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SUMMARY

This report examines patterns and trends of colorectal cancer incidence, mortality, treatment and survival in Ireland during the period 1994-2010.

Incidence

11% (in women) and 14% (in men) of all invasive cancers (excluding non-melanoma skin cancer) were colorectal cancers in 2007-2009, which makes this the second most common tumour diagnosed in women (after breast cancer), and in men (after prostate cancer)(Table 1). Colorectal cancer was the third leading cause of cancer death in women, after lung cancer and breast cancer, and the second leading cause of cancer death in men after lung cancer in 2007-2009. It accounted for 10% and 12% of cancer deaths in males and females respectively in 2007. Approximately 950 women and 1,330 men were diagnosed with colorectal cancer annually during 2007-2009. The incidence rate of colorectal cancer in Ireland was similar to the European average in 2008 (Figure 12). The numbers of colorectal cancer cases are projected to increase by 34% in women and 45% in men between 2010 and 2020.[42]

Figure 1
Age distribution of incident colorectal cancer (C18-20)
Diagnosis period: 2006-2010

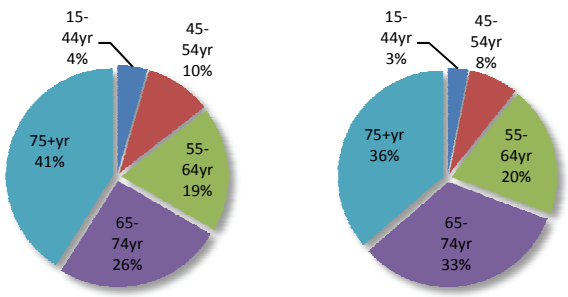
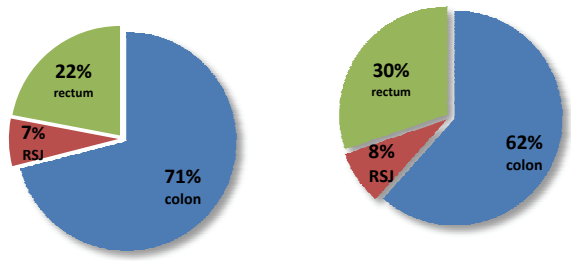


Figure 2
Site of primary colorectal tumour‡
Diagnosis period: 2006-2010



‡colon (C18), rectosigmoid junction (RSJ, C19), rectum (C20)

67% of women and 69% of men diagnosed with colorectal cancer were aged greater than 65 years (Figure 1). 14% of women and 11% of men presented aged less than 55 years. 22% of colorectal tumours in women occurred in the rectum compared with 30% for men (Figure 2). The ratio of male to female colorectal cancer is approximately 13:10. The ratio of colon to rectal cases is approximately 18:10 (15:10 in males and 23:10 in females).

While the age standardised incidence rate for colorectal cancer in both sexes was static from 1994 to 2010, the actual number of cases increased at 1.8% annually for women and 2.3% for men over the same period. This was due to an increase in the Irish population during that period (Table 1).

Mortality

424 women and 550 men died from colorectal cancer in Ireland in 2008. For all colorectal cancer cases (C18-20), this report presents evidence of a steady annual decline in mortality rate, of 2.1% in women and 1.6% in men from 1994 to 2009. However, there was 2.8% annual increase in mortality rate in women and 2.4% increase in men for the subset of rectal cancer cases (C19-20) during the same period (Table 3). The ECO estimates of cancer deaths in 2008 showed that Ireland's mortality rate was very close to the European average (Figure 23).

Survival

Survival with colorectal cancer in Ireland was in line with the European average for the period 2000-2002 (Figure 18). This report highlights a trend towards significantly improved survival across the three diagnostic periods examined: 1994-1998, 1999-2003 and 2004-2008.

Treatment

Surgery is the first line treatment for colorectal cancer. The proportion who received surgery did not change between 1995-1999 (76%) and 2005-2009 (78%) (Table 16). The proportion of cases who received chemotherapy increased significantly, from 27% during 1995-1999 to 43% for the period 2005-2009 (Table 17). The proportion of patients with rectal cancer who received radiotherapy increased from 24% in the period 1995-1999 to 40% in the period 2005-2009 (Table 18). Moreover, the proportion of cases with stage II/III rectal cancer (C19-20) who received pre-operative radiotherapy increased significantly from 5% during 1995-1999 to 38% during 2005-2009 (Table 33).

Table 1
Summary data for colorectal cancer in Ireland (C18-20)

	Females	Males	All	trend
% of all new cancer cases, 2007-2009	6.0%	9.2%	7.5%	-
% of all new cancer cases (excl. NMSC), 2007-2009	11.1%	14.2%	12.7%	-
Average number of new cases per year, 2007-2009	949	1,329	2,278	-
^APC [±95%CI] in number of cases, 1994-2010	1.8%[1.4, 2.1]	2.3%[2.0,2.7]	2.1%[1.8,2.4]	↑
Number of deaths during 2008	424	550	974	-
^APC [±95%CI] in number of deaths, 1994-2010	-0.3%[-0.9,0.4]	0.5%[-0.1,1.1]	0.2%[-0.3,0.6]	↔
Age-standardised incidence rate (per 100,000), 2007-2009	40.1	66.7	52.4	-
^APC [±95%CI] in age standardised incidence rate, 1994-2010	0.0%[-0.4,0.4]	0.2%[-0.1,0.4]	0.1%[-0.1,0.4]	↔
Age-standardised mortality rate (per 100,000), 2008	16.4	27.7	21.5	-
^APC [±95%CI]in mortality rate, 1994-2009	-2.1% [-2.8,-1.4]	-1.6% [-2.2,-1.0]	-1.8% [-2.2,-1.4]	↓
‡15 year prevalence, 1995-2009	5,578	7,100	12,678	-
‡10 year prevalence, 2000-2009	4,527	5,948	10,475	-
‡5 year prevalence, 2005-2009	2,908	4,053	6,961	-

^APC: annual percentage change

‡The number of persons still alive on 31/12/2009, who were diagnosed during the period shown.

- During the period 1994-2010, the number of colorectal cancer cases (C18-20) who presented in Ireland increased by 2.1% annually. The APC in the number of deaths was static (+0.2% annually) during the same period (Table 1).

- During the period 1994-2010, the number of colon cancer cases (C18) who presented in Ireland increased by 2.2% annually. The number of deaths fell by 1.9% annually during the same period (Table 2).

- During the period 1994-2010, the number of rectal cancer cases (C19-20) who presented in Ireland increased by 1.8% annually. The number of deaths increased by 4.5% annually during the same period (Table 3).

Table 2 Summary data for colon cancer in Ireland (C18)				
	Females	Males	All	trend
% of all new cancer cases, 2007-2009	4.3%	5.7%	5.0%	-
% of all new cancer cases (excl. NMSC), 2007-2009	8.0%	8.8%	8.4%	-
Average number of new cases per year, 2007-2009	683	815	1,498	-
APC [±95%CI] in number of cases, 1994-2010	1.8%[1.4,2.3]	2.6%[2.0,3.2]	2.2%[1.8,2.7]	↑
Number of deaths during 2008	271	310	581	-
APC [±95%CI] in number of deaths , 1994-2010	-2.1%[-3.0,-1.2]	-1.7%[-2.4,-1.0]	-1.9%[-2.4,-1.3]	↓
Age-standardised incidence rate (per 100,000), 2007-2009	28.1	40.8	33.8	-
APC [±95%CI] in age standardised incidence rate, 1994-2010	0.0%[-0.4,0.5]	0.5%[-0.1,1.0]	0.3%[-0.2,0.7]	↔
Age-standardised mortality rate (per 100,000), 2008	10.3	15.7	12.7	-
APC [±95%CI]in mortality rate, 1994-2009	-4.2% [-5.1,-3.2]	-3.7% [-4.4,-3.0]	-3.9%[-4.5,-3.3]	↓
15 year prevalence, 1995-2009	3,830	4,235	8,065	-
10 year prevalence, 2000-2009	3,107	3,532	6,639	-
5 year prevalence, 2005-2009	2,021	2,449	4,470	-

Table 3 Summary data for cancer of the rectosigmoid junction and rectum in Ireland (C19-20)				
	Females	Males	All	trend
% of all new cancer cases, 2007-2009	1.7%	3.5%	2.5%	-
% of all new cancer cases (excl. NMSC), 2007-2009	3.1%	5.4%	4.3%	-
Average number of new cases per year, 2007-2009	267	514	781	-
APC [±95%CI] in number of cases, 1994-2010	1.7%[1.0,2.4]	1.9%[1.4,2.5]	1.8%[1.4,2.3]	↑
Number of deaths during 2008	153	240	393	-
APC [±95%CI] in number of deaths, 1994-2010	4.4%[3.0,5.9]	4.6%[3.4,5.9]	4.5%[3.5,5.6]	↑
Age-standardised incidence rate (per 100,000), 2007-2009	11.5	25.8	18.2	-
APC [±95%CI] in age standardised incidence rate, 1994-2010	-0.1%[-0.9,0.7]	-0.3%[-0.9,0.3]	-0.1%[-0.6,0.4]	↔
Age-standardised mortality rate (per 100,000), 2008	6.2	12.1	8.8	-
APC [±95%CI]in age standardised mortality rate, 1994-2009	2.8%[1.2,4.4]	2.4%[1.1,3.6]	2.5%[1.5,3.5]	↑
15 year prevalence, 1995-2009	1,748	2,865	4,613	-
10 year prevalence, 2000-2009	1,420	2,416	3,836	-
5 year prevalence, 2005-2009	887	1,604	2,491	-

1. RISK FACTORS FOR COLORECTAL CANCER

Table 4
Risk factors for colorectal cancer, by strength of evidence

Evidence	Increases risk	Decreases risk
Convincing or probable	Family history of colorectal cancer (first degree relative(s) with colorectal cancer)[1]	Physical activity [3,4,11]
	Tobacco smoking (colon cancer only) [2]	Hormone replacement therapy [12]
	Alcohol[2]	Oral contraceptives [12,13]
	Greater body fatness, in particular, abdominal fatness [3,4]	Aspirin and other non-steroidal anti-inflammatory drugs [14]
	Red and processed meat [4]	Foods containing dietary fibre [4]
	Asbestos [5]	Garlic [4]
	Ionizing radiation (colon cancer only) [6]	Non starchy vegetables [4,15]
Possible	Disinfection by-products in drinking water [7]	Fruit [4,15]
	Helicobacter pylori infection [8]	Folate [16]
	Insulin-like growth factor-1 (IGF-1) [9]	Fish [4]
	Diabetes [10]	Coffee [17]
		Vitamin B6 intake and blood levels [18]
		Soya (women only)[19]
		Milk, dairy and/or calcium [20]
		Vitamin D blood level[21]

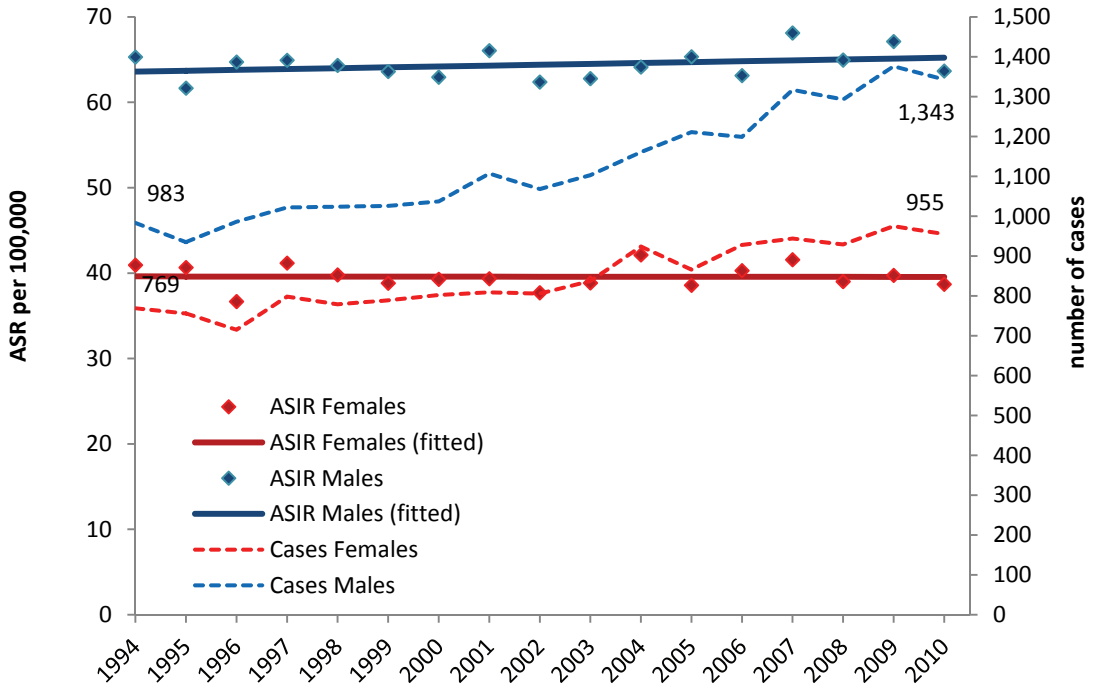
[1] Johns and Houlston, 2001; [2] Secretan et al., 2009; [3] International Agency for Research on Cancer, 2002; [4] World Cancer Research Fund / American Institute for Cancer Research, 2007; [5] Straif et al., 2009; [6] El Ghissassi et al., 2009; [7] Rahman et al., 2010; [8] Zhao et al., 2008; [9] Rinaldi et al., 2010; [10] Larsson et al., 2005; [11] Harriss et al., 2009; [12] International Agency for Research on Cancer, 2011a; [13] Bosetti et al., 2009; [14] International Agency for Research on Cancer, 1997; [15] International Agency for Research on Cancer, 2003; [16] Kennedy et al., 2011; [17] Galeone et al., 2010; [18] Larsson et al., 2010; [19] Yan et al., 2010; [20] Huncharek et al., 2009; [21] Yin et al., 2009

Up to 10% of colorectal cancers are hereditary and most of these are due to the genetic syndromes of familial adenomatous polyposis (FAP) and hereditary non-polyposis colorectal cancer (HNPCC).[43] Excluding these syndromes, individuals who have a first degree relative with colorectal cancer have around a two-fold increased risk of developing the disease themselves. Lifestyle factors are extremely important in colorectal cancer. Smoking is causally related to colon, but not rectal, cancer. Alcohol is a cause of both colon and rectal cancers. Higher levels of body fatness, and in particular central adiposity, are positively related to risk. In a recent meta-analysis, each 5kg/m^2 increment in body mass index was associated with an 18% increase in risk; the association appears stronger for colon than rectal cancer, for men than women, and in studies adjusting for physical activity.[44] In contrast, physical activity is consistently inversely associated with colon cancer, in particular, and risk decreases in a dose-response fashion with increased frequency or intensity of activity. Regular use of aspirin or other non-steroidal anti-inflammatory drugs may reduce colorectal cancer risk by up to half. In addition, risk is decreased in women taking hormone replacement therapy and is likely also to be lower in those who have taken oral contraceptives. Many studies have found increased risk in individuals who have higher intakes of processed meats (preserved by smoking, curing or salting, such as ham, bacon or salami) and red meats. In contrast, higher intake of various other dietary components may be associated with lower risk, including garlic; fruit; fish; non-starchy vegetables; milk, dairy products or calcium; coffee; soya and soya foods; and foods containing dietary fibre or the B vitamin folate.

2. INCIDENCE OF COLORECTAL CANCER

2.1 Incidence of colorectal cancer: summary data

Figure 3
Age standardised incidence rate (ASR) and incident cases of invasive colorectal cancer (C18-C20): 1994-2010



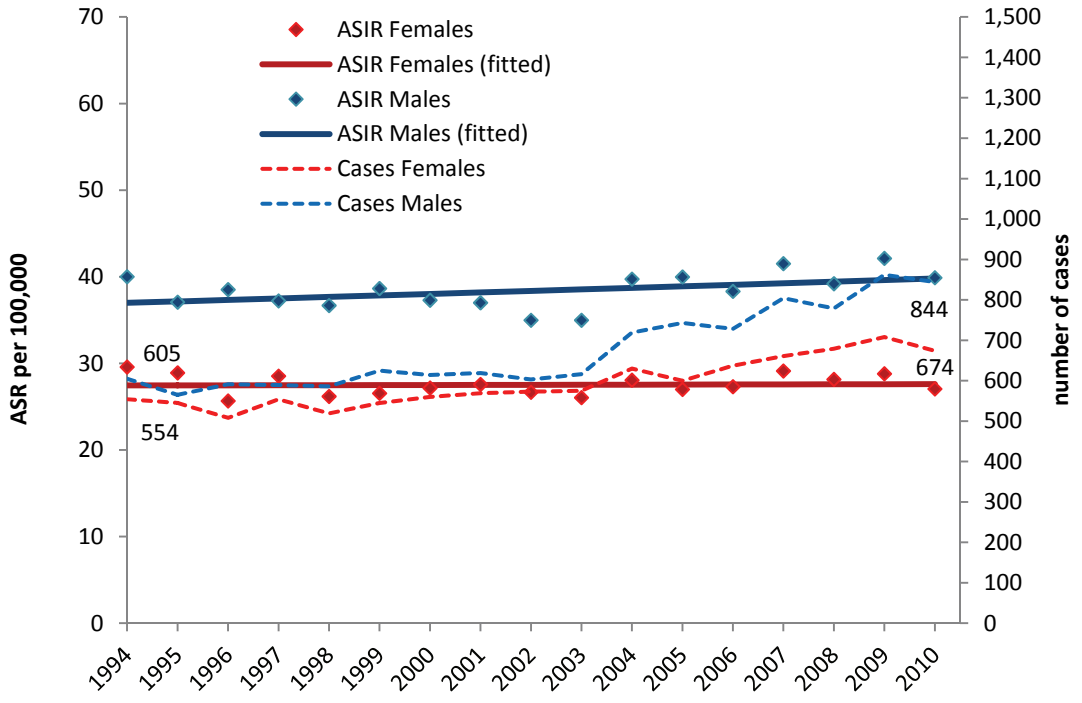
Looking at both colon and rectal cancer together, the number of male cases increased from 983 in 1994 to 1,343 in 2010. Female cases increased from 769 in 1994 to 955 in 2010 (Figure 3).

Table 5
Incidence of invasive colorectal cancer (C18- C20): 1994-2010

	Females		Males		All	
YEAR	**cases**	**ASIR**	**cases**	**ASIR**	**cases**	**ASIR**
1994	769	40.9	983	65.3	1,752	51.8
1995	756	40.7	935	61.7	1,691	49.9
1996	715	36.7	986	64.7	1,701	49.6
1997	798	41.2	1,022	64.9	1,820	51.9
1998	779	39.8	1,024	64.3	1,803	50.8
1999	789	38.8	1,026	63.6	1,815	50.1
2000	802	39.3	1,037	63.0	1,839	50.1
2001	809	39.4	1,107	66.1	1,916	51.2
2002	806	37.7	1,068	62.4	1,874	48.8
2003	837	38.9	1,103	62.8	1,940	49.7
2004	924	42.1	1,161	64.1	2,085	52.2
2005	866	38.6	1,211	65.3	2,077	50.9
2006	928	40.3	1,199	63.1	2,127	50.6
2007	944	41.6	1,317	68.1	2,261	53.8
2008	929	39.0	1,293	65.0	2,222	50.9
2009	975	39.8	1,376	67.1	2,351	52.5
2010	955	38.7	1,343	63.7	2,298	50.3
TOTAL	**14,381**		**19,191**		**33,572**	
APC	1.8%	0.0%	2.3%	0.2%	2.1%	0.1%
[95%CI]	[1.4, 2.1]	[-0.4,0.4]	[2.0,2.7]	[-0.1,0.4]	[1.8,2.4]	[-0.1,0.4]

While the number of cases increased significantly in females (1.8% per annum) and males (2.3% per annum) due to an increase in the Irish population between 1994 and 2010, there was no actual change in the age standardised rate of colorectal cancer in Ireland between 1994 and 2010 (Table 5).

Figure 4
Age standardised incidence rate (ASR) and incident cases of invasive colon cancer (C18): 1994-2010



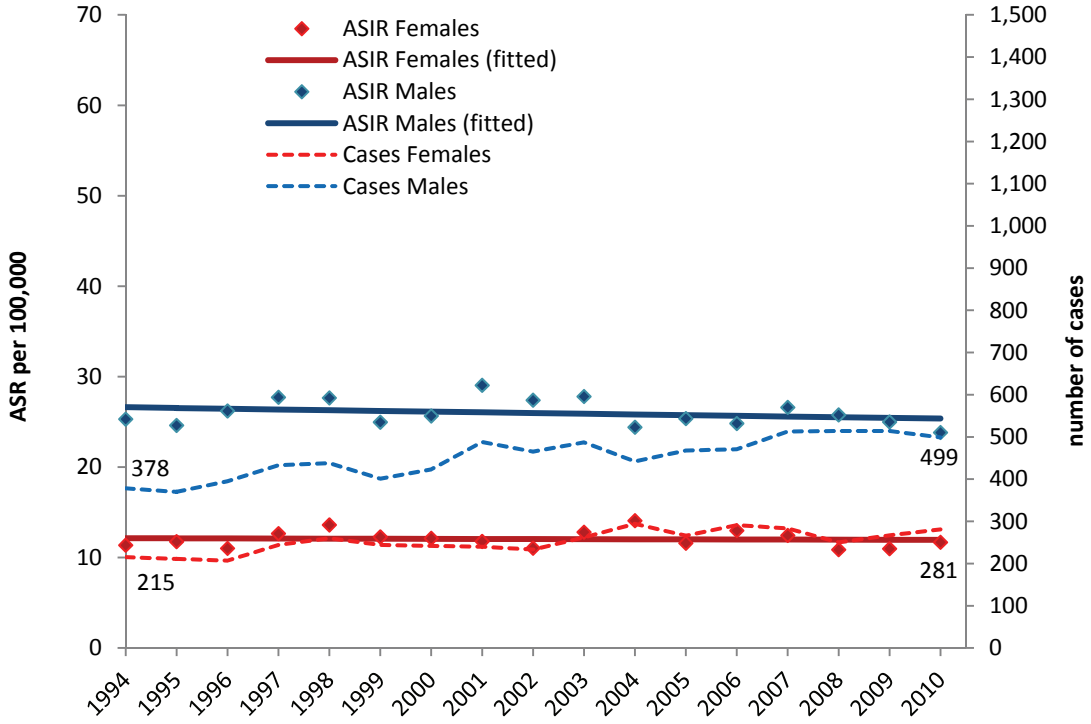
The number of male colon cancer cases increased from 605 in 1994 to 844 in 2010. Female colon cancer cases increased from 554 in 1994 to 674 in 2010 (Figure 4).

Table 6
Incidence of invasive cancer of the colon (C18): 1994-2010

	Females		Males		All	
YEAR	**cases**	**ASIR**	**cases**	**ASIR**	**cases**	**ASIR**
1994	554	29.6	605	40.0	1,159	34.2
1995	545	28.9	565	37.1	1,110	32.4
1996	508	25.7	591	38.5	1,099	31.5
1997	554	28.5	589	37.2	1,143	32.3
1998	519	26.2	586	36.7	1,105	30.9
1999	545	26.5	625	38.6	1,170	32.0
2000	560	27.1	614	37.3	1,174	31.6
2001	569	27.6	619	37.0	1,188	31.6
2002	573	26.7	603	35.0	1,176	30.3
2003	575	26.0	616	35.0	1,191	30.0
2004	630	28.1	719	39.7	1,349	33.4
2005	600	27.0	743	40.0	1,343	32.7
2006	637	27.3	728	38.3	1,365	32.2
2007	661	29.1	804	41.5	1,465	34.7
2008	679	28.1	779	39.2	1,458	33.1
2009	708	28.8	862	42.1	1,570	34.9
2010	674	27.0	844	39.9	1,518	32.9
TOTAL	**10,091**		**11,492**		**21,583**	
APC	1.8%	0.0%	2.6%	0.5%	2.2%	0.3%
[95%CI]	[1.4,2.3]	[-0.4,0.5]	[2.0,3.2]	[-0.1,1.0]	[1.8,2.7]	[-0.2,0.7]

On average 683 females and 815 males were diagnosed with colon cancer (C18) in Ireland between 2007 and 2009. There was no change in the age standardised incidence rate of colon cancer (C18) in males and females between 1994 and 2010. However, the actual number of cases increased significantly by 1.8% in females and 2.6% in males between 1994 and 2010 due to an increase in the Irish population during this period (Table 6).

Figure 5
Age standardised incidence rate (ASR) and incident cases of invasive rectal cancer (C19-20): 1994-2010



The number of male rectal cancer cases increased from 378 in 1994 to 499 in 2010. Female rectal cancer cases increased from 215 in 1994 to 281 in 2010 (Figure 5).

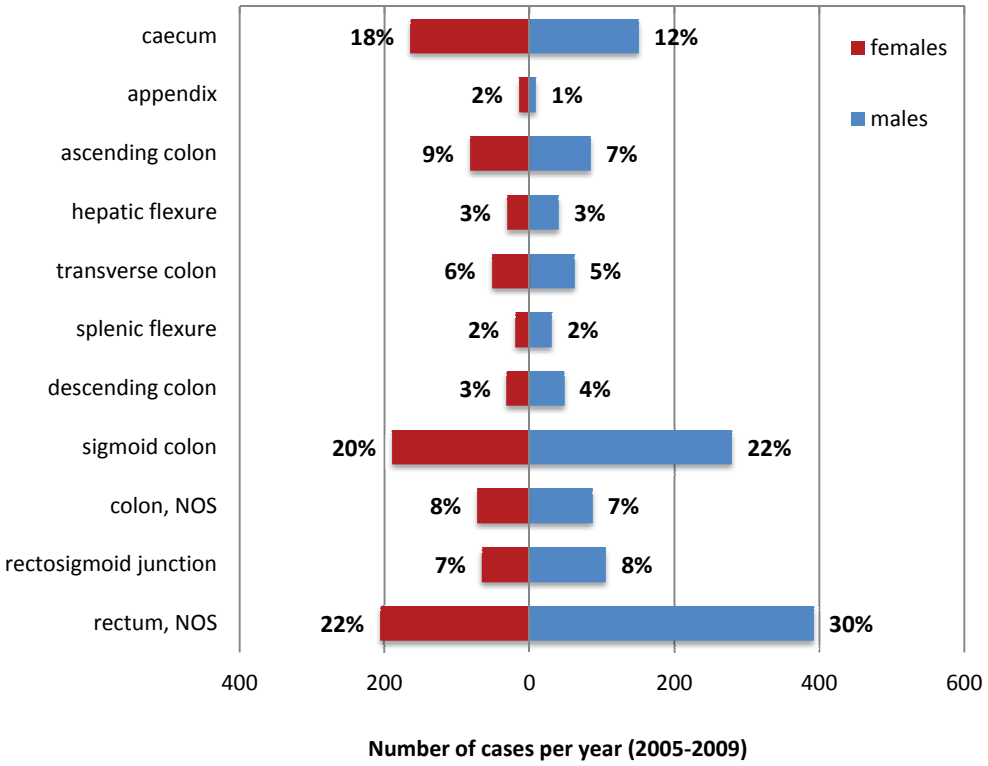
Table 7
Incidence of invasive cancer of the rectum (C19-20): 1994-2010

	Females		Males		All	
YEAR	**cases**	**ASIR**	**cases**	**ASIR**	**cases**	**ASIR**
1994	215	11.4	378	25.3	593	17.6
1995	211	11.8	370	24.6	581	17.5
1996	207	11.0	395	26.2	602	18.0
1997	244	12.7	433	27.7	677	19.6
1998	260	13.6	438	27.7	698	19.9
1999	244	12.3	401	25.0	645	18.1
2000	242	12.1	423	25.7	665	18.4
2001	240	11.8	488	29.1	728	19.6
2002	233	11.0	465	27.4	698	18.5
2003	262	12.8	487	27.8	749	19.6
2004	294	14.1	442	24.4	736	18.8
2005	266	11.6	468	25.4	734	18.1
2006	291	13.0	471	24.8	762	18.4
2007	283	12.5	513	26.6	796	19.2
2008	250	10.9	514	25.8	764	17.8
2009	267	11.0	514	25.0	781	17.6
2010	281	11.7	499	23.8	780	17.4
TOTAL	**4,290**		**7,699**		**11,989**	
APC	1.7%	-0.1%	1.9%	-0.3%	1.8%	-0.1%
[95%CI]	[1.0,2.4]	[-0.9,0.7]	[1.4,2.5]	[-0.9,0.3]	[1.4,2.3]	[-0.6,0.4]

On average 267 females and 514 males were diagnosed with cancer of the rectosigmoid/rectum (C19-20) in Ireland between 2007 and 2009. There was no change in the age standardised incidence rate of cancer of the rectosigmoid/rectum (C19-20). However, the actual number of cases increased significantly by 1.7% in females and 1.9% in males between 1994 and 2010 due to an increase in the Irish population during this period (Table 7).

2.2 Incidence of colorectal cancer by site of primary tumour

Figure 6
Anatomical site of colorectal cancers, 2005-2009: number and percentage of cases



The sigmoid colon was the most common site of colon cancers for both sexes between 2005 and 2009 (Figure 6). The distribution of cancers within the colon and rectosigmoid junction was similar for men and women, but rectal cancers were relatively more common in men. During the period 2005-2009, cancers of the rectum and rectosigmoid junction (combined) made up 38% of male colorectal cancers compared to 29% for females.

2.3 Incidence of colorectal cancer by age

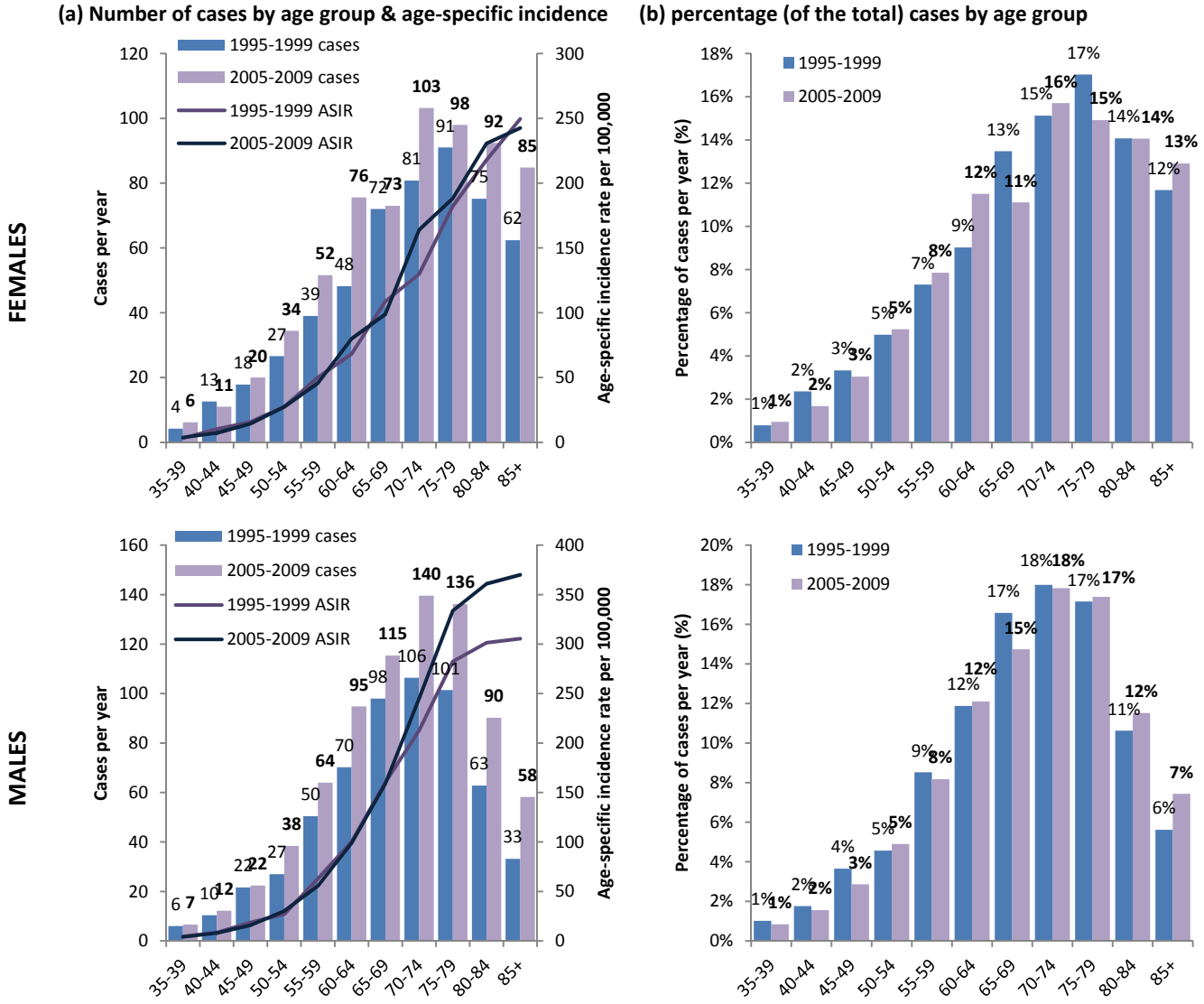
Table 8
Age distribution of patients diagnosed with colorectal cancer, by site of primary tumour and gender: Diagnostic period 1995-1999, 2000-2004, 2005-2009

SITE	AGE	1995-1999		2000-2004		2005-2009		Total	
		No.	%	No.	%	No.	%	No.	%
COLON (C18)		**FEMALES**							
	15-44	106	4%	99	3%	120	4%	325	4%
	45-54	222	8%	271	9%	272	8%	765	9%
	55-64	436	16%	489	17%	636	19%	1,561	18%
	65-74	764	29%	747	26%	881	27%	2,392	27%
	75+	1,143	43%	1,301	45%	1,376	42%	3,820	43%
	Total	**2,671**	**100%**	**2,907**	**100%**	**3,285**	**100%**	**8,863**	**100%**
		MALES							
	15-44	101	3%	87	3%	120	3%	308	3%
	45-54	243	8%	251	8%	304	8%	798	8%
	55-64	603	20%	591	19%	794	20%	1,988	20%
	65-74	1,022	35%	1,120	35%	1,275	33%	3,417	34%
	75+	987	33%	1,122	35%	1,423	36%	3,532	35%
	Total	**2,956**	**100%**	**3,171**	**100%**	**3,916**	**100%**	**10,043**	**100%**
RECTUM (C19-20)		**FEMALES**							
	15-44	57	5%	75	6%	75	6%	207	5%
	45-54	111	10%	156	12%	164	12%	431	11%
	55-64	228	20%	232	18%	260	19%	720	19%
	65-74	343	29%	366	29%	314	23%	1,023	27%
	75+	427	37%	442	35%	544	40%	1,413	37%
	Total	**1,166**	**100%**	**1,271**	**100%**	**1,357**	**100%**	**3,794**	**100%**
		MALES							
	15-44	55	3%	62	3%	76	3%	193	3%
	45-54	221	11%	252	11%	275	11%	748	11%
	55-64	460	23%	553	24%	620	25%	1,633	24%
	65-74	717	35%	764	33%	787	32%	2,268	33%
	75+	584	29%	674	29%	722	29%	1,980	29%
	Total	**2,037**	**100%**	**2,305**	**100%**	**2,480**	**100%**	**6,822**	**100%**

For colon cancer incident during 1995-2009, 43% of female cases and 35% of male cases were older than 75 years. For rectal cancer incident during 1995-2009, 37% of female cases and 29% of males cases were older than 75 years (Table 8). For females, there was no change in the age distribution of colon or rectal cases across three diagnostic periods 1995-1999, 2000-2004 and 2005-2009. For male colon cancer cases, there was a significant upward shift in the proportion diagnosed in the 75+ age group from 33% during 1995-1999 to 36% during 2005-2009 (Table 8, Figure 9). For male rectal cases, there was no change in the proportion diagnosed in each of the age categories, across the three diagnostic periods.

The ratio of male to female colorectal cancer cases was stable at 13:10 across the three diagnostic periods. The ratio of colon to rectal cases did not vary from 18:10 over the same periods (15:10 in males and 23:10 in females).

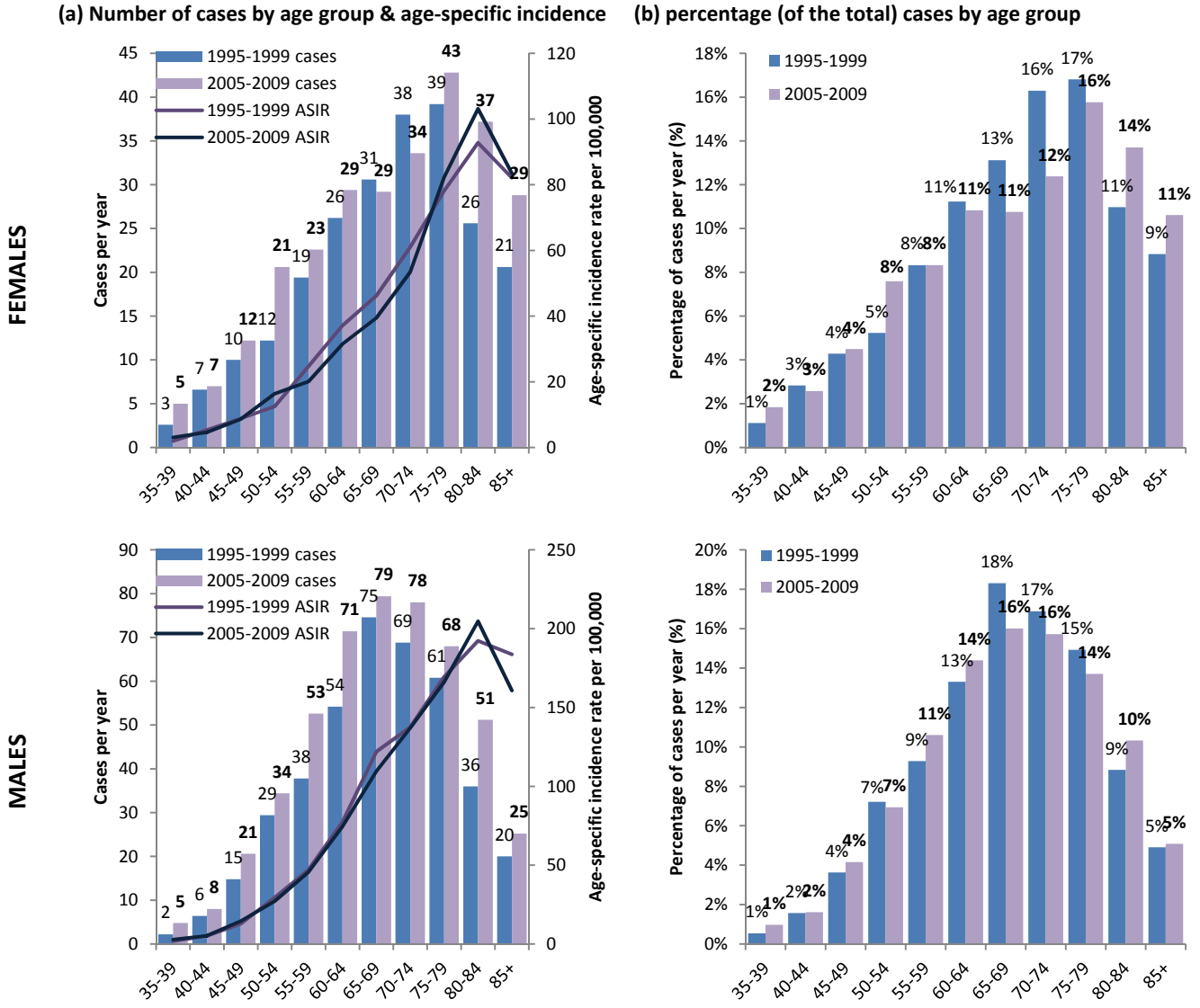
Figure 7
Age-specific incidence of invasive cancer of the colon (C18): diagnostic periods 1995-1999 & 2005-2009



The numbers of cases presenting, and age-specific incidence rates in each 5-year age group are presented for colon cancer in Figure 7(a).

For females, the median age of diagnosis was 72 years for both 1995-1999 and 2005-2009. For males, the median age rose from 70 years in 1995-1999 to 71 years during 2005-2009. The number of cases presenting was highest in the 75-79 age group for females and 70-74 age group for males. For females, there were no significant differences in age-specific incidence rates for each age group between 1995-1999 and 2005-2009. However, for male cases, in the latter diagnostic period, there was a significant increase in the age-specific rates for the age groups 75-79 and 85+ (Figure 7a & Figure 9).

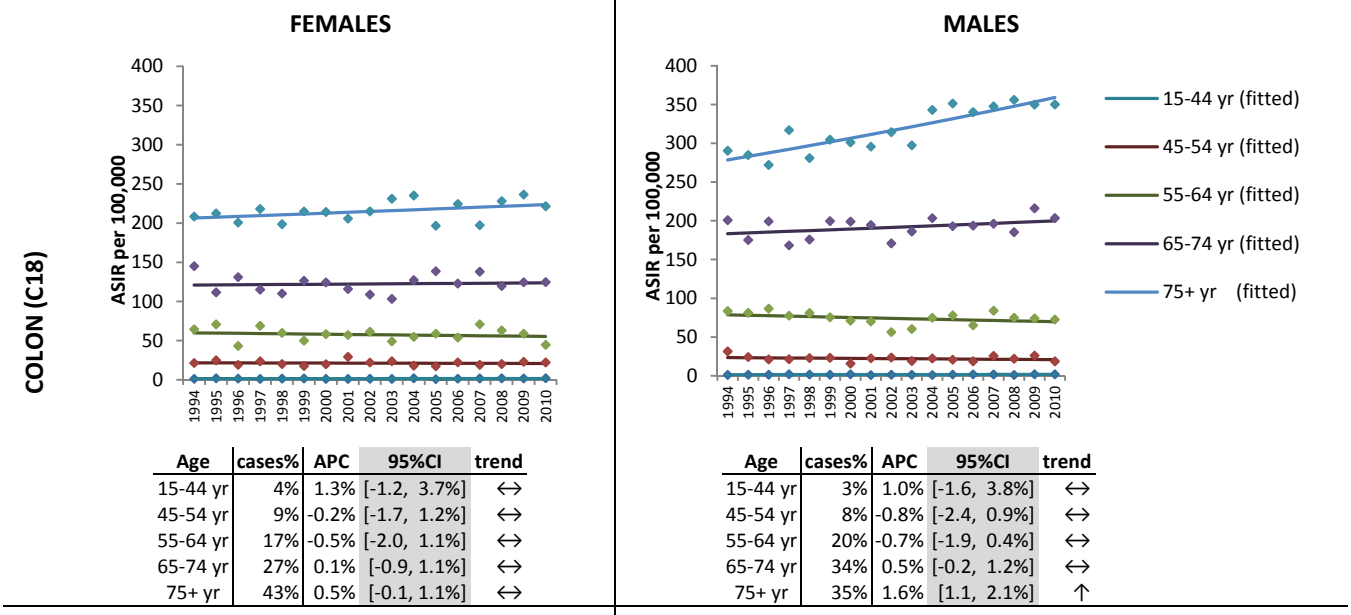
Figure 8
Age-specific incidence of invasive cancer of the rectum (C19-20): diagnostic periods 1995-1999 & 2005-2009



The numbers of cases presenting, and age-specific incidence rates in each 5-year age group are presented for rectal cancer in Figure 8(a).

For females, the median age at diagnosis increased from 70 years for the period 1995-1999 to 71 years for the period 2005-2009. For males, the median age was 68 years for both periods. The number of cases presenting was highest in the 75-79 age group for females and in the 65-69 and 70-74 age groups for males. For both sexes, there were no significant differences in age-specific incidence rates for each age group between 1995-1999 and 2005-2009 (Figure 8a & Figure 9).

Figure 9
Annual percentage change (APC) in age-specific incidence rate (ASIR) for invasive colorectal cancer (C18-C20): 1994-2010



Age	cases%	APC	95%CI	trend
15-44 yr	4%	1.3%	[-1.2, 3.7%]	↔
45-54 yr	9%	-0.2%	[-1.7, 1.2%]	↔
55-64 yr	17%	-0.5%	[-2.0, 1.1%]	↔
65-74 yr	27%	0.1%	[-0.9, 1.1%]	↔
75+ yr	43%	0.5%	[-0.1, 1.1%]	↔

Age	cases%	APC	95%CI	trend
15-44 yr	3%	1.0%	[-1.6, 3.8%]	↔
45-54 yr	8%	-0.8%	[-2.4, 0.9%]	↔
55-64 yr	20%	-0.7%	[-1.9, 0.4%]	↔
65-74 yr	34%	0.5%	[-0.2, 1.2%]	↔
75+ yr	35%	1.6%	[1.1, 2.1%]	↑

Age	cases%	APC	95%CI	trend
15-44 yr	5%	4.1%	[-0.3, 8.6%]	↔
45-54 yr	11%	1.9%	[-0.2, 4.0%]	↔
55-64 yr	19%	-1.7%	[-3.7, 0.4%]	↔
65-74 yr	27%	-0.7%	[-2.0, 0.8%]	↔
75+ yr	37%	0.2%	[-1.2, 1.6%]	↔

Age	cases%	APC	95%CI	trend
15-44 yr	3%	2.1%	[-0.4, 4.5%]	↔
45-54 yr	11%	0.3%	[-1.2, 1.8%]	↔
55-64 yr	24%	-0.4%	[-1.2, 0.3%]	↔
65-74 yr	33%	-0.7%	[-1.6, 0.2%]	↔
75+ yr	29%	0.3%	[-0.7, 1.3%]	↔

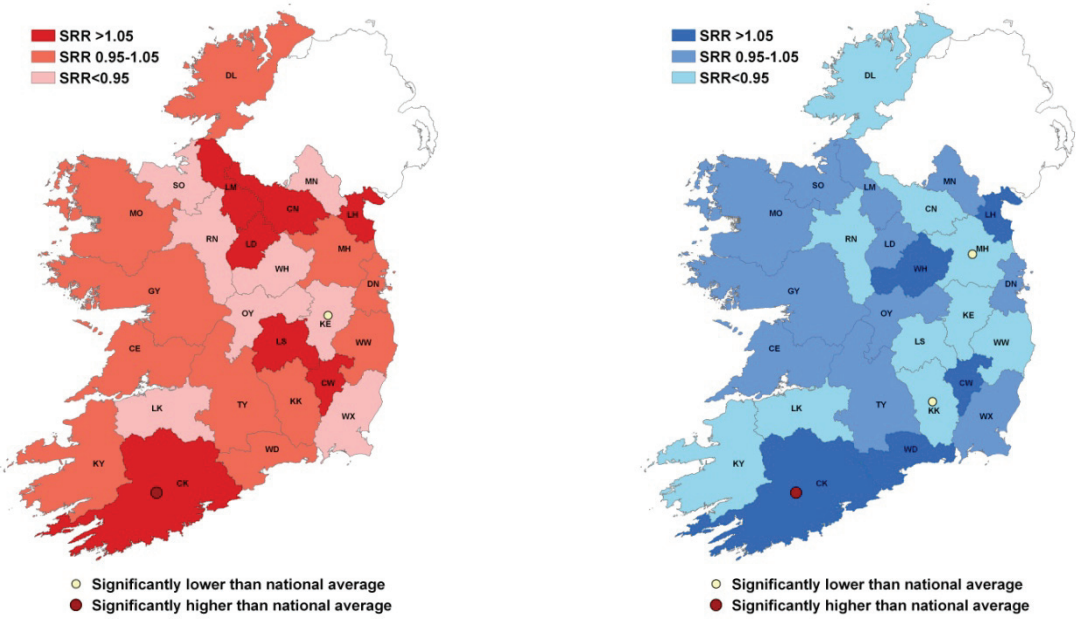
Points on graphs indicate actual age-specific incidence rate. Lines indicate fitted trends (Joinpoint)[30]

There was a significant annual 1.6% increase in the age-specific incidence rate (ASIR) of colon cancer (C18) in the oldest age group (75+ years) in males. Otherwise, there was no change in the ASIR for any age category in colon or rectal cancer (Figure 9).

2.4 Geographical variation in incidence

Figure 10
County-level variation in colorectal cancer incidence
Standardised rate ratios (SRR) relative to incidence rate for Ireland: 2006-2010

FEMALES **MALES**



Variation in colorectal cancer incidence at county level in 2006-2010 is presented in Figure 10. Age standardised rates (ASR) for incidence were calculated for the period 2006-2010 for each county. The incidence rate for Ireland as a whole was 39.9 (95%CI: 38.7, 41.0) per 100,000 females and 65.4 (95%CI: 63.8, 67.0) per 100,000 males.[a] Standardised rate ratios (SRR) were calculated as the ratio between the ASR in each country and the national ASR. For females, the incidence rate was significantly higher in Cork county than the national average and significantly lower than the national average in Kildare. For males, the incidence was significantly higher than the national average in Cork county and significantly lower than the national average in Kilkenny and Meath.

Counties are demarcated by largely arbitrary boundaries, with great variation in population densities. Geographical variation in incidence rates may be better visualised by consulting the all-Ireland cancer atlas which describes incidence ratios at the level of approximately 3,500 electoral divisions in RoI, and 580 wards in Northern Ireland during 1995-2007.[22]

Table 9
Area of residence and number of colorectal cancer patients
Diagnostic periods 1996-2000, 2001-2005, 2006-2010

HSE area of residence	1995-1999		2000-2004		2005-2009	
	cases	% of cases	cases	% of cases	cases	% of cases
Dublin Mid Leinster	2,394	27%	2,644	27%	3,125	28%
Dublin North East	1,726	20%	1,932	20%	2,105	19%
South	2,438	28%	2,617	27%	3,049	28%
West	2,272	26%	2,461	25%	2,759	25%

The distribution of cases between HSE areas remained quite constant between 1995-1999 and 2005-2009, with just under a half living in the two eastern regions (Table 9).

[a] Appendix II statistical methods

2.5 Method of verification, morphology and tumour grade

Table 10
Method of verification of colorectal tumours (C18-20)

Method of	1995-1999		2000-2004		2005-2009	
verification	cases	% of cases	cases	% of cases	cases	% of cases
Histological	7,853	89%	8,814	91%	10,407	94%
Clinical only	667	8%	616	6%	491	4%
Unknown	310	4%	224	2%	140	1%

Table 11
Morphology of colorectal cancer tumours

Morphology	1995-1999		2000-2004		2005-2009	
	cases	% of cases	cases	% of cases	cases	% of cases
Adenocarcinoma	6,832	77%	7,809	81%	9,313	84%
Mucinous type	751	9%	766	8%	807	7%
Other morphology	232	3%	209	2%	266	2%
Unspecified	1,015	11%	870	9%	652	6%

The number of cases assigned to each diagnostic verification method is shown in Table 10. The proportion of cases confirmed using histological methods increased from 89% to 94% in the periods 1995-1999 and 2005-2009 respectively.

The number of cases assigned to each morphological classification is shown in Table 11. The majority of colorectal tumours showed adenocarcinoma morphology (84% in the period 2005-2009). The proportion of unspecified morphology tumours decreased from 11% to 6% in the periods 1995-1999 and 2005-2009 respectively, which is probably reflective of more precise pathology laboratory reporting over the last 10 years.

Table 12
Grade of colorectal tumours

Level of	1995-1999		2000-2004		2005-2009	
differentiation	cases	% of cases	cases	% of cases	cases	% of cases
Good	899	10%	740	8%	545	5%
Moderate	4,544	51%	5,533	57%	7,066	64%
Poor	1,145	13%	1,066	11%	1,393	13%
Unspecified	2,242	25%	2,315	24%	2,034	18%

The number of cases assigned by grade of tumour is presented in Table 12.

The proportion of unspecified grade tumours decreased from 25% to 18% in the periods 1995-1999 and 2005-2009 respectively which is probably reflective of more precise pathology laboratory reporting over the last 10 years.

2.6 Stage at diagnosis

Table 13
Stage of disease at diagnosis for colon cancer (C18) , by gender

	Females						Males					
	1995-1999		2000-2004		2005-2009		1995-1999		2000-2004		2005-2009	
	cases	%	cases	%	cases	%	cases	%	cases	%	cases	%
stage I, Duke's A	318	12%	325	11%	367	11%	394	13%	369	12%	434	11%
stage II, Duke's B	843	32%	898	31%	943	29%	967	33%	916	29%	1,189	30%
stage III, Duke's C	576	22%	678	23%	900	27%	623	21%	782	25%	1,010	26%
stage IV	536	20%	638	22%	730	22%	666	23%	807	25%	948	24%
unstaged	398	15%	368	13%	345	11%	306	10%	297	9%	335	9%
Total	**2,671**	**100%**	**2,907**	**100%**	**3,285**	**100%**	**2,956**	**100%**	**3,171**	**100%**	**3,916**	**100%**

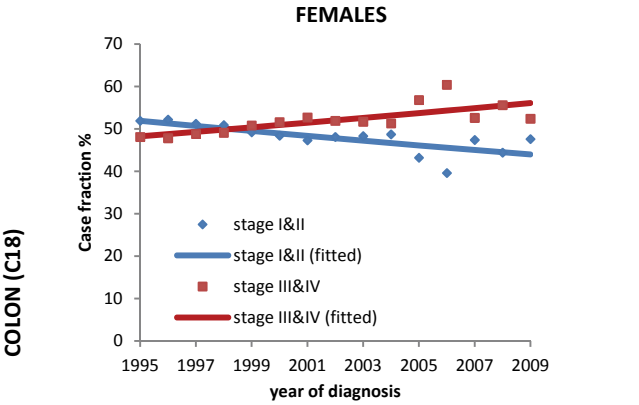
The proportion of cases with colon cancer presenting at stage I decreased from 12% to 11% for females and 13% to 11% for males between 1995-1999 and 2005-2009 (Table 13). Similarly, for stage II, the proportion of cases decreased from 32% to 29%, and 33% to 30% for females and males respectively between 1995-1999 and 2005-2009. Conversely, the proportion of cases presenting at stage III increased substantially, from 22% to 27% and 21% to 26% for females and males respectively between 1995-1999 and 2005-2009. There were also smaller increases in the proportion of cases diagnosed at stage IV for both sexes (females; 20% to 22% and males; 23 to 24%) between 1995-1999 and 2005-2009 (Table 13).

Table 14
Stage of disease at diagnosis for cancer of the rectosigmoid junction (C19) and rectum (C20), by gender

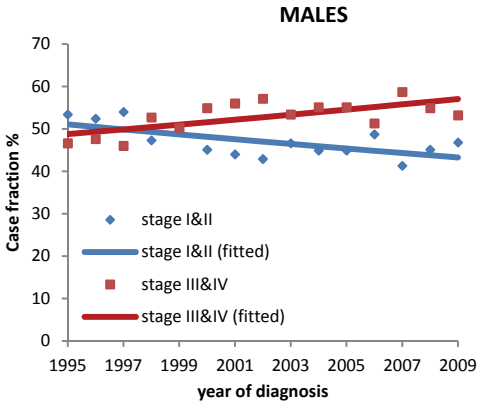
	Females						Males					
	1995-1999		2000-2004		2005-2009		1995-1999		2000-2004		2005-2009	
	cases	%	cases	%	cases	%	cases	%	cases	%	cases	%
stage I, Duke's A	255	22%	262	21%	220	16%	396	19%	401	17%	371	15%
stage II, Duke's B	287	25%	292	23%	298	22%	539	26%	538	23%	524	21%
stage III, Duke's C	246	21%	319	25%	406	30%	413	20%	626	27%	758	31%
stage IV	210	18%	222	17%	239	18%	433	21%	491	21%	534	22%
unstaged	168	14%	176	14%	194	14%	256	13%	249	11%	293	12%
Total	**1,166**	**100%**	**1,271**	**100%**	**1,357**	**100%**	**2,037**	**100%**	**2,305**	**100%**	**2,480**	**100%**

The proportion of cases with cancer of the rectosigmoid and rectum presenting at stage I decreased from 22% to 16% for females and 19% to 15% for males between 1995-1999 and 2005-2009 (Table 14). Similarly, for stage II, the proportion of cases decreased from 25% to 22% and 26% to 21% for females and males respectively between 1995-1999 and 2005-2009. Conversely, the proportion of cases presenting at stage III increased substantially, from 21% to 30% and 20% to 31% for females and males respectively between 1995-1999 and 2005-2009. There was little change over time in the proportions presenting at stage IV for both sexes (Table 14).

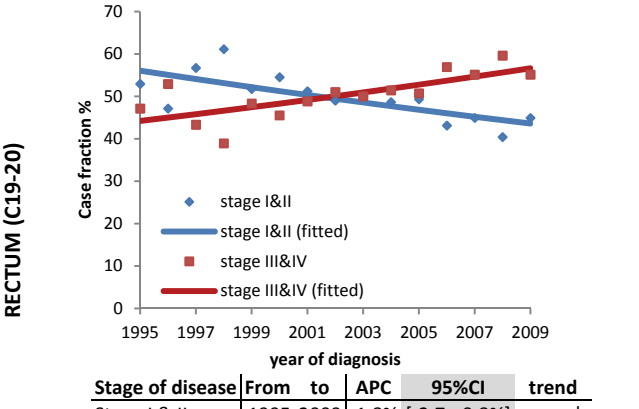
Figure 11
Case fraction for stage of disease at presentation, by gender and site of tumour: diagnostic period 1994-2009



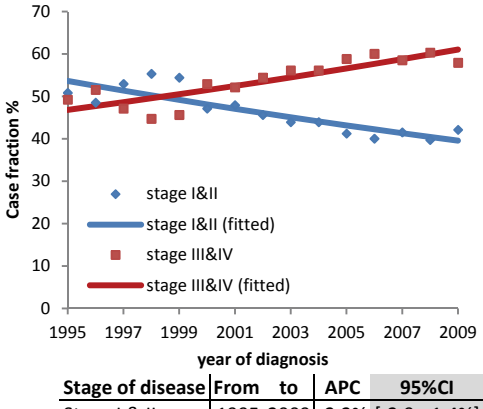
Stage of disease	From	to	APC	95%CI	trend
Stage I & II	1995	2009	-1.2%	[-1.9, -0.5%]	↓
Stage III & IV	1995	2009	1.1%	[0.5, 1.6%]	↑



Stage of disease	From	to	APC	95%CI	trend
Stage I & II	1995	2009	-1.2%	[-2.0, -0.4%]	↓
Stage III & IV	1995	2009	1.1%	[0.4, 1.9%]	↑



Stage of disease	From	to	APC	95%CI	trend
Stage I & II	1995	2009	-1.8%	[-2.7, -0.8%]	↓
Stage III & IV	1995	2009	1.8%	[0.8, 2.8%]	↑



Stage of disease	From	to	APC	95%CI	trend
Stage I & II	1995	2009	-2.2%	[-2.9, -1.4%]	↓
Stage III &IV	1995	2009	1.9%	[1.2, 2.6%]	↑

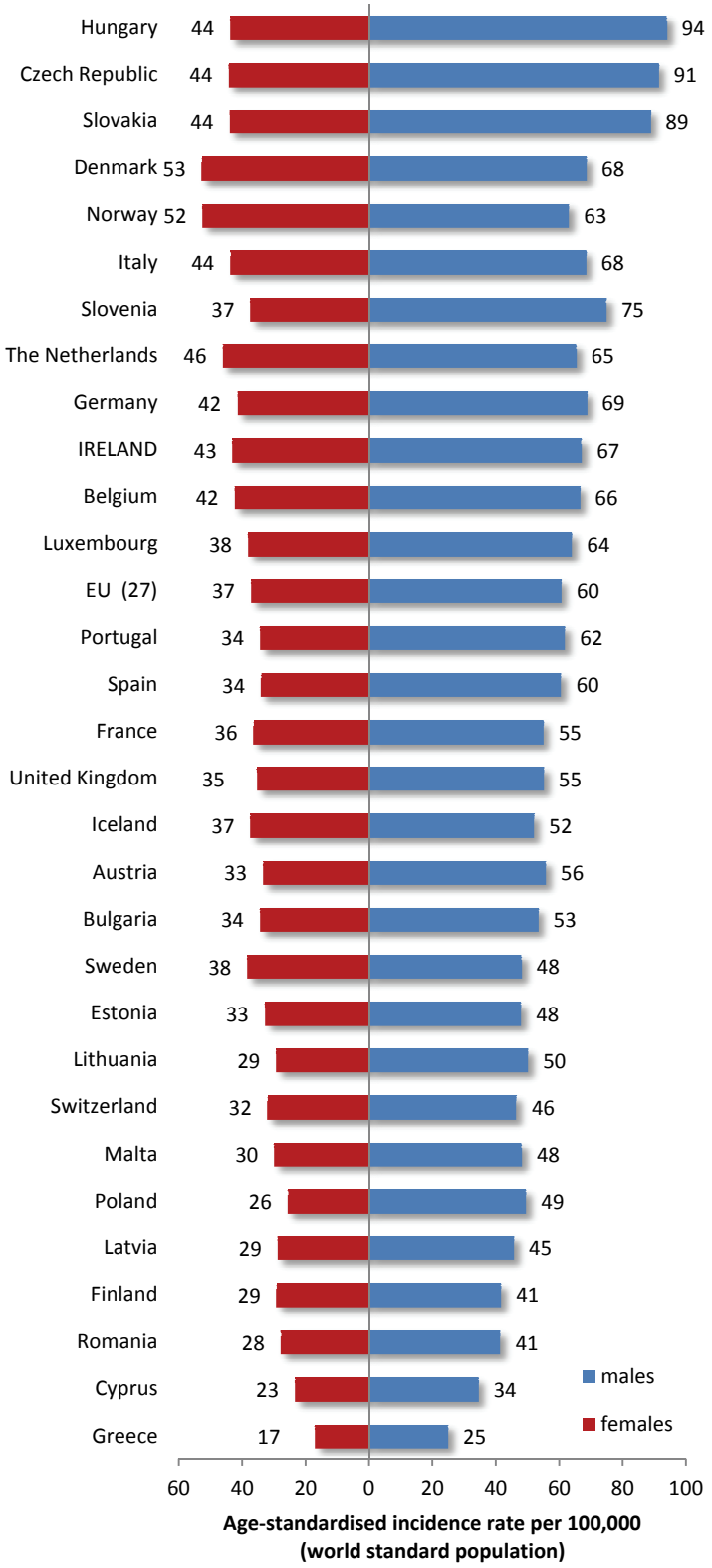
Case fractions presenting at stage I & II or stage III & IV, and the annual percentage change (APC) over the years 1994-2009 were calculated and presented for tumour site and gender (Figure 11).

For colon tumours (C18), there was a significant annual percentage decrease in the case fraction presenting at stage I & II between 1995 and 2009 (-1.2% for both males and females). Conversely, there was a significant annual increase in the case fraction presenting at stage III & IV over the same period (1.1% for both males and females). For rectal tumours (C19-20), there was a significant annual percentage decrease in the case fraction presenting at stage I & II between 1995 and 2009 (-1.8% for females, -2.2% for males). Conversely, there was a significant annual percentage increase in the case fraction presenting at stage III & IV (1.8% for females, 1.9% for males).

These data suggest that more comprehensive investigation in the peri-operative period resulted in a significant shift in stage allocation from stage I/II to stage III/IV over the years 1995-2009.

2.7 International comparison of incidence

Figure 12
Estimated incidence of colorectal cancer, 2008



European Cancer Observatory (ECO) [23]

Estimated age standardised incidence rates (ASIR) for 2008 are presented in Figure 12.[23]

Within Europe in 2008, the highest incidence of colorectal cancer in men was in Hungary, the Czech Republic and Slovakia. The highest incidence of colorectal cancer in women was in Denmark, Norway and the Netherlands. The lowest incidence, for both sexes, was in Cyprus and Greece.

Ireland had a higher incidence of colorectal cancer (43 and 67/100,000 for women and men respectively) than its nearest neighbour, the United Kingdom (35 and 55/100,000 for women and men respectively), and also higher than the EU average (37 and 60/100,000 for women and men respectively).

3. TREATMENT

3.1 Treatment options for colorectal cancer

Patients with resectable rectal cancer are recommended to undergo preoperative short-course radiotherapy (25Gy in 5 fractions in 1 week), with surgery performed within 1 week of completion of radiation.[45] However, in certain cases it may be decided that the benefits of treating patients with lower-risk disease does not justify the additional toxicity of radiotherapy.

In some cases of rectal cancer, radiotherapy (with synchronous chemotherapy) may be appropriate to downstage the tumour. A dose of 45Gy in 25 fractions over 5 weeks, with or without a reduced volume boost dose of 5.4-9Gy in 3-5 fractions, is recommended.[45] If the addition of radiotherapy to surgery is deemed necessary for rectal cancer, it should ideally be given pre-operatively.[46] However, in cases with predictive factors for local recurrence (e.g. evidence of tumour at the circumferential resection margin, mesorectal lymph node involvement and extramural vascular invasion), post operative radiotherapy and chemotherapy should be considered for patients who did not receive pre-operative radiotherapy. A fluoropyrimidine as monotherapy or oxaliplatin in combination with 5-fluorouracil and folinic acid are commonly used chemotherapy options for the adjuvant treatment of patients with node-positive colorectal cancer following potentially curative surgery.[45]

Table 15
Summary of treatment options for colorectal cancer [45]

	Colon (C18)	Rectum (C19-20)
Stage I **T1-T2, NO, MO**	Resection	T1: local excision, total mesorectal excision T2: total mesorectal excision T2: pre-operative radiotherapy
Stage II **T3-T4, NO, MO**	Resection Adjuvant chemotherapy should be considered for high risk patients‡	Total mesorectal excision Preoperative radiotherapy, or Preoperative radiotherapy (and (neo-)adjuvant chemotherapy
Stage III **T (any), N1-2, MO**	Resection Adjuvant chemotherapy	Total mesorectal excision Preoperative radiotherapy, or Preoperative radiotherapy (and (neo-)adjuvant chemotherapy
Stage IV **T(any), N(any), M1**	Consider resection (palliative/curative) Consider chemotherapy (palliative/curative)	Consider resection (palliative/curative) Consider chemotherapy (palliative/curative)

‡high risk: stage II, pT4, poorly differentiated tumour with angio-invasion, and low number of nodes sampled

[45] Guidelines for the Management of Colorectal Cancer, 3rd edition (2007). Issued by: The Association of Coloproctology of Great Britain and Ireland

For the treatment of advanced disease, in fit patients with inoperable but non-metastatic rectal carcinoma, primary chemo-radiation should be considered. When the course is completed, the tumour should be re-staged and potentially curative resection considered if appropriate. Fit patients with operable or potentially operable liver or lung metastases should be reviewed in the MDT with a hepatobiliary (or thoracic) surgeon and colorectal oncologist, to evaluate operability and to decide on a combined plan of management to optimise the chance of successful resection of all metastatic disease. Patients with evidence of unresectable metastatic disease should be considered for palliative chemotherapy.[45]

3.2 Treatment received[b]

Primary course of treatment was defined as receipt of any: surgery, chemotherapy or radiotherapy, up to one year after diagnosis date. In the following sections, 'treatment' refers to primary course of treatment only.

Table 16
Number and percentage of all patients in receipt of surgery‡: 1995-1999, 2000-2004, 2005-2009

	1995-1999		2000-2004		2005-2009		Change in annual case fraction	
Site of primary tumour	**patients**	**surgery%**	**patients**	**surgery%**	**patients**	**surgery%**	**APC%[95%CI]**	***trend**
Colon (C18)	5,627	76%	6,078	76%	7,201	79%	0.3[0.0, 0.6]	↑
Rectum (C19, C20)	3,203	75%	3,576	73%	3,837	75%	-0.1[-0.5, 0.3]	↔
Combined (C18-20)	**8,830**	**76%**	**9,654**	**75%**	**11,038**	**78%**	**0.2[-0.1, 0.4]**	**↔**

*Annual percentage change (APC) over 1995-2009:↑=significant increase, ↓=significant decrease, ↔=no change
‡ Received tumour destructive surgery (ICD-9-CM codes 45.4x, 45.7x, 45.8, 48.3, 48.35, 48.36, 48.4, 48.49, 48.5, 48.6x, 48.82)[41], regardless of age and stage.

Regardless of stage, over 75% of colorectal cancer cases underwent surgery during 2005-2009. The proportion of cases with colon cancer who received surgery increased marginally from 76% to 79% between 1995-1999 and 2005-2009. There was no change in the proportion of cases who received surgery for cancer of the rectum over the period 1995-2009 (Table 16).

Table 17
Number and percentage of all patients in receipt of chemotherapy‡: 1995-1999, 2000-2004, 2005-2009

	1995-1999		2000-2004		2005-2009		Change in annual case fraction	
Site of primary	**patients**	**chemotherapy%**	**patients**	**chemotherapy%**	**patients**	**chemotherapy%**	**APC%[95%CI]**	***trend**
Colon (C18)	5,627	26%	6,078	34%	7,201	38%	4.1[2.7, 5.4]	↑
Rectum (C19, C20)	3,203	28%	3,576	44%	3,837	51%	6.1[4.5, 7.7]	↑
Combined	**8,830**	**27%**	**9,654**	**38%**	**11,038**	**43%**	**4.8[3.4, 6.3]**	**↑**

*Annual percentage change (APC) over 1995-2009:↑=significant increase, ↓=significant decrease, ↔=no change
‡regardless of age, stage at presentation and whether patient underwent surgery

Regardless of stage and receipt of surgery, the proportion of cases with colon cancer who received chemotherapy increased from 26% to 38% between 1995-1999 and 2005-2009, while the proportion of cases with cancer of the rectum who received at least one chemotherapy administration increased significantly from 28% to 51% over the same period (Table 17).

Table 18
Number and percentage of all rectal cancer patients (C19-20) in receipt of radiotherapy‡: 1995-1999, 2000-2004, 2005-2009

	1995-1999		2000-2004		2005-2009		Change in annual case fraction	
Site of primary	**patients**	**radiotherapy%**	**patients**	**radiotherapy%**	**patients**	**radiotherapy%**	**APC%[95%CI]**	***trend**
Rectum (C19, C20)	3,203	24%	3,576	37%	3,837	40%	5.3[3.5, 7.1]	↑

*Annual percentage change (APC) over 1995-2009:↑=significant increase, ↓=significant decrease, ↔=no change
‡regardless of age, stage at presentation, receipt of surgery and sequence of receipt (pre-operative and/or post operative)

Regardless of stage and receipt of surgery, the proportion of cases with rectal cancer who received radiotherapy increased from 24% to 40% between 1995-1999 and 2005-2009 (Table 18).

[b] Appendix II: Treatment definitions

Table 19
Primary treatment for colon cancer (C18) by stage and age; percentage of patients who underwent the respective treatment

Treatment	age years	Period of diagnosis 1995-1999 %	2000-2004 %	2005-2009 %
Resection stage I-III	15-44	99	98	99
	45-54	95	97	97
	55-64	96	97	97
	65-74	95	95	96
	75+	93	93	92
Adjuvant chemotherapy stage I	15-44	36	12	12
	45-54	14	9	13
	55-64	13	9	5
	65-74	6	7	3
	75+	3	3	0
Adjuvant chemotherapy stage II	15-44	67	67	76
	45-54	58	66	58
	55-64	45	53	43
	65-74	25	31	31
	75+	6	6	6
Adjuvant chemotherapy stage III	15-44	82	82	89
	45-54	75	83	84
	55-64	68	82	89
	65-74	49	71	76
	75+	15	26	29
Resection of primary stage IV	15-44	70	68	64
	45-54	62	59	64
	55-64	61	54	63
	65-74	53	54	54
	75+	43	39	38
Chemotherapy stage IV (with or without surgery)	15-44	77	75	84
	45-54	61	73	78
	55-64	53	65	80
	65-74	29	51	60
	75+	7	14	27

Most patients (70%) presenting with colon cancer in the period 1995-2009 were older than 65 years (Table 8 above).

More than 90% of colon cases presenting at stage I-III received surgery as their first line treatment. During the period 2005-2009, 99% of cases <45 years received surgery, decreasing slightly with increasing age to 92% for patients >75 years (Table 19).

A small proportion of younger cases with stage I disease received adjuvant chemotherapy, falling from 12% in those <45 years to 3% in those aged 65-74 years.

A larger proportion of stage II colon cases received adjuvant chemotherapy, falling steadily from 76% in cases aged <45 years, to 6% of cases aged > 75 years.

89% of patients aged <45 years with stage III disease received adjuvant chemotherapy. This figure fell gradually to 76% for patients aged 65-74; only 29% of patients aged >75 years received chemotherapy.

In the period 2005-2009, the proportion of stage IV patients who received a resection of the primary tumour fell from 64% in the youngest age group to 38% in those >75 years. Over the same period, the proportion who received chemotherapy fell from 84% of patients aged <45 years to 27% of those >75 years. See Appendix III, Table 49, for a full tabulation of treatment combinations presented in order of the temporal sequence of receipt.

Pre-operative radiotherapy has been recommended for resectable rectal cancer in recent years.[45,46] The receipt of this treatment according to stage and age was explored in Table 20. 63% of patients presenting with rectal cancer in the period 1995-2009 were older than 65 years (Table 8 above).

Table 20
Trends in primary treatment for patients with rectal cancer (C19-20) According to age, stage and percentage of patients who underwent the respective treatment

Treatment	Age years	period of diagnosis 1995-1999	2000-2004	2005-2009
		%	%	%
Resection Stage I-III	15-44	96	90	96
	45-54	95	95	93
	55-64	94	92	94
	65-74	91	91	93
	75+	89	82	81
Pre-operative radiotherapy Stage I ‡	15-44	0	4	23
	45-54	1	10	18
	55-64	2	11	13
	65-74	2	8	20
	75+	1	7	9
Pre-operative radiotherapy Stage II‡	15-44	6	27	57
	45-54	13	28	47
	55-64	9	22	42
	65-74	5	19	32
	75+	2	7	16
Pre-operative radiotherapy Stage III‡	15-44	3	23	52
	45-54	7	30	46
	55-64	3	24	41
	65-74	4	21	39
	75+	0	9	20
Resection of primary Stage IV	15-44	52	56	67
	45-54	56	49	51
	55-64	63	53	41
	65-74	46	34	43
	75+	28	29	28
Chemotherapy Stage IV (with or without surgery)	15-44	70	94	93
	45-54	61	84	88
	55-64	50	73	75
	65-74	26	56	72
	75+	10	17	26

‡pre-op radiotherapy with or without adjuvant chemotherapy

The majority of patients aged <75 years presenting with stage I-III rectal cancer between 1995 and 2009 received surgery (>90%) (Table 19). For cases >75 years, the resection rate fell to less than 90% (Table 20).

The proportion who received pre-operative radiotherapy has increased markedly since 2000. Younger cases (<65) were more likely to receive the treatment relative to the older subset (>65 year).

During the diagnostic period 2005-2009, approximately 1 in 5 patients presenting with stage I disease received pre-operative radiotherapy, falling to less than 1 in 10 for cases >75 years.

Approximately half of younger cases (<65 years), presenting with stage II-III rectal cancer received pre-operative radiotherapy. Patients > 65 years presenting with stage III disease were more likely to receive pre-operative radiotherapy than stage II patients of the same age group (Table 20).

Resection of the primary tumour was less common for cases presenting with stage IV disease. During the period 2005-2009, 67% of such patients <45 years received surgery, falling steadily with age to 28% of patients >75 years. Chemotherapy was very common in the stage IV subset, with 93% of patients under 45 years receiving it, either as an adjuvant treatment, or as monotherapy. Only a quarter of patients greater than 75 years received chemotherapy.

See Appendix III, Table 49, for a full tabulation of treatment combinations presented in order of the temporal sequence of receipt.

3.3 Region of surgery

Table 21
HSE-area of colon surgery (C18) relative to HSE area of residence. Diagnostic periods: 2000-2004, 2005-2009

HSE area of residence	HSE area of surgery			
	DNML	DNNE	South	West
2000-2004				
DNML	91%	6%	1%	2%
DNNE	9%	90%	1%	1%
South	7%	1%	87%	4%
West	9%	3%	2%	85%
2005-2009				
DNML	90%	7%	1%	2%
DNNE	11%	89%	-	-
South	6%	1%	91%	2%
West	7%	3%	3%	88%

Table 22
HSE-area of rectal surgery (C19-20) relative to HSE area of residence. Diagnostic periods: 2000-2004, 2005-2009

HSE area of residence	HSE area of surgery			
	DNML	DNNE	South	West
2000-2004				
DNML	91%	7%	1%	1%
DNNE	25%	73%	1%	1%
South	11%	3%	81%	5%
West	25%	4%	2%	68%
2005-2009				
DNML	93%	5%	1%	1%
DNNE	29%	71%	-	-
South	12%	2%	82%	4%
West	12%	3%	2%	84%

The proportion of patients who underwent tumour resection, by HSE area of residence and HSE area of treatment, is presented in Table 21-22. For cases presenting with colon tumours during the period 2005-2009 (Table 21), almost all cases resident in the two eastern HSE areas had their surgery within one of these areas. 9% of cases resident in HSE South and 13% of those resident in HSE West travelled to other HSE areas for their surgery.

For rectal surgery, in the period 2005-2009, almost all patients resident within DNML or DNNE underwent their surgery in one of those areas. For patients presenting in HSE South, 82% of them had their surgery in that region, with 14% undergoing the index operation in the one of the eastern regions. Similarly, for patients originating in HSE west, 84% underwent their index surgery in HSE West, with 15% undergoing the procedure in one of the HSE eastern regions (Table 22).

3.4 Surgeon caseload

Table 23
Case volume of surgeons: Diagnostic periods: 1995-1999, 2000-2004, 2005-2009

Colon (C18)

	1995-1999		2000-2004		2005-2009	
Surgeons, resections/yr^	resections ‡	%	resections ‡	%	resections ‡	%
low vol: <10	1,983	44%	1,765	35%	1,607	25%
mid vol :11-19	1,666	37%	2,114	42%	1,814	29%
high vol:>20	816	18%	1,129	23%	2,898	46%
Total	4,465	100%	5,008	100%	6,319	100%

chi^2 test, p<0.0001

Rectum (C19-20)

	1995-1999		2000-2004		2005-2009	
surgeon resections/yr^	resections ‡	%	resections ‡	%	resections ‡	%
low vol: <10	1,367	54%	1,183	42%	718	22%
mid vol: 10-15	451	18%	490	17%	847	26%
high vol: >15	732	29%	1,171	41%	1,651	51%
Total	2,550	100%	2,844	100%	3,216	100%

chi^2 test, p<0.0001

‡Counts of surgical resections performed up to one year after diagnosis in patients with invasive colorectal cancer, by diagnostic period (Appendix II: treatment definitions). Figures include multiple resections performed on the same patient.
^ Surgeons were categorised according to the average number of such colorectal resections performed annually; averaged over each of the five year diagnostic periods: 1995-1999, 2000-2004,2005-2009

For colon cancer cases, 4,465 resections were performed during 1995-1999 as part of the primary course of treatment. Of these, 1,983 (44%) were performed by surgeons with an average annual rate of <10 per year for such resections (low volume), and 816 (18%) were performed by surgeons with an annual average rate of >20 per year for such resections (high volume) (Table 23). By 2005-2009, the situation had reversed significantly; the proportion of resections performed by 'high volume' surgeons had increased from 18% (1995-1999) to 46% in 2005-2009, with a decrease in the number of resections performed by 'low volume' surgeons (44% to 25%) and 'mid volume' surgeons (37% to 29%).

A similar shift in operating patterns was observed for resections of the rectum. 2,550 resections were performed during 1995-1999 as part of the primary course of treatment. Of these, 1,367 (54%) were performed by surgeons with an average annual rate of <10 per year for such resections (low volume), and 732 (29%) were performed by surgeons with an annual average rate of >15 per year for such resections (high volume) (Table 23). By 2005-2009, the situation had reversed significantly; the proportion of resections performed by 'high volume' surgeons had increased from 29% (1995-1999) to 51% in 2005-2009, with a decrease in the number of resections performed by 'low volume' surgeons (54% to 22%). In summary, moving from the earlier diagnostic period (1995-1999) to the latest diagnostic period (2005-2009), a greater proportion of colorectal cancer resections were performed by 'high volume' surgeons (Table 23).

3.5 Hospital caseload: surgery

Table 24
Surgical caseload by hospital: Diagnostic periods 1995-1999, 2000-2004, 2005-2009
Tumours originating in the colon (C18)

	1995-1999		2000-2004		2005-2009	
	resections ‡	%	resections ‡	%	resections ‡	%
Total	**4,465**	**100%**	**5,008**	**100%**	**6,319**	**100%**
St. James's Hospital, DN	266	6%	274	5%	411	7%
Beaumont Hospital, DN	268	6%	302	6%	366	6%
St. Vincent's Private Hospital, DN	140	3%	189	4%	336	5%
Tallaght Regional Hospital, DN	40	1%	215	4%	314	5%
University College Hospital , GY	178	4%	225	4%	309	5%
St. Vincent's University Hospital, DN	202	5%	202	4%	294	5%
Mater Misericordiae University Hospital, DN	204	5%	235	5%	278	4%
Bon Secours Hospital , CK	108	2%	157	3%	251	4%
Mercy University Hospital, CK	157	4%	166	3%	230	4%
Mid-Western Regional Hospital, LK	129	3%	156	3%	228	4%
Cork University Hospital, CK	159	4%	156	3%	208	3%
Sligo General Hospital, SO	111	2%	169	3%	200	3%
Our Lady of Lourdes Hospital, LH	92	2%	130	3%	190	3%
Letterkenny General Hospital, DL	190	4%	218	4%	184	3%
Mayo General Hospital, MO	138	3%	137	3%	180	3%
Connolly Memorial Hospital, DN	83	2%	111	2%	167	3%
Kerry General Hospital, KY	135	3%	95	2%	150	2%
Wexford General Hospital, WX	107	2%	120	2%	147	2%
Waterford Regional Hospital, WD	116	3%	131	3%	144	2%
South Infirmary Hospital, CK	100	2%	91	2%	134	2%
Cavan General Hospital, CN	87	2%	75	1%	124	2%
Midland Regional Hospital, WH	91	2%	95	2%	124	2%
St. Luke's General Hospital, KK	77	2%	135	3%	113	2%
Midland Regional Hospital , OY	67	2%	93	2%	103	2%
Other hospitals	1,220	27%	1,131	23%	1,134	18%

‡Counts of surgical resections performed up to one year after diagnosis in patients with invasive colorectal cancer, by hospital (Appendix II: treatment definitions). Figures include multiple resections performed on the same patient

Surgical resections within one year of diagnosis were considered to be part of the primary course of treatment. The number of such colon cancer resections (C18) performed is presented for each diagnostic period, by hospital, in Table 24. The hospitals listed may have carried out further surgical procedures after the 1st anniversary of diagnosis, but these were not counted. Hospitals with less than 2% of the national caseload in the period 2005-2009 are not listed individually.

The bulk of colorectal surgery (82%) was carried out in 24 hospitals during 2005-2009. St James's Hospital, DN accounted for 7% of cases in 2005-2009. Other hospitals with more than 5% of cases in 2005-2009 were: Beaumont Hospital, DN (6%), St. Vincent's Private Hospital, DN (5%), Tallaght RH, DN (5%), University College Hospital, GY (5%) and St. Vincent's UH, DN (5%).

Table 25
Surgical caseload by hospital: Diagnostic periods 1995-1999, 2000-2004, 2005-2009
Tumours originating in the rectosigmoid junction and rectum (C19-20)

	1995-1999		2000-2004		2005-2009	
	resections ‡	%	resections ‡	%	resections ‡	%
Total	**2,550**	**100%**	**2,844**	**100%**	**3,216**	**100%**
St. James's Hospital, DN	143	6%	141	5%	247	8%
Tallaght Regional Hospital, DN	37	1%	127	4%	227	7%
St. Vincent's Private Hospital, DN	114	4%	134	5%	207	6%
Beaumont Hospital, DN	163	6%	168	6%	175	5%
University College Hospital , GY	145	6%	152	5%	174	5%
St. Vincent's University Hospital, DN	81	3%	92	3%	151	5%
Mercy University Hospital, CK	138	5%	147	5%	139	4%
Cork University Hospital, CK	70	3%	125	4%	130	4%
Mater Misericordiae University Hospital, DN	180	7%	144	5%	130	4%
Bon Secours Hospital, CK	53	2%	93	3%	121	4%
Mid-Western Regional Hospital, LK	67	3%	82	3%	116	4%
Sligo General Hospital, SO	47	2%	67	2%	112	3%
Connolly Memorial Hospital, DN	75	3%	71	2%	110	3%
Mayo General Hospital, MO	99	4%	88	3%	93	3%
Kerry General Hospital, KY	52	2%	71	2%	82	3%
St. Luke's General Hospital, KK	52	2%	44	2%	81	3%
Our Lady of Lourdes Hospital, LH	54	2%	88	3%	76	2%
Wexford General Hospital, WX	30	1%	74	3%	76	2%
Letterkenny General Hospital, DL	69	3%	82	3%	74	2%
Waterford Regional Hospital, WD	71	3%	87	3%	65	2%
Cavan General Hospital, CN	48	2%	66	2%	62	2%
Midland Regional Hospital , OY	29	1%	46	2%	52	2%
Other hospitals	695	27%	604	21%	470	15%

‡Counts of surgical resections performed up to one year after diagnosis in patients with invasive colorectal cancer, by hospital (Appendix II: treatment definitions). Figures include multiple resections performed on the same patient

The annual average number of rectal cancer resections (C18-20) performed is presented for each diagnostic period, by hospital, in Table 25. The hospitals listed may have carried out further surgical procedures after the 1st anniversary of diagnosis, but these were not counted. The bulk of colorectal surgery (85%) was carried out in 22 hospitals during 2005-2009. St James's Hospital, DN accounted for 8% of cases in 2005-2009. Other hospitals with more than 5% of cases in 2005-2009 were: Tallaght RH (7%), St. Vincent's Private Hospital (6%), Beaumont Hospital, DN (5%), University College Hospital, GY (5%) and St. Vincent's UH, DN (5%). The proportion of patients who received rectal surgery in hospitals other than those listed decreased from 27% in 1995-1999, to 15% in the most recent period (2005-2009). It appeared that a process of centralisation of rectal surgery services occurred, to some extent.

3.6 Hospital caseload: radiotherapy

Table 26
Radiotherapy caseload by hospital: colorectal cancer (C18-20)
Diagnostic periods: 1995-1999, 2000-2004, 2005-2009

Diagnostic period	1995-1999		2000-2004		2005-2009	
	sessions‡	%	sessions‡	%	sessions‡	%
Total	**1,089**	**100%**	**1,581**	**100%**	**1,816**	**100%**
St. Luke's Hospital, DN	728	67%	997	63%	701	39%
Cork University Hospital, CK	174	16%	307	19%	324	18%
University College Hospital, GY	-	-	4	<1%	219	12%
Mater Private Hospital, DN	96	9%	151	10%	148	8%
Mid–Western Radiation Oncology Centre, LK	-	-	-	-	142	8%
St. Vincent's Private Hospital, DN	85	8%	112	7%	104	6%
Other private hospitals	1	<1%	8	1%	170	9%
Other clinics	5	<1%	2	<1%	8	<1%

‡Counts of radiotherapy sessions administered within 1 year of diagnosis, by hospital (Appendix II: treatment definitions).
Figures include multiple sessions administered to the same patient, up to one year after diagnosis.

Radiotherapy sessions administered within one year of diagnosis were considered to be part of the primary course of treatment. The annual average number of radiotherapy sessions is presented for each diagnostic period, by hospital, in Table 26. The hospitals shown may have administered further radiotherapy after the 1st anniversary of diagnosis, but these sessions were not counted. The bulk of radiotherapy services for colorectal cancer (91%) was provided by six hospitals over the period 2005-2009. St Luke's Hospital provided most radiotherapy sessions, albeit this share fell from 67% in 1995-1999 to 39% in 2005-2009. This fall may be accounted for by the introduction of radiotherapy at UCH Galway (12%) and the Mid-Western Radiation Oncology centre, LK (6%).

3.7 Hospital: length of stay after colorectal surgery

Table 27
Median and inter-quartile range (IQR) length-of-stay (LOS) for colorectal cancer patients (C18-20) having resection 2002-2008 and likelihood of prolonged length of stay (n=8,197) [39]

Type of admission for index surgical resection	**Elective** surgery (n=5,133, 63%)		**Emergency** surgery (n=3,064, 37%)	
	days	**[IQR]**	**days**	**[IQR]**
Median LOS (days)	14	[11-20]	21	[15-33]
Predictors of prolonged LOS (>24 days in hospital)	likelihood of prolonged LOS		likelihood of prolonged LOS	
➢ Age >60 years (vs. <60 year)	↑		↑	
➢ other marital status (*vs.* married)	↑		↑	
➢ higher co-morbidity score	↑		↑	
➢ private patient (*vs.* public patient)	↓		↓	
➢ discharge to step-down care (*vs.* home)	↑		↑	
➢ higher hospital caseload volume	-		↓	

↑= significantly greater likelihood of >24 days spent in hospital after surgery
↓= significantly lesser likelihood of >24 days spent in hospital after surgery
[39] Kelly *et al*, BMC Health Services Research (2012) 12:77

A recent study using a National Cancer Registry dataset of colorectal cancer patients calculated length-of-stay (LOS) in hospital after the index cancer resection procedure.[39] Incident colorectal cancers (C18-20), diagnosed 2002-2008, were identified from the NCR database, and linked to hospital in-patient episodes (HIPE).[40]

For those who underwent colorectal resection, the associated hospital episode was identified. Factors predicting prolonged LOS (>24 days) for elective and emergency procedures, were investigated (Table 27). 8,197 patients underwent resection, 63% (n = 5,133) elective and 37% (n = 3,063) emergency admissions. Median LOS was 14 days (inter-quartile range (IQR) = 11-20) for elective and 21 (IQR=15-33) for emergency admissions. For both emergency and elective admissions, likelihood of longer LOS was significantly higher in patients who were older, had co-morbidities and were unmarried; it was reduced for private patients (Table 27).

For emergency patients, the likelihood of longer LOS was lower for patients admitted to higher-volume hospitals. This study showed that 25% of patients stayed in hospital for at least >24 days following colorectal resection. Over one third of resected patients were emergency admissions and these had a significantly longer median LOS. Longer LOS was also associated with increased risk of emergency readmission within 28 days after discharge. Considering that the management of each case of colorectal cancer is estimated to cost around €40,000 [38] (with hospital care accounting for much of this), the cost implications of prolonged LOS are significant.

3.8 Colon cancer: factors associated with receipt of treatment

The patient and tumour factors associated with tumour directed treatment were identified and are presented in Tables 28-37. *Treatment* was defined as receipt of any: surgery, radiotherapy, chemotherapy within one year of diagnosis date. A *risk ratio (RR)* less than 1.0 indicates a lesser likelihood of treatment relative to the baseline level of a variable (1.0). Similarly, a risk ratio greater than 1.0 indicates a greater likelihood of treatment after adjusting for the other variables in the models.

Most patients (95%) presenting with stage II/III disease received surgery as first line treatment in 1995-1999, 2000-2004, 2005-2009; there was no change in the proportion in receipt of surgery over the three diagnostic periods (Table 28). Adjuvant chemotherapy became an important part of the patient management in more recent years. Cases diagnosed during 2005-2009 were more likely to receive adjuvant chemotherapy compared to cases diagnosed during 1995-1999 (42% *vs.* 33% respectively, RR=1.33 95%CI: 1.23, 1.44) (Table 28).

Table 28
Diagnostic period and treatment modalities in colon cancer (C18): Cases diagnosed at stage II/III

period	SURGERY					SURGERY and ADJUVANT CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
1995-1999	3,009	94%	1.00			33%	1.00		
2000-2004	3,274	94%	1.00	[0.95,1.05]		40%	1.29	[1.19,1.40]	***
2005-2009	4,042	95%	1.00	[0.95,1.05]		42%	1.33	[1.23,1.44]	***
total	**10,325**	**95%**				**39%**			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, grade, deprivation, HSE area of residence. * p<0.05, **p<0.001, *** p<0.0001

Table 29
Age and treatment modalities in colon cancer (C18):
Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

age	SURGERY					SURGERY and ADJUVANT CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
15-44	347	99%	1.00			78%	1.00		
45-54	863	97%	0.97	[0.86,1.10]		69%	0.91	[0.79,1.05]	
55-64	2,028	96%	0.97	[0.87,1.09]		61%	0.81	[0.71,0.93]	**
65-74	3,253	95%	0.96	[0.86,1.08]		44%	0.59	[0.51,0.67]	***
75+	3,834	92%	0.94	[0.84,1.05]		13%	0.17	[0.15,0.20]	***
total	**10,325**	**95%**				**39%**			

T%: Percentage treated
RR: Risk ratios were adjusted for sex, stage, grade, deprivation, HSE area of residence. * p<0.05, **p<0.001, *** p<0.0001

The proportion in receipt of surgery fell from 99% of cases under 45 years, to 92% of cases older than 75 years (Table 29). The proportion of patients who received adjuvant chemotherapy fell steadily from 78% of patients less than 45 years, to only 13% of patients older than 75 years (RR=0.17 95%CI: 0.15, 0.20) (Table 29).

Table 30
Gender and treatment modalities in colon cancer (C18):
Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

sex	SURGERY					SURGERY and ADJUVANT CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
females	4,838	94%	1.00			37%	1.00		
males	5,487	95%	1.00	[0.96,1.04]		40%	1.02	[0.95,1.08]	
total	10,325	95%				39%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, stage, grade, deprivation, HSE area of residence. * p<0.05, **p<0.001, *** p<0.0001

The proportion in receipt of surgery was the same for males and females. A marginally higher proportion of males (40%) with colon cancer received adjuvant chemotherapy compared to females (37%), but the difference was not significant (RR=1.02, 95%CI: 0.95, 1.08) (Table 30).

Table 31
Deprivation and treatment modalities in colon cancer (C18):
Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

deprivation	SURGERY					SURGERY and ADJUVANT CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
least	2,082	95%	1.00			38%	1.00		
2	1,435	95%	1.00	[0.93,1.07]		40%	1.02	[0.92,1.14]	
3	1,376	95%	1.00	[0.93,1.08]		39%	1.05	[0.94,1.17]	
4	1,742	94%	1.00	[0.94,1.07]		39%	1.04	[0.94,1.15]	
most	3,149	94%	0.99	[0.94,1.05]		39%	1.04	[0.95,1.14]	
unknown	541	96%	1.01	[0.92,1.11]		40%	1.03	[0.88,1.19]	
total	10,325	95%				39%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, grade, HSE area of residence. * p<0.05, **p<0.001, *** p<0.0001

Receipt of surgery or adjuvant chemotherapy was not dependent on the deprivation quintile of patient's area of residence (Table 31).

Table 32
HSE area and treatment modalities in colon cancer (C18): Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

HSE area	SURGERY					SURGERY and ADJUVANT CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
DNML	2,951	95%	1.00			37%	1.00		
DNNE	1,920	95%	1.00	[0.94,1.06]		37%	0.98	[0.89,1.08]	
South	2,764	95%	1.00	[0.95,1.06]		41%	1.09	[1.00,1.18]	
West	2,690	94%	1.01	[0.95,1.06]		40%	1.05	[0.97,1.15]	
total	10,325	95%				39%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, deprivation.
* p<0.05, **p<0.001, *** p<0.0001

Receipt of surgery or adjuvant chemotherapy was not dependent on the patient's HSE area of residence (Table 32).

3.9 Rectal cancer: Factors associated with receipt of treatment

Pre-operative radiotherapy has been recommended for resectable rectal cancer in recent years.[45,46] Factors affecting receipt of this treatment were explored (Tables 33-37). Most patients (89%) presenting with stage II/III rectal cancer received surgery as first line treatment during the periods: 1995-1999, 2000-2004, 2005-2009 (Table 33). Pre-operative radiotherapy became an important part of patient management after 2000. Cases diagnosed during 2005-2009 were more likely to receive pre-operative radiotherapy compared to cases diagnosed during 1995-1999 (5% *vs.* 38% respectively). RR=7.59 95%CI: 5.87, 9.82) (Table 33).

Table 33
Diagnostic period and treatment modalities in rectal cancer (C19-20): Cases diagnosed at stage II/III

period	SURGERY					SURGERY and PRE-OPERATIVE RADIOTHERAPY *±(neo-) adjuvant CHEMOTHERAPY*			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
1995-1999	1,485	91%	1.00			5%	1.00		
2000-2004	1,775	88%	0.96	[0.89,1.03]		21%	4.13	[3.16,5.40]	***
2005-2009	1,986	89%	0.96	[0.90,1.03]		38%	7.59	[5.87,9.82]	***
total	5,246	89%				23%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, grade, deprivation, HSE area of residence. p: * p<0.05, **p<0.001, *** p<0.0001

The proportion of patients in receipt of surgery decreased from 95% for cases <45 years, to 81% for cases > 75 years (Table 34). The proportion of patients who received pre-operative radiotherapy decreased from 31% for patients < 45 years, to only 12% for patients > 75 years (RR=0.32 95%CI: 0.24, 0.44) (Table 34).

Table 34
Age and treatment modalities in rectal cancer (C19-20): Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

age	SURGERY					SURGERY and PRE-OPERATIVE RADIOTHERAPY *±(neo-) adjuvant CHEMOTHERAPY*			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
15-44	206	95%	1.00			31%	1.00		
45-54	580	94%	0.98	[0.83,1.15]		33%	0.98	[0.73,1.31]	
55-64	1,221	93%	0.97	[0.84,1.13]		27%	0.82	[0.63,1.09]	
65-74	1,683	91%	0.95	[0.82,1.10]		23%	0.69	[0.53,0.91]	**
75+	1,556	81%	0.86	[0.74,0.99]	*	12%	0.32	[0.24,0.44]	***
total	5,246	89%				23%			

T%: Percentage treated
RR: Risk ratios were adjusted for sex, stage, grade, deprivation, HSE area of residence. p: * p<0.05, **p<0.001, *** p<0.0001

Table 35
Gender and treatment modalities in rectal cancer (C19-20): Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

gender	SURGERY					SURGERY and PRE-OPERATIVE RADIOTHERAPY ±(neo-) adjuvant CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
females	1,848	88%	1.00			19%	1.00		
males	3,398	89%	1.01	[0.95,1.07]		25%	1.25	[1.10,1.43]	***
total	5,246	89%				23%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, stage, grade, deprivation and HSE area of residence. p: * p<0.05, **p<0.001, *** p<0.0001

There was no difference between males and females in the receipt of surgery (Table 35). However, males were significantly more likely to receive pre-operative radiotherapy (25% *vs.* 19% for males and females respectively, RR=1.25 95%CI: 1.10, 1.43) (Table 35).

Table 36
Deprivation and treatment modalities in rectal cancer (C19-20): Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

Depriv-ation	SURGERY					SURGERY and PRE-OPERATIVE RADIOTHERAPY ±(neo-) adjuvant CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
least	1,038	89%	1.00			23%	1.00		
2	738	91%	1.02	[0.92,1.12]		22%	1.13	[0.92,1.39]	
3	711	89%	1.00	[0.90,1.10]		25%	0.94	[0.75,1.18]	
4	883	90%	1.01	[0.91,1.11]		20%	1.03	[0.84,1.26]	
most	1,610	88%	0.98	[0.90,1.07]		22%	1.09	[0.92,1.30]	
unknown	266	90%	1.03	[0.89,1.18]		23%	1.21	[0.91,1.61]	
total	5,246	89%				23%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, grade and HSE area of residence. p: * p<0.05, **p<0.001, *** p<0.0001

Receipt of surgery, or pre-operative radiotherapy was not dependent on the deprivation quintile of patient's area of residence (Table 36).

Table 37
HSE area of residence and treatment modalities in rectal cancer (C19-20) Diagnostic period: 1995-2009. Cases diagnosed at stage II/III

HSE area	SURGERY					SURGERY and PRE-OPERATIVE RADIOTHERAPY ±(neo-) adjuvant CHEMOTHERAPY			
	Cases	T%	RR	95%CI	p	T%	RR	95%CI	p
DNML	1,395	88%				25%			
DNNE	1,006	89%	1.02	[0.94,1.11]		22%	0.88	[0.74,1.06]	
South	1,481	90%	1.03	[0.95,1.11]		22%	0.83	[0.70,0.97]	*
West	1,364	89%	1.04	[0.95,1.12]		22%	0.86	[0.72,1.01]	
total	5,246	89%				23%			

T%: Percentage treated
RR: Risk ratios were adjusted for age, sex, stage, grade, deprivation
p: * p<0.05, **p<0.001, *** p<0.0001

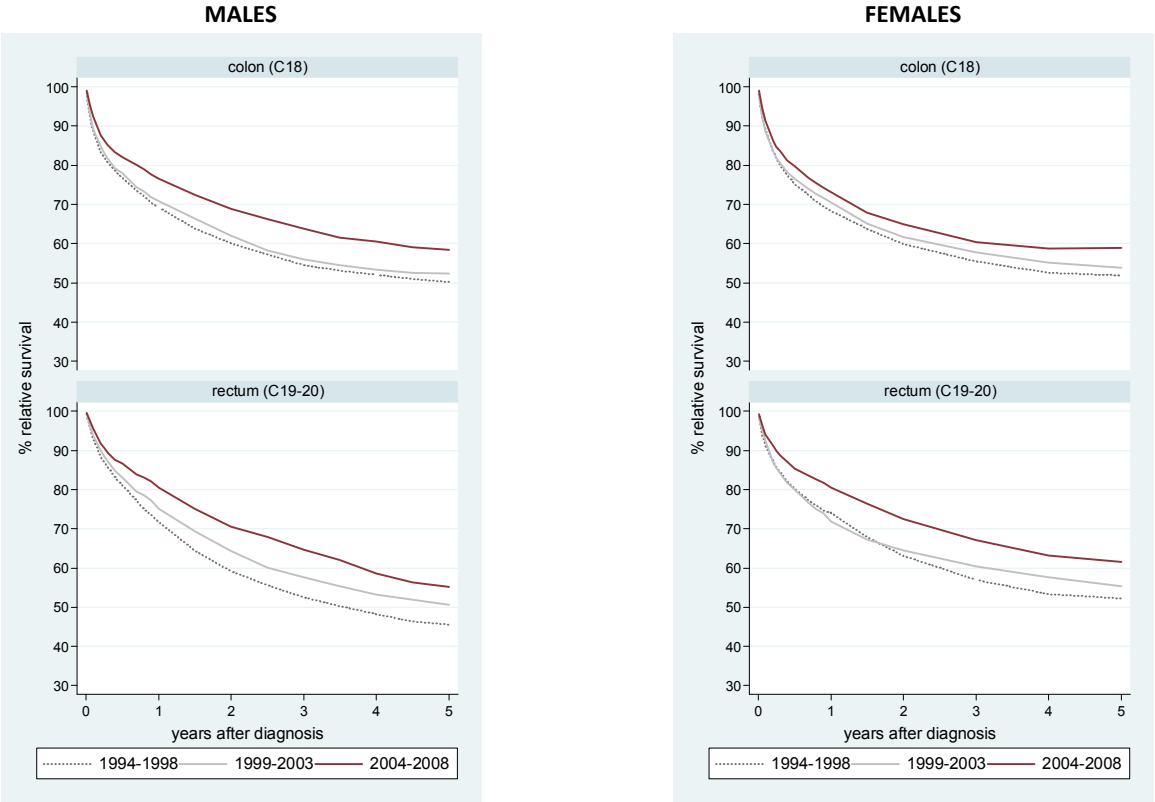
HSE area of residence had no influence on whether a patient received surgery (Table 37). However, patients from HSE South (22%) were marginally less likely to receive pre-operative radiotherapy relative to patients within HSE DNML (25%), (South *vs.* DNML, RR=0.83 95%CI: 0.70, 0.97).

4. SURVIVAL

4.1 Comparison of survival

Observed survival is simply the proportion remaining alive after a given period of time. *Relative survival (RS)* is the ratio of the observed survival proportion for a given group of cancer cases to the expected survival proportion of a group of individuals with the same demographic attributes. In practice, relative survival is similar to *cause-specific survival*—it measures the excess mortality due specifically to the cancer, and so is always greater than observed survival. Relative survival is now used by most cancer registries in place of *cause specific survival* because the actual cause of death in any given cancer case is not always known. Relative survival also facilitates international comparison, as it reduces problems related to international inconsistency in coding cause of death. Autopsy-only cases, DCO cases, colorectal cancers concurrent with another invasive malignancy and colorectal cancers incident during 2009 and 2010 were excluded for survival analysis (Table 47).

Figure 13
Percentage relative survival for invasive colorectal cancer (C18-C20), by gender and site of primary tumour
Diagnostic period: 1994-1998, 1999-2003, 2004-2008



period	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
1994-1998	colon (C18)	69	[67,71]	50	[48,53]
1999-2003	colon (C18)	71	[69,73]	52	[50,55]
2004-2008	colon (C18)	77	[75,78]	58	[56,61]
1994-1998	rectum (C19-20)	72	[70,74]	46	[43,48]
1999-2003	rectum (C19-20)	75	[73,77]	51	[48,53]
2004-2008	rectum (C19-20)	81	[79,82]	55	[52,59]

period	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
1994-1998	colon (C18)	68	[66,70]	52	[49,54]
1999-2003	colon (C18)	70	[69,72]	54	[52,56]
2004-2008	colon (C18)	73	[71,75]	59	[56,62]
1994-1998	rectum (C19-20)	74	[71,77]	52	[49,56]
1999-2003	rectum (C19-20)	72	[69,75]	55	[52,59]
2004-2008	rectum (C19-20)	80	[78,83]	61	[57,65]

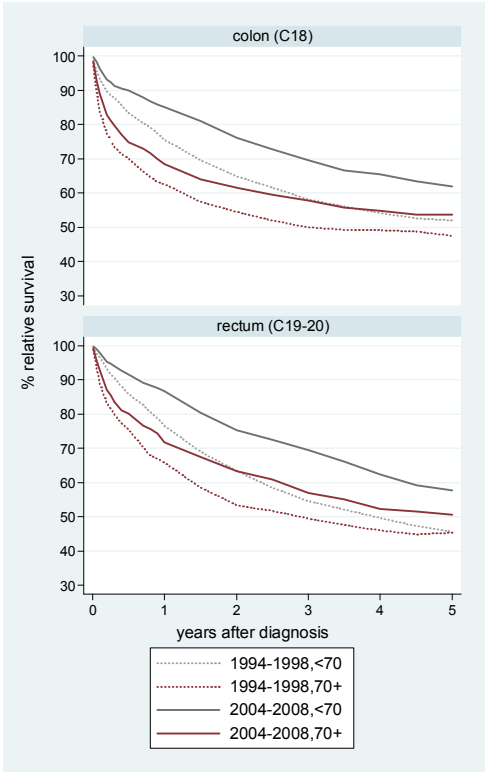
In colon cancer, 1 year survival improved by 8 percentage points (69-77%) for males and 5 points (68-73%) for females between the periods 1994-1998 and 2004-2008. The improvement was maintained at 5 years; 8 points (50-58%) for males and 7 points

(52-59%) for females. The scale of the improvement in survival in colon cancer, between the earlier and later periods (1994-1998 and 2004-2008) was greater for males, at 1 year and 5 years (Figure 13).

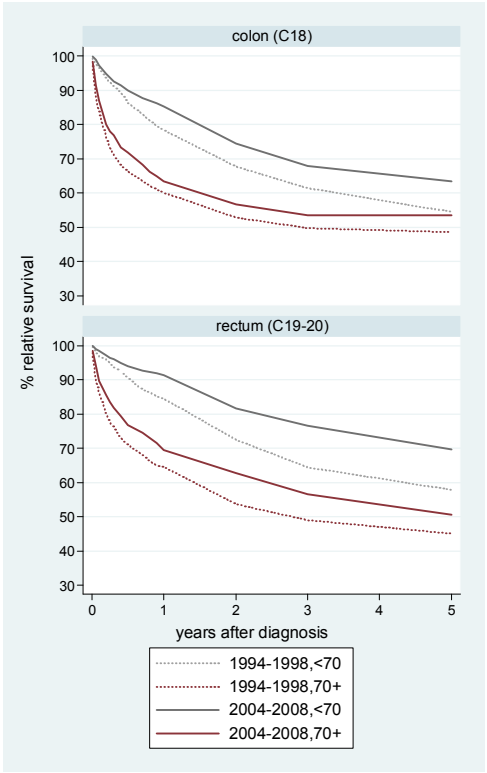
In rectal cancer, 1 year survival improved by 9 points (72-81%) for males and 6 points (74- 80%) for females between the periods 1994-1998 and 2004-2008. The improvement was maintained at 5 years; 9 points (46-55%) for males and 9 points (52-61%) for females. The scale of the improvement in survival at 1 year for rectal cancer, between the earlier and later periods (1994-1998 and 2004-2008) was greater for males (Figure 13).

Figure 14
Percentage relative survival for invasive colorectal cancer (C18-C20), by gender, age and site of primary tumour
Diagnostic periods: 1994-1998 and 2004-2008

MALES



FEMALES



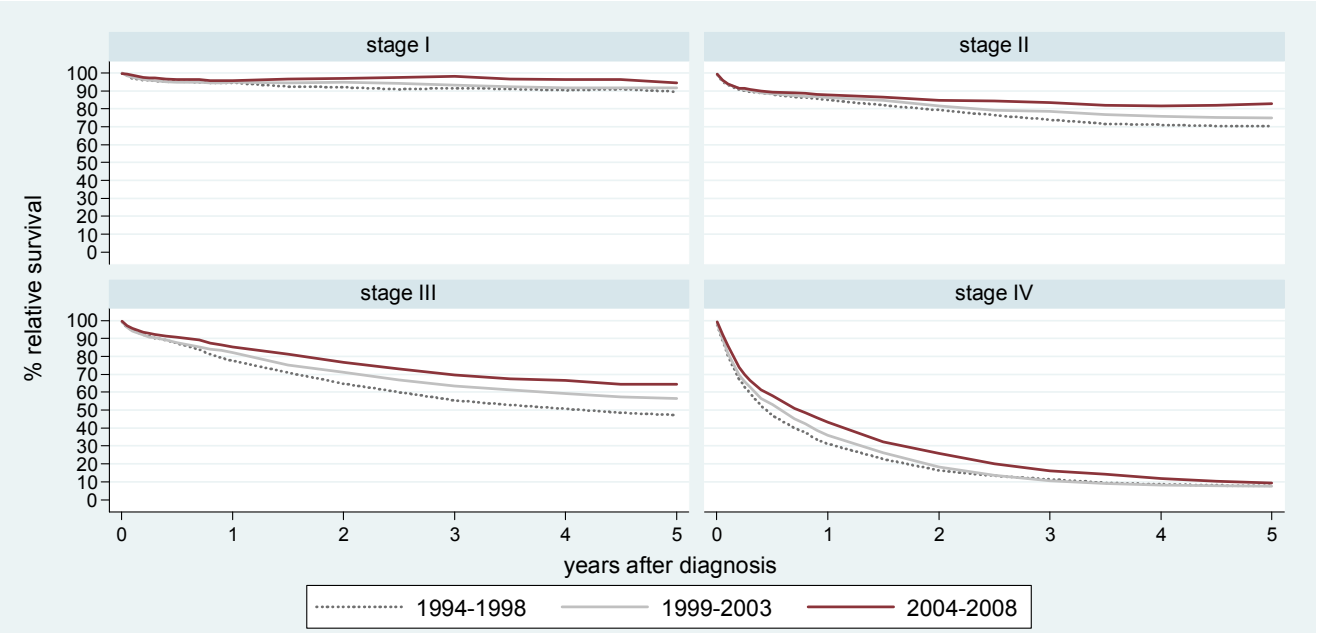
site	*relative survival at:*	*age*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
colon (C18)	1994-1998	<70yr	75	[73,78]	52	[49,55]
colon (C18)	1994-1998	70+yr	63	[60,65]	48	[44,52]
colon (C18)	2004-2008	<70yr	85	[83,87]	62	[59,65]
colon (C18)	2004-2008	70+yr	69	[66,71]	54	[49,58]
rectum (C19-20)	1994-1998	<70yr	77	[74,79]	46	[42,49]
rectum (C19-20)	1994-1998	70+yr	66	[62,69]	45	[41,50]
rectum (C19-20)	2004-2008	<70yr	87	[85,89]	58	[54,62]
rectum (C19-20)	2004-2008	70+yr	72	[68,75]	51	[45,57]

site	*relative survival at:*	*age*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
colon (C18)	1994-1998	<70yr	78	[76,81]	55	[51,58]
colon (C18)	1994-1998	70+yr	60	[57,63]	49	[45,52]
colon (C18)	2004-2008	<70yr	85	[83,87]	63	[60,67]
colon (C18)	2004-2008	70+yr	63	[61,66]	53	[50,57]
rectum (C19-20)	1994-1998	<70yr	84	[81,87]	58	[53,62]
rectum (C19-20)	1994-1998	70+yr	65	[60,69]	45	[40,51]
rectum (C19-20)	2004-2008	<70yr	91	[89,93]	70	[65,74]
rectum (C19-20)	2004-2008	70+yr	69	[65,73]	51	[44,57]

In colon cancer, in the under 70 years subset, 1 year survival improved by 10 points (75-85%) for males and 7 points (78- 85%) for females between the periods 1994-1998 and 2004-2008. The improvement was maintained at 5 years; 10 points (52-62%) for males and 8 points (55-63%) for females. In the greater than 70 years subset, I year survival improved by 6 points (63%-69%) in males and 3 points in females (60-63%). The improvement was maintained at 5 years; 6 points (48-54%) in males and 4 points (49-53%) in females. The scale of the improvement in survival between the earlier and later periods (1994-1998 and 2004-2008) in colon cancer was greater for males (Figure 14).

In rectal cancer, in the less than 70 years subset, 1 year survival improved by 10 points (77-87%) for males and 7 points (84-91%) for females between the periods 1994-1998 and 2004-2008. The improvement was maintained at 5 years; 12 points (46-58%) for males and 12 points (58-70%) for females. In the greater than 70 years subset, I year survival improved by 6 points (66%-72%) in males and 4 points in females (65-69%). The improvement was maintained at 5 years; 6 points (45-51%) in males and 6 points (45-51%) in females. For survival at 1 year, the scale of the improvement in survival between the earlier and later periods (1994-1998 and 2004-2008) in rectal cancer was greater for males; at five years the scale of the improvement was similar for males and females (Figure 14).

Figure 15
Percentage relative survival for colon cancer (C18), by stage of disease
Diagnostic periods: 1994-1998, 1999-2003, 2004-2008

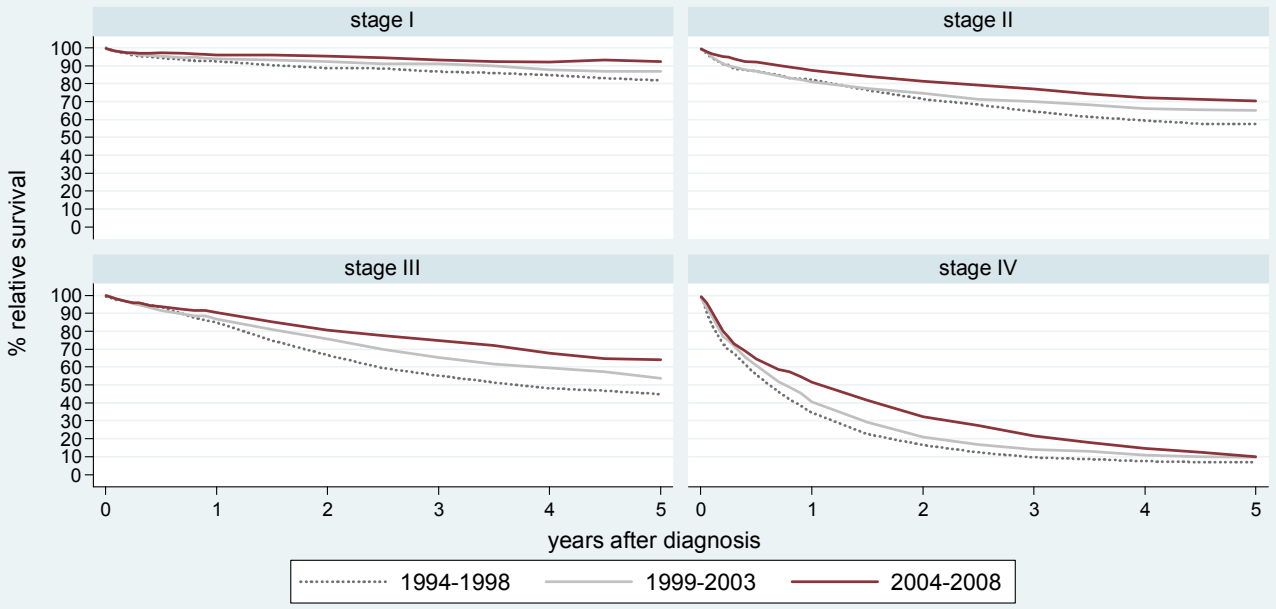


stage	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
stage I	1994-1998	95	[92,97]	90	[85,94]
stage I	1999-2003	95	[92,97]	92	[87,96]
stage I	2004-2008	96	[93,98]	95	[89,99]
stage III	1994-1998	78	[75,80]	47	[44,51]
stage III	1999-2003	82	[80,84]	56	[53,60]
stage III	2004-2008	85	[83,87]	64	[61,68]

stage	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
stage II	1994-1998	85	[83,87]	70	[67,73]
stage II	1999-2003	86	[84,88]	75	[72,78]
stage II	2004-2008	88	[86,89]	83	[79,86]
stage IV	1994-1998	31	[28,34]	8	[6,10]
stage IV	1999-2003	36	[33,39]	8	[6,9]
stage IV	2004-2008	43	[41,46]	9	[7,12]

For colon cancer patients presenting at stage I, relative survival at 5 years was high, ranging from 90% for cases presenting in 1994-1998, to 95% for cases presenting in 2004-2008 (an improvement of 5 percentage points). For stage II patients, relative survival at 5 years increased from 70% during the period 1994-1998, to 83% during 2004-2008 (an improvement of 13 percentage points). For stage III patients, relative survival at 5 years increased from 47% during the period 1994-1998, to 64% during 2004-2008 (an improvement of 17 percentage points). For stage IV patients, there was no change in relative survival at five years (<10% for each of the periods: 1994-1998, 1999-2003, and 2004-2008). However, 1 year survival for stage IV patients did improve from 31% during 1994-1998 to 43% during 2004-2008 (an improvement of 12 percentage points) (Figure 15).

Figure 16
Percentage relative survival for rectal cancer (C19-20), by stage of disease
Diagnostic periods: 1994-1998, 1999-2003, 2004-2008

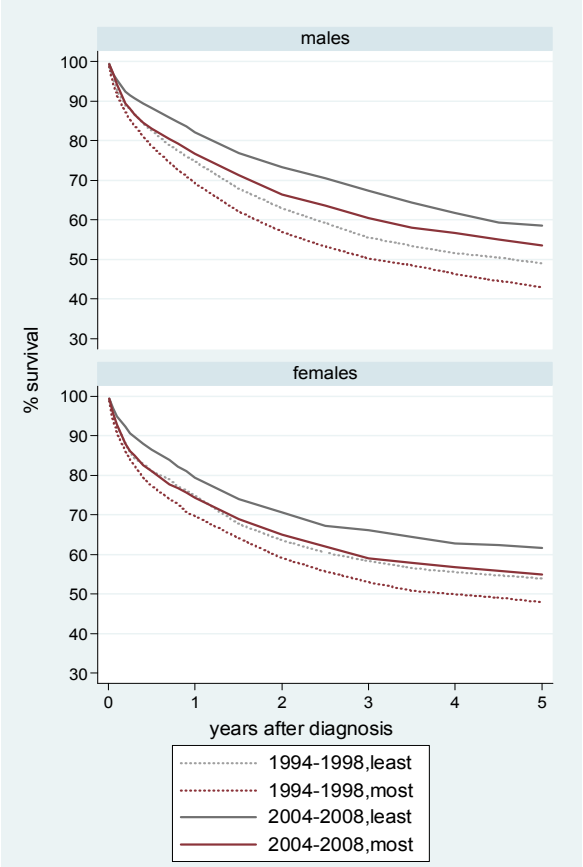


stage	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
stage I	1994-1998	92	[90,95]	82	[77,86]
stage I	1999-2003	94	[91,96]	87	[82,91]
stage I	2004-2008	96	[93,98]	92	[86,97]
stage III	1994-1998	85	[82,88]	45	[40,49]
stage III	1999-2003	87	[84,89]	54	[50,58]
stage III	2004-2008	90	[88,92]	64	[59,69]

stage	*relative survival at:*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
stage II	1994-1998	82	[79,85]	58	[53,62]
stage II	1999-2003	81	[78,84]	65	[61,69]
stage II	2004-2008	88	[85,90]	70	[65,76]
stage IV	1994-1998	35	[31,38]	7	[5,9]
stage IV	1999-2003	41	[37,44]	10	[7,12]
stage IV	2004-2008	51	[48,55]	10	[7,14]

For rectal cancer patients presenting at stage I, relative survival at 5 years was high, ranging from 82% for cases presenting in 1994-1998, to 92% for cases presenting in 2004-2008 (an improvement of 10 percentage points). For stage II patients, relative survival at 5 years increased from 58% during the period 1994-1998, to 70% during 2004-2008 (an improvement of 12 percentage points). For stage III patients, relative survival at 5 years increased from 45% during the period 1994-1998, to 64% during 2004-2008 (an improvement of 19 percentage points). For stage IV patients, relative survival at 5 years increased from 7% during the period 1994-1998, to 10% during 2004-2008 (an improvement of 3 percentage points). Relative survival at 1 year for stage IV patients improved from 35% during 1994-1998 to 51% during 2004-2008 (an improvement of 16 percentage points) (Figure 16).

Figure 17
Cause specific survival for colorectal cancer (C18-20), by gender and deprivation (least and most) Diagnostic periods 1994-1998 & 2004-2008



gender	*deprivation*	*cause sp. survival at*	*1-yr%*	*95%CI*	*5-yr%*	*95%CI*
males	least	1994-1998	75	[72,77]	49	[45,52]
males	most	1994-1998	69	[67,72]	43	[40,46]
males	least	2004-2008	82	[80,84]	58	[55,62]
males	most	2004-2008	77	[75,79]	54	[50,57]
females	least	1994-1998	75	[71,78]	54	[50,58]
females	most	1994-1998	70	[67,72]	48	[45,51]
females	least	2004-2008	79	[77,82]	62	[58,65]
females	most	2004-2008	74	[72,77]	55	[51,58]

1-year and 5-year cause specific survival was calculated by deprivation quintile ('least' and 'most' only) and diagnostic periods 1994-1998 and 2004-2008 (Figure 17).

For females, in the earliest period (1994-1998), 5-year survival was notably lower (48%) in the most deprived quintile compared to least deprived quintile (54%). The difference in survival between these quintiles *increased* from 6% in 1994-1998 to 7% in 2004-2008.

By contrast, for men, in the earliest period (1994-1998), 5-year survival was 43% in the most deprived quintile compared 49% to least deprived quintile. The difference in survival between these quintiles *decreased* from 6% in 1994-1998 to 4% in 2004-2008.

Therefore, for the two diagnostic periods examined, the differences in cancer survival associated with deprivation seemed to converge for males and diverge for females.

4.2 Factors associated with cause-specific survival

Survival analysis, stratified by age, gender, stage and site of tumour, was performed on colorectal cancer cases accrued over three diagnostic periods 1994-1998, 1999-2003 and 2004-2008. Cases were followed up until date of death (due to cancer) or censoring date (31/12/09), whichever occurred first.[c] Adjusted (multivariate) Cox regression models of the effect of period of diagnosis on cause-specific overall survival were derived. Hazard ratios less than 1.0 indicate relatively improved survival when compared with the reference diagnostic period: 1994-1998.

Table 38
Cancer cause-specific survival in patients with colorectal cancer (C18-20): ALL STAGES and ALL AGES
Diagnostic period: 1994-2008
Percentage survival at 5 years, adjusted hazard ratios, by site of primary tumour

Site	‡No.	5-yr%‡	HR	95%CI	p
colon (C18)	17,086	57%	1.00		
rectum (C19-20)	9,831	57%	1.04	[1.01,1.08]	*
total	**26,917**				

‡ Total number of patients in category and percentage of those who survived cancer related death up to 5 years after diagnosis
Model adjusted for age, sex, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation and diagnostic period. p= *p<0.05
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

While the percentage cause specific survival at 5 years is 57% for both colon and rectal cancer, rectal cancer showed marginally poorer survival for all patients accrued during the period 1994-2008 (HR=1.04 95%CI: 1.01, 1.08) (Table 38).

Table 39
Cancer cause-specific survival in patients with colorectal cancer (C18-20): ALL STAGES, ALL AGES, MALES AND FEMALES
Percentage survival at 1-year, adjusted hazard ratios, by diagnostic period and site of primary tumour

period	site	‡No.	‡1-yr%	HR	95%CI	p
1994-1998	**colon (C18)**	5,306	72%	1.00		
1999-2003		5,417	73%	0.88	[0.83,0.93]	***
2004-2008		6,363	77%	0.71	[0.68,0.76]	***
1994-1998	**rectum (C19-20)**	3,048	75%	1.00		
1999-2003		3,290	76%	0.86	[0.80,0.92]	***
2004-2008		3,493	82%	0.65	[0.60,0.70]	***

‡ Total number of patients in category and percentage of those who survived cancer related death up to 1 year after diagnosis
Models adjusted for age, sex, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation
p= *p<0.05, **p<0.001, ***p<0.0001
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

While rectal cancer showed marginally poorer survival overall (Table 38), for the comparison between the earliest and latest diagnostic periods, the improvement in survival was greater for rectal cancer relative to colon cancer (Table 39); (HR=0.65 95%CI: 0.60,0.70) *vs.* (HR=0.71 95%CI: 0.68,0.76), for rectal and colon respectively.

[c] Appendix II: Statistical methods

Table 40
Cancer cause-specific survival in patients with stage II/III colorectal cancer (C18-20): MALES
Percentage survival at 1-year, adjusted hazard ratios, by diagnostic period, age and site of primary tumour

period	age	site	‡No.	1-yr%‡	HR	95%CI	p
1994-1998	**<70 years**	**colon (C18)**	752	88%	1.00		
1999-2003			743	91%	0.73	[0.62,0.86]	***
2004-2008			935	96%	0.51	[0.42,0.62]	***
1994-1998		**rectum (C19-20)**	502	89%	1.00		
1999-2003			622	92%	0.69	[0.58,0.83]	***
2004-2008			666	95%	0.51	[0.41,0.63]	***
1994-1998	**70+ years**	**colon (C18)**	763	79%	1.00		
1999-2003			801	81%	0.91	[0.79,1.06]	
2004-2008			1,014	85%	0.67	[0.57,0.79]	***
1994-1998		**rectum (C19-20)**	428	80%	1.00		
1999-2003			462	82%	0.86	[0.71,1.03]	
2004-2008			488	86%	0.66	[0.53,0.81]	***

‡ Total number of patients in category and percentage of those who survived cancer related death up to 1-year after diagnosis
Models adjusted for age, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation
p= *p<0.05, **p<0.001, ***p<0.0001
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

For younger males (<70 years) with stage II/III colon cancer, the proportion who survived cancer after one year increased incrementally from 88% in the earliest period (1994-1998), to 96% in the latest period (2004-2008) (HR=0.51 95%CI:0.42,0.62). There was also a simultaneous and incremental increase in survival for rectal cancer; starting from 89% during 1994-1998, to 95% for the period 2004-2008 (HR=0.51 95%CI: 0.41, 0.63) (Table 40).

For older males (>70 years) with colon cancer, there was a significant improvement in survival from 79% in the earliest period to 85% in the latest period (HR=0.67 95%CI: 0.57, 0.79). There was also a simultaneous improvement in survival for older males with rectal cancer, starting from 80% in the earliest period to 86% in the latest period (HR=0.66 95%CI: 0.53, 0.81) (Table 40).

These data show a highly significant improvement in cancer survival for males (<70 and >70 years) with colorectal cancer. The improved survival was probably due to greater uptake of treatment and earlier diagnosis.

Table 41
Cancer cause-specific survival in patients with stage II/III colorectal cancer (C18-20): FEMALES
Percentage survival at 1-year, adjusted hazard ratios, by diagnostic period, age and site of primary tumour

period	age	site	‡No.	‡1-yr%	HR	95%CI	p
1994-1998	**<70 years**	**colon (C18)**	657	89%	1.00		
1999-2003			640	91%	0.76	[0.63,0.92]	**
2004-2008			725	94%	0.53	[0.42,0.66]	***
1994-1998		**rectum (C19-20)**	257	93%	1.00		
1999-2003			290	92%	0.86	[0.66,1.13]	
2004-2008			354	96%	0.58	[0.41,0.80]	**
1994-1998	**70+ years**	**colon (C18)**	734	78%	1.00		
1999-2003			834	79%	0.91	[0.79,1.05]	
2004-2008			973	79%	0.82	[0.70,0.96]	*
1994-1998		**rectum (C19-20)**	261	77%	1.00		
1999-2003			271	70%	1.05	[0.83,1.32]	
2004-2008			320	81%	0.81	[0.62,1.04]	

‡ Total number of patients in category and percentage of those who survived cancer related death up to 1-year after diagnosis
Models adjusted for age, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation
p= *p<0.05, **p<0.001, ***p<0.0001
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

For younger females (<70 years) with stage II/III colon cancer, the proportion who survived cancer after one year increased from 89% in the earliest period (1994-1998), to 94% in the latest period (2004-2008) (HR=0.53 95%CI:0.42,0.66). There was also a simultaneous increase in survival for rectal cancer; starting from 93% during 1994-1998, to 96% for the period 2004-2008 (HR=0.58 95%CI: 0.41, 0.80) (Table 41).

For older females (>70 years) with colon cancer, there was a modest improvement in survival from 78% in the earliest period to 79% in the latest period (HR=0.82 95%CI: 0.70, 0.96). For rectal cancer, the proportion who survived to one year increased from 77% in 1994-1998 to 81% in 2004-2008. However, the improvement was not statistically significant (HR=0.81 95%CI: 0.62, 1.04). These data show a significant improvement in cancer survival for younger females (<70 years) with colon cancer. There was also an improvement in survival from rectal cancer in the latest period (2004-2008) (Table 41).

In contrast with the data for older males (>70 years) (Table 40), older females showed only a modest improvement in survival for colon cancer, and no improvement for rectal cancer (Table 41).

Table 42
Cancer cause-specific survival in patients with stage IV colorectal cancer (C18-20): MALES
Percentage survival at 1-year, adjusted hazard ratios, by diagnostic period, age and site of primary tumour

period	age	site	‡No.	‡1-yr%	HR	95%CI	p
1994-1998	**<70 years**	**colon (C18)**	348	41%	1.00		
1999-2003			378	47%	0.84	[0.72,0.99]	*
2004-2008			401	58%	0.67	[0.57,0.79]	***
1994-1998		**rectum (C19-20)**	236	42%	1.00		
1999-2003			250	49%	0.75	[0.61,0.91]	**
2004-2008			299	64%	0.51	[0.42,0.62]	***
1994-1998	**70+ years**	**colon (C18)**	284	26%	1.00		
1999-2003			361	31%	0.97	[0.81,1.15]	
2004-2008			460	36%	0.85	[0.72,1.01]	
1994-1998		**rectum (C19-20)**	164	27%	1.00		
1999-2003			199	36%	0.80	[0.63,1.01]	
2004-2008			201	38%	0.71	[0.56,0.89]	**

‡ Total number of patients in category and percentage of those who survived cancer related death up to 1-year after diagnosis
Models adjusted for age, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation
p= *p<0.05, **p<0.001, ***p<0.0001
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

For younger males (<70 years) with stage IV colon cancer, the proportion who survived cancer after one year increased incrementally from 41% in the earliest period (1994-1998), to 58% in the latest period (2004-2008) (HR=0.67 95%CI:0.57, 0.79). There was also a simultaneous and incremental increase in survival for rectal cancer; starting from 42% during 1994-1998, to 64% for the period 2004-2008 (HR=0.51 95%CI: 0.42, 0.62) (Table 42).

For older males (>70 years) with stage IV colon cancer, there was no real improvement in survival across three diagnostic periods. However, there was an improvement in survival for older males with rectal cancer, from 27% in the earliest period to 38% in the latest period (HR=0.71 95%CI: 0.56, 0.89) (Table 42).

Table 43
Cancer cause-specific survival in patients with stage IV colorectal cancer (C18-20): FEMALES
Percentage survival at 1-year, adjusted hazard ratios, by diagnostic period, age and site of primary tumour

period	age	site	‡No.	S‡1-yr%	HR	95%CI	p
1994-1998	**<70 years**	**colon (C18)**	242	45%	1.00		
1999-2003			257	47%	1.03	[0.84,1.25]	
2004-2008			329	63%	0.76	[0.62,0.92]	**
1994-1998		**rectum (C19-20)**	94	51%	1.00		
1999-2003			89	52%	0.98	[0.69,1.37]	
2004-2008			113	71%	0.67	[0.48,0.94]	*
1994-1998	**70+ years**	**colon (C18)**	292	28%	1.00		
1999-2003			305	33%	0.92	[0.77,1.10]	
2004-2008			355	30%	0.93	[0.78,1.10]	
1994-1998		**rectum (C19-20)**	101	31%	1.00		
1999-2003			106	38%	0.71	[0.52,0.97]	*
2004-2008			124	43%	0.66	[0.49,0.91]	**

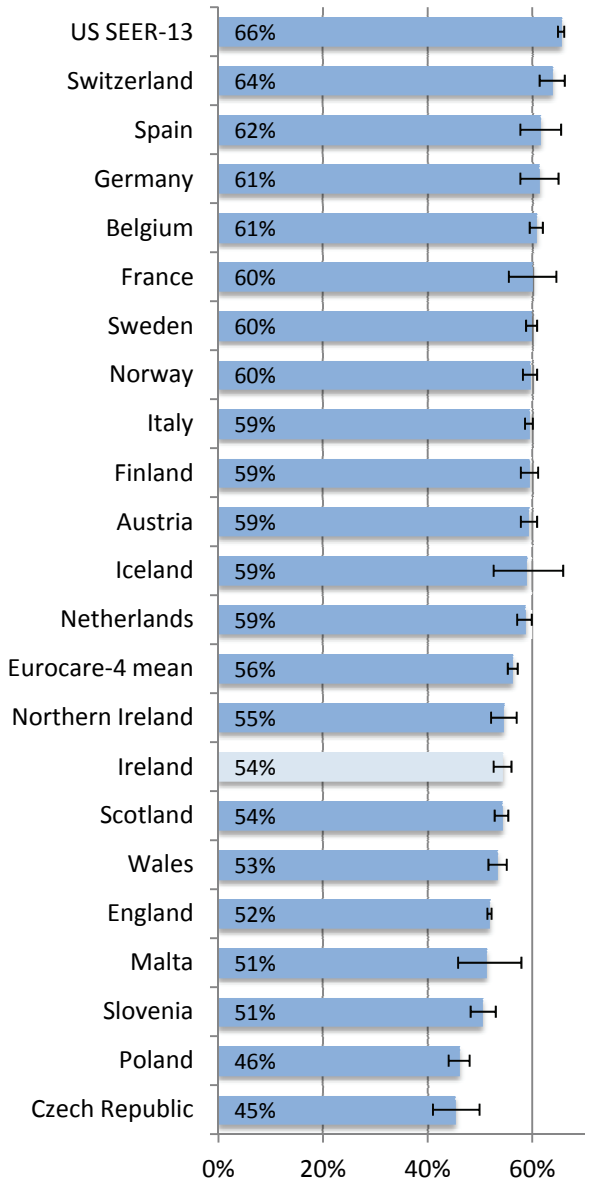
‡ Total number of patients in category and percentage of those who survived cancer related death up to 1-year after diagnosis
Models adjusted for age, stage, grade of tumour, smoking status, marital status, HSE area of residence and deprivation
p= *p<0.05, **p<0.001, ***p<0.0001
HR=adjusted hazard ratio for cause specific survival (overall time to censoring date or cause specific death)

For younger females (<70 years) with stage IV colon cancer, the proportion who survived cancer after one year increased significantly from 45% in the earliest period (1994-1998), to 63% in the latest period (2004-2008) (HR=0.76 95%CI:0.62, 0.92). There was also a modest increase in survival for rectal cancer, starting from 51% during 1994-1998, to 71% for the period 2004-2008 (HR=0.67 95%CI: 0.48, 0.94) (Table 43).

For older females (>70 years) with stage IV colon cancer, there was no real improvement in survival across the three diagnostic periods. However, there was an improvement in survival for rectal cancer, starting from 31% in the earliest period to 43% in the latest period (HR=0.66 95%CI: 0.49, 0.91) (Table 43).

4.3 International comparison of relative survival

Figure 18
Age adjusted 5-year relative survival of colorectal cancer
Diagnosis period: 2000-2002



(Eurocare-4. Verdecchia A, et al., 2007) [24]

A comparison of 5-year period relative survival for colorectal cancer cases accrued during the years 2000-2002 is presented in Figure 18.[24]

Across Europe, five-year relative survival from colorectal cancer for patients diagnosed in 2000-2002 ranged from 45% in the Czech Republic to 64% in Switzerland. Survival in Ireland (54%) was similar to that of our nearest neighbours, England (52%), Scotland (54%), Wales (53%) and Northern Ireland (55%), and just below the European average (56%).

Pooled 5-year relative survival estimates derived from 13 SEER registries in the United States was 66%, which was significantly higher than 5-year survival for cases in Ireland during the same period (54%).

Considering only the countries with national cancer registries, Iceland (59%), Sweden (60%), Finland (59%), Norway (60%) and the Netherlands (59%) all had significantly higher relative survival than Ireland while Malta (51%), Slovenia (51%), Poland (46%) and the Czech Republic (45%) all had marginally lower relative survival than Ireland.

5. MORTALITY

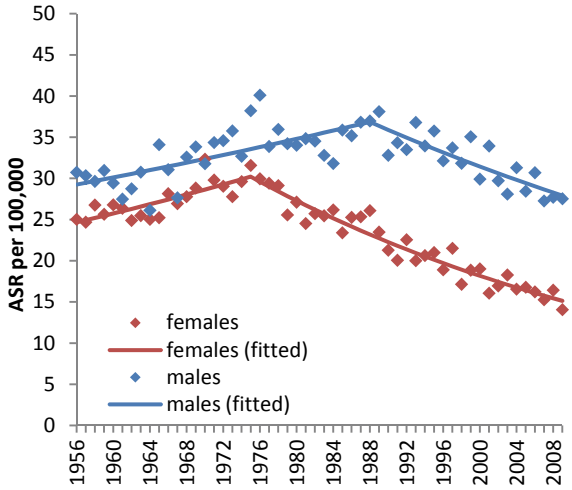
Colorectal cancer was the third leading cause of cancer death in females in 2007-2009, after lung cancer and breast cancer, and the second leading cause of cancer death in males after lung cancer. It accounted for 10% and 12% of cancer deaths in males and females respectively in 2007.[25]

5.1 Mortality trends

Mortality data obtained from the CSO for the period 1994-2009 is presented in Tables 44-46. [36]

There were on average 400 female and 552 male deaths per year from colorectal cancer (C18-20) between 2005 and 2009. For females, the age standardised rate (ASR) of mortality fell from 21/100,000 in 1994 to 14/100,000 in 2009, an annual decrease of 2.1%. For males, the ASR fell from 34/100,000 to 28/100,000 in 2009, an annual decrease of 1.6% (Table 44).

Figure 19
Age standardised rate (ASR): mortality colorectal cancer C18-C20: 1956-2009



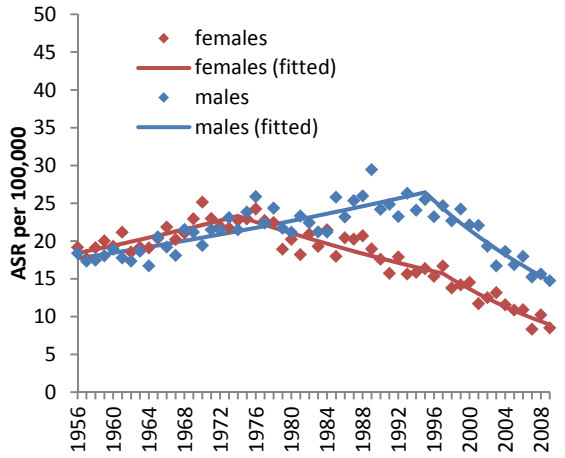
Gender	Period	APC	[95%CI]	trend
Females	1956-1975	1.1%	[0.6, 1.5%]	↑
	1976-2009	-2.0%	[-2.2, -1.8%]	↓
Males	1956-1988	0.7%	[0.5, 1.0%]	↑
	1989-2009	-1.3%	[-1.8, -0.8%]	↓

Table 44
Age standardised rate (ASR): mortality colorectal cancer C18-C20: 1994-2009

	females		males		all	
year	deaths	ASR	deaths	ASR	deaths	ASR
1994	415	20.6	508	34.0	923	26.5
1995	424	21.0	550	35.8	974	27.6
1996	403	18.9	493	32.2	896	25.0
1997	443	21.5	528	33.7	971	26.9
1998	369	17.2	509	31.8	878	23.7
1999	409	18.9	561	35.1	970	26.1
2000	411	19.0	493	29.9	904	23.8
2001	359	16.1	564	33.9	923	23.8
2002	388	17.0	510	29.7	898	22.7
2003	426	18.3	492	28.1	918	22.7
2004	400	16.6	557	31.3	957	23.0
2005	402	16.8	532	28.5	934	21.8
2006	417	16.2	582	30.7	999	22.8
2007	377	15.3	533	27.3	910	20.5
2008	424	16.4	550	27.7	974	21.5
2009	381	14.1	564	27.5	945	20.2
total	**6,448**		**8,526**		**14,974**	
APC(94-09)	-0.3%	-2.1%	0.5%	-1.6%	0.2%	-1.8%
[95% CI]	[-0.9,0.4]	[-2.8,-1.4]	[-0.1,1.1]	[-2.2,-1.0]	[-0.3,0.6]	[-2.2,-1.4]

Age standardised rates of mortality for colorectal cancer (C18-20) for the period 1956-2009 are presented in Figure 19. A significant 1.1% annual percentage increase in the female mortality rate was observed from 1956 to 1975. Thereafter, there was a significant 2% annual decrease in mortality, from 1976 to 2009. A significant 0.7% annual percentage increase in the male mortality rate was observed from 1956 to 1988. Thereafter, there was a significant 1.3% annual decrease in mortality, from 1989 to 2009.

Figure 20
Age standardised rate (ASR): mortality
colon cancer C18: 1956-2009



Gender	Period	APC	[95%CI]	trend
Females	1956-1974	1.3%	[0.7, 2.0%]	↑
	1975-1997	-1.7%	[-2.2, -1.2%]	↓
	1998-2009	-4.6%	[-5.7, -3.4%]	↓
Males	1956-1995	1.0%	[0.8, 1.2%]	↑
	1996-2009	-4.1%	[-5.0, -3.1%]	↓

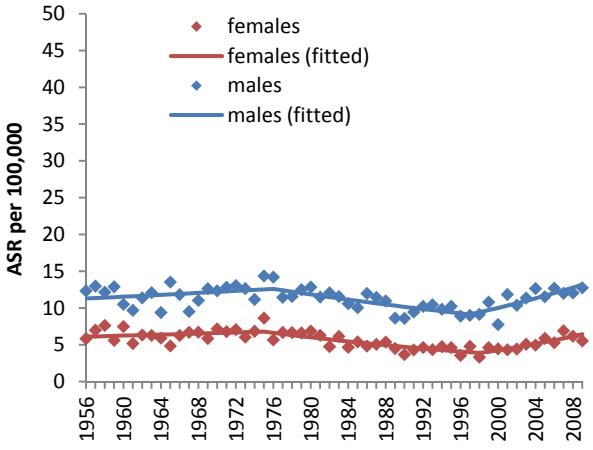
Table 45
Age standardised rate (ASR): mortality
colon cancer C18: 1994-2009

	females		males		all	
year	deaths	ASR	deaths	ASR	deaths	ASR
1994	321	15.9	360	24.1	681	19.5
1995	331	16.4	397	25.5	728	20.5
1996	327	15.4	358	23.2	685	18.9
1997	342	16.7	385	24.7	727	20.2
1998	296	13.8	363	22.7	659	17.8
1999	315	14.2	391	24.3	706	18.8
2000	313	14.6	364	22.2	677	17.8
2001	264	11.7	367	22.1	631	16.2
2002	283	12.5	334	19.3	617	15.6
2003	313	13.2	293	16.7	606	14.9
2004	284	11.6	333	18.7	617	14.7
2005	268	10.9	317	16.9	585	13.4
2006	282	10.9	339	18.0	621	14.1
2007	213	8.4	298	15.3	511	11.4
2008	271	10.3	310	15.7	581	12.7
2009	240	8.5	302	14.8	542	11.3
total	**4,663**		**5,511**		**10,174**	
APC(94-09)	-2.1%	-4.2%	-1.7%	-3.7%	-1.9%	-3.9%
[95%CI]	[-3.0,-1.2]	[-5.1,-3.2]	[-2.4,-1.0]	[-4.4,-3.0]	[-2.4,-1.3]	[-4.5,-3.3]

There were on average 255 female and 313 male deaths per year from colon cancer (C18) between 2005 and 2009. For females, the age standardised rate (ASR) fell from 16/100,000 in 1994 to 9/100,000 in 2009, an annual decrease of 4.2%. For males, the ASR fell from 24/100,000 in 1994 to 15/100,000 in 2009, an annual decrease of 3.7% (Table 45).

Age standardised rates of mortality for colon cancer (C18) for the period 1956-2009 are presented in Figure 20. A significant 1.3% annual percentage increase in the female mortality rate was observed from 1956 to 1974. Thereafter, there was a significant 1.7% annual decrease in mortality from 1975 to 1997, followed by another significant annual decrease of 4.6% from 1998 to 2009. A significant 1.0% annual percentage increase in the male mortality rate was observed from 1956 to 1995. Thereafter, there was a significant 4.1% annual percentage decrease in mortality from 1996 to 2009 (Figure 20).

Figure 21
Age standardised rate (ASR): mortality rectal cancer (C19-20): 1956-2009



Gender	Period	APC	[95%CI]	trend
Females	1956-1975	0.6%	[-0.4, 1.5%]	↔
	1976-1998	-2.4%	[-3.1, -1.6%]	↓
	1999-2009	4.7%	[2.4, 7.0%]	↑
Males	1956-1976	0.6%	[-0.3, 1.4%]	↔
	1977-1997	-1.5%	[-2.3, -0.7%]	↓
	1998-2009	3.1%	[1.3, 4.9%]	↑

Table 46
Age standardised rate (ASR): mortality rectal cancer C19-20: 1994-2009

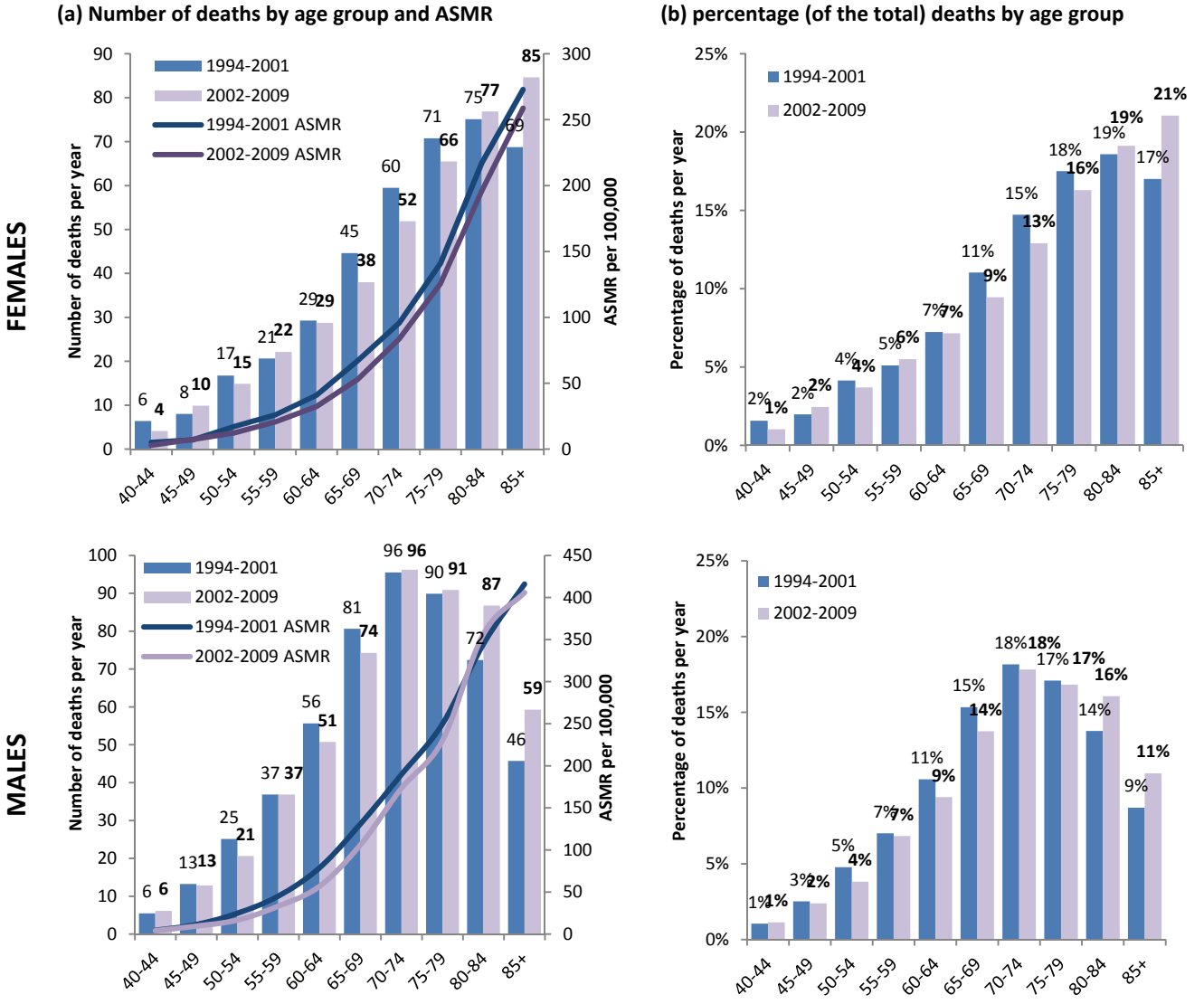
	females		males		all	
year	deaths	ASR	deaths	ASR	deaths	ASR
1994	94	4.8	148	9.9	242	7.0
1995	93	4.6	153	10.3	246	7.1
1996	76	3.6	135	8.9	211	6.0
1997	101	4.8	143	9.0	244	6.7
1998	73	3.3	146	9.1	219	5.9
1999	94	4.6	170	10.8	264	7.3
2000	98	4.5	129	7.8	227	6.0
2001	95	4.3	197	11.9	292	7.6
2002	105	4.4	176	10.4	281	7.2
2003	113	5.1	199	11.4	312	7.8
2004	116	5.0	224	12.7	340	8.3
2005	134	5.9	215	11.5	349	8.4
2006	135	5.3	243	12.7	378	8.7
2007	164	6.9	235	12.0	399	9.1
2008	153	6.2	240	12.1	393	8.8
2009	141	5.5	262	12.8	403	8.9
total	**1,785**		**3,015**		**4,800**	
APC(94-09)	4.4%	2.8%	4.6%	2.4%	4.5%	2.5%
[95%CI]	[3.0,5.9]	[1.2,4.4]	[3.4,5.9]	[1.1,3.6]	[3.5,5.6]	[1.5,3.5]

There were on average 145 female and 239 male deaths per year from cancer of the rectosigmoid junction and rectum (C19-20) between 2005 and 2009. For females, the age standardised rate (ASR) of mortality increased from 4.8/100,000 in 1994 to 5.5/100,000 in 2009, an annual increase of 2.8%. For males, the ASR increased from 9.9/100,000 in 1994 to 12.8/100,000 in 2009, an annual increase of 2.4% (Table 46).

Age standardised rates for colorectal cancer (C19-20) for the period 1956-2009 are presented in Figure 21. There was a 0.6% annual percentage increase in female mortality rate from 1956 to 1975. Thereafter, there was a significant 2.4% annual decrease in mortality from 1976 to 1998, followed by a significant annual increase of 4.7% from 1999 to 2009. For, males, a similar pattern was evident; a 0.6% annual percentage increase in mortality rate from 1956 to 1976. Thereafter, there was a significant 1.5% annual decrease in mortality from 1977 to 1997, followed by a significant annual increase of 3.1% from 1998 to 2009 (Figure 21).

5.2 Age distribution of mortality

Figure 22
Age-specific mortality rate (ASMR) for colorectal cancer (C18-C20): periods: 1994-2001 and 2002-2009

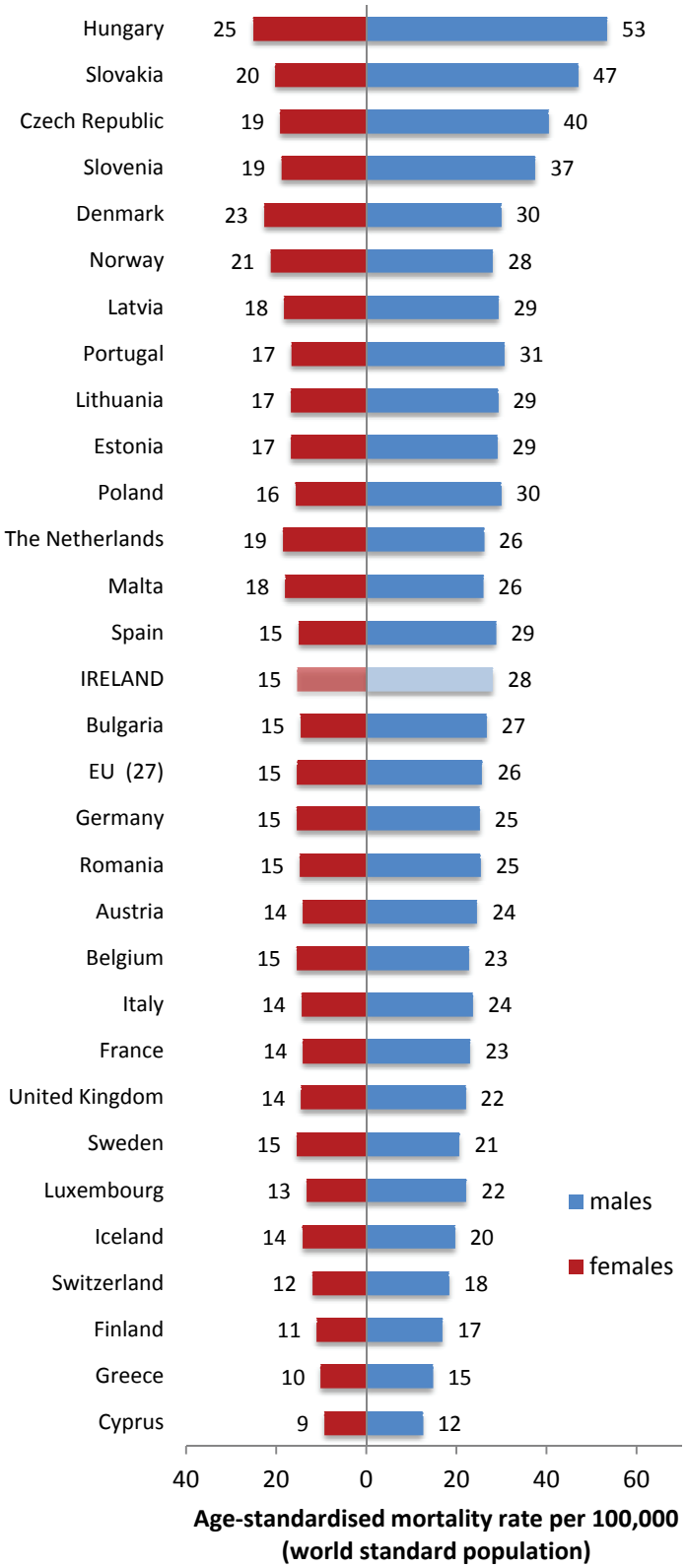


The number of colorectal cancer deaths per year by age group over the periods 1994-2001 and 2002-2009 is presented in Figure 22a.[36] For females, the number of deaths per year (75 per year) was highest in the 80-84 age group during 1994-2001 and in the 85+ age group (85 per year) during 2002-2009. The peak age-specific mortality rate, which occurred in the 85+ age group in both periods, was 273/100,000 women during 1994-2001, and 256/100,000 women during 2002-2009 (Figure 22a).

For males, the number of deaths per year (96 per year) was highest in the 70-74 age group during 1994-2001 and 2002-2009. The peak age-specific mortality rate, which occurred in the 85+ age group in both periods, was 416/100,000 men during 1994-2001, and 406/100,000 men during 2002-2009.

5.3 International comparison of mortality

Figure 23
Comparisons of age standardised mortality rates (ASMR) for colorectal cancer: 2008



European Cancer Observatory (ECO), 2008.[23]

An international comparison of estimated mortality rates for European countries in 2008 is presented for colorectal cancer in Figure 23.[23]

The highest colorectal cancer mortality for both men (53/100,000) and women (25/100,000) was in Hungary

Ireland ranked approximately midway of the 30 countries shown, with an age standardised mortality rate of 28 and 15 per 100,000 men and women respectively.

Ireland's mortality rate was marginally higher that of the UK (22 and 14 per 100,000 men and women respectively) but similar to the European average (26 and 15/100,000 men and women respectively).

The three countries with the lowest recorded mortality rates in 2008 were: Cyprus, Greece and Finland.

APPENDIX I

Colorectal cancer: Data sources and dataset

Since 1st January 1994, all newly diagnosed cancers in Ireland have been registered by the National Cancer Registry. The process is highly effective. Currently the completeness of cancer registration for all invasive cancers diagnosed to end of 2008 is estimated to be over 97%.[37] Prior to 1994, there was no national cancer registration and therefore no reliable information on cancer incidence.

The dataset used in this report consisted of all primary invasive colorectal cancers; C18 (colon), C19 (rectosigmoid junction) and C20 (rectum), registered by the National Cancer Registry (NCR) with a date of diagnosis from 1 January 1994 to 31 December 2010. Dataset inclusions and exclusions are shown in Table 47.

For analysis of incidence and treatment patterns, the dataset was divided into three diagnostic periods: 1995-1999, 2000-2004 and 2005-2009. For survival analysis, the dataset was divided into three separate diagnostic periods: 1994-1998, 1999-2003 and 2004-2008. Survival time was censored at 31 December 2009 to ensure that all cases had follow-up for at least one year. Only the first primary invasive tumour(s) of the colon and rectum (C18-C20) were included in the survival dataset.

Colorectal cancers were excluded from survival analyses if they were preceded by another cancer (other than non-melanoma skin cancer). Following convention, cases where the sole evidence of cancer was diagnosis from a death certificate or at autopsy were excluded from survival analysis.

Table 47
Cases of colorectal cancer (C18-C20) diagnosed between 1994-2010 in females and males

	Females	Males	Total
Incident cases of malignant colorectal cancer, C18-C20, (1994-2010)	**14,381**	**19,191**	**33,572**
Exclusions before survival analysis:			
1. Cases incident during 2009 and 2010	1,930	2,719	4,649
2. Autopsy and DCO cases (1994-2008)	315	200	515
3. Cases with another prior or concurrent invasive malignancy (1994-2008)^	537	954	1,491
Survival data subset ‡	**11,599**	**15,318**	**26,917**

‡ diagnosed during 1994-2008 and all followed up until death or 31/12/09, whichever occurred first
^ except for non melanoma skin cancer (NMSC)

APPENDIX II

Variable definitions and methods of analysis

Demographic variables

Age

This was the age at diagnosis; the difference between date of birth and date of diagnosis. This variable was available for all patients. The EUROCARE convention for age categories in colorectal cancer was used: 15-44 years, 45-54 years, 55-64 years, 65-74 years and 75+ years. [27]

Smoking status

Colorectal cancer cases were classified as 'non smokers' if they had never smoked, 'ex-smokers' if they had ever smoked but had not smoked for a year prior to diagnosis. Current smokers were classified as 'smokers'.

Marital status

Colorectal cancer cases were classified as 'ever married' if they were married, widowed, divorced or separated, or, 'never married'.

Date of incidence

The NCR subscribes to the European Network of Cancer Registries (ENCR) guidance for this data item.[28] Date of incidence was taken to be the date of histological confirmation (or date of clinical diagnosis if there was no histological confirmation).

Date of death

For survival calculations, the last day of follow-up was taken to be 31 December 2009 (censoring date). The date of death was taken to be that recorded on the death certificate if available, otherwise the date of death was that observed in the hospital case notes.

HSE area of residence

All patients in the dataset were allocated to a HSE administrative area according to their main address at the time of diagnosis: Dublin Mid Leinster (DNML), Dublin North East (DNNE), West (W) and South (S).

Deprivation

Quintiles of deprivation were derived from data in the 2002 census at electoral division (ED) level, and applied to individual patients by linkage of address.[35] The score consisted of 1 (least deprived) through to 5 (most deprived).

Tumour characteristics

TNM

TNM category of tumour was described in the medical record. Where a pathological T (primary tumour), N (regional nodes) or M (distant metastasis) category was given, this was used; otherwise the clinical diagnosis was used. Cases diagnosed between 1994 and 1999 were staged using version 4 of the TNM AJCC manual.[29] Version 5 of the manual was used for cases after 2000. Cases where the metastasis was coded as 'MX' (unknown) were re-coded to 'M0' (i.e. assumed that metastasis had not occurred).

Table 48
Stage grouping: colorectal cancer

	T size	N nodes	M 'mets'	Dukes
Stage 0	Tis	N0	M0	-
Stage I	T1	N0	M0	A
	T2	N0	M0	A
Stage II	T3	N0	M0	B
	T4	N0	M0	B
Stage III	Any T	N1	M0	C
	Any T	N2	M0	C
	Any T	N3	M0	C
Stage IV	Any T	Any N	M1	-

Summary stage

Summary stage was derived by algorithm from TNM categories. (Table 48)

Grade

Tumour grade was transcribed from pathology reports and listed as 1 (well differentiated), 2 (moderately differentiated), 3 (poorly differentiated or undifferentiated) and 4 (unknown).

Site of primary tumour

Site of tumour was classified according to ICD10. Two broad sub-categories of colorectal cancer were used throughout the report:

1) Primary tumour in the colon (C18): 'colon'

2) Primary tumour in the rectosigmoid junction (C19) or rectum (C20): 'rectum'

Morphology

Four categories of tumour histology were derived as follows: 'adenocarcinoma', 'mucinous morphology' and 'other specified morphology'. Morphologies other than these three types were pooled as a single category, 'other unspecified'.

Basis of diagnosis

Cases were classified as *microscopically verified* if the tumour had been confirmed by histological or cytological methods. Cases were classified as *clinically verified* if diagnosed by radiology, ultrasound or by autopsy.

Treatment definitions

The focus was on *tumour-directed treatment* administered within one year of the diagnosis date. This was interpreted as the primary course of treatment aimed at removing, reducing, destroying or preventing further growth of tumour. No distinction was made between 'curative' and 'palliative' treatment. For the purposes of this report, five treatment scenarios (a-e) were defined as follows:

a) *Surgery*

A case was considered to have undergone *surgery* if at least one tumour resection was recorded (ICD-9-CM procedure codes 45.4x, 45.7x, 45.8, 48.3, 48.35, 48.36, 48.4, 48.49, 48.5, 48.6x, 48.82).[41]

b) *chemotherapy*

A case was considered to have undergone *chemotherapy* if at least one chemotherapeutic agent was administered. Chemotherapy administered *before* surgery was referred to as neo-adjuvant chemotherapy, and after surgery, as adjuvant chemotherapy.

c) *Radiotherapy*

A case was considered to have undergone *radiotherapy* if least one radiotherapy session was recorded. Pre-operative and post-operative radiotherapy was recorded.

d) *Treated*

A case was considered to have been *treated* if at least one treatment was recorded for that case (i.e. treatment as defined in a-c above).

e) Not treated

A case was considered as *not treated* if there was no treatment recorded for that case as defined in a-d above. However, many cases had other types of medical and surgical interventions not covered in a-c above.

Statistical methods

Age standardised rates (ASR) for incidence and mortality were weighted by the European standard population. Annual percentage change (APC) of incidence and mortality over time was calculated using the Joinpoint regression program.[30] Joinpoint regression was also used to test for *linear trend* over time for selected variables in sections 2 (incidence) and 3 (treatment).

Standardised rate ratios (SRR) were calculated for the period 2004-2008. The age standardised (ASR) incidence rate is the proportion of cases in a given population (and year) weighted by the European age structure. Rather than consider the most recent year (2008), the numbers of cases occurring during 2004-2008 in Ireland were summed and divided by the sum of persons at risk in Ireland (summed for 2004-2008) using intercensal population estimates. The ASR for 2004-2008 was calculated for each county in a similar fashion. The ratio of county ASR over country ASR gives the standardised rate ratio (SRR). The 95% CI of the SRR ratio was also calculated.[31] A county was considered to have a significantly higher (or lower) incidence of cases than the national average if the 95% confidence interval of the SRR did not include unity.

Variables affecting treatment receipt were identified using logistic regression. An explanatory variable was included in a final model if the likelihood ratio test for exclusion of that variable from the multivariate model had a p-value less than 0.10. As treatment was common, the odds ratio overestimated the risk of treatment when it was more than 1 or underestimated the risk when it was less than 1. To overcome this problem, odds ratios were converted to risk ratios (RR) according to the formula $RR=[OR]/[(1-P_0)+(ORxP_0)]$ where OR is the odds ratio for a group of patients who received treatment relative to the baseline group, and the proportion of patients treated in the baseline group is give by P_0.[32] Looking at tables of adjusted RR's leads to the same conclusions as adjusted OR's; except that the RR can be conveniently interpreted as the proportion who received treatment relative to the baseline level of a variable.

Survival data is presented as *relative survival* (RS); the ratio of observed survival among a group of cases to the expected survival among the general population of the same age, sex and country. Relative survival was calculated using the '*strs*' command in STATA 11.0.[33] RS was derived for each level of the variables: i.e., diagnostic period, stage etc. As the life tables (for RoI) used to calculate relative survival did not take account of deprivation quintiles, *cause specific survival* for each quintile of the deprivation score was calculated using the Kaplan-Meier method. The effect of diagnostic period on cause specific survival was determined using Cox proportional hazards regression models, stratified by age, sex, stage and site of primary tumour. An explanatory variable was included in the final Cox model if the likelihood ratio test for exclusion of that variable from the multivariate model had a p-value less than 0.10.

APPENDIX III

Treatment administration

Table 49 Temporal sequence of treatment administration, by site of tumour, stage and period of diagnosis

Site of primary tumour: colon (C18)

Treatments in temporal sequence of administration	1995-1999		2000-2004		2005-2009	
	n	%	n	%	n	%
Stage I						
a_surgery	635	89.2	625	90.1	728	90.9
b_surgery_chemotherapy	45	6.3	39	5.6	26	3.2
c_surgery_chemotherapy_radiation	9	1.3	2	0.3	0	-
e_chemotherapy_radiation_surgery	0	-	0	-	1	0.1
f_chemotherapy_surgery	0	-	1	0.1	1	0.1
g_surgery_radiation	4	0.6	1	0.1	3	0.4
h_radiation_surgery	1	0.1	0	-	1	0.1
j_chemotherapy	0	-	3	0.4	1	0.1
k_radiation	0	-	0	-	1	0.1
l_chemotherapy_radiation	0	-	2	0.3	1	0.1
m_no_treatment	18	2.5	21	3.0	38	4.7
Total	**712**	**100**	**694**	**100**	**801**	**100**
Stage II						
a_surgery	1,203	66.5	1,196	65.9	1,471	69
b_surgery_chemotherapy	391	21.6	435	24	477	22.4
c_surgery_chemotherapy_radiation	49	2.7	39	2.1	36	1.7
e_chemotherapy_radiation_surgery	0	-	2	0.1	7	0.3
f_chemotherapy_surgery	4	0.2	4	0.2	4	0.2
g_surgery_radiation	25	1.4	13	0.7	14	0.7
h_radiation_surgery	0	-	4	0.2	2	0.1
i_radiation_surgery_chemotherapy	1	0.1	0	-	0	-
j_chemotherapy	14	0.8	12	0.7	17	0.8
k_radiation	6	0.3	4	0.2	2	0.1
l_chemotherapy_radiation	2	0.1	3	0.2	3	0.1
m_no_treatment	115	6.4	102	5.6	99	4.6
Total	**1,810**	**100**	**1,814**	**100**	**2,132**	**100**
Stage III						
a_surgery	594	49.5	541	37.1	636	33.3
b_surgery_chemotherapy	479	39.9	780	53.4	1,099	57.5
c_surgery_chemotherapy_radiation	55	4.6	53	3.6	55	2.9
d_chemotherapy_surgery_radiation	0	-	0	-	1	0.1
e_chemotherapy_radiation_surgery	1	0.1	1	0.1	12	0.6
f_chemotherapy_surgery	4	0.3	2	0.1	10	0.5
g_surgery_radiation	28	2.3	19	1.3	6	0.3
h_radiation_surgery	0	-	0	-	2	0.1
i_radiation_surgery_chemotherapy	0	-	0	-	1	0.1
j_chemotherapy	10	0.8	18	1.2	19	1.0
k_radiation	1	0.1	1	0.1	3	0.2
l_chemotherapy_radiation	3	0.3	1	0.1	0	-
m_no_treatment	24	2.0	44	3.0	66	3.5
Total	**1,199**	**100**	**1,460**	**100**	**1,910**	**100**
Stage IV						
a_surgery	352	29.3	302	20.9	280	16.7
b_surgery_chemotherapy	250	20.8	364	25.2	523	31.2
c_surgery_chemotherapy_radiation	17	1.4	28	1.9	21	1.3
d_chemotherapy_surgery_radiation	1	0.1	1	0.1	3	0.2
e_chemotherapy_radiation_surgery	0	-	2	0.1	2	0.1
f_chemotherapy_surgery	7	0.6	20	1.4	27	1.6
g_surgery_radiation	9	0.7	6	0.4	5	0.3
h_radiation_surgery	1	0.1	0	-	1	0.1
i_radiation_surgery_chemotherapy	0	-	0	-	1	0.1
j_chemotherapy	96	8	210	14.5	322	19.2
k_radiation	7	0.6	20	1.4	20	1.2
l_chemotherapy_radiation	5	0.4	16	1.1	25	1.5
m_no_treatment	457	38	476	32.9	448	26.7
Total	**1,202**	**100**	**1,445**	**100**	**1,678**	**100**
Unstaged						
a_surgery	124	17.6	131	19.7	190	27.9
b_surgery_chemotherapy	7	1.0	17	2.6	21	3.1
c_surgery_chemotherapy_radiation	1	0.1	0	-	2	0.3
e_chemotherapy_radiation_surgery	1	0.1	1	0.2	5	0.7
f_chemotherapy_surgery	0	-	1	0.2	8	1.2
g_surgery_radiation	3	0.4	0	-	1	0.1
h_radiation_surgery	0	-	1	0.2	2	0.3
i_radiation_surgery_chemotherapy	0	-	0	-	2	0.3
j_chemotherapy	5	0.7	11	1.7	24	3.5
k_radiation	4	0.6	7	1.1	3	0.4
l_chemotherapy_radiation	0	-	3	0.5	1	0.1
m_no_treatment	559	79.4	493	74.1	421	61.9
Total	**704**	**100**	**665**	**100**	**680**	**100**

Site of primary tumour: rectum (C19-20)

Treatments in temporal sequence of administration	1995-1999		2000-2004		2005-2009	
	n	%	n	%	n	%
Stage I						
a_surgery	544	83.6	491	74.1	432	73.1
b_surgery_chemotherapy	20	3.1	17	2.6	9	1.5
c_surgery_chemotherapy_radiation	18	2.8	34	5.1	14	2.4
e_chemotherapy_radiation_surgery	4	0.6	35	5.3	66	11.2
f_chemotherapy_surgery	0	-	2	0.3	0	-
g_surgery_radiation	15	2.3	14	2.1	11	1.9
h_radiation_surgery	4	0.6	18	2.7	20	3.4
i_radiation_surgery_chemotherapy	1	0.2	3	0.5	0	-
j_chemotherapy	0	-	2	0.3	2	0.3
k_radiation	6	0.9	10	1.5	5	0.8
l_chemotherapy_radiation	5	0.8	11	1.7	3	0.5
m_no_treatment	34	5.2	26	3.9	29	4.9
Total	**651**	**100**	**663**	**100**	**591**	**100**
Stage II						
a_surgery	434	52.5	309	37.2	310	37.7
b_surgery_chemotherapy	73	8.8	86	10.4	81	9.9
c_surgery_chemotherapy_radiation	117	14.2	119	14.3	57	6.9
d_chemotherapy_surgery_radiation	0	-	1	0.1	0	-
e_chemotherapy_radiation_surgery	22	2.7	103	12.4	191	23.2
f_chemotherapy_surgery	3	0.4	6	0.7	3	0.4
g_surgery_radiation	46	5.6	37	4.5	18	2.2
h_radiation_surgery	18	2.2	25	3.0	41	5.0
i_radiation_surgery_chemotherapy	5	0.6	13	1.6	16	1.9
j_chemotherapy	4	0.5	5	0.6	3	0.4
k_radiation	19	2.3	30	3.6	31	3.8
l_chemotherapy_radiation	18	2.2	34	4.1	25	3.0
m_no_treatment	67	8.1	62	7.5	46	5.6
Total	**826**	**100**	**830**	**100**	**822**	**100**
Stage III						
a_surgery	250	37.9	191	20.2	195	16.8
b_surgery_chemotherapy	144	21.9	188	19.9	255	21.9
c_surgery_chemotherapy_radiation	173	26.3	248	26.2	138	11.9
d_chemotherapy_surgery_radiation	2	0.3	2	0.2	0	-
e_chemotherapy_radiation_surgery	7	1.1	136	14.4	334	28.7
f_chemotherapy_surgery	2	0.3	11	1.2	14	1.2
g_surgery_radiation	46	7.0	36	3.8	21	1.8
h_radiation_surgery	9	1.4	22	2.3	45	3.9
i_radiation_surgery_chemotherapy	2	0.3	28	3.0	38	3.3
j_chemotherapy	2	0.3	7	0.7	12	1
k_radiation	5	0.8	24	2.5	23	2
l_chemotherapy_radiation	6	0.9	26	2.8	49	4.2
m_no_treatment	11	1.7	26	2.8	40	3.4
Total	**659**	**100**	**945**	**100**	**1,164**	**100**
Stage IV						
a_surgery	158	24.6	78	10.9	67	8.7
b_surgery_chemotherapy	92	14.3	137	19.2	155	20.1
c_surgery_chemotherapy_radiation	40	6.2	35	4.9	18	2.3
d_chemotherapy_surgery_radiation	0	-	3	0.4	2	0.3
e_chemotherapy_radiation_surgery	5	0.8	25	3.5	42	5.4
f_chemotherapy_surgery	3	0.5	3	0.4	17	2.2
g_surgery_radiation	20	3.1	12	1.7	10	1.3
h_radiation_surgery	4	0.6	8	1.1	5	0.6
i_radiation_surgery_chemotherapy	2	0.3	5	0.7	13	1.7
j_chemotherapy	38	5.9	98	13.7	154	19.9
k_radiation	34	5.3	41	5.8	50	6.5
l_chemotherapy_radiation	41	6.4	75	10.5	70	9.1
m_no_treatment	206	32.0	193	27.1	170	22.0
Total	**643**	**100**	**713**	**100**	**773**	**100**
Unstaged						
a_surgery	86	20.3	78	18.4	84	17.2
b_surgery_chemotherapy	0	-	5	1.2	7	1.4
c_surgery_chemotherapy_radiation	4	0.9	4	0.9	8	1.6
d_chemotherapy_surgery_radiation	0	-	1	0.2	0	-
e_chemotherapy_radiation_surgery	14	3.3	37	8.7	78	16
f_chemotherapy_surgery	0	-	3	0.7	17	3.5
g_surgery_radiation	8	1.9	2	0.5	10	2.1
h_radiation_surgery	9	2.1	9	2.1	19	3.9
i_radiation_surgery_chemotherapy	7	1.7	5	1.2	7	1.4
j_chemotherapy	5	1.2	15	3.5	20	4.1
k_radiation	24	5.7	30	7.1	20	4.1
l_chemotherapy_radiation	14	3.3	14	3.3	23	4.7
m_no_treatment	253	59.7	222	52.2	194	39.8
Total	**424**	**100**	**425**	**100**	**487**	**100**

CONTRIBUTORS

The information in this report is based on the data held by the National Cancer Registry, and has been collected, processed and analysed since 1994 by dedicated and skilled Registry staff. The Registry, in turn, is dependent on the help and support of hospital staff throughout the country. The CSO and General Register Office provided the death certificate data. Most of the data analysis was carried out by the writing group; Paul M Walsh extracted the colorectal cancer survival dataset. Neil McCluskey provided map graphics in section 3. The writing group for this report was: Joe McDevitt, Maria Kelly, Linda Sharp and Harry Comber.

REFERENCES

1. Johns, L.E. & Houlston, R.S. 2001, A systematic review and meta-analysis of familial colorectal cancer risk, Am J Gastroenterol, vol. 96, no. 10, pp. 2992-3003.
2. Secretan, B., Straif, K., Baan, R., Grosse, Y., El Ghissassi, F., Bouvard, V., Benbrahim-Tallaa, L., Guha, N., Freeman, C., Galichet, L., Cogliano, V. & WHO International Agency for Research on Cancer Monograph Working Group 2009, A review of human carcinogens-Part E: tobacco, areca nut, alcohol, coal smoke, and salted fish, Lancet Oncol, vol. 10, no. 11, pp. 1033-1034.
3. International Agency for Research on Cancer 2002, IARC handbooks of cancer prevention. Volume 6. Weight control and physical activity., IARC Press, Lyon, France.
4. World Cancer Research Fund / American Institute for Cancer Research 2007, Food, nutrition, physical activity, and the prevention of cancer: a global perspective, AICR, Washington DC.
5. Straif, K., Benbrahim-Tallaa, L., Baan, R., Grosse, Y., Secretan, B., El Ghissassi, F., Bouvard, V., Guha, N., Freeman, C., Galichet, L., Cogliano, V. & WHO International Agency for Research on Cancer Monograph Working Group 2009, A review of human carcinogens--part C: metals, arsenic, dusts, and fibres, Lancet Oncol, vol. 10, no. 5, pp. 453-454.
6. El Ghissassi, F., Baan, R., Straif, K., Grosse, Y., Secretan, B., Bouvard, V., Benbrahim-Tallaa, L., Guha, N., Freeman, C., Galichet, L., Cogliano, V. & WHO International Agency for Research on Cancer Monograph Working Group 2009, A review of human carcinogens--part D: radiation, Lancet Oncol, vol. 10, no. 8, pp. 751-752.
7. Rahman, M.B., Driscoll, T., Cowie, C. & Armstrong, B.K. 2010, Disinfection by-products in drinking water and colorectal cancer: a meta-analysis, Int J Epidemiol, vol. 39, no. 3, pp. 733-745.
8. Zhao, Y.S., Wang, F., Chang, D., Han, B. & You, D.Y. 2008, Meta-analysis of different test indicators: Helicobacter pylori infection and the risk of colorectal cancer, Int J Colorectal Dis, vol. 23, no. 9, pp. 875-882.
9. Rinaldi, S., Cleveland, et al, 2010, Serum levels of IGF-I, IGFBP-3 and colorectal cancer risk: results from the EPIC cohort, plus a meta-analysis of prospective studies, Int J Cancer, vol. 126, no. 7, pp. 1702- 1715.
10. Larsson, S.C., Orsini, N. & Wolk, A. 2005, Diabetes mellitus and risk of colorectal cancer: a meta-analysis, J Natl Cancer Inst, vol. 97, no. 22, pp. 1679-1687.
11. Harriss, D.J., Atkinson, G., Batterham, A., George, K., Cable, N.T., Reilly, T., Haboubi, N., Renehan, A.G. & Colorectal Cancer, Lifestyle, Exercise And Research Group 2009, Lifestyle factors and colorectal cancer risk (2): a systematic review and meta-analysis of associations with leisure-time physical activity, Colorectal Dis, vol. 11, no. 7, pp. 689-701.
12. International Agency for Research on Cancer 2011a, IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, A review of human carcinogens. Part A: pharmaceuticals, IARC monographs on the evaluation of carcinogenic risks to humans, Lyon, France.
13. Bosetti, C., Bravi, F., Negri, E. & La Vecchia, C. 2009, Oral contraceptives and colorectal cancer risk: a systematic review and meta-analysis, Hum Reprod Update, vol. 15, no. 5, pp. 489-498.
14. International Agency for Research on Cancer 1997, IARC handbooks of cancer prevention. Non-steroidal anti-inflammatory drugs., IARC, Lyon, France.
15. International Agency for Research on Cancer 2003, IARC handbooks of cancer prevention. Volume 8. Fruit and vegetables., IARC Press, Lyon France.
16. Kennedy, D.A., Stern, S.J., Moretti, M., Matok, I., Sarkar, M., Nickel, C. & Koren, G. 2011, Folate intake and the risk of colorectal cancer: a systematic review and meta-analysis, Cancer Epidemiol, vol. 35, no. 1, pp. 2-10.
17. Galeone, C., Turati, F., La Vecchia, C. & Tavani, A. 2010, Coffee consumption and risk of colorectal cancer: a meta-analysis of case-control studies, Cancer Causes Control, vol. 21, no. 11, pp. 1949-1959.
18. Larsson, S.C., Orsini, N. & Wolk, A. 2010, Vitamin B6 and risk of colorectal cancer: a meta-analysis of prospective studies, JAMA, vol. 303, no. 11, pp. 1077-1083.
19. Yan, L., Spitznagel, E.L. & Bosland, M.C. 2010, Soy consumption and colorectal cancer risk in humans: a meta-analysis, Cancer Epidemiol Biomarkers Prev, vol. 19, no. 1, pp. 148-158.
20. Huncharek, M., Muscat, J. & Kupelnick, B. 2009, Colorectal cancer risk and dietary intake of calcium, vitamin D, and dairy products: a meta-analysis of 26,335 cases from 60 observational studies, Nutr Cancer, vol. 61, no. 1, pp. 47-69.

21. Yin, L., Grandi, N., Raum, E., Haug, U., Arndt, V. & Brenner, H. 2009, Meta-analysis: longitudinal studies of serum vitamin D and colorectal cancer risk, Aliment Pharmacol Ther, vol. 30, no. 2, pp. 113-125.
22. National Cancer Registry/ Northern Ireland Cancer Registry. All Ireland Cancer Atlas 1995-2007, Cork/Belfast.
23. European Cancer Observatory (ECO) http://eu-cancer.iarc.fr/ [accessed May 2012]
24. Verdecchia A, Francisci S, Brenner H, Gatta G, Micheli A, Mangone L, Kunkler I; EUROCARE-4 Working Group (2007). Recent cancer survival in Europe: a 2000-02 period analysis of EUROCARE-4 data. Lancet Oncol 8(9):784-96.
25. Cancer in Ireland 2011: Annual Report of the National Cancer Registry, Cork, Ireland (2011)
26. National Cancer Registry, Colorectal cancer Mortality Data from 1956 to 2008 (unpublished: data available on request from: NCR, Building 6800, Cork Airport Business Park, Cork, Ireland).
27. Corazziari I, Quinn M, Capocaccia R. (2004). Standard cancer patient populations for age standardising survival ratios. Eur J Cancer 40:2307-2316.
28. European Network of Cancer Registries (ENCR). Recommendations for coding Incidence date. http://www.encr.com.fr/incideng.pdf [Accessed March 2011].
29. Hermanek DE, Sobin LH (1997). International Union Against Cancer (UICC), TNM classification of malignant tumours. 4th Edition, Springer, 1992.
30. Kim HJ, Fay MP, Feuer EJ, Midthune DN. (2010). Permutation tests for Joinpoint regression with applications to cancer rates. Stat Med 19:335-351. Software available at URL: http://surveillance.cancer.gov/joinpoint/ [Accessed Jan 2011].
31. Cancer registration principles and methods. Eds. Jensen OM, Parkin DM, MacLennan R, Muir CS, Skeet RG (1991). IARC Scientific Publications No. 95. Lyon, pp 138-139.
32. Zhang J, Yu, K. (1998) What is the relative risk? A method for correcting odds ratios in cohort studies of common outcomes. JAMA;280:1690-1691
33. Dickman PW, Sloggett M, Hills M, Hakulinen T (2004). Regression models for relative survival. Stat Med 23(1):51-64.
34. National Cancer Registry. Cancer in Ireland, 1994 to 1998: Incidence, mortality, treatment and survival. NCRI, Cork, 2001. Available at URL: http://www.ncri.ie/pubs/report-1998.shtml [Accessed Jan 2011].
35. Kelly A, Teljeur C. The National deprivation index for health services research. SAHRU Technical Report December 2007. Trinity College Dublin.
36. Central Statistics Office, Ireland.[http://www.cso.ie/releasespublications/documents/vitalstats/] Accessed September 2011
37. Data quality and completeness at the Irish National Cancer registry, National Cancer Registry, 2012 [www.ncri.ie]
38. Tilson L, Sharp L, Usher C, Walsh C, Whyte S, O'Ceilleachair A, Stuart C, et al. (2011) Cost of care for colorectal cancer in Ireland: A healthcare payer perspective. The Eur J Health Econ [DOI: 10.1007/s10198-011-0325-z]
39. Kelly M, Sharp L, Dwane F, Kelleher T, Comber H. Factors predicting hospital length-of-stay and readmission after colorectal resection: a population based study of elective and emergency admissions.(2012) BMC Health Services Research 12:77
40. Hospital in-patient episode information system: [http://www.esri.ie/health_information/hipe]
41. Karaffa MC, Practice Management Information Corporation (1991): ICD-9-CM: The international classification of diseases, 9th revision, clinical modification. Practice Management Information Corp, Los Angeles, Ca. USA.
42. National Cancer Registry (2008). Cancer projections 2005-2035. National Cancer Registry, Cork.
43. Hawkins, N.J. & Ward, R.L. 2001, Sporadic colorectal cancers with microsatellite instability and their possible origin in hyperplastic polyps and serrated adenomas, J Natl Cancer Inst, vol. 93, no. 17, pp. 1307-1313.
44. Ning, Y., Wang, L. & Giovannucci, E.L. (2010) A quantitative analysis of body mass index and colorectal cancer: findings from 56 observational studies, Obesity reviews : an official journal of the International Association for the Study of Obesity, vol. 11, no. 1, pp. 19-30.
45. Guidelines for the Management of Colorectal Cancer, 3rd edition (2007). Issued by: The Association of Coloproctology of Great Britain and Ireland [www.acpgbi.org.uk/assets/documents/COLO_guides.pdf, Accessed 13/08/2012]
46. Sauer R, Becker H, Hohenberger W, et al. (2004) Preoperative versus postoperative chemo-radiotherapy for rectal cancer. N Engl J Med 351 (17): 1731-40.