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Supporting Information

Supplementary material

This appendix was part of the submitted manuscript and has been peer reviewed. It is posted as supplied by the authors.

Appendix to: Bainomugisa CK, Cameron J, Dasgupta P, Baade P. The number of cancer-related deaths that could be attributable to spatial disparities in survival in Australia, 2010−2019: a retrospective population-based cohort study. *Med J Aust* 2025; doi: 10.5694/mja2.70102.

Supplementary methods

1. Types of cancer included

Spatial modelling was carried out for 27 types of cancer along with all cancers combined. Analyses of the attributable deaths was restricted to the 20 types of cancer that had evidence of spatial variation (based on the Maximised Excess Events Test described below).[1,2] From these analyses, all invasive cancers combined, rare cancers and the five cancer types with the highest mortality rates[3] were selected for further analysis and discussion: bowel, female breast, lung, pancreatic and prostate. Rare cancers were classified by International classification of diseases for oncology – 3rd edition (ICD-O-3) topography and morphology codes and included all invasive neoplasms with a crude annual incidence rate of less than 6 cases per 100,000 Australians.[4]

The types of cancer modelled are shown in the table below, along with the corresponding ICD-O-3 codes. Evidence of spatial variation is shown in terms of p-values from the Maximised Excess Events Test (MEET). P-values less than 0.05 were considered to indicate evidence of spatial variation in survival rates. The age-standardised mortality rates (AMRs, per 100,000 person-years), based on the 2021 Australian standard population age distribution were obtained from the Australian Institute of Health and Welfare.[3]

Table 1. Cancer types assessed for possible inclusion in the study along with the p-value from the Maximised Excess Events Test (MEET, one significant figure) for assessing evidence of spatial variation in survival and the age-standardised mortality rate (AMR) used to select the types of cancer to be included in the text

Type of cancer	ICD-10 codes	Sex	AMR	MEET p
All malignant cancers combined	C00–C96, D45, D46, D47.1, D47.3–D47.5	Persons	218.15	0.001
Lung cancer	C33–C34	Persons	40.49	0.001
Prostate cancer	C61	Males	38.59	0.001
Breast cancer	C50	Females	25.51	0.02
Colorectal cancer	C18–C20	Persons	25.45*	0.01
Pancreatic cancer	C25	Persons	13.23	0.001
Leukaemia	C91–C95	Persons	8.54[∞]	0.001
Ovarian cancer	C56	Females	8.51	> 0.999
Liver cancer	C22	Persons	8.28	0.001
Non-Hodgkin lymphoma	C82–C86	Persons	7.22	0.005
Melanoma of the skin	C43	Persons	6.99	0.001
Brain cancer	C71	Persons	6.27	0.02
Oesophageal cancer	C15	Persons	6.12	0.01
Stomach cancer	C16	Persons	5.53	0.001
Bladder cancer	C67	Persons	5.13	> 0.999
Head and neck cancer	C00–C14, C30–C32	Persons	5.09	0.003
Kidney cancer	C64	Persons	4.45	0.002
Multiple myeloma	C90	Persons	4.39[$]	0.2
Uterine cancer	C54–C55	Females	4.26	> 0.999
Mesothelioma	C45	Persons	3.33	> 0.999

Oral cancer	C00–C10	Persons	2.96	0.03
Cervical cancer	C53	Females	2.01	> 0.999
Myeloproliferative neoplasms	ICD-O-3 histology codes: 9950, 9960–9962	Persons	1.47^	0.2
Vulvar cancer	C51	Females	0.75	> 0.999
Rare cancers	All malignant neoplasms with an incidence rate of <6 cases per 100,000 Australians (except basal and squamous carcinomas of skin)[5]	Persons	N/A	0.001
Rare blood cancers	Haematological malignancies meeting the criteria for a rare cancer, including lymphoid malignancies, myelodysplastic syndromes, myeloproliferative neoplasms, myelodysplastic neoplasms, myeloid or lymphoid neoplasms with eosinophilia and specific growth factor abnormalities, acute myeloid leukaemia and related neoplasms[5]	Persons	N/A	0.001
Neuroendocrine tumours	ICD-O-3 histology codes: 8013, 8040–8045, 8150–8156, 8158, 8240–8249, 8345–8347, 8680–8683, 8690–8693, 8700, 9091 for all topography codes or 8510 for topography C73	Persons	N/A	0.001
Soft tissue sarcomas	RARECAREnet project definition and Cancer data in Australia definition of soft tissue sarcoma[6] (Table 5 and 6)	Persons	N/A	0.001

N/A: not available.

ICD-O-3: International classification of diseases for oncology – 3rd edition.

ICD-10: International classification of diseases – 10th edition.

AMR: Age-standardised mortality rates, obtained from the Australian Institute of Health and Welfare.[3]

MEET: Maximised Excess Events Test. P-values provided to 1 significant figure.

† Age-standardised mortality rate includes C97, while spatial modelling does not

***** Age-standardised mortality rate includes diagnoses of C26.0, while spatial modelling does not.

∞ Age-standardised mortality rate excludes C94.1.

$ Age-standardised mortality rate based on code C90.0 only.

^ Age-standardised mortality rate based on codes C92.1, C94.1, D45, D47.1, D47.3–D47.5.

2. Population mortality data

Population mortality estimates by sex, year, single-year age groups and area were generated using published population data[7] and death counts obtained from the registries of births, deaths and marriages.[8] Probability of death estimates were smoothed using flexible multivariable Poisson models with groups of neighbouring areas combined to give more stable estimates.[2]

Spatial modelling

The Bayesian spatial survival model is described in Equation 1:[9]

$$d_{ktis} \sim Poisson(\mu_{ktis}+d^*_{ktis})$$

$$\log(\mu_{ktis}) = \log(y_{ktis}) + \alpha_t + \beta_k + \zeta_s + R_i \qquad [1]$$

where d_{ktis} was the observed deaths in the k^{th} age group, t^{th} year since diagnosis, for sex s and the i^{th} area; μ_{kti} was the modelled cancer-related deaths; d^*_{kti} was the expected number of deaths due to non-cancer causes based on the population mortality and y_{ktis} was the person-time at risk. The model included an intercept for each year since diagnosis (α_t) and effects for age group (β_k, where the age groups were 15−54, 55−64, 65−74, 75−89), sex (ζ_s), and a spatial random effect (R_i). The spatial random effects had a Leroux[10] or BYM2[11] (rare cancers only) conditional autoregressive prior that incorporated both spatial and random area-level variation. The excess hazard ratio (EHR) for area i was calculated as $\exp(R_i)$ and the survival ratio (SR_i) was the inverse of the EHR.

$$SR_i = \frac{1}{EHR_i} = \exp(-R_i)$$

For rare cancers and all invasive cancers, a 'survival group' effect was added to Equation 1 to ensure the model was adjusted for differences in survival between different types of cancer. Cancer types were grouped according to their relative survival rates calculated nationally.

Models were fitted using Markov chain Monte Carlo (MCMC) simulations, with a burn-in period of 50,000 iterations followed by 100,000 iterations with every 10$^{\text{th}}$ iteration kept. Tango's Maximized Excess Events Test[1] was used to test for evidence of spatial variation across Australia by comparing the modelled number of cancer-related deaths with the number of deaths that would be expected in the absence of spatial variation, based on the age and sex distribution of the cancer cohort.

Modelled number of cancer-related deaths

The modelled number of cancer-related deaths within five years of diagnosis for each area was estimated as per Equation 2, using the parameters estimated by the spatial model and the observed person-time at risk (y_{ktis}).

$$\hat{\mu}_i = \sum_{t=1}^{5}\sum_{k=1}^{4}\sum_{s=1}^{2} y_{ktis}\, exp(\alpha_t + \beta_k + \zeta_s + R_i) \qquad [2]$$

Benchmark number of cancer-related deaths

To estimate the benchmark number of cancer-related deaths for area i, we calculated the number of deaths that would be observed within five years of diagnosis if the area met the benchmark. This was calculated separately for each age group, sex and follow-up interval:

$$\hat{\mu}_{B,i} = \sum_{t=1}^{5}\sum_{k=1}^{4}\sum_{s=1}^{2} y_{ktis} \exp\left(\alpha_t + \beta_k + \zeta_s + R_B\right) \qquad [3]$$

where R_B was $R_{AB} = 0$ for the 'average' benchmark or $R_{OB} = Q_{20}(R_i)$ for the optimal benchmark. Other parameters are as described in Equation 1.

The number of attributable deaths due to spatial inequalities was defined as the total number of deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark, i.e.:

$$\hat{\mu}_{avoidable,i} = \begin{cases} 0 & if\ R_i \leq R_B \\ \hat{\mu}_i - \hat{\mu}_{B,i} & if\ R_i > R_B \end{cases} \qquad [4]$$

The number of attributable deaths was then aggregated over each category of remoteness or area disadvantage:

$$\hat{\mu}_{avoidable,r} = \sum_{i \in I_r} \hat{\mu}_{avoidable,i}$$

where $\hat{\mu}_{avoidable,r}$ was the number of attributable deaths for category r and I_r was the set of areas within that category. $\hat{\mu}_{avoidable,r}$ was calculated for each MCMC iteration and the median and 2.5th and 97.5th centiles of the MCMC samples were taken to obtain the point estimate and 95% credible intervals. The proportion of attributable cancer-related deaths was finally estimated by dividing $\hat{\mu}_{avoidable,r}$ by the modelled cancer-related deaths ($\hat{\mu}_r = \sum_{i \in I_r} \hat{\mu}_i$).

Attributable proportions

For each area, the proportion of cancer-related deaths that were attributable to spatial disparities ($\hat{p}_i$) was calculated as the ratio of the attributable deaths ($\hat{\mu}_{avoidable,i}$) to the total cancer-related deaths ($\hat{\mu}_i$):

$$\hat{p}_i = \frac{\hat{\mu}_{avoidable,i}}{\hat{\mu}_i}$$

By substituting Equations 2–4 into the above and simplifying, we get:

$$\hat{p}_i = \begin{cases} 0 & if\ R_i \leq R_B \\ \dfrac{\exp(R_i) - \exp(R_B)}{\exp(R_i)} & if\ R_i > R_B \end{cases}$$

The proportions can therefore be calculated even for areas without observations ($\sum_{t=1}^{5}\sum_{k=1}^{4}\sum_{s=1}^{2} y_{ktis} = 0$). The proportions were mapped as percentages. Using a continuous colour palette, areas where 0% of cancer-related deaths were attributable to survival disparities were coloured yellow, while areas where more than 50% of attributable cancer-related deaths were coloured dark blue.

Note that these ‘attributable proportions’ are analogous to population attributable fractions (PAFs), which is defined as follows, where O is the observed number of cancer-related deaths and E is the expected number of cancer-related deaths that would occur in the absence of exposure to the specified risk factor.[12]

$$PAF = \frac{O - E}{O}$$

In the context of spatial disparities in survival, the population at risk is people who had a diagnosis of cancer no more than 5 years previously, the ‘exposure’ is living in an area that does not meet the survival benchmark, the comparator is the benchmark and the outcome is a cancer-related death.

Supplementary results

Table 2. Number and percentage of areas where survival at least met the optimal benchmark or did not meet the benchmark, by remoteness and by area-level disadvantage categories

Characteristic	Total	Number of areas that at least met the optimal benchmark	Number of areas (suboptimal)
Remoteness			
Major city	1328	459 (34.6%)	869 (65.4%)
Inner regional	494	21 (4.3%)	473 (95.7%)
Outer regional	321	3 (0.9%)	318 (99.1%)
Remote	95	0 (0%)	95 (100%)
Area-level disadvantage			
Least disadvantaged	437	285 (65.2%)	152 (34.8%)
Less disadvantaged	436	130 (29.8%)	306 (70.2%)
Middle	435	46 (10.6%)	389 (89.4%)
More disadvantaged	437	10 (2.3%)	427 (97.7%)
Most disadvantaged	435	5 (1.1%)	430 (98.9%)

Remoteness was measured using the 2016 Remoteness Areas classification[13] with remote and very remote areas combined.

Area disadvantage was measured as the quintiles of the 2016 Index of Relative Socio-economic Disadvantage.[14]

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

Table 3. Cancer-related deaths attributable to geographic differences in survival for types of cancer with lower mortality rates, by remoteness category

			Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Remoteness level**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Brain cancer	Major city	7423 (7260, 7582)	380 (255, 509)	5.1%	154 (67, 253)	2.1%
Brain cancer	Inner regional	2290 (2220, 2365)	182 (123, 252)	7.9%	90 (40, 150)	4.0%
Brain cancer	Outer regional	889 (854, 929)	83 (53, 121)	9.3%	43 (16, 76)	4.8%
Brain cancer	Remote	144 (133, 156)	13 (4, 25)	9.2%	6 (0, 17)	4.3%
Head and neck cancers	Major city	6639 (6493, 6784)	768 (645, 891)	11.6%	322 (218, 435)	4.9%
Head and neck cancers	Inner regional	2533 (2463, 2609)	444 (371, 519)	17.5%	221 (161, 272)	8.7%
Head and neck cancers	Outer regional	1426 (1360, 1487)	345 (292, 409)	24.2%	209 (157, 271)	14.7%
Head and neck cancers	Remote	370 (347, 395)	162 (143, 190)	43.8%	134 (115, 164)	36.2%
Kidney cancer	Major city	3415 (3296, 3540)	282 (171, 396)	8.3%	117 (41, 199)	3.4%
Kidney cancer	Inner regional	1203 (1145, 1264)	180 (123, 245)	14.9%	107 (55, 167)	8.9%
Kidney cancer	Outer regional	537 (505, 574)	88 (56, 126)	16.4%	51 (21, 85)	9.5%
Kidney cancer	Remote	82 (73, 92)	16 (7, 27)	19.4%	10 (2, 21)	12.4%
Leukaemia	Major city	6527 (6363, 6693)	578 (394, 775)	8.9%	255 (113, 380)	3.9%
Leukaemia	Inner regional	2132 (2059, 2208)	237 (160, 325)	11.1%	106 (40, 175)	5.0%
Leukaemia	Outer regional	970 (925, 1020)	135 (88, 185)	13.9%	75 (27, 122)	7.8%
Leukaemia	Remote	136 (123, 151)	26 (14, 42)	19.4%	16 (4, 31)	11.7%
Liver cancer	Major city	8501 (8318, 8698)	548 (350, 734)	6.4%	171 (89, 257)	2.0%
Liver cancer	Inner regional	2206 (2128, 2287)	417 (333, 509)	18.9%	216 (139, 301)	9.8%
Liver cancer	Outer regional	1131 (1073, 1191)	249 (193, 312)	22.0%	146 (93, 207)	12.9%
Liver cancer	Remote	265 (242, 291)	72 (49, 99)	27.3%	48 (25, 75)	18.3%
Melanoma	Major city	4368 (4189, 4546)	560 (400, 728)	12.8%	264 (144, 379)	6.0%
Melanoma	Inner regional	1780 (1690, 1873)	292 (210, 377)	16.4%	152 (83, 221)	8.6%
Melanoma	Outer regional	753 (703, 809)	125 (80, 179)	16.6%	60 (27, 100)	7.9%
Melanoma	Remote	97 (85, 111)	17 (6, 31)	17.5%	7 (0, 19)	7.2%
Neuroendocrine tumours	Major city	11208 (10995, 11419)	336 (177, 476)	3.0%	127 (34, 226)	1.1%

			Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Remoteness level**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Neuroendocrine tumours	Inner regional	3927 (3832, 4029)	233 (154, 330)	5.9%	120 (53, 205)	3.1%
Neuroendocrine tumours	Outer regional	1801 (1744, 1869)	136 (86, 203)	7.6%	76 (29, 139)	4.2%
Neuroendocrine tumours	Remote	301 (285, 319)	23 (9, 41)	7.7%	13 (0, 30)	4.3%
Non-Hodgkin lymphoma	Major city	6218 (6051, 6382)	426 (291, 577)	6.8%	186 (81, 311)	3.0%
Non-Hodgkin lymphoma	Inner regional	1985 (1912, 2061)	221 (154, 306)	11.1%	112 (51, 189)	5.6%
Non-Hodgkin lymphoma	Outer regional	829 (791, 873)	102 (68, 148)	12.3%	53 (20, 97)	6.4%
Non-Hodgkin lymphoma	Remote	104 (96, 115)	14 (6, 24)	13.3%	7 (0, 17)	6.7%
Oesophageal cancer	Major city	5446 (5304, 5592)	258 (166, 375)	4.7%	110 (34, 198)	2.0%
Oesophageal cancer	Inner regional	2209 (2137, 2285)	198 (130, 284)	8.9%	104 (35, 182)	4.7%
Oesophageal cancer	Outer regional	1023 (981, 1069)	99 (60, 150)	9.7%	52 (14, 98)	5.0%
Oesophageal cancer	Remote	161 (149, 176)	19 (8, 34)	11.9%	11 (0, 26)	6.9%
Oral cancers	Major city	4204 (4067, 4340)	457 (287, 611)	10.9%	190 (80, 293)	4.5%
Oral cancers	Inner regional	1582 (1514, 1652)	247 (164, 330)	15.6%	114 (51, 179)	7.2%
Oral cancers	Outer regional	869 (819, 922)	195 (142, 256)	22.5%	113 (64, 168)	13.0%
Oral cancers	Remote	225 (199, 253)	92 (66, 122)	41.2%	76 (49, 105)	33.6%
Rare blood cancers	Major city	14826 (14579, 15077)	1239 (943, 1446)	8.4%	475 (266, 618)	3.2%
Rare blood cancers	Inner regional	4768 (4654, 4881)	593 (482, 722)	12.4%	273 (194, 383)	5.7%
Rare blood cancers	Outer regional	2160 (2085, 2241)	290 (233, 354)	13.4%	138 (88, 196)	6.4%
Rare blood cancers	Remote	286 (269, 305)	56 (39, 74)	19.7%	34 (16, 51)	11.8%
Soft tissue sarcomas	Major city	3007 (2904, 3114)	281 (217, 352)	9.4%	150 (90, 216)	5.0%
Soft tissue sarcomas	Inner regional	911 (869, 954)	96 (69, 129)	10.5%	56 (32, 85)	6.2%
Soft tissue sarcomas	Outer regional	423 (400, 448)	45 (28, 65)	10.7%	24 (10, 40)	5.6%
Soft tissue sarcomas	Remote	60 (55, 67)	5 (1, 10)	9.0%	2 (0, 7)	4.1%
Stomach cancer	Major city	7774 (7599, 7954)	539 (358, 719)	6.9%	187 (73, 310)	2.4%
Stomach cancer	Inner regional	2289 (2210, 2371)	304 (221, 401)	13.3%	159 (80, 247)	6.9%
Stomach cancer	Outer regional	981 (937, 1027)	143 (101, 195)	14.6%	73 (36, 117)	7.5%
Stomach cancer	Remote	150 (139, 164)	25 (14, 39)	16.7%	14 (4, 27)	9.2%

CrI = credible interval.

Remoteness was measured using the 2016 Remoteness Areas classification with remote and very remote areas combined.[13]

Modelled cancer-related deaths were the numbers of cancer-related deaths estimated from Bayesian spatial models.

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

Average benchmark survival ratio was 1, which is the model baseline and is equivalent to the national average.

The number of attributable deaths was calculated as the difference between the modelled number of cancer-related deaths and the number of deaths expected if all areas met the benchmark.

Cancer types were defined by the International classification of diseases for oncology – 3rd edition (ICD-O-3) codes (Supporting Information, part 1).

Table 4. Cancer-related deaths attributable to geographic differences in survival for types of cancer with lower mortality rates, by remoteness category: sex-specific models

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Remoteness level**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
All cancers	Females	Major city	84219 (83599, 84852)	5892 (4593, 7090)	7.0%	1781 (1105, 2413)	2.1%
All cancers	Females	Inner regional	27994 (27671, 28321)	4121 (3525, 4703)	14.7%	1868 (1351, 2372)	6.7%
All cancers	Females	Outer regional	12321 (12117, 12537)	2345 (2050, 2644)	19.0%	1310 (1021, 1604)	10.6%
All cancers	Females	Remote	1882 (1808, 1957)	510 (432, 590)	27.1%	362 (284, 443)	19.3%
All cancers	Males	Major city	103461 (102792, 104150)	8220 (6796, 9907)	7.9%	2666 (1934, 3589)	2.6%
All cancers	Males	Inner regional	37011 (36610, 37411)	6015 (5135, 6724)	16.3%	2840 (2073, 3481)	7.7%
All cancers	Males	Outer regional	18477 (18217, 18736)	3818 (3289, 4268)	20.7%	2154 (1638, 2593)	11.7%
All cancers	Males	Remote	3170 (3073, 3267)	883 (777, 1015)	27.9%	623 (515, 760)	19.7%
Head and neck cancers	Males	Major city	4984 (4836, 5130)	490 (304, 673)	9.8%	183 (69, 299)	3.7%
Head and neck cancers	Males	Inner regional	1970 (1894, 2048)	313 (216, 418)	15.9%	137 (61, 218)	6.9%
Head and neck cancers	Males	Outer regional	1155 (1097, 1217)	281 (214, 356)	24.3%	173 (108, 248)	15.0%
Head and neck cancers	Males	Remote	293 (264, 326)	122 (91, 156)	41.4%	98 (67, 134)	33.5%
Leukaemia	Females	Major city	2731 (2633, 2832)	310 (211, 412)	11.4%	146 (74, 226)	5.3%
Leukaemia	Females	Inner regional	830 (787, 876)	108 (69, 152)	13.0%	53 (21, 88)	6.3%
Leukaemia	Females	Outer regional	357 (333, 384)	53 (33, 78)	14.9%	29 (12, 51)	8.3%
Leukaemia	Females	Remote	47 (40, 55)	10 (3, 18)	20.4%	6 (1, 13)	12.4%
Leukaemia	Males	Major city	3812 (3690, 3933)	320 (216, 432)	8.4%	136 (53, 224)	3.6%
Leukaemia	Males	Inner regional	1299 (1245, 1355)	144 (94, 202)	11.1%	67 (25, 117)	5.2%
Leukaemia	Males	Outer regional	610 (578, 647)	79 (49, 114)	13.0%	41 (14, 73)	6.8%
Leukaemia	Males	Remote	85 (77, 96)	13 (5, 24)	15.8%	7 (0, 17)	8.4%
Liver cancer	Males	Major city	6158 (5995, 6322)	431 (284, 581)	7.0%	129 (61, 202)	2.1%
Liver cancer	Males	Inner regional	1641 (1573, 1713)	335 (264, 415)	20.4%	176 (109, 249)	10.7%
Liver cancer	Males	Outer regional	850 (806, 898)	191 (145, 242)	22.4%	106 (62, 156)	12.5%
Liver cancer	Males	Remote	192 (174, 212)	47 (29, 68)	24.5%	28 (10, 48)	14.6%
Lung cancer	Females	Major city	19118 (18837, 19401)	1215 (859, 1553)	6.4%	411 (210, 609)	2.1%
Lung cancer	Females	Inner regional	6473 (6333, 6618)	908 (724, 1098)	14.0%	444 (290, 603)	6.9%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Remoteness level**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Lung cancer	Females	Outer regional	2892 (2800, 2983)	502 (400, 609)	17.4%	293 (198, 393)	10.1%
Lung cancer	Females	Remote	425 (400, 453)	85 (59, 114)	20.0%	54 (30, 82)	12.7%
Lung cancer	Males	Major city	26817 (26475, 27169)	1430 (1030, 1797)	5.3%	435 (232, 633)	1.6%
Lung cancer	Males	Inner regional	9607 (9435, 9787)	1243 (1027, 1477)	12.9%	581 (393, 789)	6.0%
Lung cancer	Males	Outer regional	5000 (4873, 5128)	802 (665, 956)	16.0%	454 (318, 602)	9.1%
Lung cancer	Males	Remote	832 (793, 874)	165 (126, 208)	19.9%	109 (70, 151)	13.1%
Melanoma	Males	Major city	3080 (2935, 3227)	354 (237, 481)	11.5%	169 (69, 274)	5.5%
Melanoma	Males	Inner regional	1247 (1175, 1325)	194 (128, 268)	15.5%	97 (39, 160)	7.8%
Melanoma	Males	Outer regional	537 (496, 579)	80 (48, 121)	14.9%	39 (13, 71)	7.3%
Melanoma	Males	Remote	69 (60, 79)	11 (4, 20)	15.9%	5 (0, 12)	7.0%
Neuroendocrine tumours	Females	Major city	4554 (4431, 4678)	146 (81, 222)	3.2%	73 (19, 137)	1.6%
Neuroendocrine tumours	Females	Inner regional	1612 (1560, 1671)	78 (41, 128)	4.8%	46 (12, 89)	2.8%
Neuroendocrine tumours	Females	Outer regional	669 (644, 699)	31 (13, 57)	4.6%	17 (2, 39)	2.5%
Neuroendocrine tumours	Females	Remote	113 (106, 122)	6 (0, 13)	4.9%	3 (0, 10)	2.6%
Neuroendocrine tumours	Males	Major city	6693 (6529, 6856)	219 (116, 322)	3.3%	89 (23, 168)	1.3%
Neuroendocrine tumours	Males	Inner regional	2293 (2224, 2371)	133 (80, 206)	5.8%	69 (22, 130)	3.0%
Neuroendocrine tumours	Males	Outer regional	1113 (1069, 1169)	89 (50, 140)	8.0%	52 (16, 101)	4.7%
Neuroendocrine tumours	Males	Remote	185 (174, 200)	14 (4, 27)	7.5%	8 (0, 20)	4.1%
Pancreatic cancer	Males	Major city	7663 (7492, 7835)	545 (375, 712)	7.1%	209 (105, 315)	2.7%
Pancreatic cancer	Males	Inner regional	2378 (2304, 2461)	274 (197, 362)	11.5%	134 (79, 197)	5.6%
Pancreatic cancer	Males	Outer regional	1120 (1069, 1179)	178 (128, 238)	15.9%	102 (54, 157)	9.1%
Pancreatic cancer	Males	Remote	161 (147, 177)	27 (14, 42)	16.5%	15 (4, 29)	9.5%
Rare blood cancers	Females	Major city	5767 (5618, 5920)	447 (294, 603)	7.8%	184 (86, 289)	3.2%
Rare blood cancers	Females	Inner regional	1750 (1684, 1820)	197 (135, 266)	11.2%	102 (50, 159)	5.8%
Rare blood cancers	Females	Outer regional	734 (697, 775)	89 (59, 126)	12.2%	48 (21, 80)	6.5%
Rare blood cancers	Females	Remote	89 (80, 100)	15 (7, 26)	17.1%	9 (1, 19)	10.0%
Rare blood cancers	Males	Major city	9106 (8916, 9300)	715 (522, 907)	7.8%	302 (176, 445)	3.3%
Rare blood cancers	Males	Inner regional	3000 (2910, 3094)	350 (255, 454)	11.7%	169 (94, 257)	5.6%
Rare blood cancers	Males	Outer regional	1414 (1359, 1474)	169 (116, 228)	12.0%	80 (38, 127)	5.6%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Remoteness level**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Rare blood cancers	Males	Remote	190 (176, 207)	33 (18, 49)	17.1%	18 (5, 35)	9.7%
Rare cancers	Females	Major city	25135 (24810, 25463)	1380 (967, 1795)	5.5%	484 (232, 745)	1.9%
Rare cancers	Females	Inner regional	8157 (8004, 8315)	789 (606, 985)	9.7%	372 (217, 537)	4.6%
Rare cancers	Females	Outer regional	3565 (3468, 3663)	432 (327, 542)	12.1%	231 (138, 329)	6.5%
Rare cancers	Females	Remote	534 (502, 569)	109 (77, 144)	20.4%	78 (46, 113)	14.7%
Rare cancers	Males	Major city	35936 (35548, 36322)	2393 (1671, 3013)	6.7%	766 (358, 1142)	2.1%
Rare cancers	Males	Inner regional	12560 (12366, 12764)	1510 (1164, 1830)	12.0%	640 (373, 902)	5.1%
Rare cancers	Males	Outer regional	6221 (6088, 6357)	972 (791, 1156)	15.6%	524 (365, 688)	8.4%
Rare cancers	Males	Remote	1075 (1025, 1130)	262 (209, 321)	24.4%	189 (135, 248)	17.6%
Soft tissue sarcomas	Females	Major city	1406 (1338, 1475)	104 (62, 159)	7.4%	58 (20, 107)	4.1%
Soft tissue sarcomas	Females	Inner regional	405 (381, 431)	34 (17, 56)	8.4%	20 (6, 40)	5.0%
Soft tissue sarcomas	Females	Outer regional	196 (182, 210)	15 (6, 28)	7.8%	8 (1, 18)	4.1%
Soft tissue sarcomas	Females	Remote	31 (27, 35)	2 (0, 5)	6.3%	1 (0, 3)	2.7%
Soft tissue sarcomas	Males	Major city	1597 (1522, 1674)	111 (59, 163)	7.0%	61 (12, 103)	3.8%
Soft tissue sarcomas	Males	Inner regional	504 (474, 537)	40 (21, 62)	8.0%	23 (5, 42)	4.6%
Soft tissue sarcomas	Males	Outer regional	229 (214, 246)	20 (9, 33)	8.8%	11 (2, 22)	4.9%
Soft tissue sarcomas	Males	Remote	30 (26, 34)	2 (0, 5)	7.5%	1 (0, 4)	3.9%
Stomach cancer	Females	Major city	2663 (2563, 2762)	258 (177, 343)	9.7%	109 (48, 179)	4.1%
Stomach cancer	Females	Inner regional	656 (620, 697)	97 (65, 136)	14.7%	53 (25, 88)	8.1%
Stomach cancer	Females	Outer regional	272 (252, 294)	42 (25, 63)	15.3%	21 (7, 40)	7.8%
Stomach cancer	Females	Remote	42 (37, 48)	7 (2, 13)	17.2%	4 (0, 10)	8.9%
Stomach cancer	Males	Major city	5156 (5016, 5298)	264 (150, 380)	5.1%	99 (32, 175)	1.9%
Stomach cancer	Males	Inner regional	1607 (1547, 1673)	170 (112, 239)	10.5%	85 (34, 147)	5.3%
Stomach cancer	Males	Outer regional	691 (658, 729)	80 (49, 118)	11.6%	43 (15, 77)	6.2%
Stomach cancer	Males	Remote	104 (96, 115)	13 (6, 23)	12.7%	7 (1, 17)	6.9%

CrI = credible interval.

Remoteness was measured using the 2016 Remoteness Areas classification with remote and very remote areas combined.[13]

Modelled cancer-related deaths were the numbers of cancer-related deaths estimated from Bayesian spatial models.

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

Average benchmark survival ratio was 1, which is the model baseline and is equivalent to the national average.

The number of attributable deaths was calculated as the difference between the modelled number of cancer-related deaths and the number of deaths expected if all areas met the benchmark.

Cancer types were defined by the International classification of diseases for oncology – 3rd edition (ICD-O-3) codes (Supporting Information, part 1).

Table 5. Cancer-related deaths attributable to geographic differences in survival for types of cancer with lower mortality rates, by area-level socio-economic status category

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Brain cancer	Persons	Least disadvantaged	2346 (2268, 2425)	71 (37, 108)	3.0%	26 (5, 53)	1.1%
Brain cancer	Persons	Less disadvantaged	2169 (2114, 2222)	120 (80, 165)	5.5%	49 (20, 83)	2.3%
Brain cancer	Persons	Middle	2233 (2179, 2290)	154 (107, 210)	6.9%	66 (27, 110)	2.9%
Brain cancer	Persons	More disadvantaged	2154 (2099, 2210)	149 (102, 204)	6.9%	66 (28, 109)	3.1%
Brain cancer	Persons	Most disadvantaged	1842 (1789, 1899)	162 (113, 220)	8.8%	86 (40, 140)	4.7%
Head and neck cancers	Persons	Least disadvantaged	1698 (1649, 1751)	110 (86, 131)	6.5%	37 (23, 52)	2.2%
Head and neck cancers	Persons	Less disadvantaged	1809 (1755, 1865)	197 (160, 222)	10.9%	78 (55, 99)	4.3%
Head and neck cancers	Persons	Middle	2174 (2105, 2238)	311 (273, 358)	14.3%	143 (112, 192)	6.6%
Head and neck cancers	Persons	More disadvantaged	2549 (2480, 2612)	482 (409, 556)	18.9%	258 (194, 322)	10.1%
Head and neck cancers	Persons	Most disadvantaged	2731 (2652, 2839)	604 (529, 744)	22.1%	368 (288, 493)	13.5%
Kidney cancer	Persons	Least disadvantaged	886 (840, 932)	46 (18, 75)	5.2%	14 (0, 30)	1.5%
Kidney cancer	Persons	Less disadvantaged	954 (916, 992)	74 (42, 107)	7.8%	28 (7, 52)	3.0%
Kidney cancer	Persons	Middle	1074 (1033, 1116)	112 (74, 153)	10.4%	51 (22, 83)	4.7%
Kidney cancer	Persons	More disadvantaged	1201 (1153, 1250)	163 (113, 216)	13.5%	88 (43, 135)	7.3%
Kidney cancer	Persons	Most disadvantaged	1122 (1073, 1174)	172 (119, 231)	15.3%	104 (54, 159)	9.3%
Leukaemia	Persons	Least disadvantaged	1890 (1817, 1972)	107 (62, 155)	5.6%	41 (18, 66)	2.2%
Leukaemia	Persons	Less disadvantaged	1856 (1802, 1910)	156 (100, 217)	8.4%	63 (28, 96)	3.4%
Leukaemia	Persons	Middle	1958 (1904, 2012)	205 (145, 271)	10.5%	101 (48, 149)	5.2%
Leukaemia	Persons	More disadvantaged	2114 (2051, 2178)	260 (183, 344)	12.3%	125 (51, 194)	5.9%
Leukaemia	Persons	Most disadvantaged	1947 (1881, 2016)	249 (166, 335)	12.8%	123 (43, 193)	6.3%
Liver cancer	Persons	Least disadvantaged	2142 (2069, 2218)	86 (37, 135)	4.0%	20 (4, 37)	0.9%
Liver cancer	Persons	Less disadvantaged	2178 (2118, 2238)	136 (84, 188)	6.2%	39 (17, 62)	1.8%
Liver cancer	Persons	Middle	2334 (2275, 2395)	260 (190, 330)	11.2%	100 (58, 147)	4.3%
Liver cancer	Persons	More disadvantaged	2612 (2543, 2683)	387 (311, 471)	14.8%	200 (137, 272)	7.6%
Liver cancer	Persons	Most disadvantaged	2833 (2755, 2913)	416 (334, 506)	14.7%	222 (151, 301)	7.8%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Melanoma	Persons	Least disadvantaged	1391 (1315, 1467)	118 (65, 173)	8.5%	41 (13, 72)	3.0%
Melanoma	Persons	Less disadvantaged	1291 (1232, 1351)	160 (110, 217)	12.4%	71 (33, 114)	5.5%
Melanoma	Persons	Middle	1437 (1374, 1501)	204 (149, 267)	14.2%	100 (59, 147)	7.0%
Melanoma	Persons	More disadvantaged	1544 (1478, 1616)	264 (193, 339)	17.1%	133 (74, 195)	8.6%
Melanoma	Persons	Most disadvantaged	1333 (1266, 1405)	247 (181, 321)	18.5%	136 (83, 195)	10.2%
Neuroendocrine tumours	Persons	Least disadvantaged	2603 (2519, 2681)	37 (8, 63)	1.4%	10 (0, 25)	0.4%
Neuroendocrine tumours	Persons	Less disadvantaged	2839 (2780, 2898)	81 (38, 123)	2.8%	25 (4, 51)	0.9%
Neuroendocrine tumours	Persons	Middle	3459 (3391, 3526)	146 (93, 206)	4.2%	62 (22, 109)	1.8%
Neuroendocrine tumours	Persons	More disadvantaged	4162 (4080, 4248)	222 (155, 306)	5.3%	111 (51, 187)	2.7%
Neuroendocrine tumours	Persons	Most disadvantaged	4173 (4086, 4265)	240 (164, 332)	5.8%	128 (63, 210)	3.1%
Non-Hodgkin lymphoma	Persons	Least disadvantaged	1894 (1814, 1975)	71 (28, 112)	3.7%	19 (0, 43)	1.0%
Non-Hodgkin lymphoma	Persons	Less disadvantaged	1742 (1688, 1793)	107 (68, 150)	6.1%	42 (14, 74)	2.4%
Non-Hodgkin lymphoma	Persons	Middle	1822 (1770, 1875)	159 (111, 218)	8.7%	72 (30, 122)	3.9%
Non-Hodgkin lymphoma	Persons	More disadvantaged	1952 (1890, 2019)	221 (159, 301)	11.3%	115 (55, 188)	5.9%
Non-Hodgkin lymphoma	Persons	Most disadvantaged	1726 (1667, 1791)	205 (147, 280)	11.9%	112 (55, 183)	6.5%
Oesophageal cancer	Persons	Least disadvantaged	1519 (1465, 1572)	64 (26, 104)	4.2%	20 (0, 47)	1.3%
Oesophageal cancer	Persons	Less disadvantaged	1494 (1449, 1538)	62 (37, 93)	4.2%	25 (6, 49)	1.7%
Oesophageal cancer	Persons	Middle	1747 (1699, 1794)	90 (59, 133)	5.2%	39 (12, 75)	2.3%
Oesophageal cancer	Persons	More disadvantaged	2083 (2024, 2143)	177 (121, 250)	8.5%	94 (36, 158)	4.5%
Oesophageal cancer	Persons	Most disadvantaged	1997 (1936, 2062)	181 (121, 257)	9.1%	99 (38, 168)	4.9%
Oral cancers	Persons	Least disadvantaged	1137 (1079, 1195)	63 (28, 99)	5.6%	19 (3, 37)	1.7%
Oral cancers	Persons	Less disadvantaged	1185 (1141, 1229)	126 (75, 173)	10.6%	47 (17, 77)	4.0%
Oral cancers	Persons	Middle	1377 (1328, 1428)	183 (123, 245)	13.3%	81 (41, 122)	5.9%
Oral cancers	Persons	More disadvantaged	1574 (1516, 1632)	279 (204, 356)	17.7%	144 (80, 209)	9.2%
Oral cancers	Persons	Most disadvantaged	1605 (1541, 1673)	340 (251, 427)	21.2%	202 (123, 280)	12.6%
Rare blood cancers	Persons	Least disadvantaged	4372 (4267, 4484)	203 (136, 277)	4.6%	65 (23, 100)	1.5%
Rare blood cancers	Persons	Less disadvantaged	4163 (4083, 4243)	335 (258, 405)	8.1%	121 (67, 171)	2.9%
Rare blood cancers	Persons	Middle	4307 (4226, 4389)	448 (353, 525)	10.4%	179 (121, 242)	4.2%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Rare blood cancers	Persons	More disadvantaged	4797 (4701, 4888)	604 (500, 697)	12.6%	273 (188, 358)	5.7%
Rare blood cancers	Persons	Most disadvantaged	4399 (4302, 4493)	581 (460, 699)	13.2%	278 (177, 378)	6.3%
Soft tissue sarcomas	Persons	Least disadvantaged	960 (914, 1004)	74 (48, 104)	7.8%	38 (18, 62)	4.0%
Soft tissue sarcomas	Persons	Less disadvantaged	835 (800, 870)	68 (46, 92)	8.2%	32 (13, 54)	3.9%
Soft tissue sarcomas	Persons	Middle	853 (817, 890)	86 (61, 116)	10.1%	45 (22, 69)	5.3%
Soft tissue sarcomas	Persons	More disadvantaged	920 (880, 961)	105 (76, 138)	11.4%	63 (36, 90)	6.8%
Soft tissue sarcomas	Persons	Most disadvantaged	834 (797, 873)	93 (65, 123)	11.2%	53 (28, 83)	6.4%
Stomach cancer	Persons	Least disadvantaged	2075 (2005, 2147)	99 (48, 149)	4.8%	24 (0, 57)	1.2%
Stomach cancer	Persons	Less disadvantaged	2105 (2047, 2162)	129 (81, 178)	6.1%	40 (12, 72)	1.9%
Stomach cancer	Persons	Middle	2195 (2143, 2249)	203 (146, 266)	9.3%	85 (39, 135)	3.9%
Stomach cancer	Persons	More disadvantaged	2444 (2379, 2511)	296 (223, 381)	12.1%	146 (79, 222)	6.0%
Stomach cancer	Persons	Most disadvantaged	2375 (2308, 2446)	284 (208, 374)	12.0%	140 (74, 213)	5.9%

CrI = credible interval.

Area disadvantage was measured as the quintile of the 2016 Index of Relative Socio-economic Disadvantage.[14]

Modelled cancer-related deaths were the numbers of cancer-related deaths estimated from Bayesian spatial models.

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

Average benchmark survival ratio was 1, which is the model baseline and is equivalent to the national average.

The number of attributable deaths was calculated as the difference between the modelled number of cancer-related deaths and the number of deaths expected if all areas met the benchmark.

Cancer types were defined by the International classification of diseases for oncology – 3rd edition (ICD-O-3) codes (Supporting Information, part 1).

Table 6. Cancer-related deaths attributable to geographic differences in survival for types of cancer with lower mortality rates, by area-level socio-economic status category: sex-specific models

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
All cancers	Females	Least disadvantaged	22623 (22335, 22911)	417 (224, 590)	1.8%	54 (0, 107)	0.2%
All cancers	Females	Less disadvantaged	22586 (22349, 22824)	1182 (801, 1522)	5.2%	244 (124, 359)	1.1%
All cancers	Females	Middle	25098 (24852, 25343)	2543 (2049, 3006)	10.1%	857 (558, 1149)	3.4%
All cancers	Females	More disadvantaged	28243 (27965, 28525)	3988 (3399, 4542)	14.1%	1730 (1253, 2190)	6.1%
All cancers	Females	Most disadvantaged	27859 (27567, 28167)	4745 (4154, 5318)	17.0%	2435 (1883, 2972)	8.7%
All cancers	Males	Least disadvantaged	26459 (26115, 26767)	680 (446, 949)	2.6%	147 (61, 245)	0.6%
All cancers	Males	Less disadvantaged	28022 (27761, 28298)	1599 (1128, 2105)	5.7%	274 (125, 417)	1.0%
All cancers	Males	Middle	32056 (31755, 32361)	3295 (2716, 3873)	10.3%	1082 (721, 1450)	3.4%
All cancers	Males	More disadvantaged	37527 (37164, 37893)	5949 (5068, 6685)	15.9%	2747 (1975, 3354)	7.3%
All cancers	Males	Most disadvantaged	38041 (37643, 38401)	7462 (6589, 8363)	19.6%	4100 (3276, 4922)	10.8%
Head and neck cancers	Males	Least disadvantaged	1293 (1233, 1354)	76 (34, 117)	5.8%	21 (2, 42)	1.6%
Head and neck cancers	Males	Less disadvantaged	1364 (1316, 1411)	135 (82, 187)	9.9%	51 (21, 83)	3.7%
Head and neck cancers	Males	Middle	1672 (1619, 1727)	208 (142, 277)	12.4%	90 (45, 137)	5.4%
Head and neck cancers	Males	More disadvantaged	1963 (1902, 2028)	344 (254, 441)	17.5%	171 (95, 253)	8.7%
Head and neck cancers	Males	Most disadvantaged	2110 (2032, 2191)	443 (334, 560)	21.0%	260 (161, 364)	12.3%
Leukaemia	Females	Least disadvantaged	790 (748, 831)	72 (41, 106)	9.1%	30 (11, 53)	3.8%
Leukaemia	Females	Less disadvantaged	773 (740, 808)	85 (53, 119)	11.0%	36 (14, 61)	4.6%
Leukaemia	Females	Middle	793 (759, 828)	97 (66, 131)	12.2%	48 (23, 76)	6.0%
Leukaemia	Females	More disadvantaged	827 (790, 864)	103 (70, 139)	12.4%	51 (23, 81)	6.1%
Leukaemia	Females	Most disadvantaged	783 (745, 825)	124 (84, 168)	15.9%	69 (34, 109)	8.9%
Leukaemia	Males	Least disadvantaged	1119 (1065, 1176)	55 (28, 84)	4.9%	19 (5, 36)	1.7%
Leukaemia	Males	Less disadvantaged	1088 (1049, 1127)	86 (53, 121)	7.9%	34 (12, 58)	3.1%
Leukaemia	Males	Middle	1160 (1120, 1202)	116 (80, 158)	10.0%	53 (22, 88)	4.6%
Leukaemia	Males	More disadvantaged	1274 (1225, 1324)	159 (110, 215)	12.5%	78 (31, 127)	6.1%
Leukaemia	Males	Most disadvantaged	1164 (1121, 1211)	139 (94, 190)	12.0%	68 (25, 114)	5.8%
Liver cancer	Males	Least disadvantaged	1518 (1457, 1581)	71 (34, 110)	4.7%	16 (3, 32)	1.1%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Liver cancer	Males	Less disadvantaged	1572 (1524, 1622)	112 (70, 156)	7.1%	32 (14, 53)	2.0%
Liver cancer	Males	Middle	1712 (1664, 1762)	200 (145, 261)	11.7%	73 (38, 113)	4.3%
Liver cancer	Males	More disadvantaged	1936 (1879, 1996)	296 (233, 369)	15.3%	147 (92, 210)	7.6%
Liver cancer	Males	Most disadvantaged	2096 (2032, 2164)	322 (257, 397)	15.4%	169 (110, 234)	8.1%
Lung cancer	Females	Least disadvantaged	4659 (4542, 4775)	114 (53, 174)	2.4%	16 (0, 38)	0.3%
Lung cancer	Females	Less disadvantaged	4837 (4751, 4927)	276 (180, 371)	5.7%	79 (30, 129)	1.6%
Lung cancer	Females	Middle	5704 (5609, 5801)	524 (399, 653)	9.2%	212 (119, 307)	3.7%
Lung cancer	Females	More disadvantaged	6720 (6602, 6839)	811 (644, 983)	12.1%	376 (243, 514)	5.6%
Lung cancer	Females	Most disadvantaged	6985 (6857, 7117)	982 (795, 1171)	14.1%	519 (361, 677)	7.4%
Lung cancer	Males	Least disadvantaged	5856 (5730, 5987)	172 (95, 246)	2.9%	33 (3, 65)	0.6%
Lung cancer	Males	Less disadvantaged	6907 (6800, 7017)	322 (219, 423)	4.7%	86 (42, 132)	1.3%
Lung cancer	Males	Middle	8365 (8248, 8484)	656 (511, 804)	7.8%	246 (150, 346)	2.9%
Lung cancer	Males	More disadvantaged	10221 (10075, 10369)	1123 (927, 1331)	11.0%	509 (346, 683)	5.0%
Lung cancer	Males	Most disadvantaged	10906 (10744, 11077)	1363 (1142, 1594)	12.5%	704 (512, 904)	6.5%
Melanoma	Males	Least disadvantaged	1009 (941, 1075)	83 (43, 126)	8.2%	29 (6, 56)	2.9%
Melanoma	Males	Less disadvantaged	911 (863, 959)	106 (72, 147)	11.6%	50 (20, 87)	5.5%
Melanoma	Males	Middle	1009 (959, 1062)	128 (85, 176)	12.7%	60 (24, 99)	6.0%
Melanoma	Males	More disadvantaged	1076 (1019, 1135)	161 (106, 220)	14.9%	81 (32, 131)	7.6%
Melanoma	Males	Most disadvantaged	928 (873, 990)	161 (104, 224)	17.3%	88 (38, 141)	9.5%
Neuroendocrine tumours	Females	Least disadvantaged	1059 (1012, 1100)	21 (3, 38)	1.9%	7 (0, 18)	0.6%
Neuroendocrine tumours	Females	Less disadvantaged	1086 (1053, 1120)	35 (16, 58)	3.2%	16 (2, 35)	1.5%
Neuroendocrine tumours	Females	Middle	1434 (1391, 1476)	48 (25, 78)	3.4%	24 (3, 49)	1.6%
Neuroendocrine tumours	Females	More disadvantaged	1663 (1616, 1715)	73 (40, 115)	4.4%	40 (10, 77)	2.4%
Neuroendocrine tumours	Females	Most disadvantaged	1706 (1656, 1760)	83 (46, 131)	4.9%	51 (16, 95)	3.0%
Neuroendocrine tumours	Males	Least disadvantaged	1574 (1511, 1632)	29 (6, 51)	1.8%	9 (0, 22)	0.6%
Neuroendocrine tumours	Males	Less disadvantaged	1754 (1705, 1802)	52 (25, 83)	3.0%	17 (2, 37)	1.0%
Neuroendocrine tumours	Males	Middle	2027 (1978, 2080)	94 (58, 139)	4.6%	45 (15, 85)	2.2%
Neuroendocrine tumours	Males	More disadvantaged	2479 (2417, 2546)	134 (87, 197)	5.4%	70 (25, 127)	2.8%
Neuroendocrine tumours	Males	Most disadvantaged	2452 (2387, 2523)	145 (92, 212)	5.9%	76 (28, 137)	3.1%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Pancreatic cancer	Males	Least disadvantaged	2217 (2138, 2297)	85 (33, 135)	3.8%	15 (0, 38)	0.7%
Pancreatic cancer	Males	Less disadvantaged	2179 (2118, 2239)	142 (91, 198)	6.5%	49 (19, 82)	2.2%
Pancreatic cancer	Males	Middle	2247 (2187, 2306)	194 (135, 257)	8.6%	76 (37, 120)	3.4%
Pancreatic cancer	Males	More disadvantaged	2389 (2323, 2460)	297 (226, 376)	12.4%	156 (97, 221)	6.5%
Pancreatic cancer	Males	Most disadvantaged	2290 (2222, 2362)	304 (232, 385)	13.3%	163 (101, 232)	7.1%
Rare blood cancers	Females	Least disadvantaged	1694 (1629, 1762)	82 (36, 128)	4.9%	26 (4, 51)	1.6%
Rare blood cancers	Females	Less disadvantaged	1609 (1560, 1660)	125 (79, 175)	7.7%	50 (20, 84)	3.1%
Rare blood cancers	Females	Middle	1626 (1578, 1678)	151 (103, 205)	9.3%	69 (34, 108)	4.2%
Rare blood cancers	Females	More disadvantaged	1764 (1709, 1821)	191 (135, 254)	10.8%	95 (51, 146)	5.4%
Rare blood cancers	Females	Most disadvantaged	1646 (1591, 1706)	199 (141, 264)	12.1%	102 (51, 159)	6.2%
Rare blood cancers	Males	Least disadvantaged	2713 (2627, 2802)	127 (72, 181)	4.7%	47 (17, 78)	1.7%
Rare blood cancers	Males	Less disadvantaged	2567 (2503, 2630)	188 (130, 248)	7.3%	71 (34, 115)	2.8%
Rare blood cancers	Males	Middle	2675 (2611, 2740)	250 (183, 320)	9.4%	110 (62, 165)	4.1%
Rare blood cancers	Males	More disadvantaged	3016 (2940, 3097)	362 (276, 456)	12.0%	176 (105, 255)	5.8%
Rare blood cancers	Males	Most disadvantaged	2739 (2664, 2819)	338 (254, 429)	12.3%	166 (96, 246)	6.1%
Rare cancers	Females	Least disadvantaged	6890 (6748, 7039)	152 (69, 237)	2.2%	31 (2, 63)	0.5%
Rare cancers	Females	Less disadvantaged	6741 (6634, 6846)	325 (213, 439)	4.8%	100 (34, 168)	1.5%
Rare cancers	Females	Middle	7438 (7325, 7550)	551 (400, 706)	7.4%	207 (104, 316)	2.8%
Rare cancers	Females	More disadvantaged	8301 (8172, 8434)	808 (631, 997)	9.7%	376 (231, 533)	4.5%
Rare cancers	Females	Most disadvantaged	8014 (7883, 8156)	876 (692, 1074)	10.9%	451 (293, 623)	5.6%
Rare cancers	Males	Least disadvantaged	9670 (9497, 9844)	253 (127, 368)	2.6%	48 (5, 91)	0.5%
Rare cancers	Males	Less disadvantaged	9962 (9822, 10100)	588 (382, 773)	5.9%	154 (48, 258)	1.5%
Rare cancers	Males	Middle	11058 (10914, 11200)	981 (723, 1217)	8.9%	347 (188, 502)	3.1%
Rare cancers	Males	More disadvantaged	12750 (12584, 12923)	1578 (1250, 1884)	12.4%	699 (430, 960)	5.5%
Rare cancers	Males	Most disadvantaged	12344 (12157, 12536)	1737 (1406, 2056)	14.1%	870 (595, 1144)	7.0%
Soft tissue sarcomas	Females	Least disadvantaged	457 (429, 484)	31 (15, 53)	6.8%	16 (4, 34)	3.6%
Soft tissue sarcomas	Females	Less disadvantaged	389 (367, 411)	25 (13, 41)	6.4%	13 (3, 26)	3.2%
Soft tissue sarcomas	Females	Middle	386 (364, 408)	31 (17, 50)	7.9%	17 (5, 34)	4.4%
Soft tissue sarcomas	Females	More disadvantaged	419 (395, 443)	36 (20, 57)	8.5%	21 (7, 41)	5.0%

				Cancer deaths attributable to geographic differences in survival: optimal survival benchmark		Cancer deaths attributable to geographic differences in survival: average survival benchmark	
Cancer type	**Sex**	**Area disadvantage**	**Total modelled cancer-related deaths (95% CrI)**	**Number (95% CrI)**	**Percentage**	**Number (95% CrI)**	**Percentage**
Soft tissue sarcomas	Females	Most disadvantaged	387 (365, 411)	33 (18, 54)	8.4%	20 (6, 39)	5.1%
Soft tissue sarcomas	Males	Least disadvantaged	505 (475, 537)	29 (10, 48)	5.7%	15 (1, 30)	2.9%
Soft tissue sarcomas	Males	Less disadvantaged	450 (426, 475)	26 (13, 42)	5.9%	12 (1, 23)	2.6%
Soft tissue sarcomas	Males	Middle	466 (441, 491)	35 (18, 53)	7.5%	19 (4, 35)	4.1%
Soft tissue sarcomas	Males	More disadvantaged	495 (467, 522)	44 (23, 67)	9.0%	27 (6, 47)	5.4%
Soft tissue sarcomas	Males	Most disadvantaged	445 (420, 471)	39 (20, 59)	8.7%	23 (5, 40)	5.1%
Stomach cancer	Females	Least disadvantaged	741 (702, 781)	51 (26, 77)	6.9%	16 (3, 33)	2.2%
Stomach cancer	Females	Less disadvantaged	682 (651, 714)	62 (40, 87)	9.1%	26 (9, 46)	3.8%
Stomach cancer	Females	Middle	708 (678, 740)	84 (58, 114)	11.8%	40 (17, 67)	5.6%
Stomach cancer	Females	More disadvantaged	751 (715, 788)	105 (73, 142)	13.9%	54 (27, 86)	7.2%
Stomach cancer	Females	Most disadvantaged	750 (715, 787)	101 (70, 139)	13.5%	51 (23, 84)	6.8%
Stomach cancer	Males	Least disadvantaged	1355 (1302, 1408)	50 (17, 85)	3.7%	14 (0, 36)	1.0%
Stomach cancer	Males	Less disadvantaged	1440 (1393, 1484)	63 (32, 95)	4.4%	19 (2, 40)	1.3%
Stomach cancer	Males	Middle	1489 (1447, 1532)	104 (66, 147)	7.0%	45 (17, 79)	3.0%
Stomach cancer	Males	More disadvantaged	1667 (1616, 1721)	156 (107, 214)	9.3%	77 (34, 129)	4.6%
Stomach cancer	Males	Most disadvantaged	1609 (1559, 1667)	154 (104, 217)	9.6%	78 (36, 131)	4.9%

CrI = credible interval.

Area disadvantage was measured as the quintile of the 2016 Index of Relative Socio-economic Disadvantage.[14]

Modelled cancer-related deaths were the numbers of cancer-related deaths estimated from Bayesian spatial models.

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

Average benchmark survival ratio was 1, which is the model baseline and is equivalent to the national average.

The number of attributable deaths was calculated as the difference between the modelled number of cancer-related deaths and the number of deaths expected if all areas met the benchmark.

Cancer types were defined by International classification of diseases for oncology – 3rd edition (ICD-O-3) codes (Supporting Information, part 1).

Table 7. The number and percentage of cancer deaths attributable to geographic disparities in survival, cross-tabulated by area disadvantage and remoteness category; data presented are for all invasive cancers and all persons (aged 15–89 years), estimated using the optimal benchmark

Area disadvantage	Major city	Inner regional	Outer regional	Remote
Most disadvantaged	4866 (16.9%)	4755 (21.0%)	3100 (23.1%)	637 (35.4%)
More disadvantaged	3844 (13.2%)	3480 (15.5%)	2573 (20.5%)	566 (28.2%)
Middle quintile	3434 (8.9%)	1830 (13.2%)	566 (16.0%)	287 (25.2%)
Less disadvantaged	1984 (4.5%)	432 (8.4%)	168 (14.0%)	63 (28.5%)
Least disadvantaged	866 (1.8%)	65 (5.6%)	74 (22.3%)	7 (20.9%)
Not specified	2 (9.0%)	1 (13.3%)	1 (20.0%)	0 (0%)

Modelled number of cancer-related deaths was estimated from Bayesian spatial models.

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

The number of attributable deaths was calculated as the difference between the modelled number of cancer-related deaths and the number of deaths expected if all areas at least met the benchmark.

Remoteness was measured using the 2016 Remoteness Areas classification[12] with remote and very remote areas combined.

Area disadvantage was measured as the quintile of the 2016 Index of Relative Socio-economic Disadvantage.[14] The Australian Bureau of Statistics does not release socioeconomic data for areas with small populations and these areas are labelled ‘not specified’.

Table 8. The distribution of cancer deaths attributable to geographic disparities in survival, by area disadvantage (IRSD) within each remoteness category, shown as column percentages; data presented are for all invasive cancers and all persons (aged 15–89 years), estimated using the optimal benchmark. The total number of attributable deaths per remoteness category are also provided

Area disadvantage	Major city (*N* = 14 996)	Inner regional (*N* = 10 563)	Outer regional (*N* = 6482)	Remote (*N* = 1560)
Most disadvantaged	32.4%	45.0%	47.8%	40.8%
More disadvantaged	25.6%	32.9%	39.7%	36.3%
Middle quintile	22.9%	17.3%	8.7%	18.4%
Less disadvantaged	13.2%	4.1%	2.6%	4.0%
Least disadvantaged	5.8%	0.6%	1.1%	0.5%
Not specified	< 0.1%	< 0.1%	< 0.1%	0.0%
Total	**100%**	**100%**	**100%**	**100%**

Attributable cancer deaths were the modelled cancer-related deaths within five years of diagnosis that could be avoided if all areas at least met the optimal benchmark.

Optimal benchmark was the 5-year relative survival for the area where survival was better than 80% of all areas.

The column percentages are the number of attributable deaths in each cell expressed as a percentage of the total attributable deaths by remoteness category.

Remoteness was measured with the 2016 Remoteness Areas classification[12] with remote and very remote areas combined.

Area disadvantage was measured as the quintile of the 2016 Index of Relative Socio-economic Disadvantage.[14] The Australian Bureau of Statistics does not release socioeconomic data for areas with small populations and these areas are labelled ‘not specified’.

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