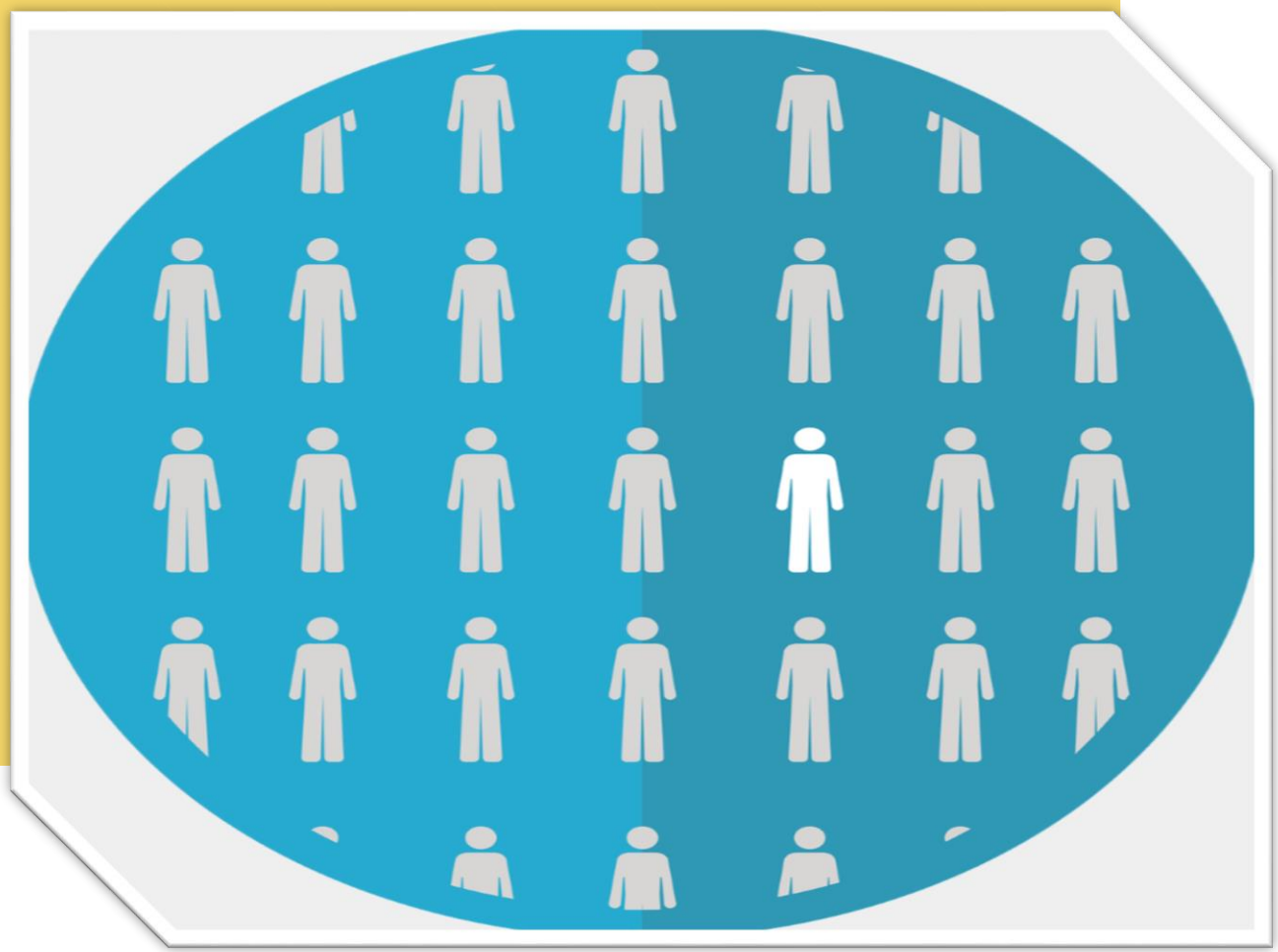

MEASURING CANCER CURE IN IRELAND

2019

ICBP
International Cancer
Benchmarking Partnership

National
Cancer
Registry
Ireland

ABBREVIATIONS	
95% CI	95% confidence interval
APC	Annual percentage change
ASR	Age-standardised rate (European standard population)
IARC	International Agency for Research on Cancer
ICBP	International Cancer Benchmarking Partnership
ICD	International Statistical Classification of Diseases and Related Health Problems
LOLE	Loss of life expectation
NCCP	National Cancer Control Programme
NCRI	National Cancer Registry, Ireland
NMSC	Non-melanoma skin cancer
NOS	Not otherwise specified
RS	Relative survival
WHO	World Health Organisation

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Introduction and Summary

Background

A common question that cancer patients have at diagnosis is: *"What are my chances of being cured?"* While it may not be possible to determine with certainty if and when any individual is cured of cancer, at the population level '*statistical cure*' is a useful concept in cancer epidemiology. Statistical cure is when a group of cancer patients has the same mortality as cancer-free individuals and is a useful way of monitoring progress in cancer care (*Summary Figure 1*). The estimated proportion of people with cancer that have been cured by their treatment (*cure proportion*) in Ireland is reported here for the first time.

Summary Figure 1

Relative survival and population cure

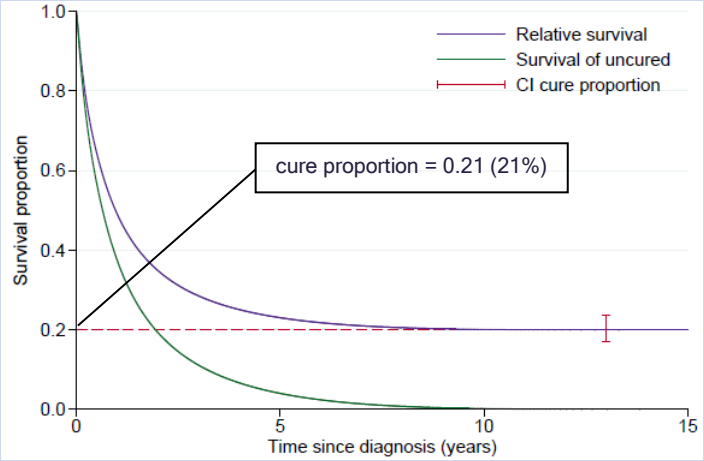


Illustration of relationship between relative survival and cure. In this cancer type (stomach: females), the proportion cured is 0.21 (or 21%) and the 'time to cure' is modeled at ≥10 years.

Another way to look at this question following a cancer diagnosis is: "How has my life expectancy changed?" *Loss of life expectation* expressed as 'years lost' is easy to understand and can be calculated for different types of cancers for different age groups. *Relative survival* (expressed as a percentage) is a third way of comparing the survival of people who have cancer with those who don't, over a certain period of time. The relative survival percentage shows whether the disease shortens life.

Each of these ways of presenting survival statistics has value, although none in itself conveys the full story. Relative survival to five years after diagnosis can be readily calculated and provides a useful summary measure, including for cancer types for which cure estimation is difficult (because of different patterns of disease progression). However, five-year survival will generally overestimate cure to some extent, and the cure probability is of interest to patients and clinicians. The implications of the cure proportion (combined with average survival time of patients who are not cured) in terms of years of potential life lost (or saved) are also useful to quantify.

In this report we present initial results for Ireland on cure proportions, loss of life expectation and relative survival from a collaborative international project, the International Cancer Benchmarking Partnership (ICBP) SurvMark-2 study. This study uses data and funding support from cancer registries in seven high-income countries (Australia, Canada, Denmark, Ireland, New Zealand, Norway, and the UK).

The ICBP SurvMark-2 study aims to establish the most up-to-date international cancer survival standards for a group of cancers of poor to moderate average survival: cancers of the *oesophagus*, *stomach*, *colon*, *rectum*, *liver*, *pancreas*, *lung*, and *ovary*. Colorectal and lung cancers are the 3rd and 4th most common incident cancers in Ireland (excluding non-melanoma skin cancers) (1). Although the other cancers studied are rarer in incidence terms, all eight cancer sites rank highly in terms of numbers of cancer-related deaths in Ireland annually – 1st (lung), 2nd (colon and rectum), 5th (pancreas), 6th (oesophagus), 7th (stomach), 8th (liver) and 11th (ovary – 4th in women). In total, they accounted for 52% of all cancer deaths on Ireland during 2013-2015 (1). The two most common major cancers, breast and prostate cancer, which are the 3rd and 4th most common cause of cancer death, are not included in theSurvMark-2 study, but these are difficult cancers in which to quantify cure because the risk of cancer death (though low on average) may remain elevated for many years after diagnosis.

Main findings

Using data from 2011-2013, the probability of cure among Irish patients was lowest for cancers of the pancreas (5% in both males and females), lung (8% male, 12% female), oesophagus (13% in both males and females), liver (18% male, 8% female), stomach (19% male, 21% female) and ovary (21%). The probability of cure was substantially higher for cancers of the rectum (38% male, 45% female) and colon (43% male, 47% female).

Specific figures are not yet available on how these cure statistics have changed over time within Ireland, but other figures in this report confirm that five-year relative survival for all of these cancers has improved substantially in recent decades – in line with previous NCRI findings.

Rankings, by cancer type, of average cure proportions are quite similar to the average five-year relative survival for the various cancers examined. The five-year relative survival figures for Ireland for the same time period were: pancreas (7% in both males and females); lung (10% male, 16% female); oesophagus (16% male, 19% female); liver (21% male, 10% female); stomach (23% male, 25% female); ovary (31%); rectum (54% male, 59% female); and colon (53% male, 55% female).

Typically, the likelihood of cure is highest for the younger patients, when stage and treatment options may be more favourable, but average loss of years of life is greatest for younger patients, for a given cancer type.

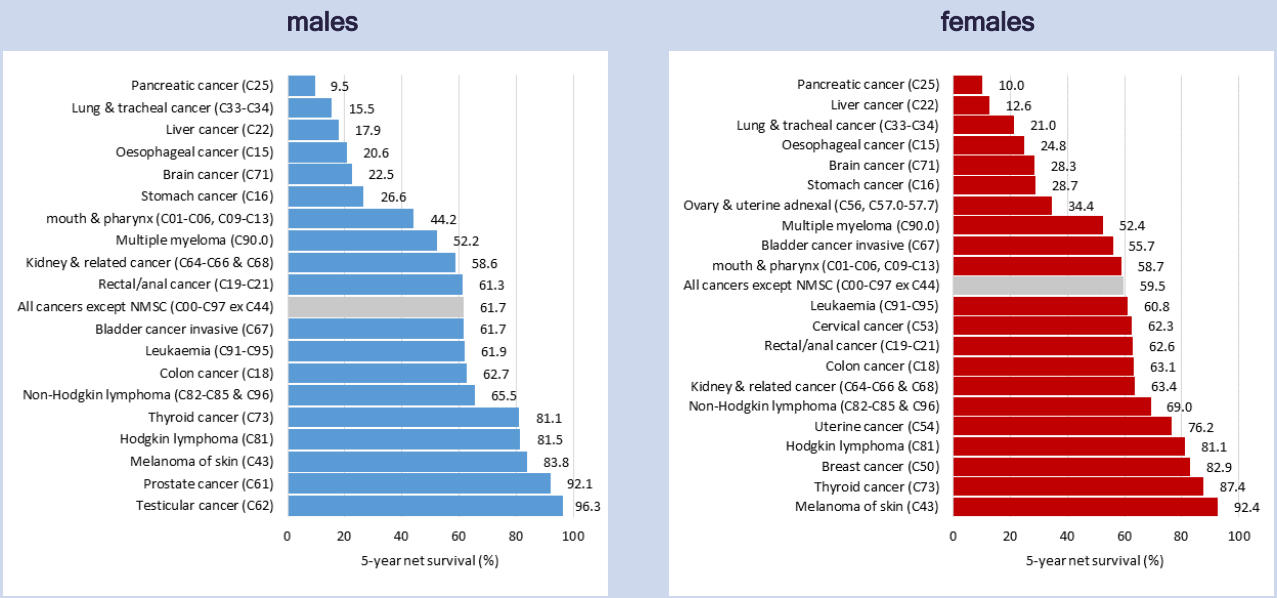
Fuller results of ICBP study, including international comparisons, were not available at the time of this report's preparation, but publication of this information is expected later this year, comparing survival statistics across the seven countries involved in this project. Methods used in this project are likely to be adopted by NCRI as part of its ongoing role in surveillance of progress in cancer prevention and treatment.

Five-year relative survival

This section presents a summary of survival estimates for Irish cancer patients, using figures available on *net (relative) survival* from the NCRI website and also published in the annual report of 2018 (1). In the following sections, a summary of Irish results from the International Cancer Benchmarking Partnership's (ICBP) SurvMark-2 project is also included, for a smaller number of cancers, covering relative survival and two further measures - *loss of life expectation* (LOLE), and *cure* estimates.

Figure 1 summarises the most recent NCRI estimates of relative survival of Irish patients. Relative survival is the expected survival in the hypothetical situation in which cancer is the only cause of death, thus it will be close to actual survival in younger patients but higher than actual survival in older patients. The measure of relative survival presented here (and in subsequent sections of this report) takes better account of variation of non-cancer-related mortality risk at different ages, and is sometimes referred to as *net survival* (2).

Figure 1
Ranked 5-year average relative survival of Irish cancer patients (age 15-99): 2010-2014*

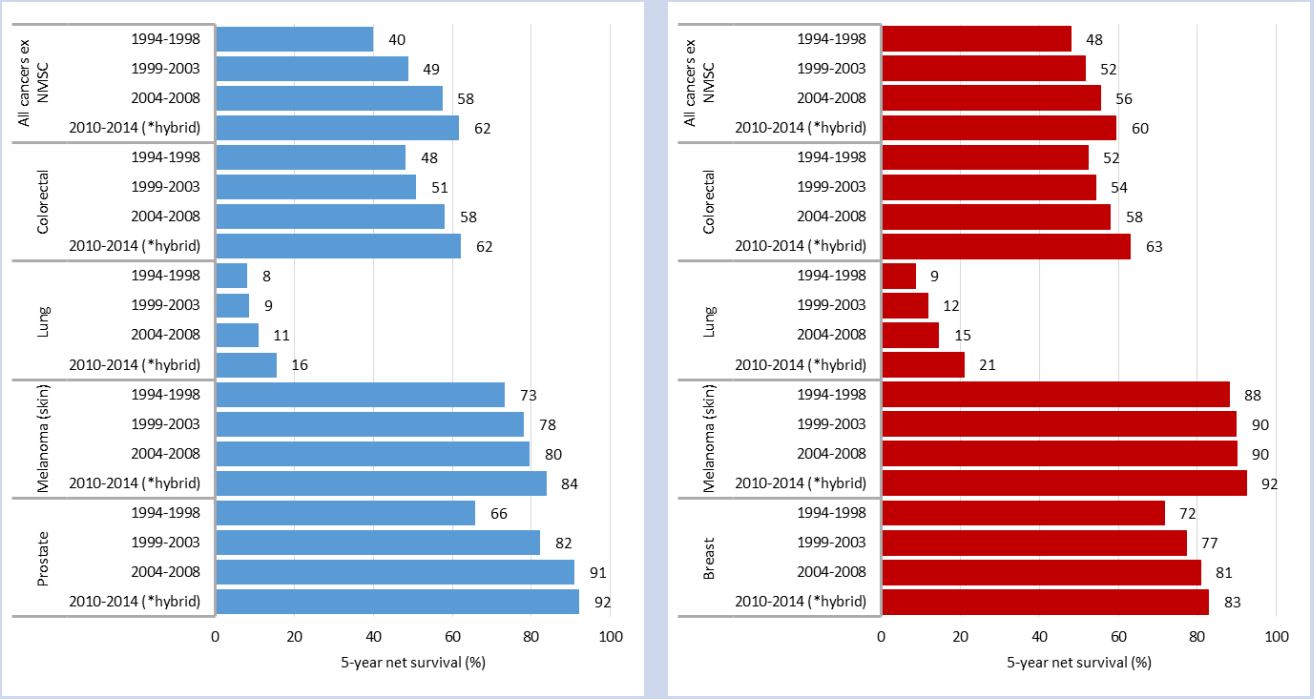


Interpretation, e.g. *83% of women diagnosed with invasive breast cancer during 2010-2014 had avoided cancer death by the five-year mark after diagnosis.*
All estimates were age-standardised i.e. survival for all ages 15-99 (15-64 for testicular cancer) was standardised to recommended population age weights (3); the age groups used differ for prostate cancer, and greater weighting is given to younger patients for some cancers (melanoma, cervix, testis, brain and thyroid), reflecting difference in typical age at diagnosis for these cancers.
*2010-2014: relative survival hybrid estimate: i.e. all patients alive at some point 2010-2013 or diagnosed in 2009 were followed up to 31/12/2014; Source: https://www.ncri.ie/data/survival-statistics

- In males, age-standardised five-year relative survival averaged 96% for testicular cancer, 92% for prostate cancer and 84% for melanoma of the skin during the 2010-2014 follow-up period.
- In females, five-year relative survival averaged 92% for melanoma skin cancer, 87% for thyroid cancer and 83% for breast cancer.

- At the other end of the spectrum, five-year relative survival for remains very poor for cancers of the pancreas (M: F; 10% in both), liver (18%, 13%), lung (16%, 21%), oesophagus (21%, 25%), stomach (27%, 29%) and ovary (34%) - these cancers are explored further under ICBP SurvMark-2 results later.
- Cancers of the colon (five-year relative survival 63% in both sexes) and rectum (61%, 63%) fell within the mid-range for survival, and are also included under ICBP SurvMark-2 results.
- For all invasive cancers combined - excluding the generally less serious non-melanoma skin cancers (NMSC) - five-year relative survival averaged 62% in males and 60% in females.

Figure 2
Trends in five-year net survival for the 4 most common cancers in males and females: 1994-1998, 1999-2003, 2004-2008, and cross-sectional period 2010-2014



All estimates are age-standardised i.e. survival for all ages 15-99 is standardised to the standard populations recommended by Corazziari et al, (3).
*Hybrid: by year of follow-up (all patients alive at some point 2010-2013, or diagnosed in 2009, followed up to 31/12/2014)

- Five-year relative survival has improved markedly for cancers as a whole and for the most common cancer types since the mid-1990s (Figure 2).
- For invasive cancers (excluding NMSC), overall five-year relative survival increased from 40% for males during 1994-1998 to 62% during 2010-2014; in females, five-year relative survival increased from 48% for those diagnosed during 1994-1998 to 60% during 2010-2014.
- Over the same 20-year period, five-year survival for colorectal cancer increased from 48% to 62% in males and from 52% to 63% in females; for lung cancer, from 8% to 16% in males, and from 9% to 21% in females; for female breast cancer, from 72% to 83%; for prostate cancer from 66% to 92%; and for melanoma of the skin, from 73% to 84% in males and from 88% to 92% in females.

Relative survival and loss of life expectation (LOLE)

As the Irish population ages, the number of people diagnosed with cancer continues to increase along with increases in average survival time. While the majority of patients with cancer want information on their survival prospects and life expectancy, conveying this information presents a challenge. By convention, cancer registries present relative survival figures (at 1 and 5 years after diagnosis*). Relative survival* (RS) compares survival of cancer patients with survival in a comparable set of *cancer-free* individuals, where the mortality rate of the national population is used a proxy for that of the *cancer-free* population. While RS is a useful measure for comparison among different regions and cancer registries and it adjusts for the chance of dying of causes other than cancer (which increases with age), it tends to underplay the greater long-term impact that a cancer diagnosis has at a younger age (potentially more life years lost), and it is generally fixed to a certain time (e.g. 1 year, 5 years and 10 years post-diagnosis). Other more intuitive measures of survival can be derived during the calculation of RS and are explored below for common cancers, some with very poor prognoses.

Figure 3
Relative survival and population cure

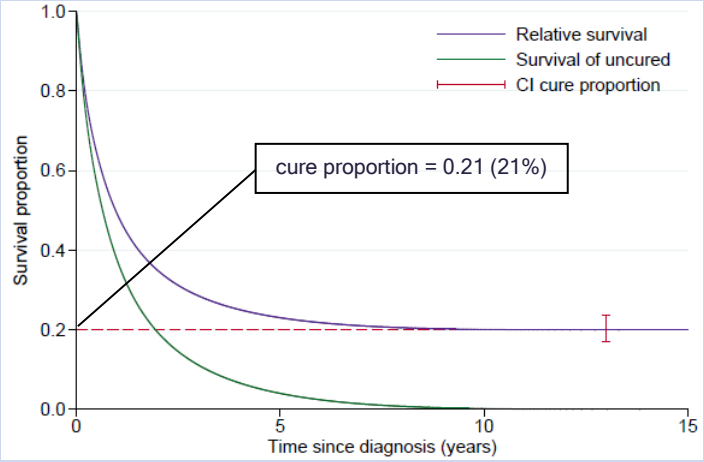


Illustration of relationship between relative survival and cure. In this cancer type (stomach: females), the proportion cured is 0.21 (or 21%) and the 'time to cure' is modeled at ≥10 years.
Source: SurvMark-2 report card for Ireland (2010-2013) (4)

A common question that cancer patients have at diagnosis is: *"What are my chances of being cured?"* While it may not be possible to determine with certainty *if and when* any individual is cured of cancer, at the population level statistical *cure* is a useful concept in cancer epidemiology. It is defined as the proportion surviving when the relative survival curve reaches a plateau (Figure 3), and *time to cure* is defined as the time point after diagnosis at which the relative survival curve reaches this plateau. This plateau indicates that survival now matches the survival expected in the general population of the same age and sex.

It is possible to determine the plateau for many cancers, but in others (notably the two most common cancers, breast and prostate) there remains a lingering excess mortality over and above that of the general population which makes it difficult to demonstrate the plateau. While these two common cancers show very good survival prospects overall (Figure 2), it is technically difficult to determine the cure proportion and how long after diagnosis patients can be considered cured.

Figure 4
Relative survival and loss of life expectation

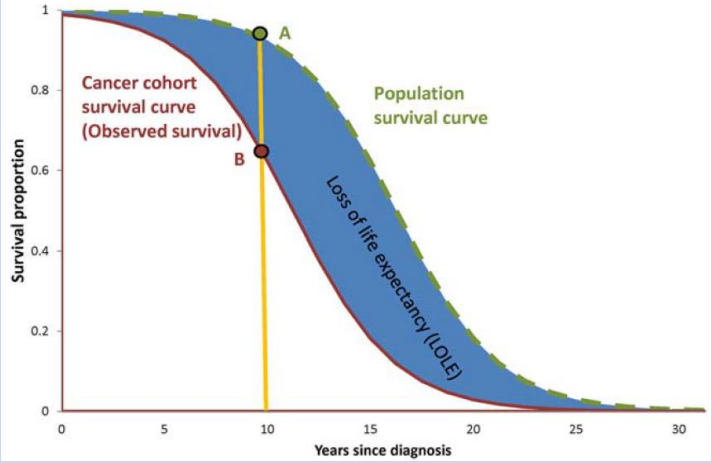


Illustration of relationship between relative survival
(calculated as the ratio of B:A at specific points along the curve)
and the loss of life expectancy
(calculated as the area between the survival curves)
Source of illustration, Baade et al, (2015) (5)

Another approach to answering the above cure question might be to reframe the patient's question as - "*How much does my life expectancy change now that I have been diagnosed with cancer?*"

The concept of *loss of life expectation* (LOLE) is illustrated in Figure 4. The remaining life expectancy for a hypothetical cohort of patients with cancer is represented by the area under the observed survival curve (lower red solid line), with survival time on the x-axis. The area under the expected survival curve (upper green dashed line) represents the life expectancy of the age-sex-year-matched general population. The difference between these two measures, i.e. the blue shaded area between the two curves represents the LOLE from the time of diagnosis onwards and can be conveniently calculated and reported as the *'number of life years lost'* due to diagnosis of cancer (5). LOLE is easy to understand and can be calculated for different types of cancers and a range of ages, and is not fixed to a time point after diagnosis like RS.

The International Cancer Benchmarking Partnership (ICBP) SurvMark-2 project

In the next sections of this report we present results for Ireland on relative survival, cure proportions and loss of life expectation from the International Cancer Benchmarking Partnership's (ICBP) SurvMark-2 project. This project, using data and funding support from collaborating cancer registries, aims to establish the most up-to-date international cancer survival benchmarks for a group of cancers of poor to moderate average survival – those of the oesophagus, stomach, colon, rectum, liver, pancreas, lung, and ovary – across seven high-income countries (Australia, Canada, Denmark, Ireland, New Zealand, Norway, and the UK) (4). Fuller results of the study (including international comparisons) are in preparation for publication by the ICBP.

The methods used to calculate relative survival, cure, LOLE and probability of death fall under the framework of flexible parametric survival models which involves extrapolation of both the expected and observed survival curves beyond the available follow-up period (6-8). Estimates for relative survival, probability of death and LOLE were predicted from the models for single years of age and then reported for each cancer type at 50, 60, 70 and 80 years of age, and at the average age of each cancer cohort. *Percent of life lost* (i.e. the percentage of remaining life expectancy) due to the cancer diagnosis was calculated by dividing the average LOLE at each age by the age-specific population life expectancy for Ireland.

Summary survival measures from ICBP SurvMark-2 pertaining to Ireland are presented below (and in Appendix I) for cancers of the oesophagus, stomach, colon, rectum, liver, pancreas, lung and ovary (Table 1). For context available NCRI figures for breast, prostate and melanoma skin cancers are also tabulated.

Table 1
Summary survival measures in Ireland, by cancer type and sex calculated at the average age: (2011-2013 period window) (4)

cancer	relative survival at 5 years (RS-5yr)‡		probability of cure		loss of life expectation (LOLE) years		% life lost	
	male	female	male	female	male	female	male	female
oesophagus (C15)	0.16	0.19	0.13	0.16	13.8	11.7	81.5%	78.0%
stomach (C16)	0.23	0.25	0.19	0.21	12.4	13.0	75.3%	73.2%
colon (C18-19)	0.53	0.55	0.43	0.47	7.6	7.9	47.7%	46.0%
rectum (C20)	0.54	0.59	0.38	0.45	8.4	9.0	49.4%	45.8%
liver (C22.0-1)	0.21	0.10	0.18	0.08	14.4	18.8	79.5%	89.5%
pancreas (C25)	0.07	0.07	0.05	0.05	14.8	13.6	90.5%	90.6%
lung (C34)	0.10	0.16	0.08	0.12	13.2	14.5	86.8%	82.9%
ovary (C48.1-2, C56. C57.0)		0.31		0.21		14.5		71.6%
melanoma of skin (C43)	**0.84**	**0.92**	-	-				
breast (C50)		**0.83**	**-**	**-**				
prostate (C61)	**0.92**		**-**					

- ‡RS-5yr: relative survival at 5 years after diagnosis expressed as a probability (0.0-1.0).

- Probabilities can also be expressed as a percentage, thus a cure probability of 0.05 may be expressed as 5%, e.g. patients diagnosed with pancreatic cancer during 2010-2013 had a 5% chance of being cured, or 1 in 20 such patients were cured.
- Figures are calculated at average age of the contributing cancer cohort (cases diagnosed 2010-2013); for figures at age 40, 50, 60 and 70 see Appendix I.
- Common cancers in ***bold italics*** are those with good survival prospects but were not part of the ICBP SurvMark-2 study; these figures relate to age-standardized 5-year net survival for patients diagnosed during 2010-2014 (see Figure 1, hybrid RS method). Cure statistics are not available for these cancers.

- In the cancers considered by the ICBP SurvMark-2 project, at the average age, five-year relative survival (5-yr RS) was lowest for cancers of the pancreas (M,F; 7% in both), lung (10%, 16%), oesophagus (16%, 19%), liver (21%, 10%) and stomach (23%, 25%); higher for cancer of the rectum (54%; 59%) and colon (53%, 55%); and intermediate for cancer of the ovary (31%).
- For each cancer type, relative survival was lower in males, except for cancer of the liver (Table 1).
- For major cancers not considered in the ICBP SurvMark-2 report, 5-yr RS was much higher for melanoma (84%, 92%), female breast cancer (83%) and prostate cancer (92%).
- Probability of *cure, LOLE and % life lost* mirror relative survival figures as might be expected.
- The probability of *cure* was lowest for cancers of the pancreas (M, F; 0.05, 0.05), lung (0.08, 0.12), oesophagus (0.13, 0.16), liver (0.18, 0.08) and stomach (0.19, 0.21); higher for cancers of the rectum (0.38, 0.45) and colon (0.43, 0.47); and intermediate for cancer of the ovary (0.21) (Table1).
- *Loss of life expectation and % life lost* were greatest for cancer of the pancreas (M, F; 15 years, 14 years – both 91%), and least for cancer of the colon (M, F; 8 years for both - 48%, 46% respectively) (Table 1).

Fuller graphical summaries are presented below for relative survival (Figures 5 & 6); cure proportions Figures 7 & 8); loss of life expectation (Figures 9 & 10); and probability of dying from cancer compared with probability of dying from other causes (Figure 11).

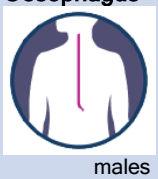
Age-specific relative survival (RS) (ICBP SurvMark-2)

Figure 5. Age-specific relative survival (2011-2013 period window)

The graph panel on the right shows sex- and age-specific variation in relative survival where the effect of age is modelled continuously. The x-axis is age at diagnosis. 1-yr RS, 5-yr RS and '5-yr RS conditional on 1-yr' are shown as curves.
'5-yr RS conditional on 1-yr' comprised patients who survived 5 years beyond the 1st year – a measure of updated prognosis for those patients who survive early mortality risk & who will generally have undergone first-line treatment.
A histogram showing the distribution of patients by age in 2013 is also shown, with the scale on the right y-axis.
Left-most panel: summary of 1-yr RS and 5-yr RS at the average age for males and females in Ireland.

Relative survival at average age (RS)

Oesophagus



	males	females
1 year	48%	45%
5-year	16%	19%

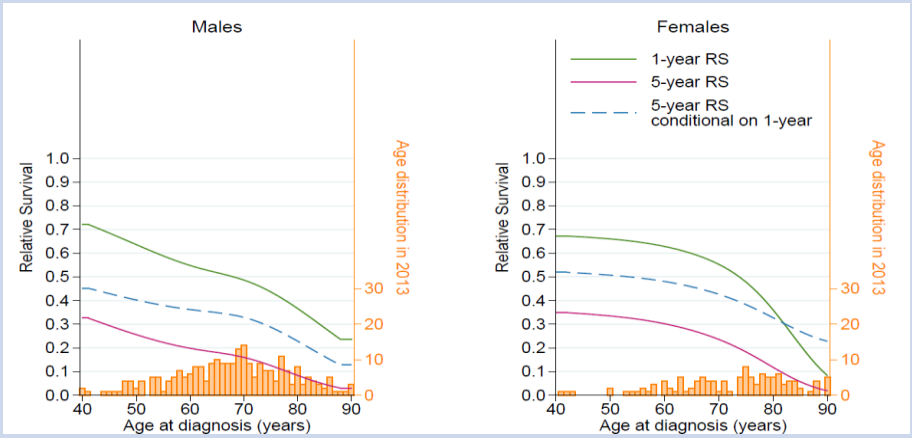
Stomach

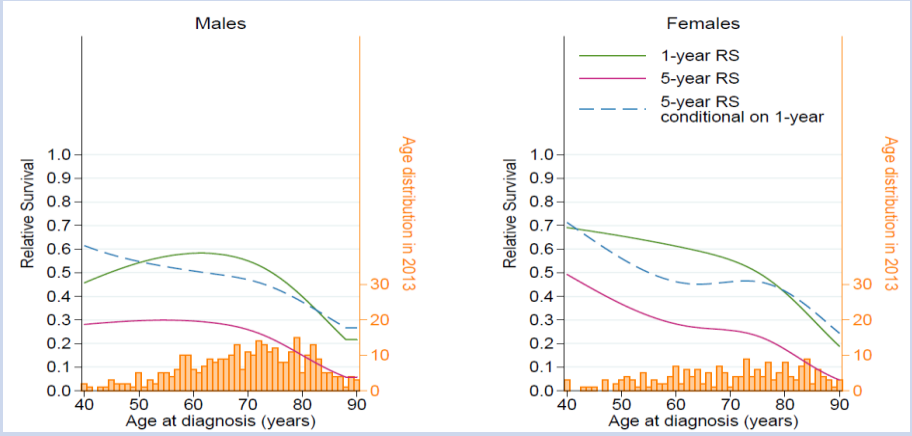
	males	females
1 year	49%	51%
5-year	23%	25%

Colon

	males	females
1 year	79%	78%
5-year	53%	55%

Age- and sex-specific relative survival (RS)





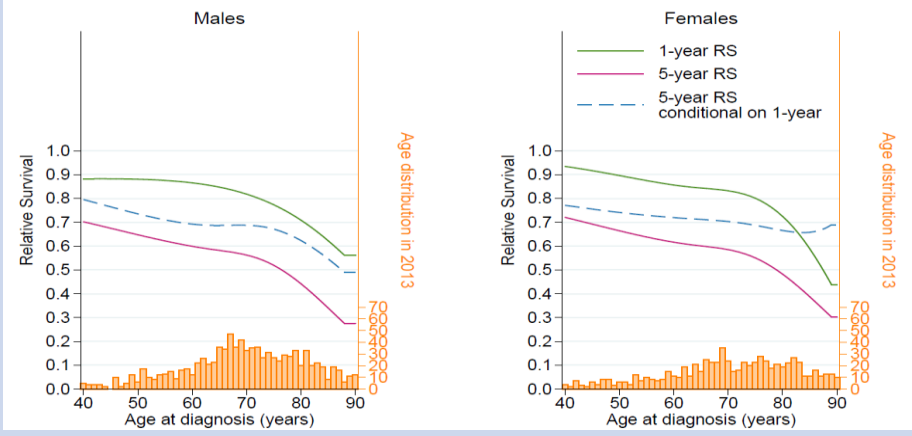


Figure 5. Age-specific relative survival (2011-2013 period window)

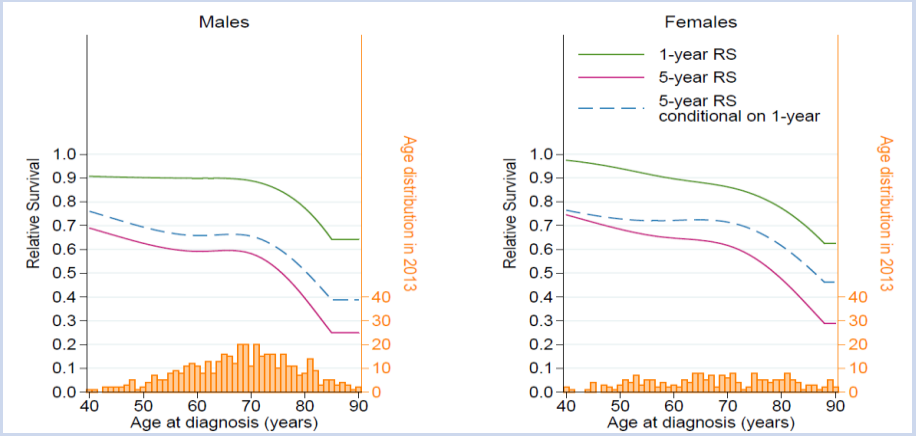
The graph panel on the right shows sex- and age-specific variation in relative survival where the effect of age is modelled continuously. The x-axis is age at diagnosis. 1-yr RS, 5-yr RS and '5-yr RS conditional on 1-yr' are shown as curves.
'5-yr RS conditional on 1-yr' comprised patients who survived 5 years beyond the 1st year – a measure of updated prognosis for those patients who survive early mortality risk & who will generally have undergone first-line treatment.
A histogram showing the distribution of patients by age in 2013 is also shown, with the scale on the right y-axis.
Left-most panel: summary of 1-yr RS and 5-yr RS at the average age for males and females in Ireland.

Relative survival at average age (RS)

Age- and sex-specific relative survival (RS)

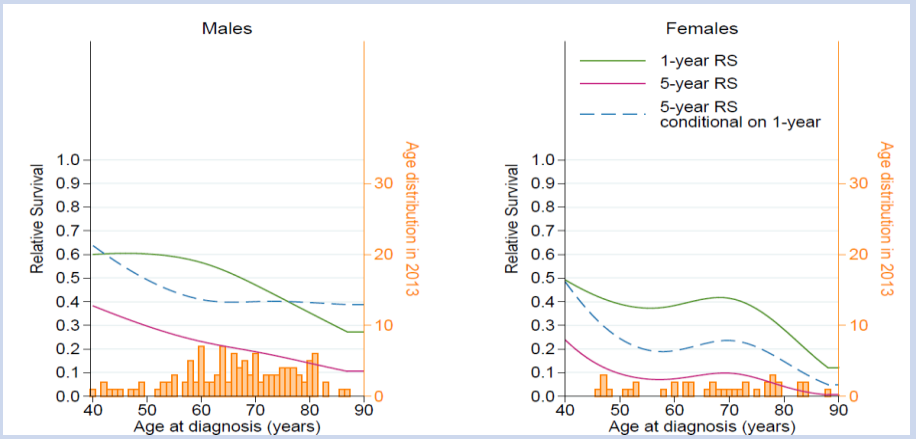
Rectum

	males	females
1 year	86%	85%
5-year	54%	59%



Liver

	males	females
1 year	49%	37%
5-year	21%	10%



Pancreas

	males	females
1 year	27%	26%
5-year	7%	7%

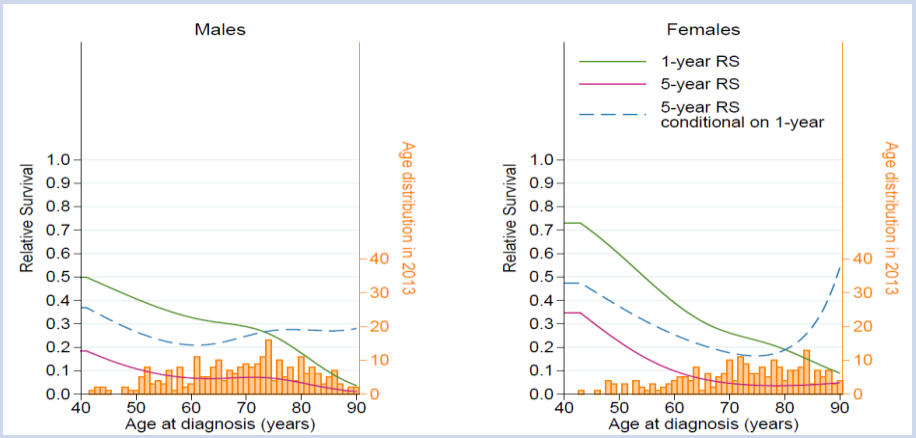


Figure 5. Age-specific relative survival (2011-2013 period window)

The graph panel on the right shows sex- and age-specific variation in relative survival where the effect of age is modelled continuously. The x-axis is age at diagnosis. 1-yr RS, 5-yr RS and '5-yr RS conditional on 1-yr' are shown as curves.
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A histogram showing the distribution of patients by age in 2013 is also shown, with the scale on the right y-axis.
Left-most panel: summary of 1-yr RS and 5-yr RS at the average age for males and females in Ireland.

Relative survival at average age (RS)

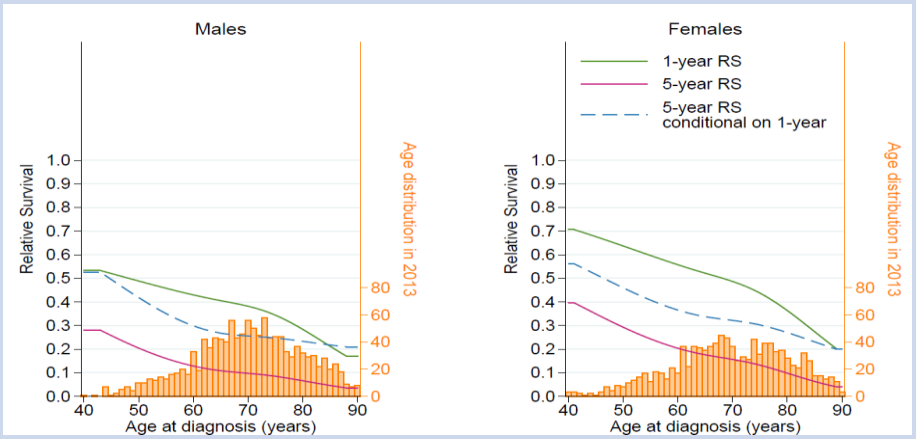
Lung

	males	females
1 year	36%	46%
5-year	10%	16%

Ovary

	females
1 year	69%
5-year	31%

Age- and sex-specific relative survival (RS)



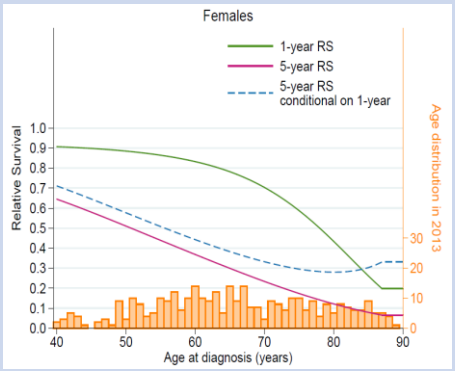
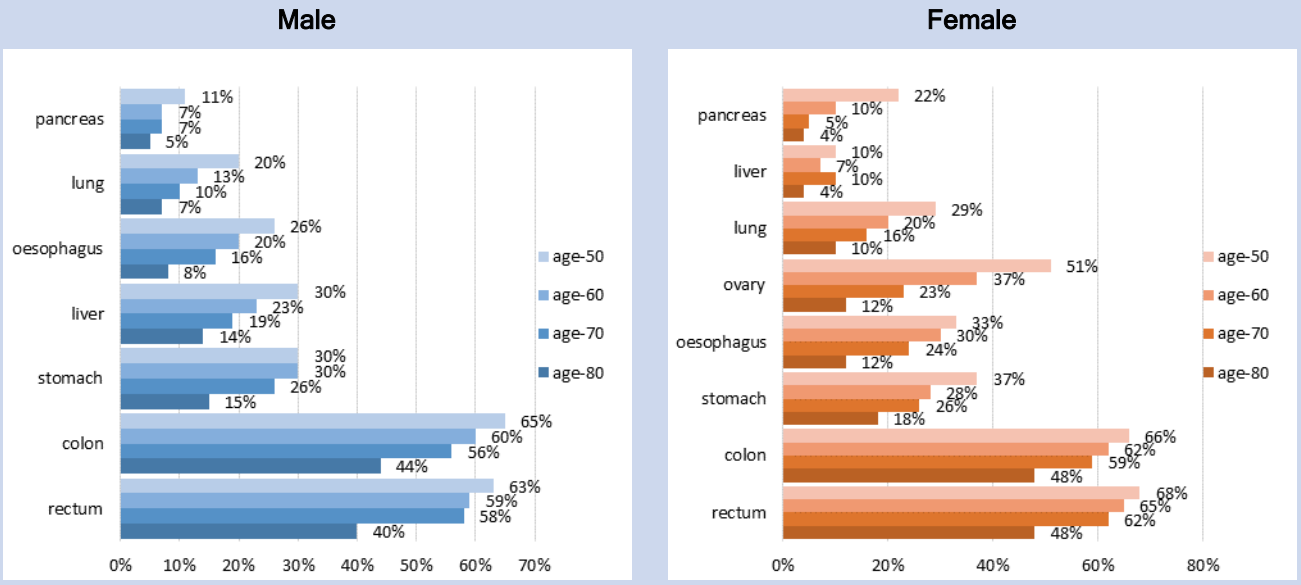


Figure 6
Summary: age-specific relative survival (RS) at 5 years, by cancer and sex (2011-2013 period window)



Relative survival expressed as a percentage, sorted by RS at age 70 (which was close to the median age for individual cancers presented)

- In males, of the cancers included in ICBP SurvMark2, relative survival at five years (5-yr RS) was poorest for pancreas, lung, oesophagus, liver and stomach, where survival decreased in a stepwise fashion with each ten-year increment in age from age 50 to 80. At the other end of the spectrum, 5-yr relative survival was better for cancer of the rectum and colon (Figure 5, 6).
- While females fared better than males overall for 5-yr RS at all ages and for all cancers (except liver), poor survival was evident for cancers of the pancreas, liver, lung, ovary, oesophagus and stomach with better survival for cancers of the colon and rectum (Figure 5, 6).

Cure proportions (ICBP SurvMark-2)

Figure 7
Estimated cure proportions by cancer type and sex: 2011-2013 period window

Cure proportion at average age

Relative survival and cure proportion

The average (across-age) cure proportion. The area under the red dashed line shows the cure proportion with a corresponding 95% confidence interval (CI, red).

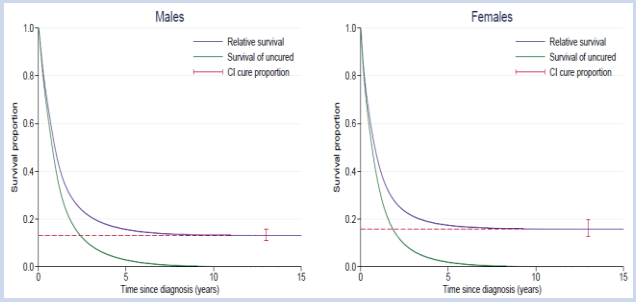
The purple line represents the relative survival curve overall, with a plateau to estimate the cure proportion. The green overlay curve shows the survival experience of those who died, often summarised by the median survival time of the *uncured*

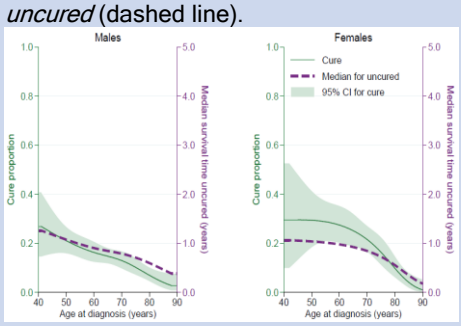
Age-specific cure proportion

The x-axis shows age at diagnosis. The left hand y-axis shows the cure proportion; the green area around the solid green line represents the 95%CI for the cure proportion with greater uncertainty at younger ages reflecting fewer cases. The right hand y-axis shows the median survival time of the *uncured* (dashed line).

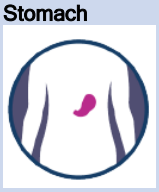
Oesophagus

male 13%
female 16%

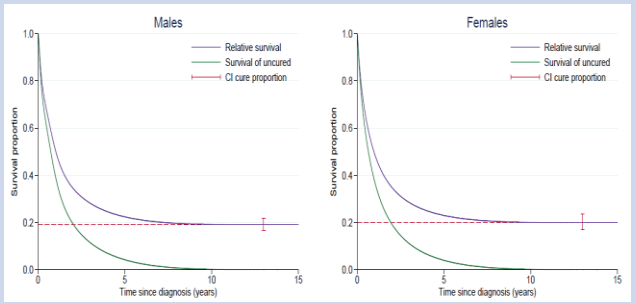


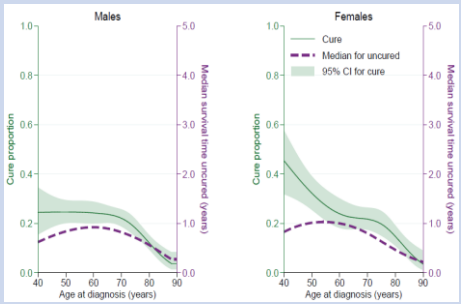


Stomach



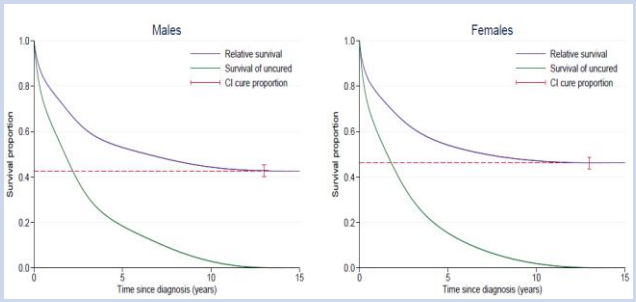
male 19%
female 21%

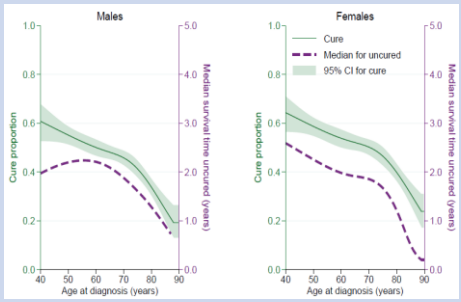




Colon

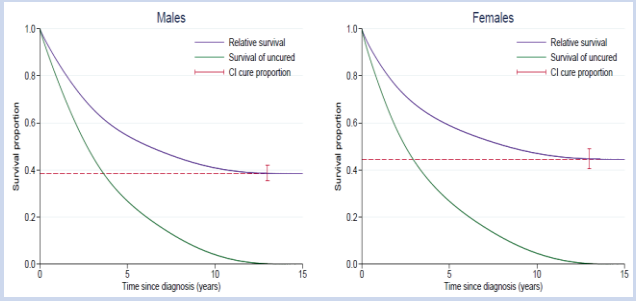
male 43%
female 47%





Rectum

male 38%
female 45%



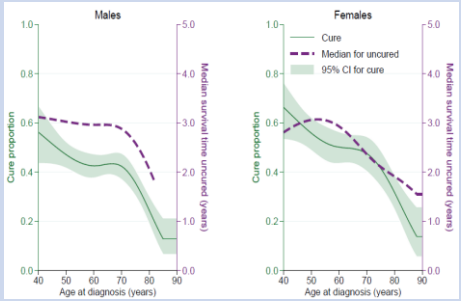


Figure 7
Estimated cure proportions by cancer type and sex: 2011-2013 period window

Cure proportion at average age

Relative survival and cure proportion

The average (across-age) cure proportion. The area under the red dashed line shows the cure proportion with a corresponding 95% confidence interval (CI, red).

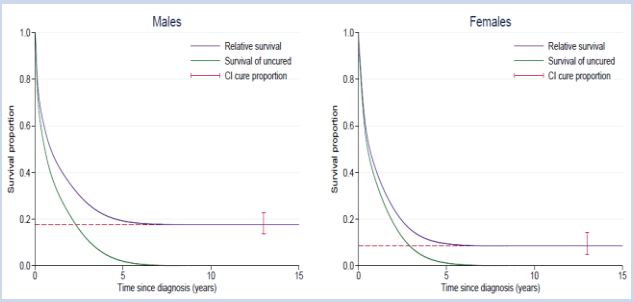
The purple line represents the relative survival curve overall, with a plateau to estimate the cure proportion. The green overlay curve shows the survival experience of those who died, often summarised by the median survival time of the *uncured*

Age-specific cure proportion

The x-axis shows age at diagnosis. The left hand y-axis shows the cure proportion; the green area around the solid green line represents the 95%CI for the cure proportion with greater uncertainty at younger ages reflecting fewer cases. The right hand y-axis shows the median survival time of the *uncured* (dashed line).

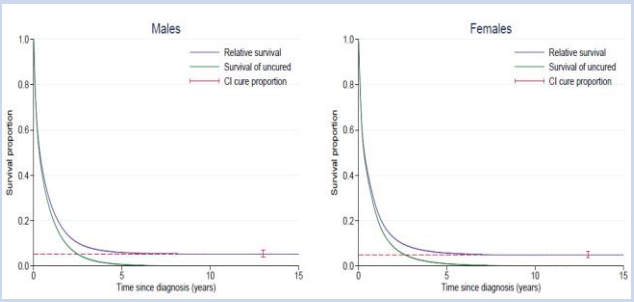
Liver

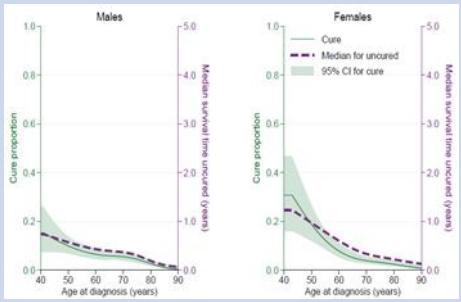
male 18%
female 8%



Pancreas

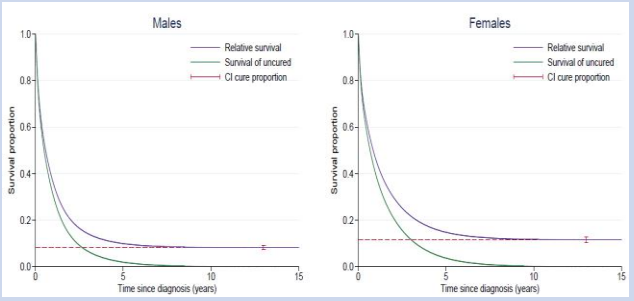
male 5%
female 5%

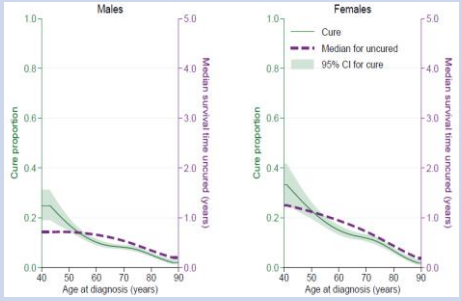




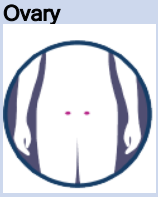
Lung

male 8%
female 12%

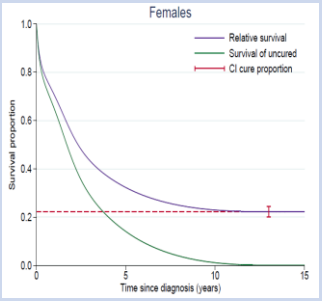




Ovary



female 21%



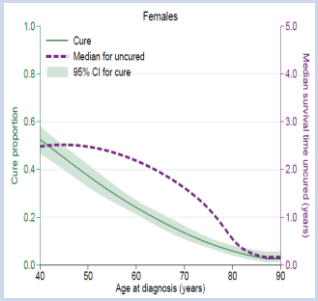
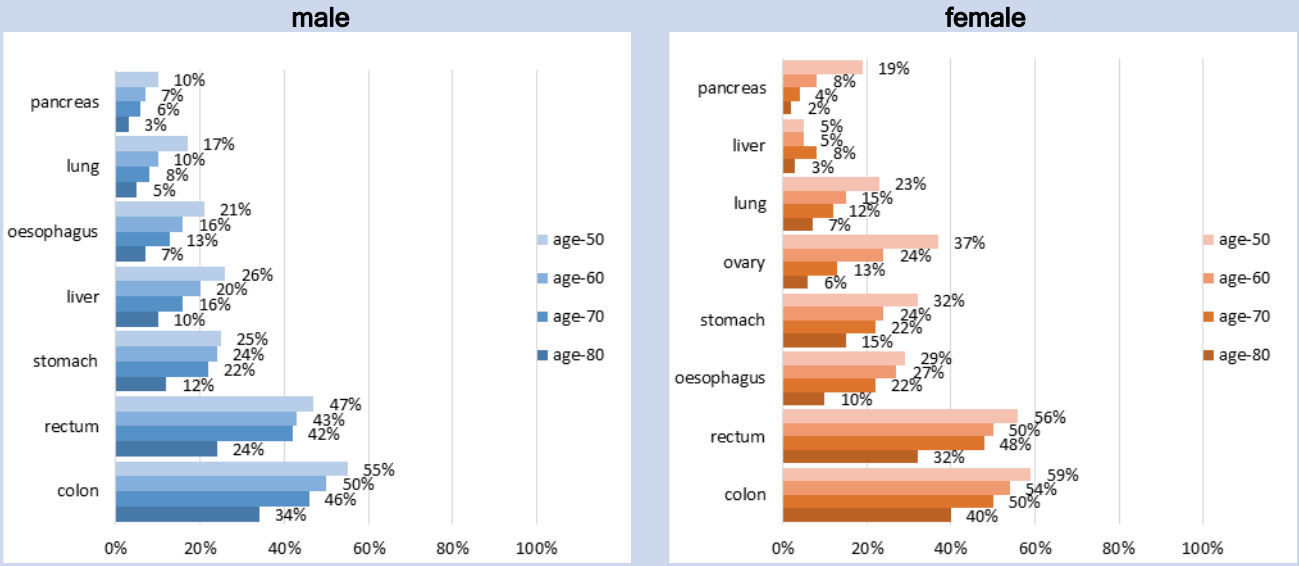


Figure 8
Summary: age-specific cure proportion by cancer and sex (2011-2013 period window)



'Cure' expressed as a percentage, sorted by cure % at age 70 (which was close to the median age for individual cancers)

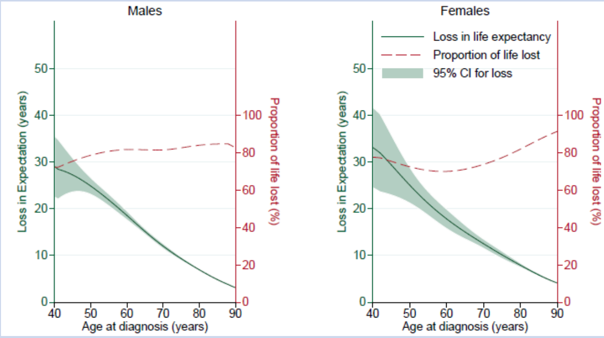
- Cure proportions mirrored relative survival, i.e. cancers with lower relative survival showed lower cure proportions. In males, the cure proportion was lowest for pancreas, lung, oesophagus, liver and stomach, where the cure proportion decreased in a stepwise fashion with each 10-year increment in age from age 50 to 80. For example, of pancreatic cancers diagnosed at age 70, only 6 out of 100 males are estimated to be cured. At the other end of the spectrum, the cure proportion was better for cancer of the rectum and colon at all ages, apart from fall-off in cure at age 80 (Figure 7, 8).
- While females showed higher cure proportions than males at all ages and for all cancers (except liver), low cure proportions were also in evidence for cancers of the pancreas, liver, lung, ovary, stomach and oesophagus with better cure prospects for cancers of the colon and rectum (Figure 7, 8).

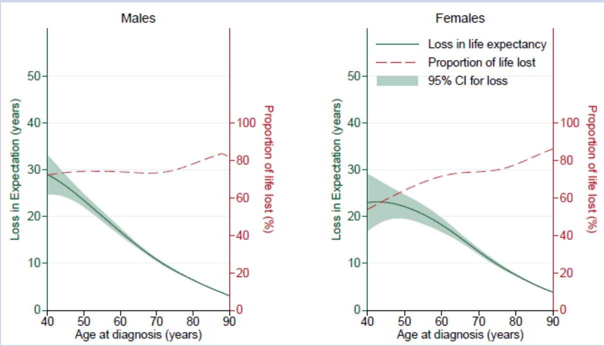
Loss of life expectation (ICBP SurvMark-2)

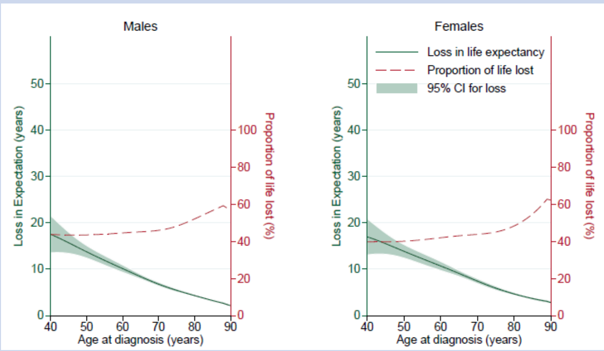
Figure 9
Loss of life expectation (LOLE) and probability of death, by cancer type, age and sex (2011-2013 period window)

LOLE, by age and sex

Loss in life expectancy metrics are summarised across age. The green line (left y-axis) shows the loss of life expectation (LOLE), i.e. the average number of remaining years of life lost due to a cancer diagnosis, scaled against Ireland's general population life expectancy as the comparator. Younger persons have greater life expectancy and therefore a larger portion of life years to lose. The red line (right y-axis) shows the % of remaining life lost as a counter-balance to lost years.







Probability of death (at age 70)

For persons diagnosed at age 70, the total probability of death at five years after diagnosis is partitioned into cancer cause and other causes (see Appendix I for similar data at other ages)

Oesophagus

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	12.0	81%	82%	4%
F	12.5	74%	75%	3%

Stomach

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	10.8	73%	72%	5%
F	12.5	74%	73%	3%

Colon

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	6.8	46%	42%	8%
F	7.4	44%	40%	5%

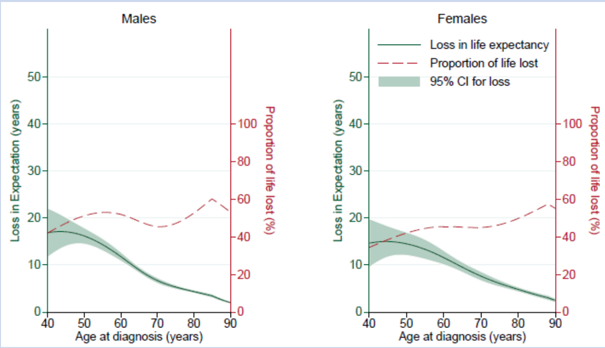
Figure 9
Loss of life expectation (LOLE) and probability of death, by cancer type, age and sex (2011-2013 period window)

LOLE, by age and sex

Loss in life expectancy metrics are summarised across age. The green line (left y-axis) shows the loss of life expectation (LOLE), i.e. the average number of remaining years of life lost due to a cancer diagnosis, scaled against Ireland's general population life expectancy as the comparator. Younger persons have greater life expectancy and therefore a larger portion of life years to lose. The red line (right y-axis) shows the % of remaining life lost as a counter-balance to lost years.

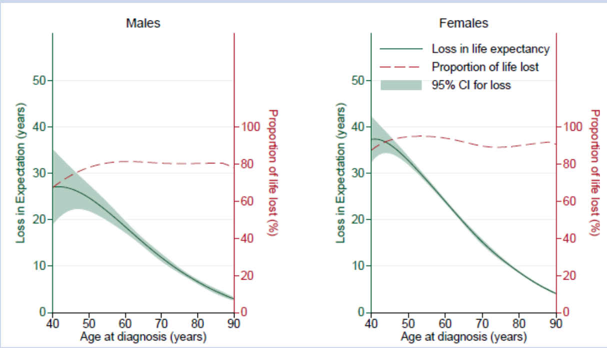
Probability of death (at age 70)

For persons diagnosed at age 70, the total probability of death at five years after diagnosis is partitioned into cancer cause and other causes (see Appendix I for similar data at other ages)



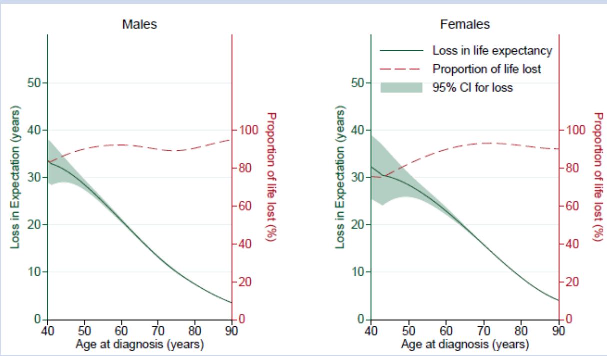
Rectum

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	6.7	45%	40%	8%
F	7.6	45%	37%	6%



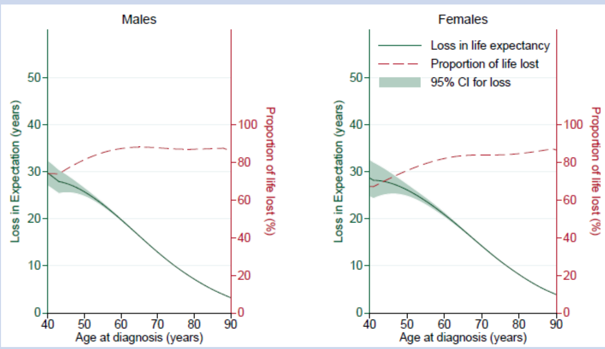
Liver

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	11.9	80%	79%	4%
F	15.2	90%	89%	2%

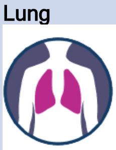


Pancreas

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	13.3	90%	91%	2%
F	15.8	93%	94%	1%



Lung

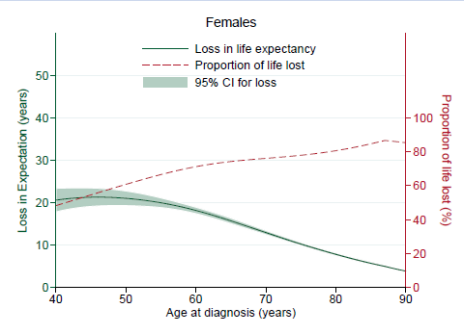


sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
M	12.9	88%	88%	3%
F	14.2	84%	83%	2%

Figure 9
Loss of life expectation (LOLE) and probability of death, by cancer type, age and sex (2011-2013 period window)

LOLE, by age and sex

Loss in life expectancy metrics are summarised across age. The green line (left y-axis) shows the loss of life expectation (LOLE), i.e. the average number of remaining years of life lost due to a cancer diagnosis, scaled against Ireland's general population life expectancy as the comparator. Younger persons have greater life expectancy and therefore a larger portion of life years to lose. The red line (right y-axis) shows the % of remaining life lost as a counter-balance to lost years.



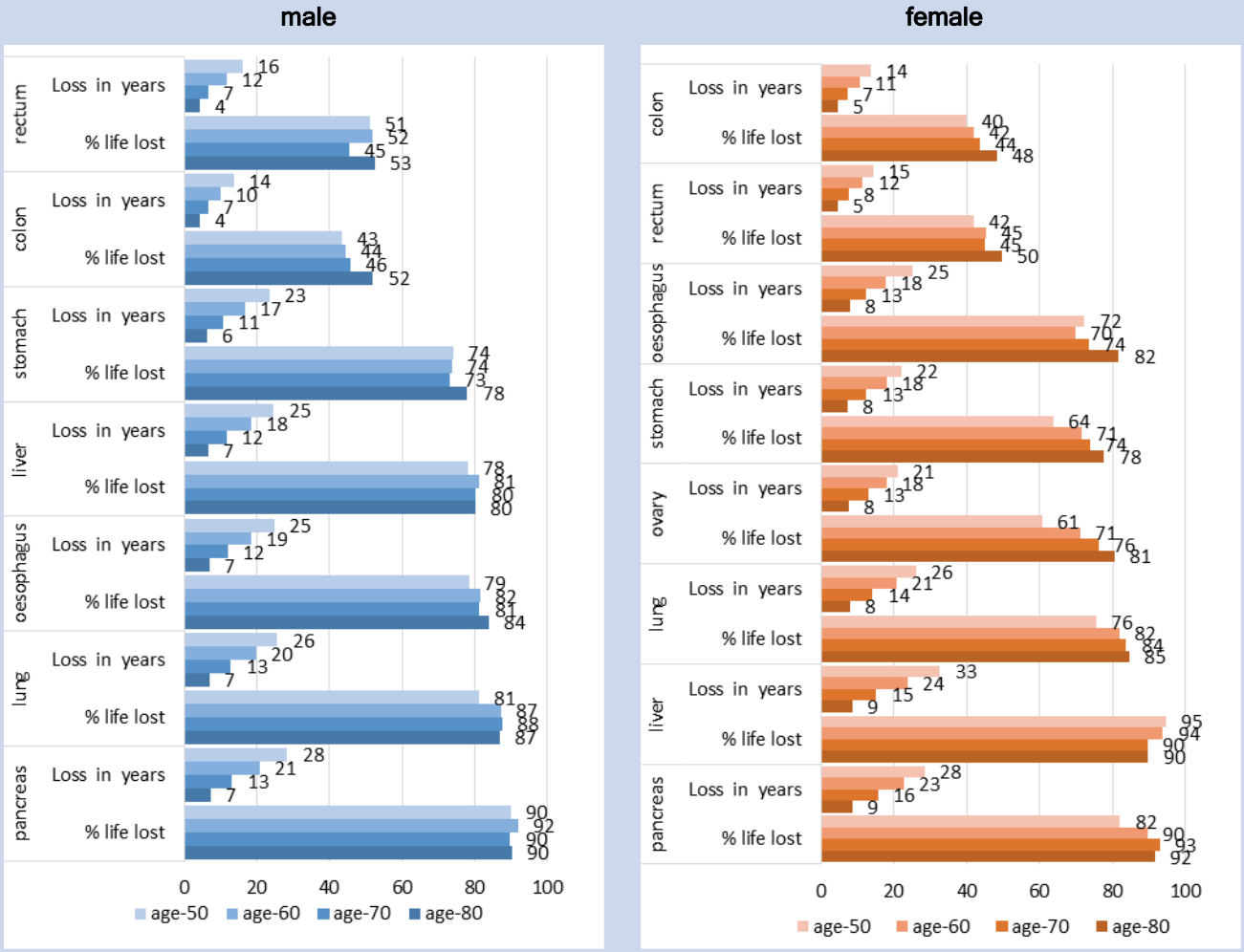
Probability of death (at age 70)

For persons diagnosed at age 70, the total probability of death at five years after diagnosis is partitioned into cancer cause and other causes (see Appendix I for similar data at other ages)

Ovary

sex	loss in years	% life lost	probability of death at 5 years (cancer)	probability of death at 5 years (other cause)
F	12.9	76%	75%	3%

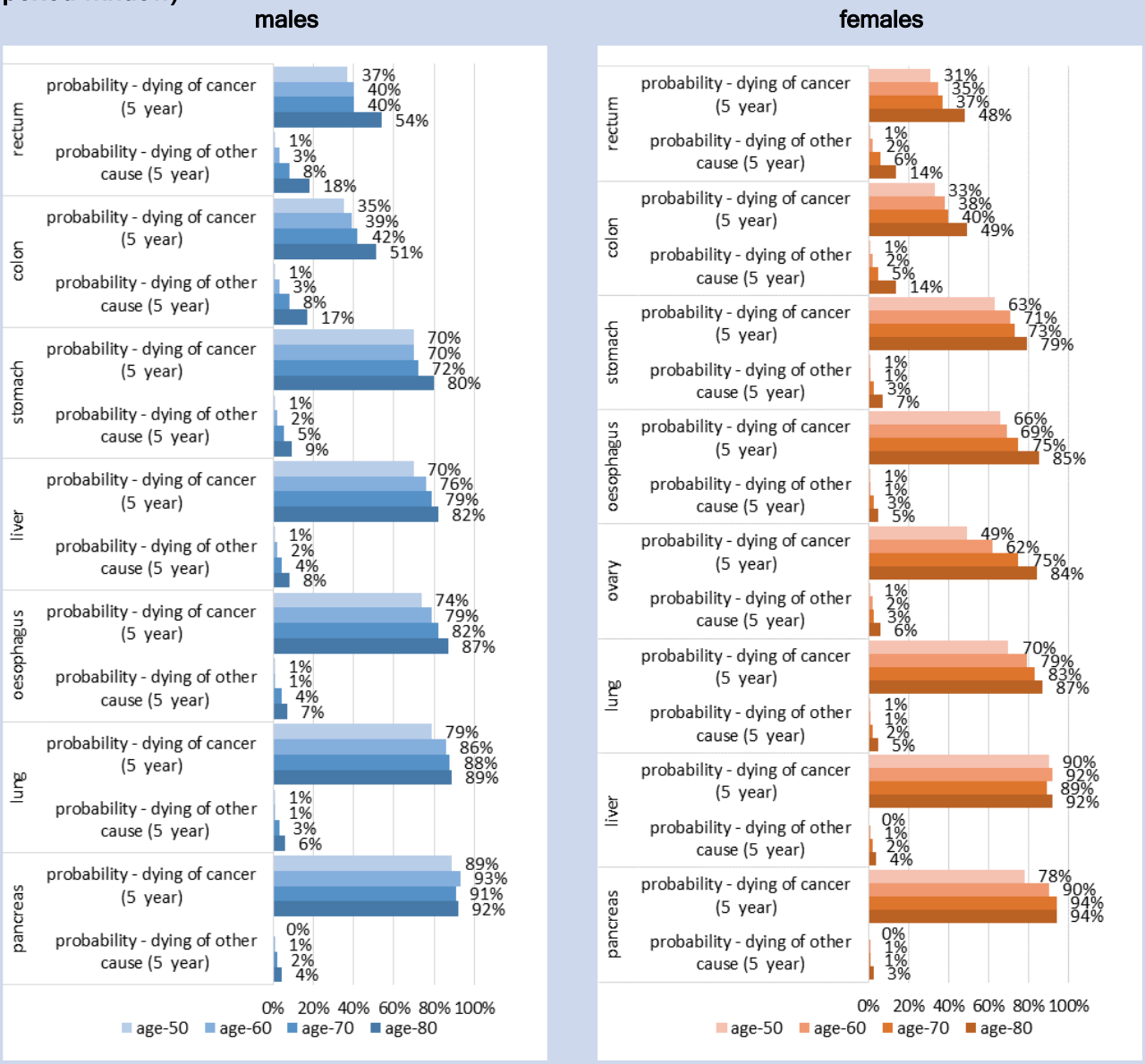
Figure 10 Summary: LOLE and % life lost, by cancer, age and sex (2011-2013 period window)



Cancer types are ranked in increasing order of 'loss in years' at age 70, close to the median diagnosis age for these cancers

- LOLE is interpreted as the loss of remaining life expectation scaled against age- and sex-specific life expectancy of the general population. As might be expected, patients diagnosed with cancer at a younger age lost more life-years than those diagnosed at an older age.
- Using pancreatic cancer as an example, an average male diagnosed at age 50 loses, on average, 28 years of life expectancy, while an average male at age 80 years at diagnosis loses 7 years. These figure are a function of the average life expectancy at a given age in the general population scaled against the net survival for that age and cancer type. Even though both males lose 90% of their respective life expectancies, the cost in actual years is much greater for the 50-year old than for the 80-year old (Figure 9, 10).

Figure 11
Summary: probability of dying of cancer and other causes at five years after diagnosis (2011-2013 period window)



Probability of dying within 5 years after diagnosis was expressed as a percentage; sorted by 'probability of dying of cancer' at age 70 which was close to the median age for individual cancers shown

- The probability of death can be interpreted as the converse of survival (after partitioning on probability of cancer deaths and other deaths). The effect that age had on five-year probability of death varied by cancer type; it increased with age in a stepwise fashion for all cancers as expected, and it was less steep in cancers with the lowest probability of deaths (cancers of the rectum and colon) and steepest in those with the highest probability of death (e.g. cancer of the pancreas) (Figure 11).
- For the most lethal cancers (e.g. lung and pancreas) the probability of dying of other causes was very small, whereas for the less lethal cancers (e.g. colon and rectum) the probability of dying of other causes was somewhat higher, i.e. patients survived longer with their cancer, only to succumb to other age-related comorbidities (e.g. cardiovascular or respiratory conditions).

METHODS

Survival analyses

Survival figures presented in this report use net survival, an 'improved' version of relative survival taking better account of competing mortality risks and allowing greater comparability between different populations or age-groups. Net survival represents the cumulative probability of a patient surviving a given time in the hypothetical situation in which the disease of interest is the only possible cause of death, i.e. survival having controlled for other possible cause of death (9). (This involves comparison of observed survival with the expected survival of persons of the same age and gender in the general population, as for relative survival). Net survival was calculated using the 'strs' command in STATA with an adjustment to obtain the Pohar-Perme estimate. All survival estimates were either age-standardised to the International Cancer Survival Standards (ICSS) (3) or, in the case of ICBP SurvMark-2 results, were presented for patients of average age at diagnosis or for specific ages.

ICBP SurvMark-2 methodology

Non-parametric estimates of relative survival (2,9) were calculated using ICSS age weights (3), generated from underlying excess mortality models fitted using Stata's 'stpm2' package (10). These models were fitted on the log cumulative excess hazard scale and rely on general population mortality rates merged at the time of event (11). Splines were fitted to define the complexity of the parametric form of the baseline (12). Period analysis was applied for the most recent calendar period to obtain up-to-date survival estimates given that follow-up was restricted for some patient groups (13). Period analysis has been shown to give better estimates of survival empirically in a number of settings (14). Conditional survival was estimated to assess the impact of cancer for those patients who survived for a given period of time following diagnosis (15). The crude probability of death was estimated (due to cancer and other causes) following the fitting of flexible parametric excess mortality models (16), as was loss in expectation of life (6). For statistical cure models, a modification to the models was made in order to force an asymptote in the relative survival function (8).

Acknowledgments

- Dr Joe McDevitt compiled the overall report, including ICBP SurvMark-2 results pertaining to Ireland. Drs Conan Donnelly and Paul Walsh are NCRI liaisons for the ICBP SurvMark-2 project and contributed to text and interpretation for this report.
- NCRI survival analyses were undertaken by Dr Paul Walsh, while fuller analyses of Irish data were undertaken at the International Agency for Research on Cancer (IARC), as part of the ICBP SurvMark-2 project. In this context, this report's authors gratefully acknowledge the contribution of Drs Melina Arnold and Isabelle Soerjomataram at IARC, and Dr Mark Rutherford of Leicester University, among other colleagues involved in the ICBP SurvMark-2 project
- ICBP SurvMark-2 analyses were funded by: Canadian Partnership Against Cancer; Cancer Council Victoria; Cancer Institute New South Wales; Cancer Research UK; Danish Cancer Society; National Cancer Registry Ireland; New Zealand Cancer Society; NHS England; Norwegian Cancer Society; Public Health Agency Northern Ireland, on behalf of the Northern Ireland Cancer Registry; The Scottish Government; Western Australia Department of Health; Wales Cancer Network.
- NCRI thanks the Department of Health for their support for this work.

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Appendix I: Extracts from ICBP SurvMark-2 'Report Card' for Ireland

Appendix I: Table 1

Survival measures in Ireland for males diagnosed with cancer: 2010-2013 (4)

	RS 1-yr	RS 5-yr	RS 5-yr conditional survived 1-yr	probability of cure	loss in life expectancy (years)	% life lost	probability of cancer death (1-yr)	probability of cancer death (5-yr)	probability of death: other cause (1-yr)	probability of death: other cause (5-yr)
OESOPHAGUS (C15)										
age-50	0.64	0.26	0.40	0.21	24.8	78.5	0.36	0.74		0.01
age-60	0.55	0.20	0.36	0.16	18.6	81.6	0.45	0.79	0.01	0.01
age-70	0.49	0.16	0.33	0.13	12.0	81.4	0.51	0.82	0.01	0.04
age-80	0.37	0.08	0.23	0.07	7.0	83.9	0.62	0.87	0.03	0.07
average	**0.48**	**0.16**	**0.32**	**0.13**	**13.8**	**81.5**	**0.51**	**0.81**	**0.02**	**0.04**
STOMACH (C16)										
age-50	0.54	0.30	0.55	0.25	23.4	74.1	0.45	0.70		0.01
age-60	0.58	0.30	0.51	0.24	16.8	73.8	0.41	0.70	0.01	0.02
age-70	0.55	0.26	0.47	0.22	10.8	73.2	0.44	0.72	0.01	0.05
age-80	0.40	0.15	0.38	0.12	6.5	78.0	0.58	0.80	0.03	0.09
average	**0.49**	**0.23**	**0.45**	**0.19**	**12.4**	**75.3**	**0.50**	**0.74**	**0.02**	**0.05**
COLON (C18-19)										
age-50	0.88	0.65	0.74	0.55	13.7	43.4	0.12	0.35		0.01
age-60	0.87	0.60	0.69	0.50	10.1	44.5	0.13	0.39	0.01	0.03
age-70	0.82	0.56	0.69	0.46	6.8	45.9	0.18	0.42	0.02	0.08
age-80	0.71	0.44	0.62	0.34	4.3	52.0	0.28	0.51	0.04	0.17
average	**0.79**	**0.53**	**0.67**	**0.43**	**7.6**	**47.7**	**0.20**	**0.44**	**0.03**	**0.10**
RECTUM (C20)										
age-50	0.90	0.63	0.69	0.47	16.2	51.1	0.10	0.37		0.01
age-60	0.90	0.59	0.66	0.43	11.8	51.9	0.10	0.40	0.01	0.03
age-70	0.89	0.58	0.66	0.42	6.7	45.4	0.11	0.40	0.02	0.08
age-80	0.77	0.40	0.51	0.24	4.4	52.5	0.22	0.54	0.05	0.18
average	**0.86**	**0.54**	**0.62**	**0.38**	**8.4**	**49.4**	**0.14**	**0.43**	**0.02**	**0.09**
LIVER (C22.0-1)										
age-50	0.60	0.30	0.49	0.26	24.7	78.1	0.40	0.70	0.00	0.01
age-60	0.57	0.23	0.41	0.20	18.5	81.3	0.43	0.76	0.00	0.02
age-70	0.47	0.19	0.40	0.16	11.9	80.4	0.52	0.79	0.01	0.04
age-80	0.35	0.14	0.40	0.10	6.7	80.2	0.64	0.82	0.03	0.08
average	**0.49**	**0.21**	**0.42**	**0.18**	**14.4**	**79.5**	**0.51**	**0.77**	**0.01**	**0.04**
PANCREAS (C25)										
age-50	0.41	0.11	0.27	0.10	28.5	90.0	0.59	0.89		
age-60	0.33	0.07	0.21	0.07	20.9	92.1	0.67	0.93		0.01
age-70	0.29	0.07	0.25	0.06	13.3	89.8	0.70	0.91	0.01	0.02
age-80	0.17	0.05	0.27	0.03	7.5	90.4	0.81	0.92	0.02	0.04
average	**0.27**	**0.07**	**0.25**	**0.05**	**14.8**	**90.5**	**0.72**	**0.91**	**0.01**	**0.02**
LUNG (C34)										
age-50	0.49	0.20	0.42	0.17	25.7	81.3	0.51	0.79		0.01
age-60	0.43	0.13	0.30	0.10	19.8	87.2	0.57	0.86		0.01
age-70	0.38	0.10	0.26	0.08	12.9	87.6	0.61	0.88	0.01	0.03
age-80	0.28	0.07	0.23	0.05	7.2	86.9	0.70	0.89	0.03	0.06
average	**0.36**	**0.10**	**0.27**	**0.08**	**13.2**	**86.8**	**0.63**	**0.87**	**0.02**	**0.03**

Key: RS-1yr/5yr=relative survival at 1 and 5 years expressed as a probability (0-1.0)

Appendix I: Table 2
Survival measures in Ireland for females diagnosed with cancer: 2010-2013 (4)

	RS 1-yr	RS 5-yr	RS 5-yr conditional survived 1-yr	probability of cure	loss in life expectancy (years)	% life lost	probability of cancer death (1-yr)	probability of cancer death (5-yr)	probability of death: other cause (1-yr)	probability of death: other cause (5-yr)
OESOPHAGUS (C15)										
age-50	0.66	0.33	0.51	0.29	25.0	72.4	0.34	0.66	-	0.01
age-60	0.63	0.30	0.48	0.27	17.8	69.9	0.37	0.69	-	0.01
age-70	0.55	0.24	0.43	0.22	12.5	73.7	0.44	0.75	0.01	0.03
age-80	0.36	0.12	0.33	0.10	7.9	81.8	0.63	0.85	0.02	0.05
average	**0.45**	**0.19**	**0.38**	**0.16**	**11.7**	**78.0**	**0.54**	**0.79**	**0.02**	**0.04**
STOMACH (C16)										
age-50	0.66	0.37	0.56	0.32	22.1	63.9	0.34	0.63	-	0.01
age-60	0.61	0.28	0.46	0.24	18.2	71.5	0.39	0.71	-	0.01
age-70	0.55	0.26	0.46	0.22	12.5	73.8	0.44	0.73	0.01	0.03
age-80	0.42	0.18	0.42	0.15	7.5	77.7	0.57	0.79	0.02	0.07
average	**0.51**	**0.25**	**0.46**	**0.21**	**13.0**	**73.2**	**0.48**	**0.73**	**0.02**	**0.04**
COLON (C18-19)										
age-50	0.90	0.66	0.74	0.59	13.8	40.0	0.10	0.33	-	0.01
age-60	0.86	0.62	0.72	0.54	10.7	41.9	0.14	0.38	-	0.02
age-70	0.83	0.59	0.70	0.50	7.4	43.7	0.17	0.4	0.01	0.05
age-80	0.72	0.48	0.67	0.40	4.7	48.2	0.27	0.49	0.03	0.14
average	**0.78**	**0.55**	**0.7**	**0.47**	**7.9**	**46.0**	**0.22**	**0.43**	**0.02**	**0.09**
RECTUM (C20)										
age-50	0.94	0.68	0.73	0.56	14.5	41.9	0.06	0.31	-	0.01
age-60	0.9	0.65	0.72	0.50	11.6	45.4	0.1	0.35	-	0.02
age-70	0.86	0.62	0.71	0.48	7.6	44.9	0.14	0.37	0.01	0.06
age-80	0.77	0.48	0.61	0.32	4.8	49.7	0.22	0.48	0.03	0.14
average	**0.85**	**0.59**	**0.68**	**0.45**	**9.0**	**45.8**	**0.14**	**0.39**	**0.02**	**0.07**
LIVER (C22.0-1)										
age-50	0.39	0.1	0.24	0.05	32.7	94.6	0.6	0.9	-	-
age-60	0.38	0.07	0.19	0.05	23.9	93.9	0.61	0.92	-	0.01
age-70	0.41	0.10	0.24	0.08	15.2	89.6	0.58	0.89	0.01	0.02
age-80	0.28	0.04	0.15	0.03	8.7	89.8	0.7	0.92	0.02	0.04
average	**0.37**	**0.1**	**0.23**	**0.08**	**18.8**	**89.5**	**0.62**	**0.88**	**0.01**	**0.02**
PANCREAS (C25)										
age-50	0.60	0.22	0.37	0.19	28.4	82.1	0.4	0.78	-	-
age-60	0.39	0.1	0.25	0.08	22.9	89.7	0.61	0.9	-	0.01
age-70	0.26	0.05	0.18	0.04	15.8	92.9	0.73	0.94	0.01	0.01
age-80	0.19	0.04	0.19	0.02	8.9	91.8	0.8	0.94	0.02	0.03
average	**0.26**	**0.07**	**0.27**	**0.05**	**13.6**	**90.6**	**0.73**	**0.91**	**0.01**	**0.02**
LUNG (C34)										
age-50	0.64	0.29	0.46	0.23	26.1	75.5	0.36	0.7	-	0.01
age-60	0.56	0.20	0.37	0.15	20.9	81.9	0.44	0.79	-	0.01
age-70	0.49	0.16	0.32	0.12	14.2	83.8	0.51	0.83	0.01	0.02
age-80	0.36	0.10	0.27	0.07	8.2	84.5	0.62	0.87	0.02	0.05
average	**0.46**	**0.16**	**0.32**	**0.12**	**14.5**	**82.9**	**0.53**	**0.82**	**0.01**	**0.03**
OVARY (C48.1-2, C56, C57.0)										
age-50	0.88	0.51	0.58	0.37	21.0	60.8	0.11	0.49	-	0.01
age-60	0.83	0.37	0.44	0.24	18.2	71.3	0.17	0.62	-	0.02
age-70	0.70	0.23	0.33	0.13	12.9	76.2	0.29	0.75	0.01	0.03
age-80	0.43	0.12	0.28	0.06	7.8	80.7	0.55	0.84	0.02	0.06
average	**0.69**	**0.31**	**0.42**	**0.21**	**14.5**	**71.6**	**0.3**	**0.67**	**0.01**	**0.03**

Key: RS-1yr/5yr=relative survival at 1 and 5 years expressed as a probability (0-1.0)