**Collider and Reporting Biases Involved in the Analyses of Cause of Death Associations in Death Certificates: an Illustration with Cancer and Suicide**

# Additional material

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**Additional table 4.** Suicide ORs by cancer site in women in observed and simulated mortality data, and estimated bias magnitudes

**Additional table 1. ICD-10 codes used to define cancer**

|  |  |
| --- | --- |
| **Cancer site** | **ICD-10 codes** |
| **Bladder** | C67 |
| **Breast (female)** | C50 |
| **Central nervous system** | C70-C72 |
| **Colorectal** | C18-C21 |
| **Corpus uteri** | C54 |
| **Cutaneous melanomaa** | C43 |
| **Head and neck** | C01-C06, C09-C14 |
| **Kidney** | C64 |
| **Larynx** | C32 |
| **Liverb** | C22 |
| **Lung** | C33-C34 |
| **Oesophagusb** | C15 |
| **Ovary** | C56, C57.0-C57.4 |
| **Pancreasb** | C25 |
| **Prostate** | C61 |
| **Stomach** | C16 |
| **Testis** | C62 |
| **Thyroid gland** | C73 |

a In Fang *et al*. study, this site was broadened to “skin cancer”.

b Liver, oesophageal, and pancreatic cancers were pooled together as a group, as in the study of Fang *et al*.

**Additional table 2. Characteristics of the simulated populations**

|  |  |  | **Data from simulation #1** | | **Data from simulation #2** | |
| --- | --- | --- | --- | --- | --- | --- |
| **Gender** | **Cause of death** | | **Number (%)** | **Age at death, median [IQR]** | **Number (%)** | **Age at death, median [IQR]** |
| **Men** | Overall |  | 4,796,597 (100%) | 75 [58-84] | 4,760,806 (100%) | 75 [61-85] |
|  | Suicide | Bladder cancer | 215 (0%) | 68 [57-81] | 596 (0%) | 70 [59-83] |
|  |  | CNS cancer | 66 (0%) | 70 [56-87] | 164 (0%) | 70 [54-81] |
|  |  | Colorectal cancer | 887 (0%) | 84 [74-92] | 1,470 (0%) | 83 [74-92] |
|  |  | Cutaneous melanoma | 172 (0%) | 86 [75-93] | 505 (0%) | 86 [76-93] |
|  |  | Head and neck cancer | 227 (0%) | 77 [68-85] | 791 (0%) | 78 [69-86] |
|  |  | Kidney cancer | 88 (0%) | 73 [60-85] | 231 (0%) | 70 [59-81] |
|  |  | Larynx cancer | 162 (0%) | 76 [58-89] | 224 (0%) | 78 [63-90] |
|  |  | Liver cancer | 146 (0%) | 79 [68-89] | 522 (0%) | 79 [68-88] |
|  |  | Lung cancer | 180 (0%) | 80 [72-89] | 716 (0%) | 81 [70-90] |
|  |  | Oesophageal cancer | 867 (0%) | 76 [66-86] | 2,571 (0.1%) | 76 [66-85] |
|  |  | Pancreatic cancer | 1,940 (0%) | 78 [69-88] | 3,639 (0.1%) | 77 [69-87] |
|  |  | Prostate cancer | 216 (0%) | 77 [63-87] | 556 (0%) | 78 [67-87] |
|  |  | Stomach cancer | 45 (0%) | 39 [33-48] | 96 (0%) | 41 [34-51] |
|  |  | Testis cancer | 45 (0%) | 59 [50-76] | 115 (0%) | 60 [48-71] |
|  |  | Thyroid gland cancer | 418 (0%) | 85 [75-93] | 1,190 (0%) | 85 [75-92] |
|  |  | Other or no cancera | 90,521 (1.9%) | 55 [40-76] | 94,377 (2%) | 55 [40-77] |
|  | Other cause | Bladder cancer | 68,391 (1.4%) | 65 [57-76] | 71,558 (1.5%) | 66 [57-76] |
|  |  | CNS cancer | 23,307 (0.5%) | 68 [58-77] | 24,288 (0.5%) | 69 [59-78] |
|  |  | Colorectal cancer | 145,311 (3%) | 79 [71-88] | 154,505 (3.3%) | 79 [71-88] |
|  |  | Cutaneous melanoma | 45,464 (1%) | 78 [69-88] | 48,924 (1%) | 78 [69-88] |
|  |  | Head and neck cancer | 62,514 (1.3%) | 73 [65-80] | 65,828 (1.4%) | 73 [65-80] |
|  |  | Kidney cancer | 18,149 (0.4%) | 69 [60-79] | 19,322 (0.4%) | 70 [60-79] |
|  |  | Larynx cancer | 13,439 (0.3%) | 80 [71-89] | 13,900 (0.3%) | 81 [72-89] |
|  |  | Liver cancer | 39,944 (0.8%) | 71 [62-81] | 42,045 (0.9%) | 72 [62-81] |
|  |  | Lung cancer | 53,025 (1.1%) | 74 [65-83] | 55,766 (1.2%) | 74 [65-83] |
|  |  | Oesophageal cancer | 263,655 (5.5%) | 70 [62-79] | 275,938 (5.8%) | 71 [62-79] |
|  |  | Pancreatic cancer | 184,993 (3.9%) | 81 [75-90] | 196,328 (4.1%) | 82 [75-91] |
|  |  | Prostate cancer | 31,891 (0.7%) | 77 [67-84] | 33,436 (0.7%) | 77 [68-85] |
|  |  | Stomach cancer | 1,343 (0%) | 43 [33-60] | 1,394 (0%) | 42 [32-58] |
|  |  | Testis cancer | 1,752 (0%) | 74 [64-79] | 1,757 (0%) | 75 [66-80] |
|  |  | Thyroid gland cancer | 77,361 (1.6%) | 81 [73-89] | 81,870 (1.7%) | 81 [73-90] |
|  |  | Other or no cancera | 3,669,863 (76.5%) | 74 [56-84] | 3,566,184 (74.9%) | 75 [59-85] |
| **Women** | Overall |  | 4,652,949 (100%) | 76 [60-86] | 4,640,867 (100%) | 76 [61-86] |
|  | Suicide | Bladder cancer | 22 (0%) | 67 [56-81] | 70 (0%) | 67 [59-84] |
|  |  | Breast cancer | 15 (0%) | 66 [55-83] | 42 (0%) | 58 [48-78] |
|  |  | CNS cancer | 165 (0%) | 78 [67-88] | 254 (0%) | 77 [67-88] |
|  |  | Colorectal cancer | 20 (0%) | 75 [72-88] | 48 (0%) | 85 [71-94] |
|  |  | Corpus uteri cancer | 15 (0%) | 76 [66-80] | 48 (0%) | 74 [65-80] |
|  |  | Cutaneous melanoma | 4 (0%) | 65 [56-68] | 10 (0%) | 63 [58-66] |
|  |  | Head and neck cancer | 37 (0%) | 66 [52-78] | 58 (0%) | 65 [53-78] |
|  |  | Kidney cancer | 13 (0%) | 77 [63-88] | 33 (0%) | 74 [65-90] |
|  |  | Larynx cancer | 34 (0%) | 73 [60-81] | 91 (0%) | 71 [59-79] |
|  |  | Liver cancer | 42 (0%) | 82 [74-89] | 156 (0%) | 79 [68-88] |
|  |  | Lung cancer | 68 (0%) | 68 [57-78] | 170 (0%) | 70 [57-79] |
|  |  | Oesophageal cancer | 32 (0%) | 79 [67-85] | 75 (0%) | 74 [63-82] |
|  |  | Ovary cancer | 399 (0%) | 63 [52-74] | 617 (0%) | 67 [56-77] |
|  |  | Pancreatic cancer | 45 (0%) | 58 [46-66] | 97 (0%) | 56 [46-67] |
|  |  | Stomach cancer | 55 (0%) | 75 [64-83] | 135 (0%) | 69 [62-80] |
|  |  | Thyroid gland cancer | 20 (0%) | 82 [73-93] | 53 (0%) | 84 [76-94] |
|  |  | Other or no cancera | 28,866 (0.6%) | 54 [42-70] | 29,112 (0.6%) | 55 [42-70] |
|  | Other cause | Bladder cancer | 21,089 (0.5%) | 69 [58-82] | 21,302 (0.5%) | 69 [58-82] |
|  |  | Breast cancer | 17,310 (0.4%) | 69 [60-79] | 17,527 (0.4%) | 70 [59-79] |
|  |  | CNS cancer | 109,621 (2.4%) | 81 [73-91] | 112,229 (2.4%) | 82 [73-91] |
|  |  | Colorectal cancer | 22,068 (0.5%) | 82 [71-91] | 22,505 (0.5%) | 82 [72-91] |
|  |  | Corpus uteri cancer | 14,771 (0.3%) | 76 [68-85] | 15,052 (0.3%) | 77 [68-85] |
|  |  | Cutaneous melanoma | 2,445 (0.1%) | 68 [59-78] | 2,325 (0.1%) | 68 [59-78] |
|  |  | Head and neck cancer | 11,657 (0.3%) | 79 [67-88] | 12,067 (0.3%) | 79 [67-88] |
|  |  | Kidney cancer | 9,941 (0.2%) | 77 [65-87] | 10,261 (0.2%) | 77 [66-88] |
|  |  | Larynx cancer | 29,969 (0.6%) | 74 [65-82] | 30,660 (0.7%) | 74 [65-83] |
|  |  | Liver cancer | 45,900 (1%) | 78 [69-87] | 46,711 (1%) | 78 [69-88] |
|  |  | Lung cancer | 77,503 (1.7%) | 69 [58-79] | 78,629 (1.7%) | 69 [58-79] |
|  |  | Oesophageal cancer | 14,965 (0.3%) | 78 [70-85] | 15,345 (0.3%) | 78 [69-85] |
|  |  | Ovary cancer | 105,194 (2.3%) | 77 [66-86] | 107,343 (2.3%) | 77 [66-86] |
|  |  | Pancreatic cancer | 3,990 (0.1%) | 73 [63-80] | 4,038 (0.1%) | 73 [62-80] |
|  |  | Stomach cancer | 25,049 (0.5%) | 76 [68-84] | 25,780 (0.6%) | 76 [68-84] |
|  |  | Thyroid gland cancer | 16,388 (0.4%) | 84 [76-92] | 16,783 (0.4%) | 84 [76-92] |
|  |  | Other or no cancera | 4,095,237 (88%) | 76 [59-85] | 4,071,241 (87.7%) | 76 [60-86] |

CNS: central nervous system; IQR: interquartile range.

a Includes other cancer sites, multiple cancers, and haematological malignancies.

Additional table 3. Suicide ORs by cancer site in men in observed and simulated mortality data, and estimated bias magnitudes

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **French mortality data** | |  | **Simulation #1:**  **Independence** | |  | **Simulation #2:**  **RR from Fang *et al.*[4]** | |  | **Fang *et al*. study[4]** | **Collider**  **biasb** | **Reporting**  **biasc** |
| **Cancer site** | **OR** | **[95% CI]** |  | **OR** | **[95% CI]** |  | **OR** | **[95% CI]** |  | **RR** |
| **Thyroid gland** | 0.06 | [0.02;0.12] |  | 1.26 | [0.94;1.7] |  | 2.98 | [2.46;3.61] |  |  |  |  |
| **No cancera** | 1.00 |  |  | 1.00 |  |  | 1.00 |  |  | 1.0 | 1.0 | 1.0 |
| **Testis** | 0.03 | [0.02;0.06] |  | 0.74 | [0.55;1.00] |  | 1.25 | [1.01;1.54] |  |  |  |  |
| **Prostate** | 0.22 | [0.20;0.23] |  | 0.68 | [0.65;0.71] |  | 1.10 | [1.07;1.14] |  | 1.9 | 1.7 | 5.1 |
| **Cutaneous melanoma** | 0.01 | [0.01;0.02] |  | 0.63 | [0.54;0.74] |  | 0.77 | [0.67;0.88] |  | 1.4 | 1.8 | 59 |
| **Kidney** | 0.06 | [0.05;0.07] |  | 0.36 | [0.32;0.41] |  | 0.82 | [0.75;0.89] |  |  |  |  |
| **Colorectal** | 0.07 | [0.06;0.08] |  | 0.35 | [0.33;0.38] |  | 0.51 | [0.48;0.53] |  | 1.6 | 3.2 | 7.1 |
| **Bladder** | 0.09 | [0.08;0.11] |  | 0.33 | [0.30;0.36] |  | 0.81 | [0.76;0.86] |  |  |  |  |
| **Larynx** | 0.09 | [0.07;0.11] |  | 0.21 | [0.17;0.26] |  | 0.47 | [0.41;0.54] |  |  |  |  |
| **Stomach** | 0.05 | [0.04;0.06] |  | 0.20 | [0.17;0.24] |  | 0.50 | [0.46;0.55] |  |  |  |  |
| **Liver** | 0.02 | [0.02;0.03] |  | 0.19 | [0.17;0.22] |  | 0.58 | [0.54;0.62] |  | 4.5 | 7.8 | 25 |
| **Pancreas** | 0.04 | [0.03;0.05] |  | 0.17 | [0.15;0.20] |  | 0.59 | [0.55;0.64] |  | 4.5 | 7.6 | 15 |
| **Oesophagus** | 0.04 | [0.03;0.05] |  | 0.17 | [0.14;0.20] |  | 0.52 | [0.48;0.57] |  | 4.5 | 8.6 | 13 |
| **Lung** | 0.03 | [0.02;0.03] |  | 0.15 | [0.14;0.16] |  | 0.39 | [0.37;0.41] |  | 3.3 | 8.5 | 14 |
| **Head and neck** | 0.05 | [0.04;0.05] |  | 0.12 | [0.11;0.14] |  | 0.29 | [0.26;0.31] |  |  |  |  |
| **Central nervous system** | 0.01 | [0.01;0.01] |  | 0.11 | [0.09;0.14] |  | 0.24 | [0.21;0.28] |  | 2.3 | 9.5 | 27 |

Logistic regression models adjusted for age (B-spline of degree 3), gender, and region of death; mainland France, 2000-2010.

OR: odds ratio; RR: relative risk; 95% CI: 95% confidence interval.

a Excluding other cancer sites, multiple cancers, and haematological malignancies.

The magnitude of the biases was estimated from the following ratios:

b Collider bias = RR from Fang *et al.* / OR estimated from the data of simulation #2

c Reporting bias = OR estimated from the data of simulation #2 / OR estimated from observed deaths

Additional table 4. Suicide ORs by cancer site in men in observed and simulated mortality data, and estimated bias magnitudes

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **French mortality data** | |  | **Simulation #1:**  **Independence** | |  | **Simulation #2:**  **RR from Fang *et al.*[4]** | |  | **Fang *et al.* study[4]** | **Collider**  **biasb** | **Reporting**  **biasc** |
| **Cancer site** | **OR** | **[95% CI]** |  | **OR** | **[95% CI]** |  | **OR** | **[95% CI]** |  | **RR** |
| **Thyroid gland** | 0.05 | [0.02;0.12] |  | 1.51 | [1.12;2.03] |  | 3.10 | [2.53;3.80] |  |  |  |  |
| **No cancera** | 1.00 |  |  | 1.00 |  |  | 1.00 |  |  | 1.0 | 1.0 | 1.0 |
| **Breast** | 0.03 | [0.03;0.03] |  | 0.56 | [0.50;0.62] |  | 0.81 | [0.75;0.88] |  | 1.6 | 2.0 | 28 |
| **Cutaneous melanoma** | 0.01 | [<.01;0.02] |  | 0.50 | [0.36;0.69] |  | 0.72 | [0.56;0.93] |  | 1.4 | 1.9 | 80 |
| **Corpus uteri** | 0.02 | [0.01;0.03] |  | 0.40 | [0.31;0.53] |  | 0.93 | [0.78;1.10] |  |  |  |  |
| **Kidney** | 0.02 | [0.01;0.04] |  | 0.39 | [0.28;0.56] |  | 0.86 | [0.69;1.09] |  |  |  |  |
| **Colorectal** | 0.02 | [0.01;0.02] |  | 0.31 | [0.27;0.37] |  | 0.46 | [0.40;0.52] |  | 1.6 | 3.5 | 25 |
| **Bladder** | 0.03 | [0.02;0.06] |  | 0.30 | [0.20;0.47] |  | 0.76 | [0.58;0.99] |  |  |  |  |
| **Oesophagus** | 0.02 | [0.01;0.05] |  | 0.20 | [0.12;0.35] |  | 0.48 | [0.34;0.67] |  | 4.5 | 9.4 | 20 |
| **Larynx** | 0.03 | [0.01;0.09] |  | 0.18 | [0.07;0.49] |  | 0.46 | [0.25;0.85] |  |  |  |  |
| **Stomach** | 0.01 | [0.01;0.02] |  | 0.17 | [0.11;0.27] |  | 0.40 | [0.30;0.53] |  |  |  |  |
| **Liver** | 0.01 | [<.01;0.01] |  | 0.17 | [0.10;0.29] |  | 0.53 | [0.40;0.70] |  | 4.5 | 8.5 | 106 |
| **Ovary** | <0.01 | [<.01;0.01] |  | 0.17 | [0.12;0.23] |  | 0.43 | [0.35;0.52] |  |  |  |  |
| **Pancreas** | 0.01 | [0.01;0.02] |  | 0.17 | [0.12;0.22] |  | 0.59 | [0.51;0.69] |  | 4.5 | 7.6 | 49 |
| **Head and neck** | 0.03 | [0.02;0.05] |  | 0.12 | [0.08;0.17] |  | 0.35 | [0.27;0.44] |  |  |  |  |
| **Central nervous system** | <0.01 | [<.01;0.01] |  | 0.10 | [0.06;0.17] |  | 0.27 | [0.20;0.37] |  | 2.3 | 8.5 | 91 |
| **Lung** | 0.01 | [0.01;0.01] |  | 0.10 | [0.08;0.12] |  | 0.23 | [0.19;0.26] |  | 3.3 | 15 | 32 |

Logistic regression models adjusted for age (B-spline of degree 3), gender, and region of death; mainland France, 2000-2010.

OR: odds ratio; RR: relative risk; 95% CI: 95% confidence interval.

a Excluding other cancer sites, multiple cancers, and haematological malignancies.

The magnitude of the biases was estimated from the following ratios:

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