorectal	**M**	+	+	+	NS	+	NS
	F	NS	NS	NS	NS	NS	NS
Laryngeal	**M**	+	+	+	+	+	+
	F	+	+	+	NS	+	NS
Lip, mouth & pharynx	**M**	+	+	+	+	+	NS
	F	+	NS	+	NS	+	NS
Lung	**M**	+	+	+	+	+	NS
	F	+	+	+	+	+	NS
Malignant melanoma	**M**	-	-	-	-	-	-
	F	-	-	-	-	-	-
Prostate	**M**	-	-	-	-	-	NS
Stomach	**M**	+	+	+	+	+	+
	F	+	NS	+	+	+	NS

Table 3b: Mortality ASR analysis of deprivation trends by cancer site, sex and country

Cancer Site	Sex	England	Wales	Scotland	N. Ireland	UK
Breast	**F**	+	NS	+	NS	+
Cervical	**F**	+	+	+	NS	+
Colorectal	**M**	+	+	+	+	+
	F	+	NS	+	NS	+
Laryngeal	**M**	+	+	+	NS	+
	F	+	NS	+	+	+
Lip, mouth & pharynx	**M**	+	+	+	NS	+
	F	+	NS	+	NS	+
Lung	**M**	+	+	+	+	+
	F	+	+	+	+	+
Malignant melanoma	**M**	-	NS	-	NS	-
	F	-	NS	NS	NS	-
Prostate	**M**	NS	NS	NS	NS	NS
Stomach	**M**	+	NS	+	NS	+
	F	+	NS	NS	+	+

\+ means that there is a significant positive trend, with ASR increasing with increasing levels of deprivation.
\- means that there is a significant negative trend, with ASR decreasing with increasing levels of deprivation.
NS means that there is no significant trend with respect to ASR and the level of deprivation.

Table 4a: Incidence ASR across the countries compared with England by cancer site and sex

Cancer Site	Sex	Wales	Scotland	N. Ireland	UK	Ireland
Breast	**F**	NS	NS	NS	NS	NS
Cervical	**F**	NS	>	NS	NS	>
Colorectal	**M**	>	>	>	>	>
	F	>	>	>	>	>
Laryngeal	**M**	NS	>	NS	NS	NS
	F	NS	NS	NS	NS	NS
Lip, mouth & pharynx	**M**	NS	>	NS	NS	NS
	F	NS	>	NS	NS	<
Lung	**M**	NS	>	NS	NS	NS
	F	NS	>	NS	NS	NS
Malignant melanoma	**M**	>	NS	NS	NS	NS
	F	NS	>	NS	NS	>
Prostate	**M**	>	<	NS	NS	>
Stomach	**M**	>	>	NS	NS	>
	F	NS	>	NS	NS	>

Table 4b: Mortality ASR across the countries compared with England by cancer site and sex

Cancer Site	Sex	Wales	Scotland	N. Ireland	UK
Breast	**F**	NS	NS	NS	NS
Cervical	**F**	NS	>	NS	NS
Colorectal	**M**	>	>	>	>
	F	NS	>	NS	>
Laryngeal	**M**	NS	NS	NS	NS
	F	NS	NS	NS	NS
Lip, mouth & pharynx	**M**	NS	>	NS	NS
	F	NS	>	NS	NS
Lung	**M**	NS	>	NS	NS
	F	NS	>	NS	NS
Malignant melanoma	**M**	NS	NS	NS	NS
	F	NS	NS	NS	NS
Prostate	**M**	NS	NS	NS	NS
Stomach	**M**	NS	>	NS	NS
	F	NS	>	NS	NS

> means that the average ASR is significantly greater in the country in question, compared with the ASR in England.

< means that the average ASR is significantly lower in the country in question, compared with the ASR in England.

NS means that the average ASR were not significantly different in the country in question, compared with the ASR in England.

Breast cancer (C50)

Female

Figure 1a: Age-standardised incidence rate for female breast cancer (per 100,000 population)

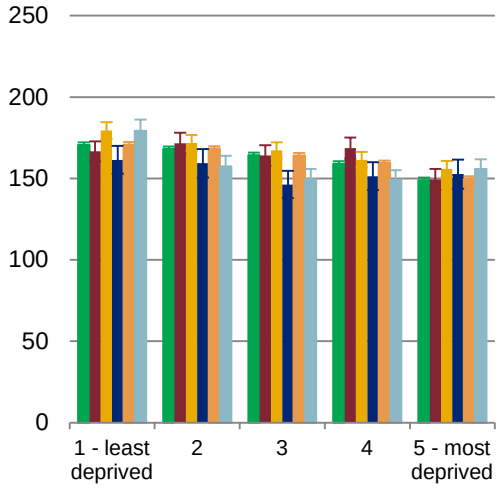
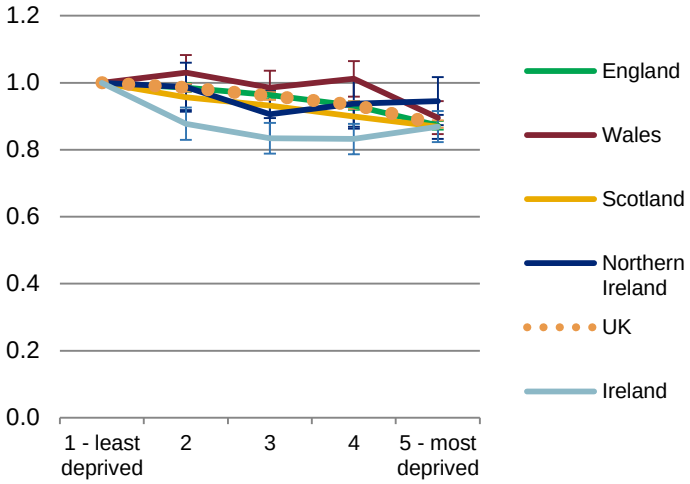


Figure 1b: Standardised incidence rate ratio for female breast cancer



Incidence - female

The incidence rates of breast cancer in females were higher among the more affluent. There were significant downward trends in England and Scotland. In Wales, Northern Ireland and Ireland the trend was not significant. Compared with England, the incidence rates of breast cancer were not significantly different across any of the countries.

Figure 1c: Age-standardised mortality rate for female breast cancer (per 100,000 population)

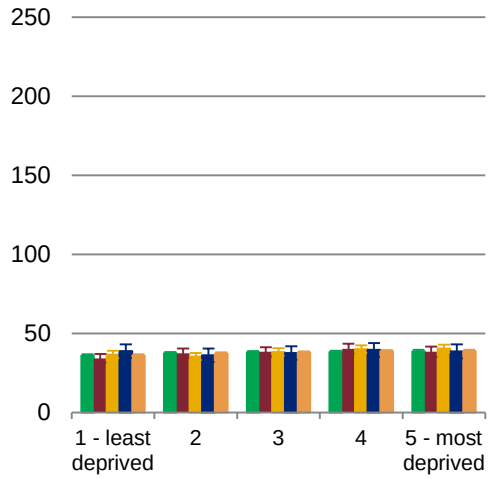
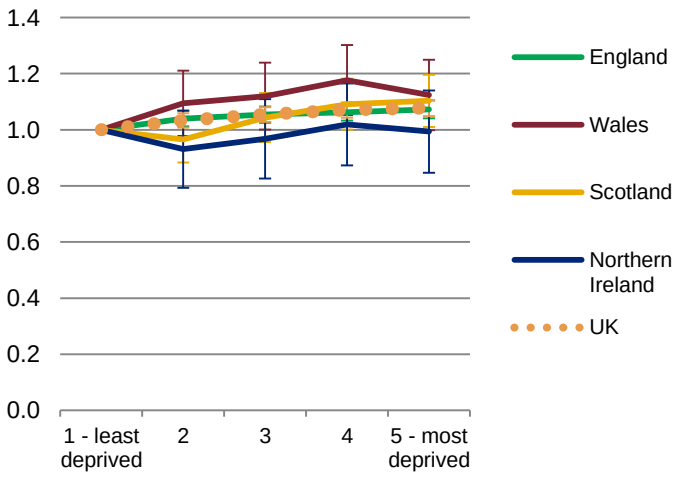


Figure 1d: Standardised mortality rate ratio for female breast cancer



Mortality - female

The mortality rates of breast cancer in females were higher among the more deprived. There were significant upward trends in England and Scotland. In Wales, Northern Ireland and Ireland the trend was not significant. Compared with England, the mortality rates of breast cancer were not significantly different across any of the countries.

Cervical cancer (C53)

Figure 2a: Age-standardised incidence rate for cervical cancer (per 100,000 population)

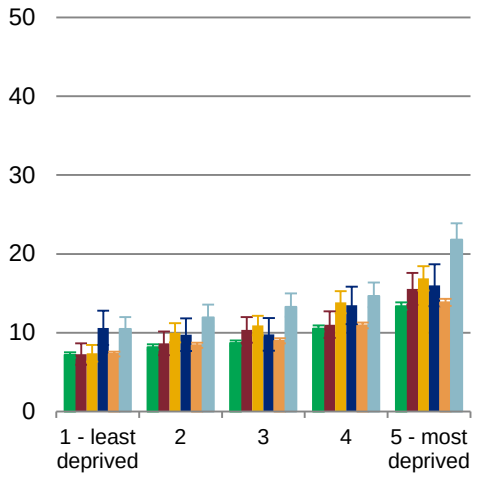
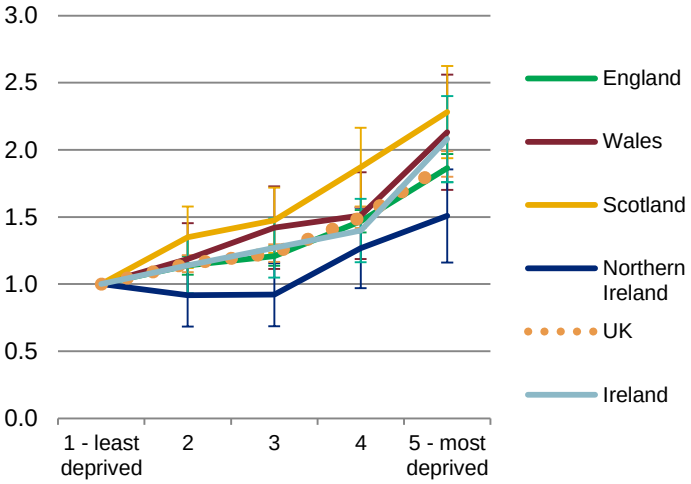


Figure 2b: Standardised incidence rate ratio for cervical cancer



Incidence

The incidence rates of cervical cancer in females were higher among the more deprived. There were significant upward trends in England, Wales, Scotland and Ireland, with no significant trend observed in Northern Ireland. Compared with England, the incidence rates of cervical cancer were significantly higher in Scotland and Ireland, with no significant difference observed in either Wales or Northern Ireland.

Figure 2c: Age-standardised mortality rate for cervical cancer (per 100,000 population)

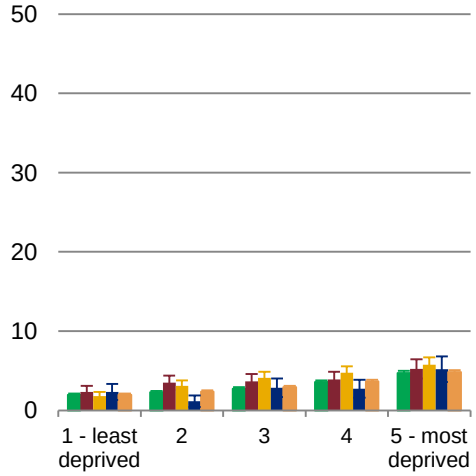
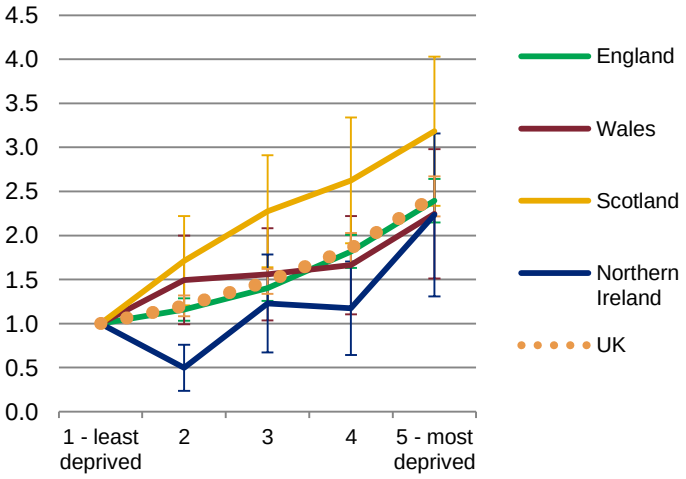


Figure 2d: Standardised mortality rate ratio for cervical cancer



Mortality

The mortality rates of cervical cancer in females were higher among the more deprived. There were significant upward trends in England, Wales and Scotland. In Northern Ireland the trend was not significant. Compared with England, the mortality rates of cervical cancer were significantly higher in Scotland, with no significant difference observed in either Wales or Northern Ireland.

Colorectal cancer (C18-C20)

Male

Figure 3a: Age-standardised incidence rate for male colorectal cancer (per 100,000 population)

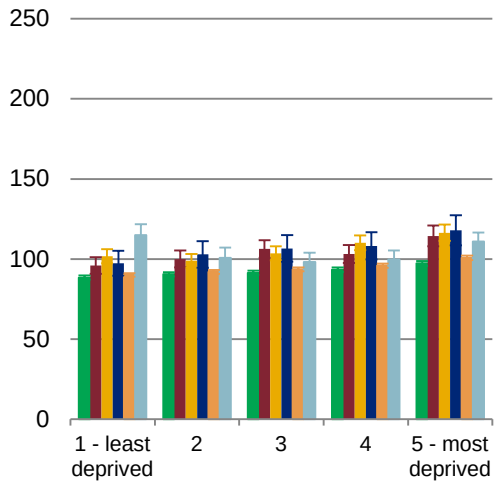
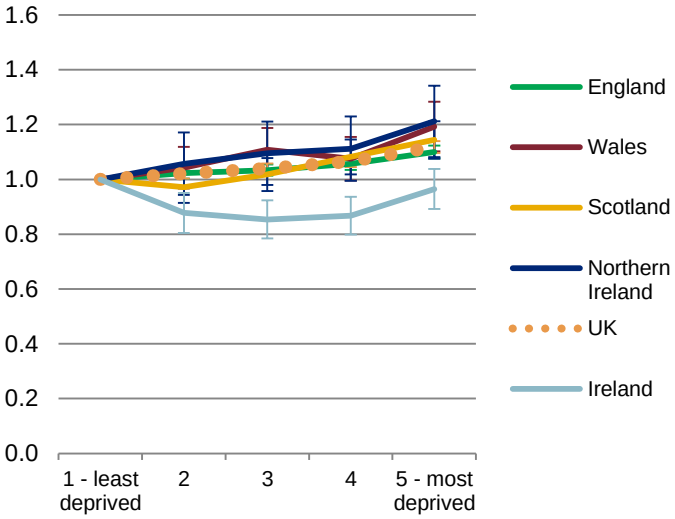


Figure 3b: Standardised incidence rate ratio for male colorectal cancer



Incidence - male

The incidence rates of colorectal cancer in males were generally higher among the more deprived. There were significant upward trends in England, Wales and Scotland. The trend was not significant in either Northern Ireland or Ireland. The incidence rates of colorectal cancer were lowest in England, with significantly higher rates observed in the other four countries, and in the UK as a whole.

Figure 3c: Age-standardised mortality rate for male colorectal cancer (per 100,000 population)

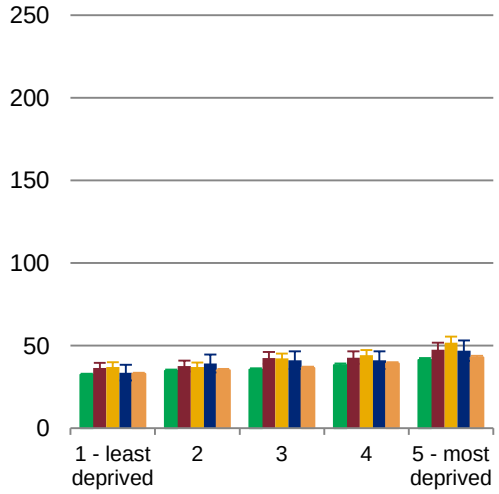
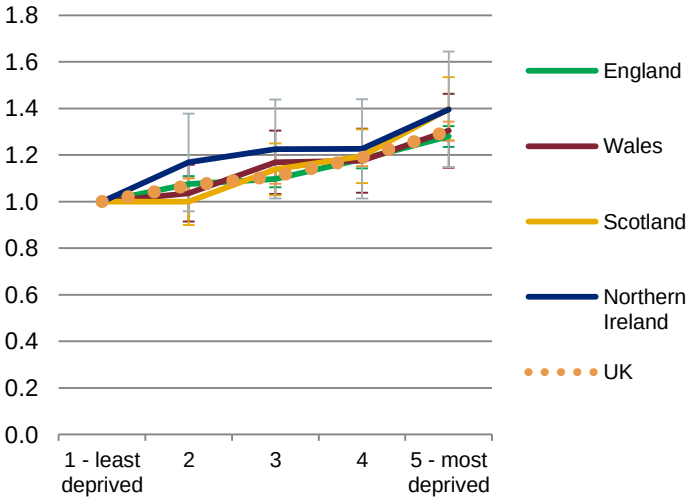


Figure 3d: Standardised mortality rate ratio for male colorectal cancer



Mortality - male

The mortality rates of colorectal cancer in males were higher among the more deprived, with significant upward trends observed in England, Wales, Scotland and Northern Ireland. The mortality rates of colorectal cancer were lowest in England, with significantly higher rates observed in the other four countries, and in the UK as a whole.

Colorectal cancer (C18-C20)

Female

Figure 4a: Age-standardised incidence rate for female colorectal cancer (per 100,000 population)

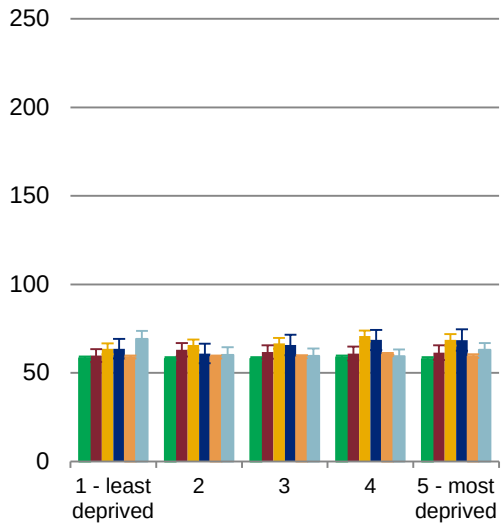
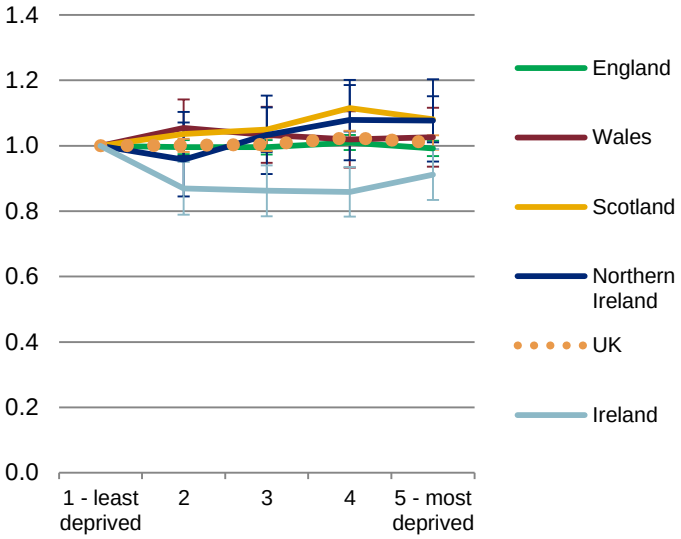


Figure 4b: Standardised incidence rate ratio for female colorectal cancer



Incidence - female

There were no significant trends in incidence rates of colorectal cancer for women across the deprivation quintiles in any of the countries. The incidence rates of colorectal cancer were lowest in England, with significantly higher rates observed in the other four countries, and in the UK as a whole.

Figure 4c: Age-standardised mortality rate for female colorectal cancer (per 100,000 population)

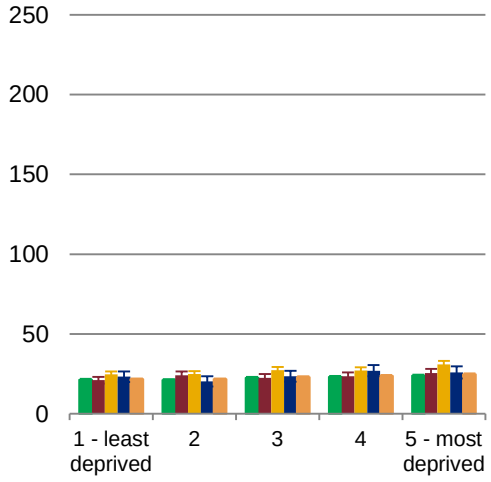
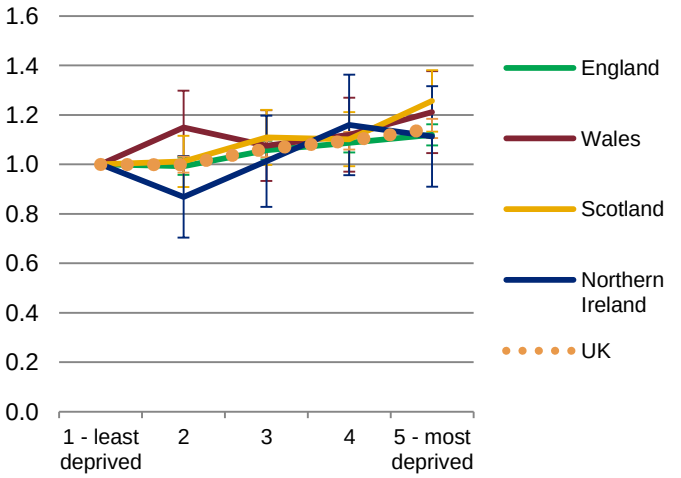


Figure 4d: Standardised mortality rate ratio for female colorectal cancer



Mortality - female

The mortality rates of colorectal cancer in females were higher among the more deprived in all four countries, with significant upward trends observed in England and Scotland. The trend was not significant in Wales and Northern Ireland. The mortality rates of colorectal cancer were lowest in England, with significantly higher rates observed in the other four countries, and in the UK as a whole.

Laryngeal cancer (C32)

Male

Figure 5a: Age-standardised incidence rate for male laryngeal cancer (per 100,000 population)

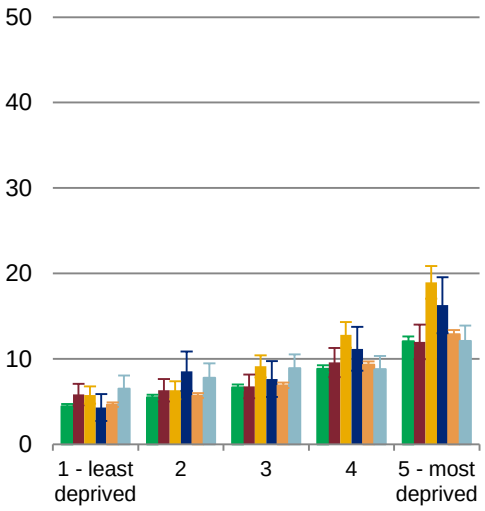
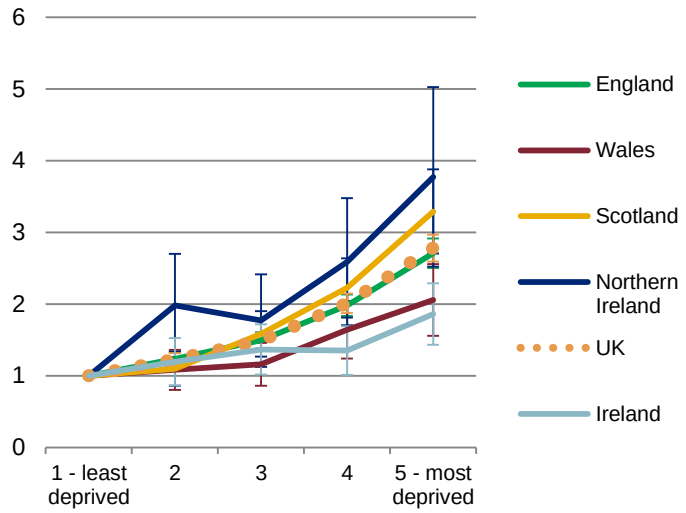


Figure 5b: Standardised incidence rate ratio for male laryngeal cancer



Incidence - male

The incidence rates of laryngeal cancer in males were higher among the more deprived. There were significant upward trends observed in all of the countries. Compared with England, the incidence rates of laryngeal cancer were significantly higher in Scotland, with no significant difference observed in Wales, Northern Ireland or Ireland.

Figure 5c: Age-standardised mortality rate for male laryngeal cancer (per 100,000 population)

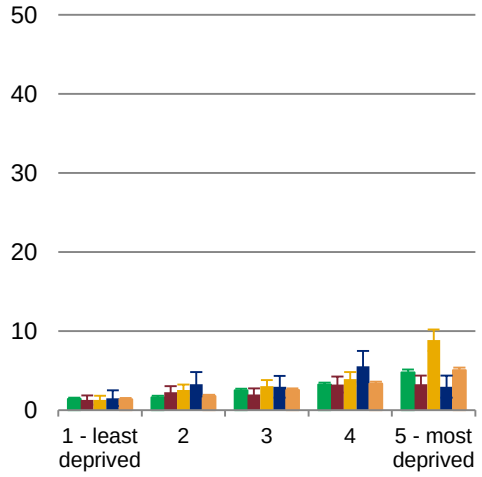
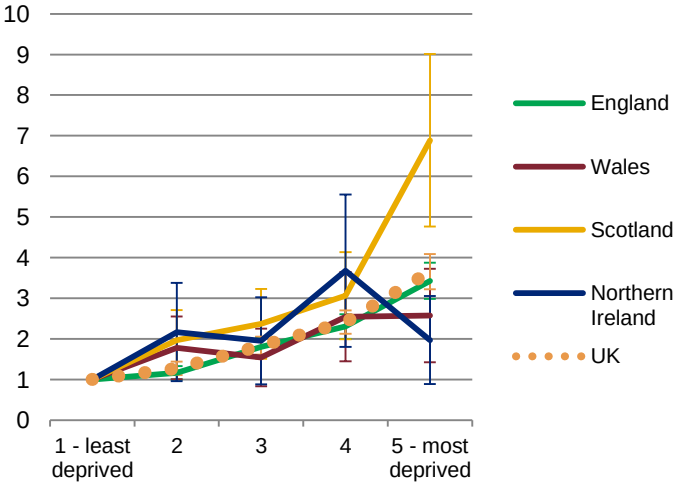


Figure 5d: Standardised mortality rate ratio for male laryngeal cancer



Mortality - male

The mortality rates of laryngeal cancer in males were higher among the more deprived. There were significant upward trends in England, Wales and Scotland. The trend in Northern Ireland was not significant. Compared with England, the mortality rates of laryngeal cancer were not significantly different across any of the countries.

Laryngeal cancer (C32)

Female

Figure 6a: Age-standardised incidence rate for female laryngeal cancer (per 100,000 population)

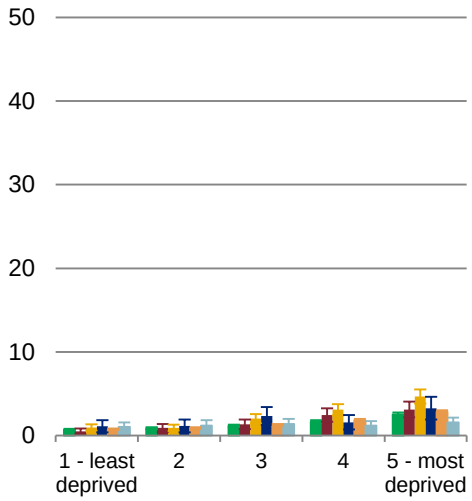
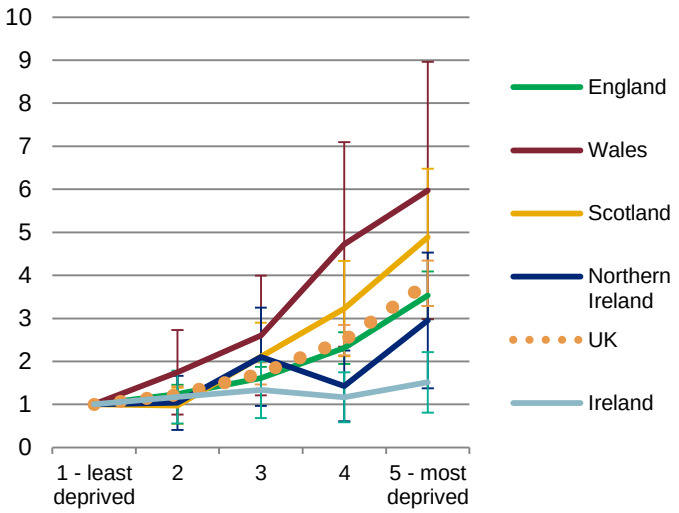


Figure 6b: Standardised incidence rate ratio for female laryngeal cancer



Incidence - female

The incidence rates of laryngeal cancer in females were higher among the more deprived. There were significant upward trends in England, Wales and Scotland. In Northern Ireland and Ireland the trend was not significant. Compared with England, the mortality rates of laryngeal cancer were not significantly different across any of the countries.

Figure 6c: Age-standardised mortality rate for female laryngeal cancer (per 100,000 population)

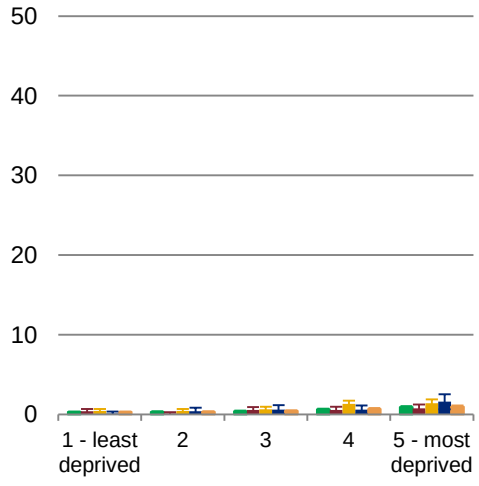
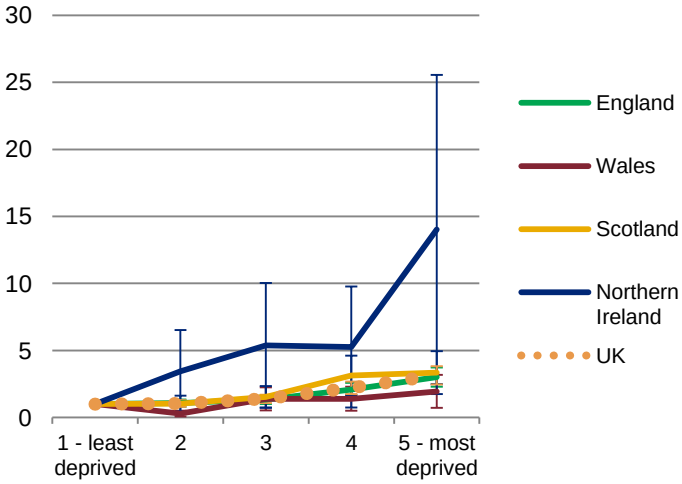


Figure 6d: Standardised mortality rate ratio for female laryngeal cancer



Mortality - female

The mortality rates of laryngeal cancer in females were higher among the more deprived. There were significant upward trends in England, Scotland and Northern Ireland. The trend in Wales was non-significant. Compared with England, the mortality rates of laryngeal cancer were not significantly different across any of the countries.

Lip, mouth and pharyngeal cancer (C00-C14)

Male

Figure 7a: Age-standardised incidence rate for male lip, mouth and pharyngeal cancer (per 100,000 population)

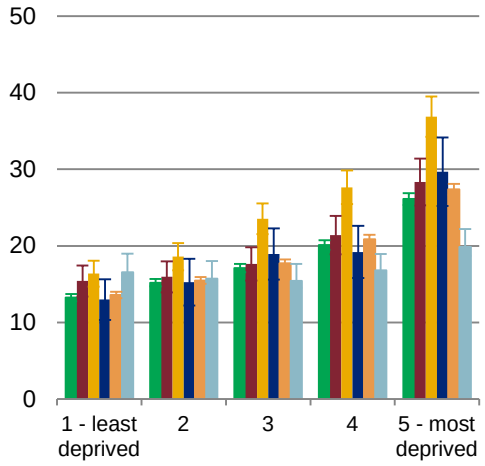
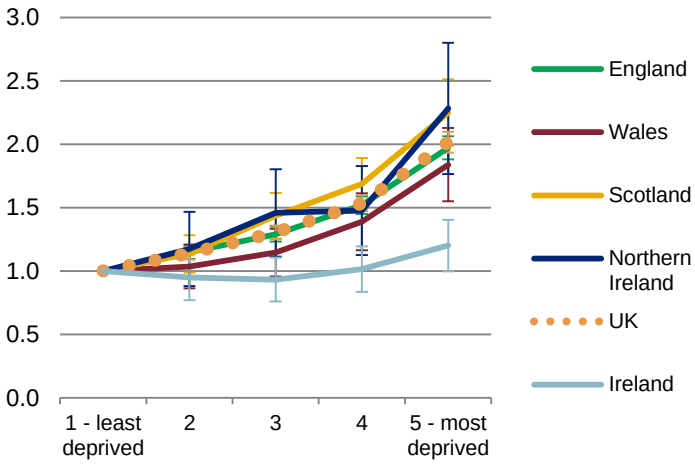


Figure 7b: Standardised incidence rate ratio for male lip, mouth and pharyngeal cancer



Incidence - male

The incidence rates of lip, mouth and pharyngeal cancer in males were higher among the more deprived. There were significant upward trends observed in England, Wales, Scotland and Northern Ireland. The trend was non-significant in Ireland. Compared with England, the incidence rates of lip, mouth and pharyngeal cancer were significantly higher in Scotland, with no significant difference observed in Wales, Northern Ireland or Ireland.

Figure 7c: Age-standardised mortality rate for male lip, mouth and pharyngeal cancer (per 100,000 population)

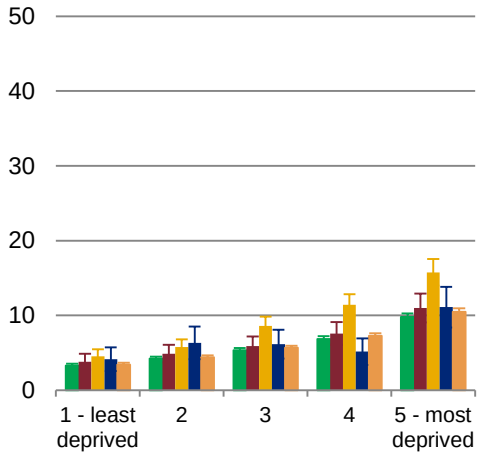
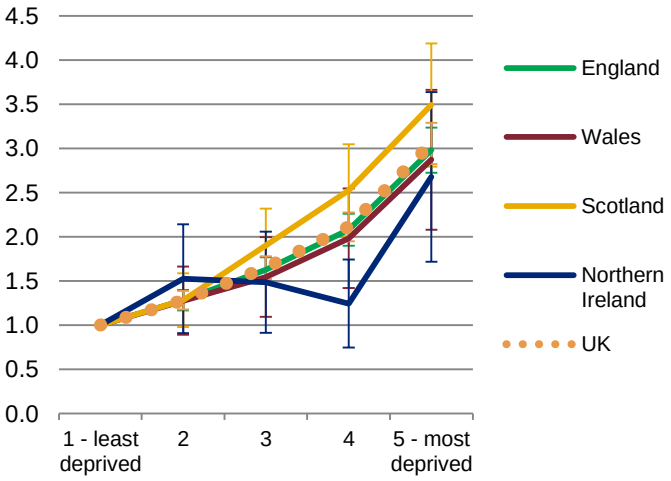


Figure 7d: Standardised mortality rate ratio for male lip, mouth and pharyngeal cancer



Mortality - male

The mortality rates of lip, mouth and pharyngeal cancer in males were higher among the more deprived. There were significant upward trends in England, Wales and Scotland. The trend in Northern Ireland was not significant. Compared with England, the mortality rates of lip, mouth and pharyngeal cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

Lip, mouth and pharyngeal cancer (C00-C14)

Female

Figure 8a: Age-standardised incidence rate for female lip, mouth and pharyngeal cancer (per 100,000 population)

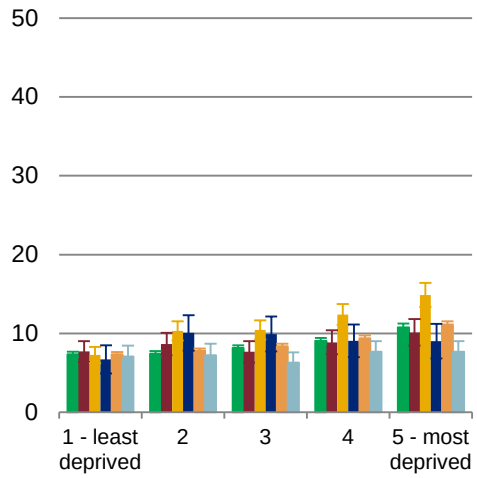
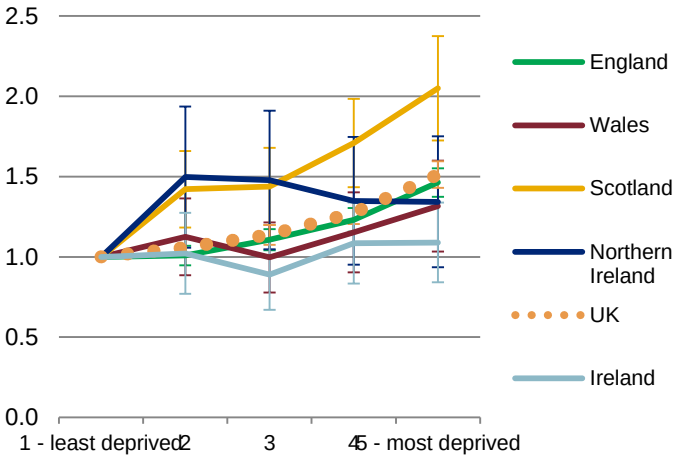


Figure 8b: Standardised incidence rate ratio for female lip, mouth and pharyngeal cancer



Incidence - female

The incidence rates of lip, mouth and pharyngeal cancer in females were higher among the more deprived. There were significant upward trends in England and Scotland. In Wales, Northern Ireland and Ireland the trend was not significant. Compared with England, the incidence rates of lip, mouth and pharyngeal cancer were significantly higher in Scotland, significant lower in Ireland, and not significantly different in Wales or Northern Ireland.

Figure 8c: Age-standardised mortality rate for female lip, mouth and pharyngeal cancer (per 100,000 population)

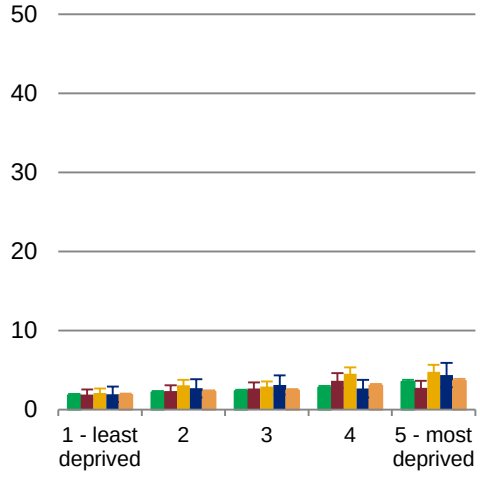
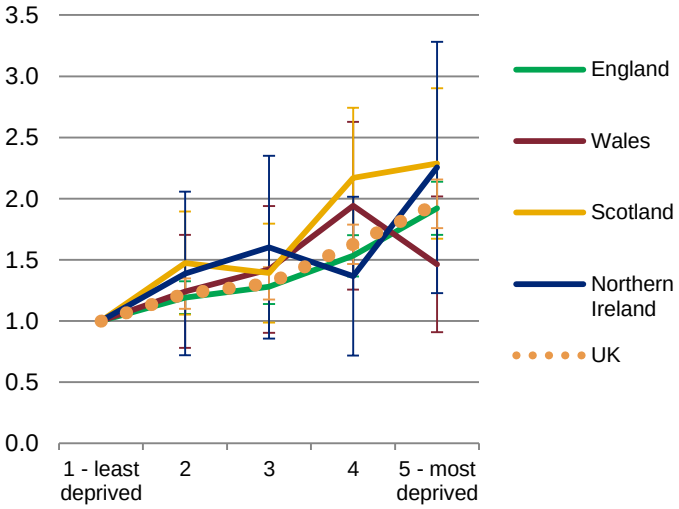


Figure 8d: Standardised mortality rate ratio for female lip, mouth and pharyngeal cancer



Mortality - female

The mortality rates of lip, mouth and pharyngeal cancer in females were higher among the more deprived. There were significant upward trends in England and Scotland. In Wales and Northern Ireland the trend was non-significant. Compared with England, the mortality rates of lip, mouth and pharyngeal cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

Lung cancer (C33-C34)

Male

Figure 9a: Age-standardised incidence rate for male lung cancer (per 100,000 population)

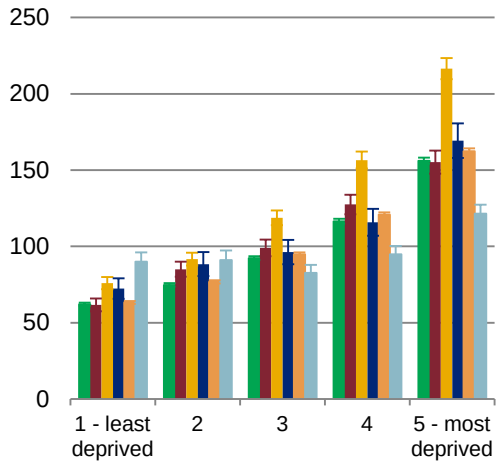
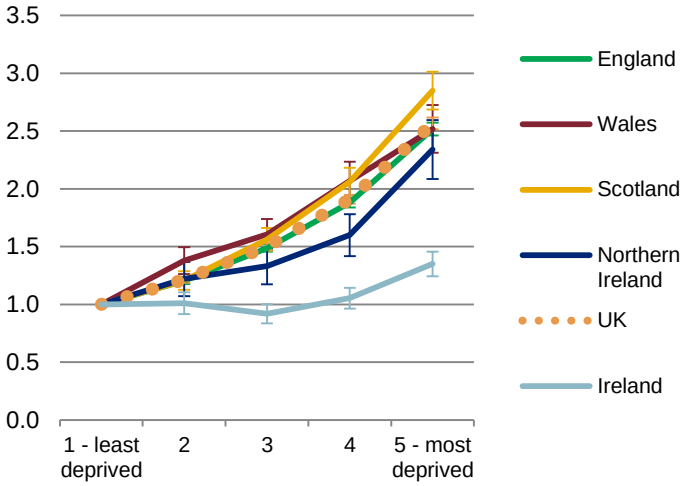


Figure 9b: Standardised incidence rate ratio for male lung cancer



Incidence - male

The incidence rates of lung cancer in males were higher among the more deprived. There were significant upward trends in England, Wales, Scotland and Northern Ireland. In Ireland the trend was not significant. Compared with England, the incidence rates of lung cancer were significantly higher in Scotland, with no significant difference observed in the other three countries.

Figure 9c: Age-standardised mortality rate for male lung cancer (per 100,000 population)

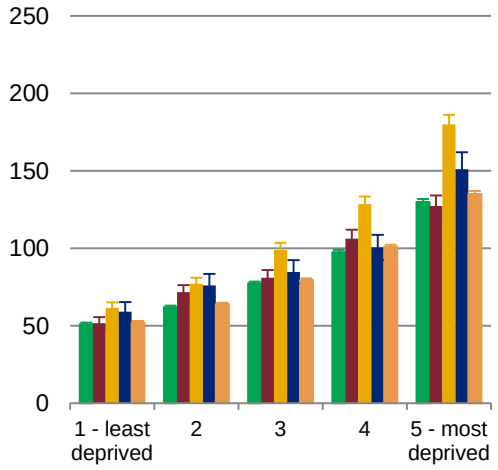
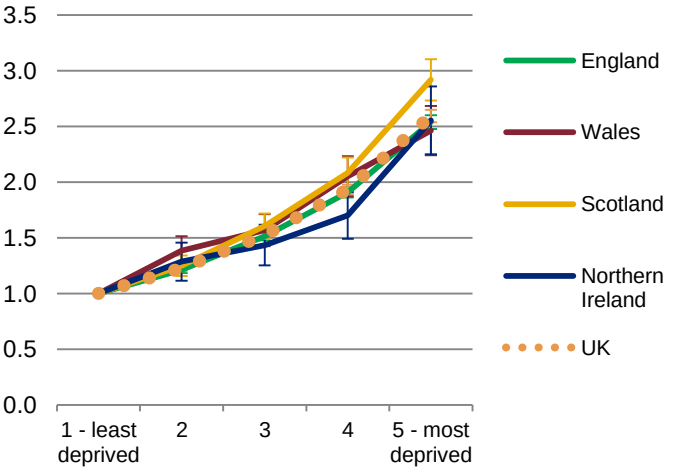


Figure 9d: Standardised mortality rate ratio for male lung cancer



Mortality - male

The mortality rates of lung cancer in males were higher among the more deprived. There were significant upward trends in England, Wales, Scotland and Northern Ireland. Compared with England, the mortality rates of lung cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

Lung cancer (C33-C34)

Female

Figure 10a: Age-standardised incidence rate for female lung cancer (per 100,000 population)

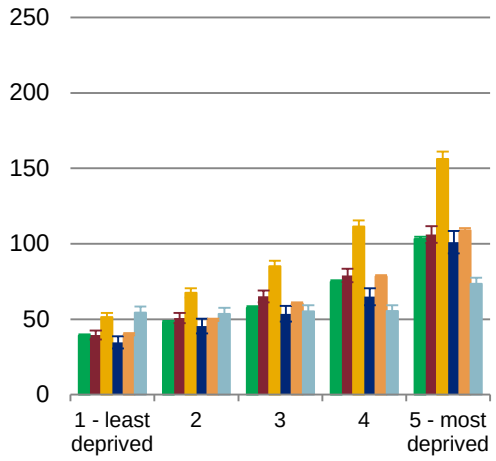
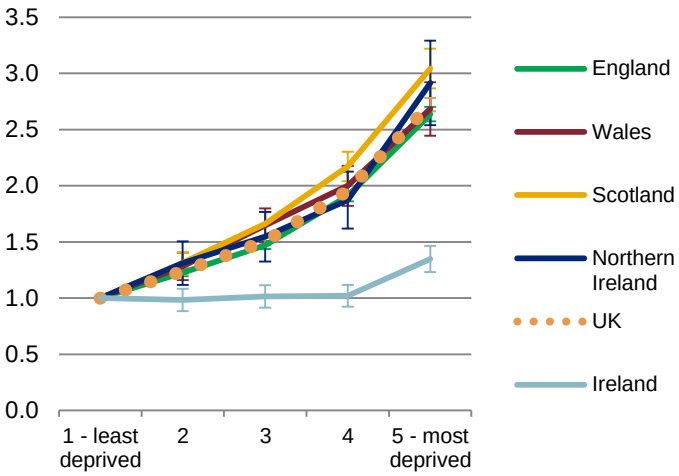


Figure 10b: Standardised incidence rate ratio for female lung cancer



Incidence - female

The incidence rates of lung cancer in females were higher among the more deprived. There were significant upward trends in England, Wales, Scotland and Northern Ireland. In Ireland the trend was not significant. Compared with England, the incidence rates of lung cancer were significantly higher in Scotland, with no significant difference observed in the other three countries.

Figure 10c: Age-standardised mortality rate for female lung cancer (per 100,000 population)

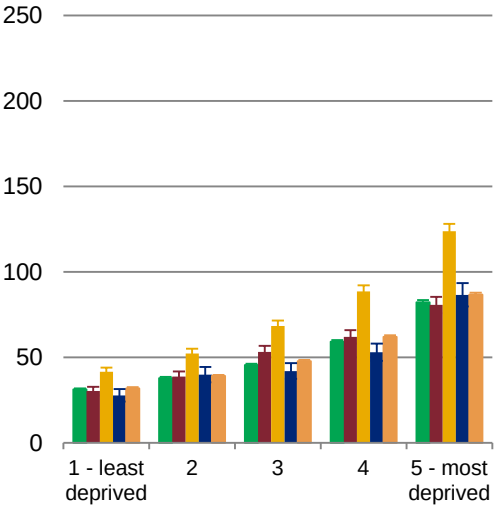
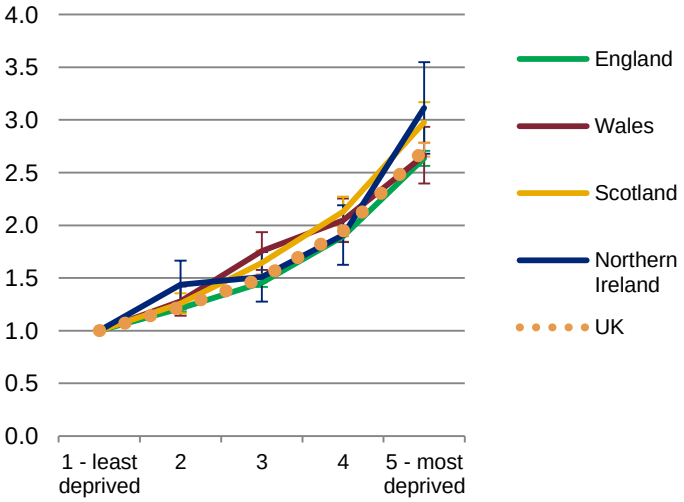


Figure 10d: Standardised mortality rate ratio for female lung cancer



Mortality - female

The mortality rates of lung cancer in females were higher among the more deprived. There were significant upward trends in England, Wales, Scotland and Northern Ireland. Compared with England, the mortality rates of lung cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

Malignant melanoma of skin (C43)

Male

Figure 11a: Age-standardised incidence rate for male malignant melanoma of skin (per 100,000 population)

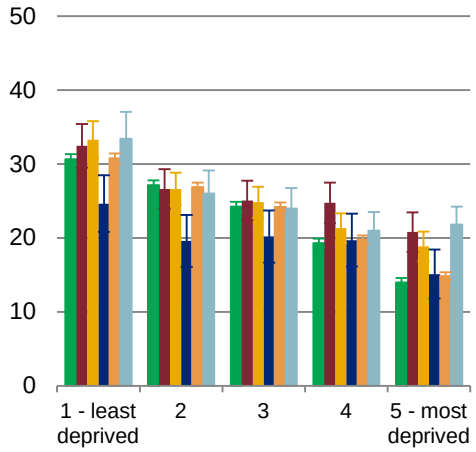
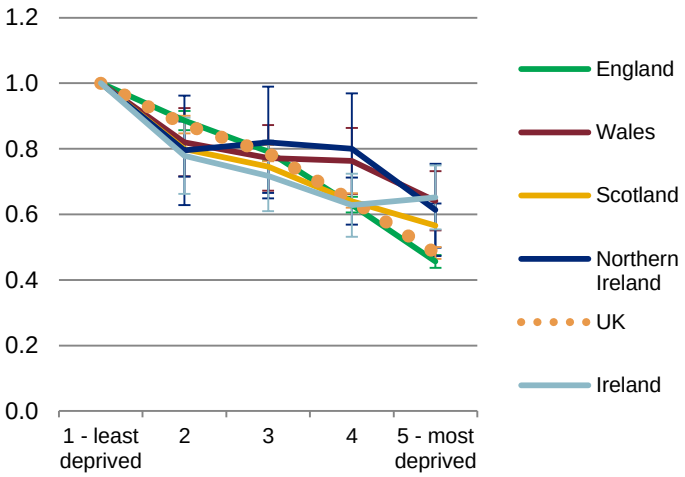


Figure 11b: Standardised incidence rate ratio for male malignant melanoma of skin



Incidence - male

The incidence rates of malignant melanoma of the skin in males were higher among the more affluent. There were significant downward trends observed in each country. Compared with England, the incidence rates of malignant melanoma of the skin were significantly higher in Wales, with no significant difference observed in Scotland, Northern Ireland or Ireland.

Figure 11c: Age-standardised mortality rate for male malignant melanoma of skin (per 100,000 population)

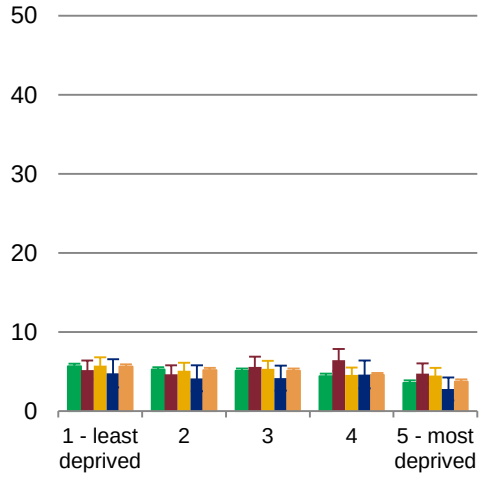
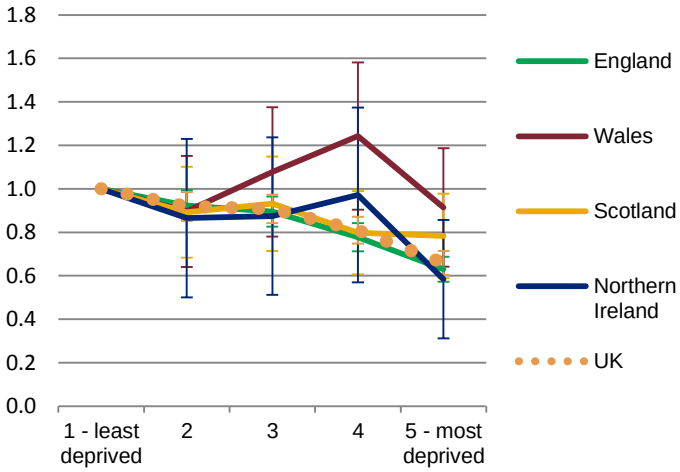


Figure 11d: Standardised mortality rate ratio for male malignant melanoma of skin



Mortality - male

The mortality rates of malignant melanoma of the skin in males were generally higher among the more affluent. There were significant downward trends in England and Scotland. The trends in Wales and Northern Ireland were not significant. Compared with England, the mortality rates of malignant melanoma of the skin were not significantly different across any of the countries.

Malignant melanoma of skin (C43)

Female

Figure 12a: Age-standardised incidence rate for female malignant melanoma of skin (per 100,000 population)

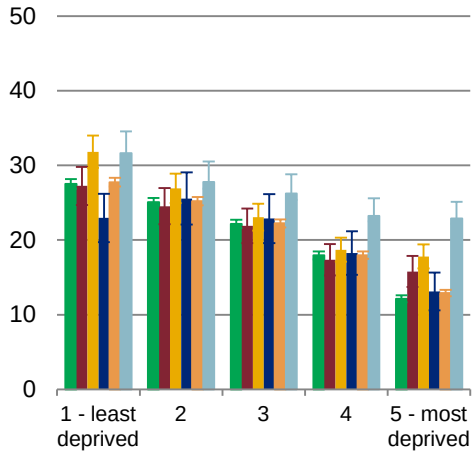
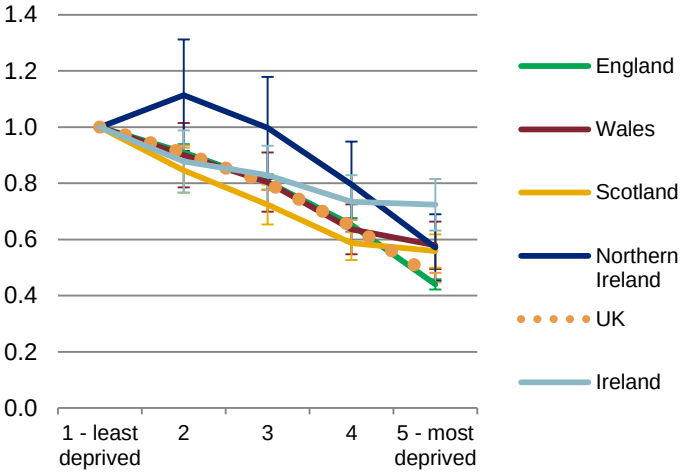


Figure 12b: Standardised incidence rate ratio for female malignant melanoma of skin



Incidence - female

The incidence rates of malignant melanoma of the skin in females were higher among the more affluent. There were significant downward trends observed in each country. Compared with England, the incidence rates of malignant melanoma of the skin were significantly higher in Scotland and Ireland, with no significant difference observed in Wales or Northern Ireland.

Figure 12c: Age-standardised mortality rate for female malignant melanoma of skin (per 100,000 population)

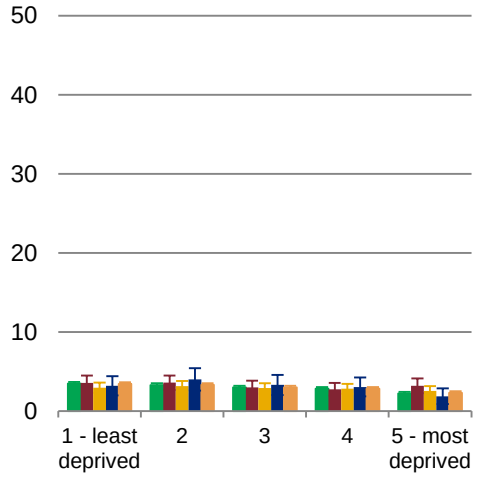
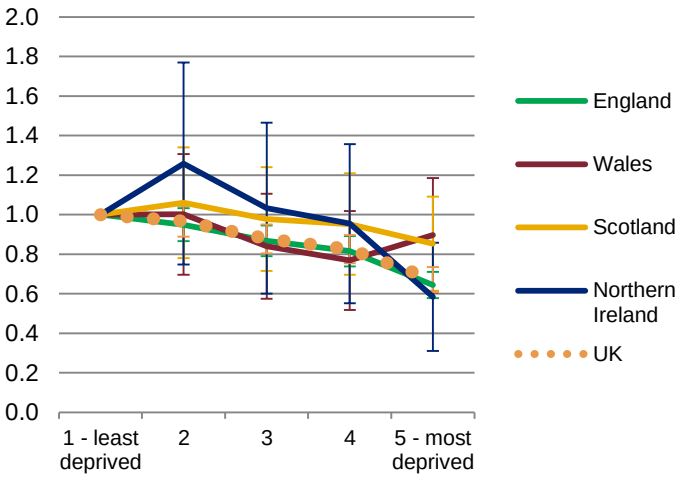


Figure 12d: Standardised mortality rate ratio for female malignant melanoma of skin



Mortality - female

The mortality rates of malignant melanoma of the skin in females were generally higher among the more affluent. The downward trend was significant in England, though not in Wales, Scotland or Northern Ireland. Compared with England, the mortality rates of malignant melanoma of the skin were not significantly different across any of the countries.

Prostate cancer (C61)

Figure 13a: Age-standardised incidence rate for prostate cancer (per 100,000 population)

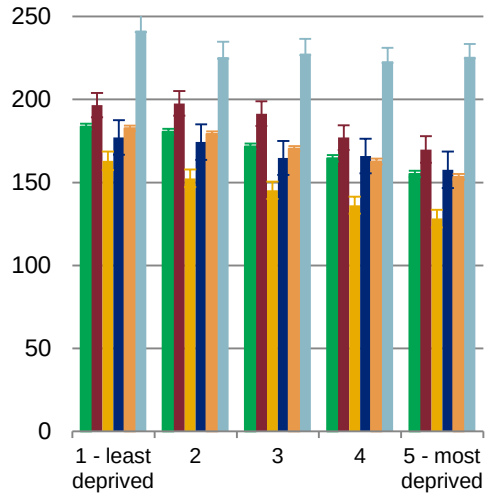
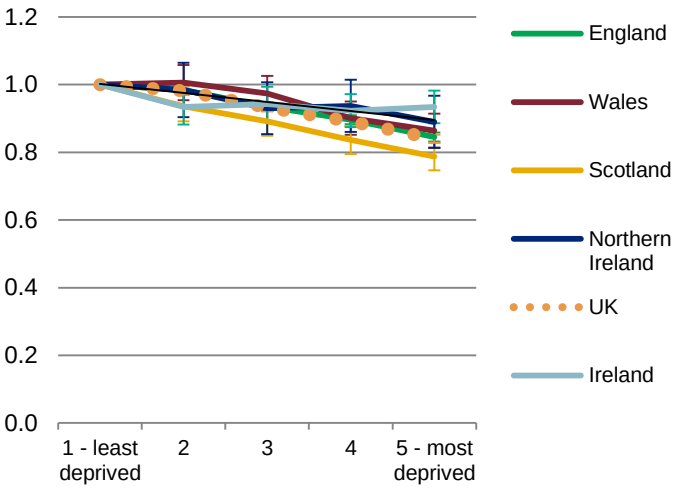


Figure 13b: Standardised incidence rate ratio for prostate cancer



Incidence

The incidence rates of prostate cancer were highest among the more affluent, with decreasing incidence rates observed with increasing levels of deprivation. The trend was significant in England, Wales, Scotland and Northern Ireland, although not in Ireland. Compared with England, the incidence rates in Wales and Ireland were significantly higher; in Scotland the rates were significantly lower, while the rates in Northern Ireland were not significantly different.

Figure 13c: Age-standardised mortality rate for prostate cancer (per 100,000 population)

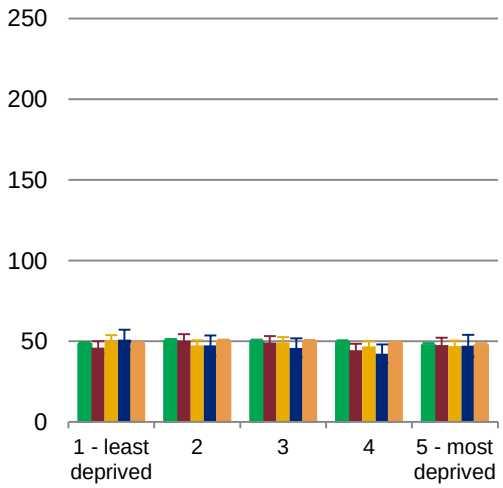
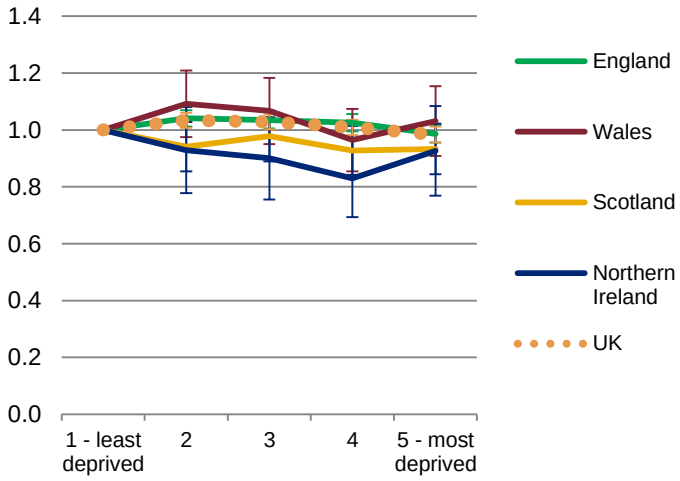


Figure 13d: Standardised mortality rate ratio for prostate cancer



Mortality

There was no clear evidence of a trend in the mortality rates across deprivation quintiles. There were no significant trends in any of the countries, and no significant differences in the mortality rates observed when comparing the rates in England with those in Wales, Scotland or Northern Ireland.

Stomach cancer (C16)

Male

Figure 14a: Age-standardised incidence rate for male stomach cancer (per 100,000 population)

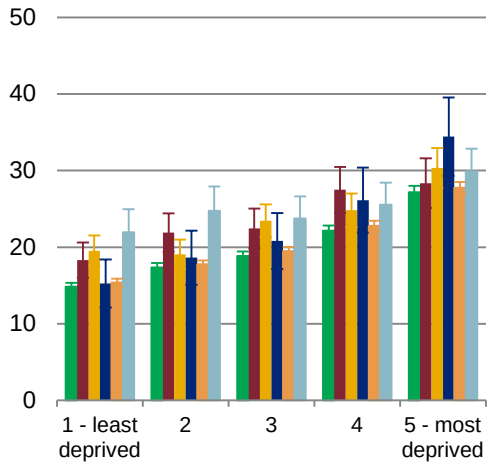
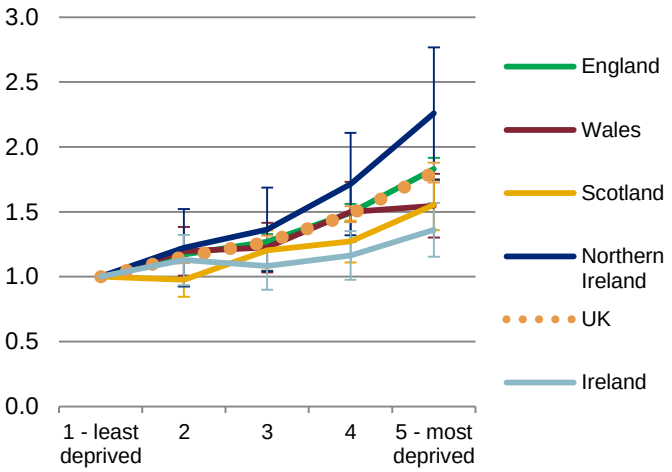


Figure 14b: Standardised incidence rate ratio for male stomach cancer



Incidence - male

The incidence rates of stomach cancer in males were higher among the more deprived. There were significant upward trends in England, Wales, Scotland, Northern Ireland and Ireland. Compared with England, the incidence rates of stomach cancer were significantly higher in Scotland and Ireland, with no significant difference observed in Wales or Northern Ireland.

Figure 14c: Age-standardised mortality rate for male stomach cancer (per 100,000 population)

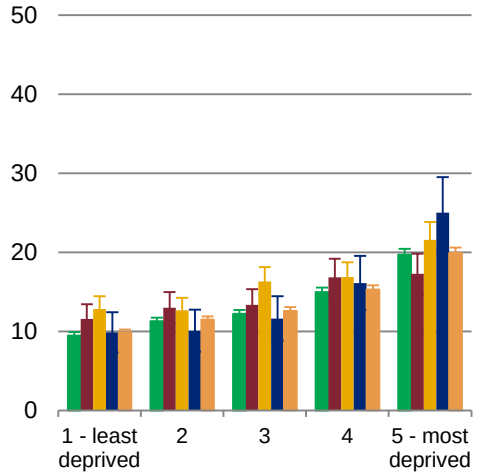
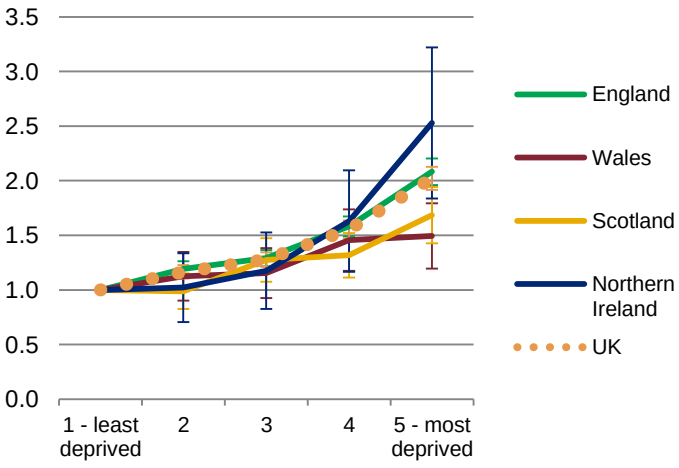


Figure 14d: Standardised mortality rate ratio for male stomach cancer



Mortality - male

The mortality rates of stomach cancer in males were higher among the more deprived. There were significant upward trends in England and Scotland. The trends in Wales and Northern Ireland were not significant. Compared with England, the mortality rates of stomach cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

Stomach cancer (C16)

Female

Figure 15a: Age-standardised incidence rate for female stomach cancer (per 100,000 population)

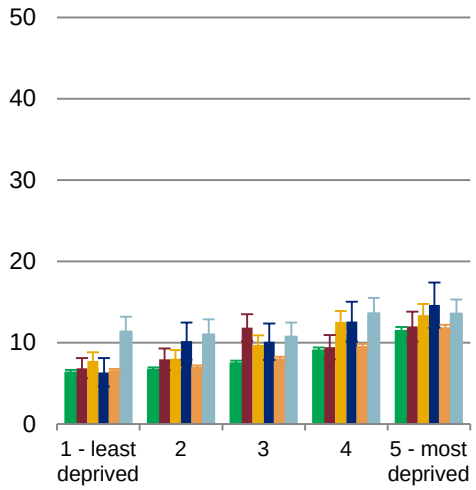
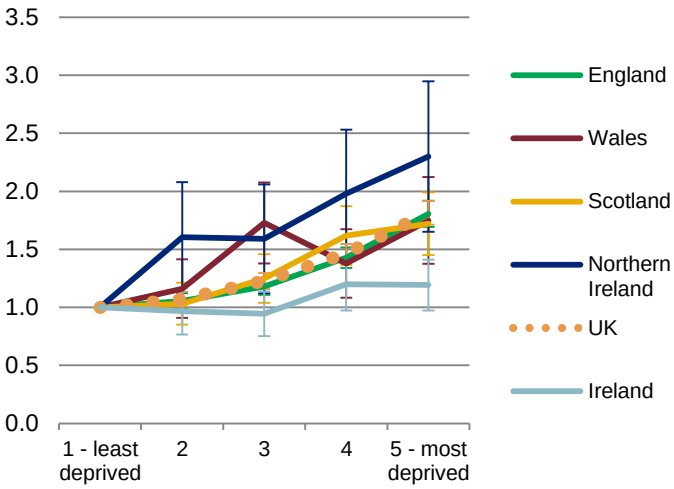


Figure 15b: Standardised incidence rate ratio for female stomach cancer



Incidence - female

The incidence rates of stomach cancer in females were higher among the more deprived. There were significant upward trends in England, Wales and Scotland. In Northern Ireland and Ireland the trend was not significant. Compared with England, the incidence rates of stomach cancer were significantly higher in Scotland and Ireland, with no significant difference observed in Wales or Northern Ireland.

Figure 15c: Age-standardised mortality rate for female stomach cancer (per 100,000 population)

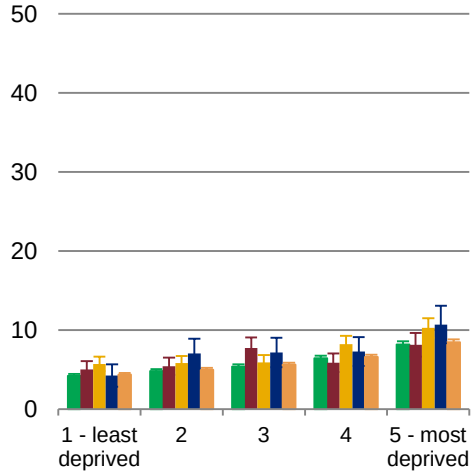
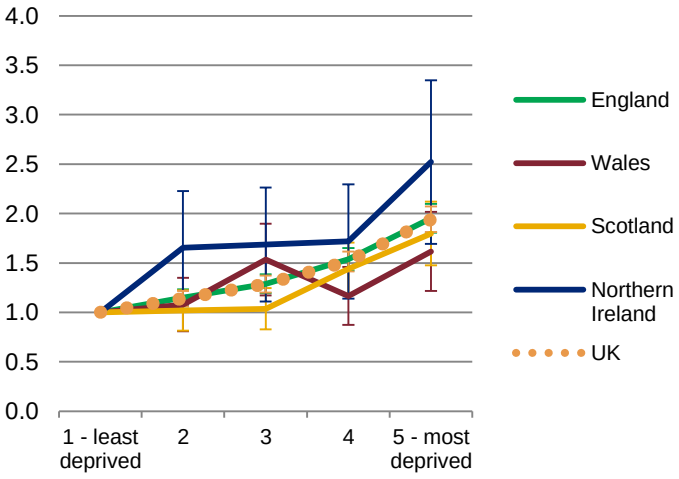


Figure 15d: Standardised mortality rate ratio for female stomach cancer



Mortality - female

The mortality rates of stomach cancer in females were higher among the more deprived. There were significant upward trends in England and Northern Ireland, with non-significant upward trends observed in Wales and Scotland. Compared with England, the mortality rates of stomach cancer were significantly higher in Scotland, with no significant difference observed in Wales or Northern Ireland.

3.3 Analysis of age-standardised rates (ASRs) by deprivation metric

The following three deprivation metrics were chosen for analysing ASRs by deprivation quintile:

1) IMD: The income domain of the respective Index of Multiple Deprivation (IMD) for England, Wales, Scotland and Northern Ireland; and the relative score from the Pobal HP Deprivation Index for Small Areas in Ireland.

2) Education: The percentage of the population, aged 16 and over, with a third level qualification (degree or higher). Lower rates of third level education were taken as an indicator of higher levels of deprivation.

3) Unemployment: The percentage of the population, aged 16-74, who were unemployed at the time of the census in 2011. Higher rates of unemployment were taken as an indicator of higher levels of deprivation.

In each country, deprivation is measured by geographic area. An IMD, education and unemployment score is calculated for each area. The areas are then grouped into quintiles, with each quintile representing 20% of the population, with the least deprived 20% of the population in quintile 1, and the most deprived in quintile 5.

3.4 New metrics: Average education and unemployment scores per quintile

A summary of education attainment and levels of unemployment by country is presented below. Figure 16 shows the rates of third level education by deprivation quintile were similar across the five countries. However, the unemployment rates in Ireland were noticeably higher across all deprivation quintiles compared with the other four countries, see Figure 17.

Figure 16: Education rates by deprivation quintile

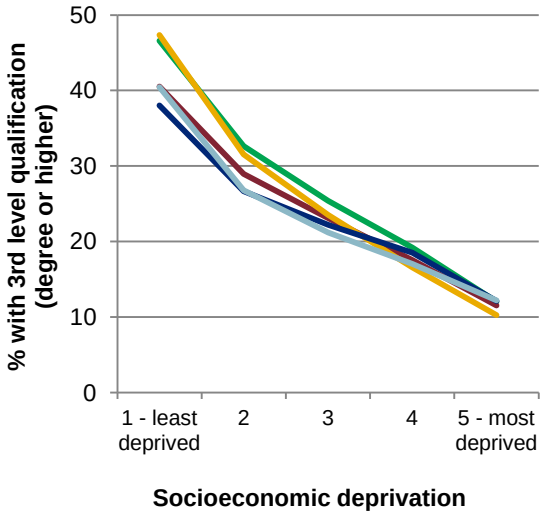
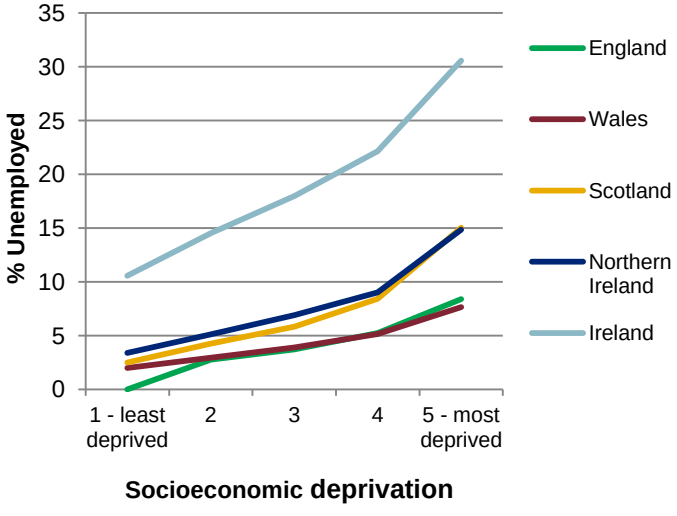


Figure 17: Unemployment rates by deprivation quintile



3.5 Testing for interactions

Using linear regression analysis, the deprivation metrics were tested to determine whether the ASRs differed significantly when comparing the results using the new metrics with those using the IMD metric, after controlling for the quintile effect.

Figures 18-22 show the age-standardised incidence rates for breast cancer using the IMD, education and unemployment metrics for all five countries.

Figure 18: England
Age-standardised incidence rates for breast cancer by deprivation metric

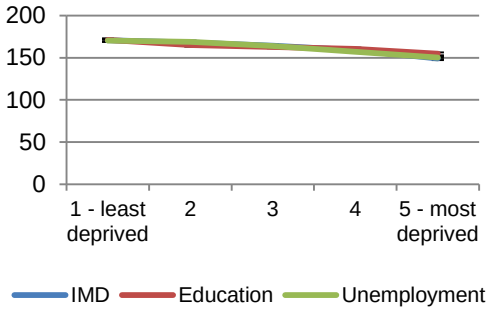


Figure 19: Wales
Age-standardised incidence rates for breast cancer by deprivation metric

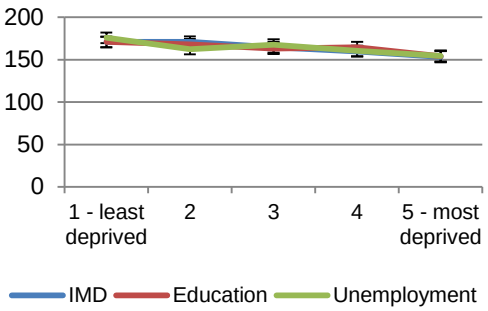


Figure 20: Scotland
Age-standardised incidence rates for breast cancer by deprivation metric

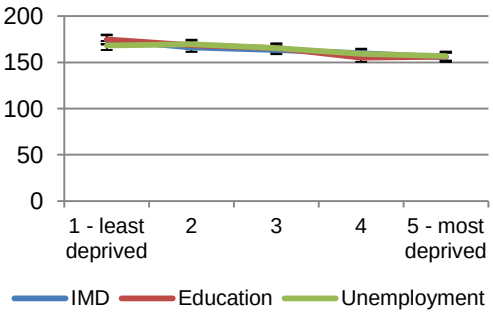


Figure 21: Northern Ireland
Age-standardised incidence rates for breast cancer by deprivation metric

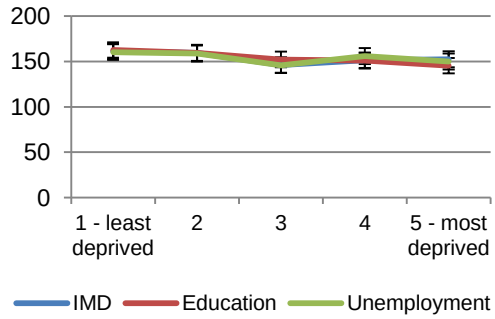
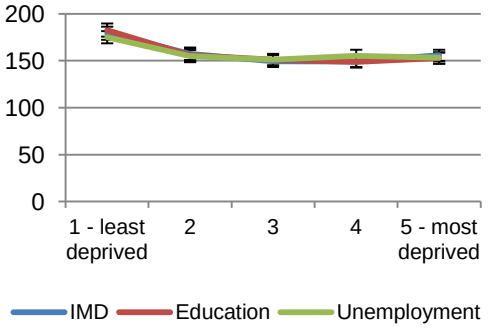


Figure 22: Ireland
Age-standardised incidence rates for breast cancer by deprivation metric



For Ireland, Northern Ireland, Scotland and Wales, no significant interactions between ASRs were found when using either the education or unemployment metrics, compared with the IMD deprivation metric.

For England, no significant interactions between ASRs were found when using the unemployment metric, compared with the IMD deprivation metric. However, significant differences were observed when using the education metric in the following four cases: incidence for female colorectal cancer (p-value=0.007), mortality for female lip, mouth and pharyngeal cancer (p-value=0.008), and incidence for both male and female malignant melanoma of skin (p-value=0.003 and p-value=0.007, respectively).

Figures 23-26 show the age-standardised rates for England when using the IMD, education and unemployment metrics in these four cases.

Figure 23: Age-standardised incidence rate for female colorectal cancer by deprivation metric

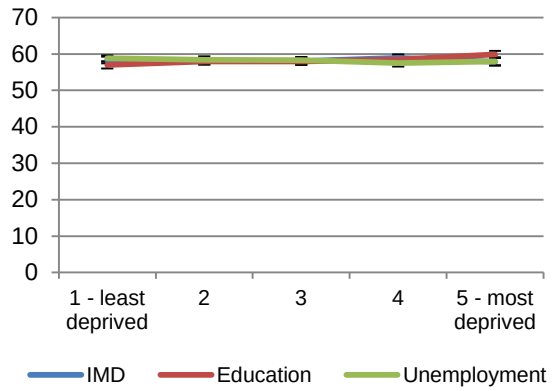


Figure 24: Age-standardised mortality rate for female lip, mouth and pharyngeal cancer by deprivation metric

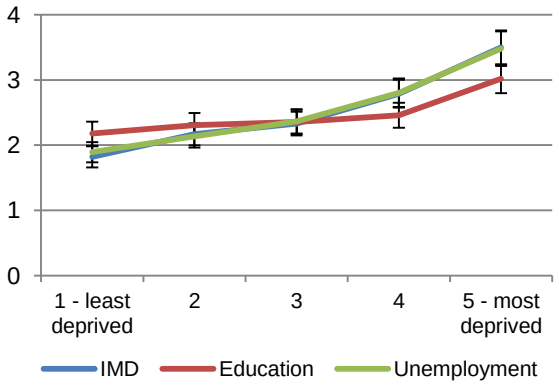


Figure 25: Age-standardised incidence rate for male malignant melanoma of skin by deprivation metric

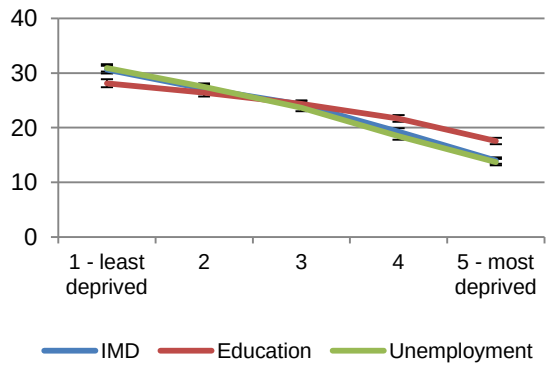
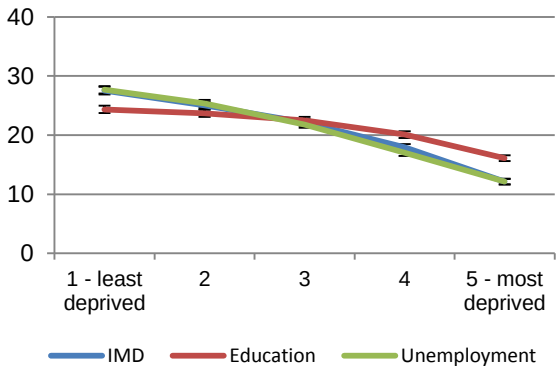


Figure 26: Age-standardised incidence rate for female malignant melanoma of skin by deprivation metric



3.6 Comparison of results by deprivation metrics

Table 5 shows the level of concurrence in the results when analysing the new deprivation metrics compared with the IMD metric.

Table 5: Level of concurrence between results using IMD metric and alternative metrics

	Education		Unemployment	
	Trend	**Across countries**	**Trend**	**Across countries**
Number of tests	165	135	165	135
Number concurrent	117	123	141	127
Percentage concurrent	71%	91%	86%	94%

Overall, the level of concurrence in results was 80% when comparing the education metric with the IMD metric, and 89% when comparing the unemployment with the IMD metric, indicating that the unemployment metric was a better alternative metric than the education metric.

Chapter 4: Discussion

This report has not estimated the number of excess cancer cases and deaths from deprivation as reported in the NCIN deprivation report *Cancer by Deprivation in England.*[10] The primary aim of this work was to examine the feasibility of producing a consistent metric within the deprivation measures that could be applied across the five countries of England, Wales, Scotland, Northern Ireland and Ireland.

4.1 Comparability of the deprivation measures across the countries

Income is considered to be the most appropriate indicator to measure deprivation. However, the five countries studied used different methodologies to measure the income metric for deprivation. The most accurate method to represent the income metric was agreed with each country; and referred to in this study as the IMD metric.

To verify whether such results using the IMD were consistent, a comparison was made using the education and unemployment metrics for deprivation. The education and unemployment metrics have common methodologies across the five countries. The level of education (degree level qualification or higher) by deprivation quintile was similar across the five countries. However, unemployment rates in Ireland were noticeably higher across all deprivation quintiles compared with the other four countries. This could be interpreted as meaning that the risk factors for developing cancer may be less strongly influenced by employment status than other aspects of deprivation. But it also implies that employment is less good as a measure of deprivation when comparing countries, but is good within a country. It may mean that the absolute values are less important than the gradient as an indicator of deprivation.

Linear regression was used to test for interactions between age-standardised cancer incidence and mortality rates and the following three deprivation metrics: IMD, education, and unemployment. The tests showed the three deprivation metrics produced similar age-standardised rates (ASRs). For Wales, Scotland, Northern Ireland and Ireland, there were no significant interactions between ASRs using the education or unemployment metrics, compared with the IMD deprivation metric. For England, the unemployment metric also showed no significant interactions, but the education metric in four cases showed significant differences between ASRs compared with the IMD metric. The following four cases showed statistically significant differences in England: incidence of female colorectal cancer; mortality of female lip, mouth and pharyngeal cancer; and incidence of male and female malignant melanoma. It is possible that these differences were not statistically significant in the other countries as a result of smaller numbers.

Inconsistencies in measuring deprivation make valid comparisons of ASRs across countries difficult. One of the main findings from this study was that the results (regarding the direction or significance of the trend, or when comparing rates across countries) were in most cases the

same whether the IMD, education or unemployment measure of deprivation was used. This shows that the magnitude of the effect, as well as the direction, was almost identical for the three measures; and implies it is possible that the relationship between deprivation and cancer is to a large extent independent of the way deprivation is measured.

This is important as it allows for comparisons of incidence and mortality rates across countries to be made, with a level of confidence that differences in methodologies used to generate IMD deprivation measures will not invalidate the conclusions. This study has demonstrated that researchers could use a measure of deprivation such as unemployment, generated using a common methodology, as the basis of deprivation studies across these five countries.

This work measures deprivation using an area-based, rather than an individual-based, indicator of socioeconomic position (SEP). Therefore, these analyses may be subject to 'ecological fallacy'. In other words, they are based on the assumption that everyone living in a particular small area of residence has the same SEP, which is unlikely to be entirely correct. In addition, indicators of SEP tend to be based on measurements recorded at a single point in time (for example, the decennial census) and applied to another single point in time (based on place of residence at the time of diagnosis). In an ideal world, with respect to incidence, one might want to use an individual indicator of SEP measured historically (at a time relevant to the social patterning of risk factors) or, even better, measured over life course (since SEP at the time of diagnosis is probably also relevant to mortality risk). Of course, it is even more complex than this because there probably are area-based (for example, local environmental) as well as individual effects. However, this level of detail is not available from current data sources.

4.2 Trends in rates and differences by deprivation across the countries

The discussion below examines the cancer specific results from the IMD deprivation metrics, using the income domain of the respective indices of multiple deprivation in England, Wales, Scotland and Northern Ireland, Scotland and Wales, and the relative deprivation score from the Pobal HP deprivation index in Ireland.

Regression models tested for trends in age-standardised incidence and mortality rates for males and females, and tested for differences across countries. Previous studies have shown that higher incidence rates are associated with higher levels of deprivation for the following six cancers: cervix; colorectal; laryngeal; lip, mouth and pharyngeal; lung; and stomach. Significant trends in incidence and mortality rates were observed for England and Scotland for these cancers for both males and females, with greater levels of deprivation being associated with higher rates of incidence and mortality. This was also true for Wales in the majority of cases, the exceptions being: incidence - colorectal cancer females and lip, mouth and pharynx cancer for males and females; mortality - stomach cancer for males and females, and cervical and colorectal cancer for females only. In Northern Ireland significant trends in incidence of cancer were observed in all six cancers for men, but only in lung cancer and stomach cancer among women. Mortality rates were significantly higher for lung cancer for both males and females, for stomach cancer among females, and colorectal cancer among males. For Ireland, significant

trends were only observed in incidence for cervical cancer among women, and stomach and laryngeal cancer among men. It is possible that this finding is related to the disparate size of the populations studied.

Higher incidence rates are associated with lower levels of deprivation for cancers of the breast; malignant melanoma of skin; and prostate. Downward trends in incidence were observed in these three cancers, with incidence decreasing as the level of deprivation increased. These trends were significant in England, Wales and Scotland for breast cancer; England, Wales, Scotland and Northern Ireland for prostate cancer, and in all five countries for males and females for malignant melanoma of skin. However, the mortality rate for breast cancer increased with increasing deprivation, significantly in England, Wales and Scotland. There was no trend observed in any country in prostate cancer mortality rates across the deprivation quintiles. For malignant melanoma of skin, the general trend in mortality rates was downward sloping, meaning the mortality rate was higher in more affluent areas, though this trend was only significant for England, in both males and females.

Regression models were used to test for trends in age-standardised cancer incidence and mortality rates by sex and to test for differences between countries, benchmarked against England. Significant differences were observed, among others, for lung; and lip, mouth and pharyngeal cancer; in Scotland, compared with England. Trends and rates of age-standardised rates in Ireland differed to those observed in England for a number of cancers. Similar trends were observed between England, Wales and Northern Ireland for most cancers. The most striking outcome from the analysis was the similarities in age-standardised rates, and trends in age-standardised rates, for incidence and mortality across the UK, with similar results in most cases. Incidence and mortality rates and trends were very similar in England, Wales and Northern Ireland for the majority of cancers. Significant differences in trends and ASRs were observed between England and Scotland, and England and Ireland, for a number of cancers.

4.3 Cancer specific findings and their risk factors by deprivation

4.3.1 Female breast cancer

In each country, there was a negative trend in female breast cancer incidence over deprivation quintiles, with higher deprivation associated with lower rates of breast cancer. This trend was statistically significant in England, Scotland and the UK as a whole.

Most of the known risk factors for breast cancer relate to a woman’s reproductive history – early menarche (onset of menstrual periods), late first pregnancy, low parity, and late menopause; endogenous hormones, both oestrogens and androgens, probably have an important role. Higher incidence of breast cancer has also been found to be linked to increasing alcohol consumption, being overweight or obese, lack of physical exercise and to not breastfeeding.[29] There are reported trends of late first pregnancy and lower parity with decreasing deprivation;[30] and increasing alcohol consumption with decreasing deprivation in England,[31] Wales,[32] and Scotland.[33] Several studies have shown that the least deprived are more likely to drink alcohol,

and also more likely to drink to excess.[32,33] This may contribute to the higher incidence of breast cancer among the least deprived. In Scotland, the uptake of screening was highest among the least deprived.[34] This trend was reflected throughout the UK and Ireland which may also explain why the incidence of breast cancer was highest in the least deprived quintile. It is possible that these effects were offset to some extent by higher rates of overweight and obesity, lower rates of physical activity and lower rates of breastfeeding among the most deprived.

Although there was a higher incidence of breast cancer in the least deprived quintile, the age-standardised mortality rate increased with increasing levels of deprivation; this trend was significant in England, Scotland and the UK as a whole. Affluent patients are more likely to have a screen-detected breast cancer.[35] Deprivation influences treatment, with the most deprived patients having higher mastectomy rates and receiving less immediate reconstruction.[35] There were no significant differences in either the incidence or mortality rates in Wales, Scotland, Northern Ireland or Ireland as compared with the rates in England. For most cancers, survival is worse for deprived groups and this gap has tended to increase as survival rates have increased overall, with the exception of breast cancer in women and a few other cancers.[36,37]

4.3.2 Cervical cancer

Incidence rates of cervical cancer increased with increasing deprivation. The trend was significant in all countries except for Northern Ireland, where the positive trend was not significant possibly as a result of small numbers.

Incidence of cervical cancer is linked to HPV infection.[38] Data on the rate of HPV infection by deprivation quintile was not available. Published evidence suggests that HPV infection is more prevalent in individuals from the lowest socioeconomic groups,[39,40] and is also associated with higher numbers of sexual partners[41] and smoking.[7] One study also found that schoolgirls over 16 from lower socioeconomic groups are less likely to take up HPV vaccination;[42] although HPV vaccination was only being introduced during the period of the study, making it unlikely that this would explain any differences seen. Smoking has been found to be a risk factor for cervical cancer in several studies.[43] Smoking rates were highest among the most deprived, and it is possible that this is related to the higher rates of cervical cancer observed in the most deprived quintile, although it is a factor that is not necessarily causal, since it is associated with higher risk sexual behaviour and also reduced immunity.[44]

Cervical screening aims to reduce the number of women who go on to develop cervical cancer by detecting and treating pre-invasive disease which may otherwise lead to cancer. Socioeconomic deprivation is associated with lower levels of cervical screening participation.[45] The incidence rates were significantly higher in Scotland and Ireland than the rates in England, with the rates in Ireland being substantially higher than those observed in the UK. In Ireland, the National Cervical Screening Programme started in 2008,[46] later than the UK. The screening activity may have had some bearing on the upward trend in rates, and the higher

rates currently in Ireland may in part reflect increased or earlier detection of invasive cancers that were prevalent cases.[6]

In England and Wales, there was a significant inverse gradient in survival with deprivation,[47] with five-year survival some four percentage points higher in the most affluent.[36] A major contributing factor in poorer survival among women living in more deprived areas is possibly lower screening uptake, resulting in more advanced, harder to treat disease at presentation. These survival differences may be one possible explanation for the trends in mortality by deprivation.

Mortality rates from cervical cancer also increase with increasing deprivation. This trend was positive in all the countries in the UK, as well as in the UK as a whole. This trend was significant in all of countries examined except for Northern Ireland, again possibly due to small numbers. The mortality rates were higher in Scotland than in England. The higher mortality rate in the most deprived quintile reflected the higher incidence rate, but also the lower screening uptake in women living in these areas.

4.3.3 Colorectal cancer

The trend for incidence of colorectal cancer across deprivation quintiles was less clear than for most of the cancers examined. For females, there was no clear trend in any of the countries. For males, there was a significant positive trend in England, Wales and Scotland, as well as in the UK as a whole.

A diet rich in processed meat and low in vegetables, obesity, lack of physical exercise, smoking and alcohol consumption have all been linked to higher incidence of colorectal cancer.[19] It is possible that the lower rates of alcohol consumption in the most deprived are offset by the effects of higher rates of obesity, smoking and lack of physical exercise. This may explain the lack of a trend in female incidence of colorectal cancer.

Colorectal is the only cancer examined for which incidence rates are significantly different in England than the rest of the UK. Compared with England, the incidence rates of colorectal cancer are higher for males and females throughout the UK and Ireland, as well as in the UK as a whole. A more systematic comparison of risk factors across the UK may shed light on why rates of colorectal cancer are higher outside of England.

In Scotland, individuals who are deprived are less likely to participate in colorectal screening, less likely to undergo colonoscopy and less likely to have cancer identified as a result of a positive test.[48] If this trend was reflected throughout the UK and Ireland, this may also explain why there is a significant difference in survival and mortality rates by deprivation. The gap in five-year survival between the most deprived and most affluent patients was six and seven percentage points in males and females respectively, for colon cancer; and nine and eight percentage points in males and females respectively, for rectal cancer.[36] This gradient in survival with deprivation, may in part explain the trends in mortality rates for colorectal cancer.

There was a significant positive trend in mortality rates of colorectal cancer in males in all five countries. As was the case for incidence, mortality rates were significantly higher in all countries compared with rates in England. There was also a positive trend in mortality rates of colorectal cancer in females in all the countries, though it was not significant in Wales or Northern Ireland. The mortality rates in Scotland and in the UK as a whole were significantly higher than the rates in England.

4.3.4 Laryngeal cancer

For laryngeal cancer, the incidence rates increased with increasing levels of deprivation. The three main risk factors associated with incidence of laryngeal cancer and their attributable risk factor exposures are: tobacco smoking (79%), a lack of fruit and vegetables (45.4%), and alcohol consumption (24.6%).[19] The trend in incidence rates reflects the higher rates of smoking, and lower rates of fruit and vegetable consumption in the most deprived quintiles.[49,50] Tobacco smoking and alcohol consumption act independently, but when combined have a synergistic effect. Lower rates of alcohol consumption may mitigate against these other risks to some extent.

For males and females in each country the incidence and mortality rates increased with increasing levels of deprivation. The positive trend in incidence rates was significant in each country for males; and also for females with the exceptions of Ireland and Northern Ireland, where the positive trend was not significant possibly due to small numbers. The incidence rates were significantly higher for males in Scotland than in England. It is possible that this is related to higher rates of smoking prevalence in Scotland than in England and Wales,[51] and also potentially due to poorer diets.[52] No other significant differences were observed.

There is also a very strong socioeconomic gradient in survival from laryngeal cancer with the more deprived groups having the lowest survival.[47] This gradient is steeper than for any other type of cancer, with a gap in five-year relative survival of 17 percentage points between the least deprived and most deprived groups.[36] This gradient in survival with deprivation partly explains some of the trends in mortality rates for laryngeal cancer.

The positive trend in mortality rates with increasing levels of deprivation was significant for males and females in each country, with the exception of males in Northern Ireland and females in Wales because of small numbers. There were no significant differences across the countries.

4.3.5 Lip, mouth and pharyngeal cancer

The risk factors associated with cancers of the lip, mouth and pharynx are the same as those for laryngeal cancer, with the three main risk factors being tobacco smoking, a lack of fruit and vegetables, and alcohol consumption, with 64.5%, 56.0% and 30.4% of incident cases estimated as being associated with these three factors.[19] It is possible that those in the most

deprived quintiles are more likely to smoke, and less likely to eat the recommended amounts of fruit and vegetables. As a result of the synergistic action of tobacco and alcohol, and to the frequent combination of the two habits in individuals, most cases are attributable to the combined effects of smoking and drinking; with incidence rates tending to increase with increasing deprivation.

The trend was significant for males in each country except for Ireland, and for females in England, Scotland and the UK as a whole. The incidence rates are significantly higher for males and females in Scotland than those in England. This could be a reflection of higher smoking rates and lower rates of consumption of fruit and vegetables in Scotland.[51,52] The incidence rates are lower for females in Ireland than for their counterparts in England. This may be due to different patterns of smoking, alcohol, or fruit and vegetable consumption, though relevant figures were not available by deprivation quintile in Ireland that would have allowed this to be investigated.

The mortality rates also increased with increasing deprivation. This was significant for males and females in England, Scotland, and the UK as a whole, and for males in Wales. Compared with rates in England, the mortality rates were significantly higher in Scotland for males and females. It is possible that this is a reflection of the significantly higher incidence rates, as well as the higher rates of smoking. These mortality trends are also to some extent influenced by survival. There is a very strong socioeconomic gradient in survival from lip, mouth and pharyngeal cancer with the more deprived groups having the lowest survival; five-year survival is some 10-15 percentage points higher in the most affluent.[47]

4.3.6 Lung cancer

In England, Wales, Scotland and Northern Ireland there were very clear increasing trends of incidence of lung cancer with increasing deprivation. In Ireland there was a much less pronounced upward trend, for both males and females. The upward trend was significant in all countries except for Ireland.

Smoking is the biggest risk factor associated with incidence of lung cancer, with an estimated 85.6% of cases in the UK being attributable to exposure to tobacco smoke.[43] The prevalence of smoking was highest among the most deprived throughout the UK and Ireland.[53] In Scotland, the mean number of cigarettes smoked was higher in the most deprived quintiles; it is possible that this is true throughout the UK.[54,55] This explains why the rates of incidence of lung cancer are much higher in the most deprived quintile. Historic trends show that the prevalence of smoking has fallen steadily in Great Britain over the past 40 years, from 46% in 1974 to 19% in 2013.[56] In Wales, the gap in incidence between the most deprived and least deprived has increased over the past ten years.[15] Over time a decrease in the rate of lung cancer may be seen, but the gap between the most deprived and the least deprived may grow. The average incidence of lung cancer was significantly higher in Scotland than in England for both males and females. It is possible that this is related to the historically higher rates of smoking in Scotland compared with England.

In Ireland the trend was not significant, though the average rate of lung cancer was not significantly different to that observed in England. Historic patterns of smoking behaviour by deprivation in Ireland prior to 2003 are unknown. So this trend may be a reflection of a more even spread in the rates of smoking across deprivation quintiles in Ireland, or possibly a lack of homogeneity in the areas used to comprise the deprivation quintiles there. The population in the electoral divisions in Ireland ranged from 73 to over 32,000. Thus the size of some of the electoral divisions may have made it difficult to get an accurate picture of deprivation. This might explain why the rates of lung cancer were higher in the least deprived in Ireland, but were lower in the most deprived there compared with their counterparts in the UK.

For mortality rates, the picture is similar to that for incidence, with increasing trends throughout the UK, and significantly higher mortality rates in Scotland compared with England. Survival rates partly explain these mortality rates. Lung cancer has very low overall survival. Despite this, there is a significant socioeconomic gradient in relative survival that is evident in both sexes, with lower short-term and longer-term survival among the more deprived groups.[36]

4.3.7 Malignant melanoma of skin

The incidence of malignant melanoma decreases with increasing deprivation. The trend was significant for males and females in each of the countries. Exposure to ultraviolet radiation has been estimated to contribute to 85.9% of incidence of melanoma in the UK.[19] Those in the least deprived quintiles almost certainly had greater exposure to UV radiation in the past. They maybe more likely in the past to have had holidays abroad than those in the most deprived quintiles. The NCIN report *Cancer by deprivation in England*[10] showed that the incidence rate increased for all deprivation quintiles over the period 1996-2010, but the gap in incidence between the least and most deprived had grown during this period. In Ireland, there has been a large increase in the registration of very thin and in-situ lesions that previously would not have been registered as malignant melanoma of skin.

However, the most deprived quintile was least likely to take protection against the sun.[57] The distribution of sunbed locations varies by level of area deprivation across the UK, with higher rates of sunbed density in more deprived areas.[58] Greater awareness of the dangers of exposure to UV radiation may eventually result in a change in pattern of incidence rates over deprivation quintiles. Incidence rates in males were significantly higher in Wales than in England, and in females the rates were significantly higher in Scotland and Ireland than the rates observed in England.

Mortality rates for malignant melanoma generally decreased with increasing deprivation. The trend was significant in England and the UK for males and females, as well for males in Scotland. Malignant melanoma was the only cancer that had a significant negative trend with deprivation in mortality rates. There were no significant differences between the mortality rates in England and those observed in any of the other countries, or in the UK as a whole. These trends in mortality can be partly explained by survival.

Survival from melanoma of the skin in England and Wales is high, with five-year survival increasing more rapidly than one-year survival.[36] This suggests a real increase in survival and cure, presumably attributable to earlier diagnosis and/or improved treatment. The socioeconomic gradient in survival also appears to be stable or declining. Survival from melanoma is substantially higher in women than in men. Five-year survival is six percentage points lower among men in the more deprived groups than among the more affluent. The deprivation gap in survival for women fell during the 1990s, and it is now only one percentage point.[36]

4.3.8 Prostate cancer

Similarly to breast cancer, there is a negative trend for prostate cancer incidence across deprivation quintiles. The rates of prostate cancer incidence were highest in the least deprived quintile in each country, with significant negative trends observed throughout the UK, though not in Ireland.

No lifestyle or environmental factors have been linked to prostate cancer, however incidence levels follow trends in PSA testing.[19] There are no systematic programmes for prostate cancer screening in the UK or Ireland. Higher rates of PSA testing among the least deprived quintiles[59] may explain the negative trend. The rapid increases in the apparent incidence of prostate cancer since the late 1990s may have widened the gap in rates between the affluent and the deprived. The incidence rates in Ireland were approximately 35% higher than the average incidence rates in the UK. It is possible that this is related to the higher level of PSA testing in Ireland relative to the UK, reflecting private healthcare provision in Ireland.[60,61] In Ireland, the number of PSA tests carried out increased five-fold between 1995 and 2004.[62] This phenomenon has been reported in most developed countries, although the rate of increase in Ireland was more than twice that in Northern Ireland.[63] The incidence rates were significantly higher in Wales than in England, and significantly lower in Scotland compared with England.

In comparison with most other cancers, survival from prostate cancer is relatively high. Five-year survival rates were similar for patients diagnosed in 2000-2007 in England (80.4%), Wales (78.2%), Scotland (78.9%), Northern Ireland (83.4%) and Ireland (85.4%).[64] The estimated survival rates are highly sensitive to the inclusion of cases of localised cancer, detected by PSA testing. These cases tend to have a good prognosis, which has the effect of increasing the survival estimates. Despite high overall survival, there is a significant deprivation gap in survival, which increased significantly during the 1990s. Survival was higher in men from affluent areas than in men from deprived areas, with a gap of about seven percentage points in five-year relative survival between these two groups.[36] These trends in survival partly explain the mortality findings below.

There were no significant trends in mortality rates by deprivation quintile in England, Wales, Scotland or Northern Ireland. This is what we would expect to see if the higher rates of prostate cancer incidence are due to higher levels of PSA testing, rather than higher rates of prostate cancer itself among those living in less deprived areas. There were no significant differences in

the average level of mortality due to prostate cancer in Wales, Scotland or Northern Ireland, when compared with the rates in England.

4.3.9 Stomach cancer

The incidence rates of stomach cancer were higher with increasing levels of deprivation, for both males and females. The trend was significant in all cases except for females in Wales and Ireland.

A diet high in very salty foods, in certain preserved foods, and red meat; and low in fresh fruit and vegetables, has been strongly associated with incidence of stomach cancer.[19] Helicobacter pylori bacteria cause an infection that increases the risk of stomach cancer in the lower part of the stomach. Historically, it was probably associated with overcrowded living conditions and was more common among deprived individuals.[65] About 1 in 5 stomach cancers (20%) in the UK is thought to be caused by smoking.[19] Those in the most deprived quintiles are more likely to smoke[49] and less likely to eat the recommended amounts of fruit and vegetables.[50] It is possible that this is reflected in the higher incidence rates. In males, the incidence rates were significantly higher in Ireland, Scotland and Wales, and in females the rates were significantly higher in Ireland and Scotland. This may be due to higher rates of smoking or related to poorer diet – consumption of salt is another identified risk factor,[19] as well as low rates of fruit and vegetable consumption.[52]

Long-term survival from stomach cancer is quite low. The frequently advanced stage of the disease at diagnosis, the aggressiveness of the disease, and the small number of patients who are suitable for curative surgery explain the low rates of survival from stomach cancer. There was little difference in survival among deprived compared with affluent groups for patients, the gap in five-year survival was around two percentage points for men, with no clear trend seen in the deprivation gap for women.[36]

Thus, the mortality rates of stomach cancer reflect incidence rates and also increase with increasing levels of deprivation. The trends were significant in England and the UK for both males and females. The trend was significant in males in Scotland and in females in Northern Ireland. The mortality rates were significantly higher in Scotland than in England for both males and females.

Chapter 5: Conclusion

This work shows that variations in cancer incidence and mortality by deprivation can be compared across the five countries of England, Wales, Scotland, Northern Ireland and Ireland. The five countries studied use different methodologies to calculate deprivation; and this has previously prevented the comparison of deprivation between the countries.

These results imply that the relationship between deprivation and cancer incidence and mortality is to an extent independent of the way deprivation is measured in the five countries. It also demonstrates that the Index of Multiple Deprivation (IMD) deprivation measure is robust, despite differences in the methodologies across the countries. The unemployment metric provides a better fit than the education metric (89% v 80%), compared with the IMD metric. The unemployment metric that has common methodology across the five countries could be considered by researchers analysing deprivation across the UK and Ireland.

The cancer incidence and mortality rates by deprivation for the nine cancers we studied were examined across the five countries. The work confirms the findings of previous studies, which have shown that higher incidence rates are associated with higher levels of deprivation for the following six cancers: cervix; colorectal; laryngeal; lip, mouth and pharyngeal; lung; and stomach. In most countries there were clear and significant trends for these six cancers with higher incidence and mortality rates associated with higher levels of deprivation. This is particularly clear in England and Scotland, with the pattern less certain in Wales and Northern Ireland, and few significant trends observed in Ireland.

Higher incidence rates are associated with lower levels of deprivation for the following three cancers: breast; malignant melanoma of skin; and prostate, confirming the findings of previous studies. For these three cancers, there were negative associations between incidence and deprivation, with higher incidence rates associated with lower levels of deprivation, but this only translated into higher mortality rates among the least deprived for malignant melanoma of skin.

The risk factors for many of the cancers studied, which were more common in deprived areas, were the same lifestyle choices: tobacco use, poor diet, being overweight, lack of exercise and alcohol. To prevent cancers and reduce inequalities these lifestyle factors should be addressed. In April 2016, PHE, NHS England and the Local Government Association made a commitment to support population-level behaviour change and improve the health of local populations by encouraging staff to make ‘healthy conversations’ part of everyday practice, known as the Making Every Contact Count (MECC) approach; this initiative is a step forward in reducing ill health that results from lifestyle choices and behaviours. Future policy should be aimed at making ‘healthier choices easier choices’ and could include changes in legislation and fiscal measures.

There is potential for a more detailed examination of cancer and deprivation across the UK and Ireland using these measures. There is an obvious limitation to significance testing when examining populations of such disparate sizes. Future work could examine the trend size and

statistical significance of the deprivation gradient in each country, and how that varies from country to country.

Appendix I

Define measures used – census questions.

England and Wales:

Q25: Which of these qualification do you have?

- Tick every box that applies if you have any of the qualifications listed
- If your UK qualification is not listed, tick the box that contains its nearest equivalent
- If you have qualifications gained outside the UK, tick the 'Foreign qualifications' box and the nearest UK equivalents (if known)

☐ 1 - 4 O levels / CSEs / GCSEs (any grades), Entry Level, Foundation Diploma
☐ NVQ Level 1, Foundation GNVQ, Basic Skills
☐ 5+ O levels (passes) / CSEs (grade 1) / GCSEs (grades A*- C), School Certificate, 1 A level / 2 - 3 AS levels / VCEs, Higher Diploma
☐ NVQ Level 2, Intermediate GNVQ, City and Guilds Craft, BTEC First / General Diploma, RSA Diploma
☐ Apprenticeship
☐ 2+ A levels / VCEs, 4+ AS levels, Higher School Certificate, Progression / Advanced Diploma
☐ NVQ Level 3, Advanced GNVQ, City and Guilds Advanced Craft, ONC, OND, BTEC National, RSA Advanced Diploma

☐ Degree (for example BA, BSc), Higher degree (for example MA, PhD, PGCE)
☐ NVQ Level 4 - 5, HNC, HND, RSA Higher Diploma, BTEC Higher Level
☐ Professional qualifications (for example teaching, nursing, accountancy)
☐ Other vocational / work-related qualifications
☐ Foreign qualifications
☐ No qualifications

Q26. Last week, were you:

- Tick all that apply
- Include any paid work, including casual or temporary work, even if only for one hour

☐ working as an employee?
☐ on a government sponsored training scheme?
☐ self-employed or freelance?
☐ working paid or unpaid for your own or your family's business?
☐ Away from work ill, on maternity leave, on holiday or temporarily laid off?
☐ Doing any other kind of paid work?
☐ None of the above

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