Original Article

Cancers Due to Excess Weight, Low Physical Activity, and Unhealthy Diet

Estimation of the Attributable Cancer Burden in Germany

Gundula Behrens*[1], Thomas Gredner*[1], Christian Stock, Michael F. Leitzmann, Hermann Brenner*[2], Ute Mons*[2]

*[1] Gundula Behrens and Thomas Gredner contributed equally to this work.

*[2] Hermann Brenner and Ute Mons contributed equally to this work.

Division of Clinical Epidemiology and Aging Research, German Cancer Research Center (DKFZ), Heidelberg: PD Dr. habil. med. Gundula Behrens; Thomas Gredner, MPH; PD Dr. sc. hum. Christian Stock, MSc; Prof. Dr. med. Hermann Brenner; PD Dr. sc. hum. Ute Mons

Medical Faculty Heidelberg, University of Heidelberg, Heidelberg: Thomas Gredner, MPH

Department of Epidemiology and Preventive Medicine, University of Regensburg, Regensburg: Prof. Dr. med. Dr. P.H. Michael F. Leitzmann

Division of Preventive Oncology, German Cancer Research Center (DKFZ) and National Center for Tumor Diseases (NCT), Heidelberg: Prof. Dr. med. Hermann Brenner

German Cancer Consortium (DKTK), German Cancer Research Center (DKFZ), Heidelberg: Prof. Dr. med. Hermann Brenner

Cancer Prevention Unit, German Cancer Research Center (DKFZ), Heidelberg: PD Dr. sc. hum. Ute Mons

Summary

Background: Excess weight, low physical activity, low intakes of dietary fiber, fruits, and vegetables, and high meat and salt intake increase cancer risk.

Methods: Numbers and proportions (population-attributable fractions, PAF) of incident cancer cases in Germany in 2018 attributable to these factors were estimated by sex and age groups for ages 35 to 84 years using population projections, national cancer incidence and exposure data, and published risk estimates.

Results: Estimated numbers (percentages) of attributable cancers were 30 567 (7%) for excess weight, 27 081 (6%) for low physical activity, 14 474 (3%) for low dietary fiber intake, 9447 (2%) for low fruit and vegetable consumption, 9454 (2%) and 1687 (0.4%) for processed meat and high red meat consumption, respectively, and 1204 (0.3%) for high salt intake. Excess weight substantially contributed to endometrial, renal, and liver cancer (PAF = 24 to 35%). Low physical activity contributed to endometrial, renal, and lung cancer (PAF = 15 to 19%), and dietary factors mainly contributed to colorectal, breast, and lung cancer (PAF = 9 to 16%).

Conclusion: A considerable proportion of cancer cases are attributable to excess weight, physical inactivity, and unhealthy dietary habits. Major prevention efforts are needed to reduce the cancer incidence attributable to these avoidable factors.

Cite this as:
Behrens G, Gredner T, Stock C, Leitzmann MF, Brenner H, Mons U:
Cancers due to excess weight, low physical activity, and unhealthy diet—estimation of the attributable cancer burden in Germany. Dtsch Arztebl Int 2018; 115: 578–85. DOI: 10.3238/arztebl.2018.0578

Excess weight, low physical activity, and unhealthy diet contribute substantially to the development of cancer (1–3). However, no information on the attributable cancer incidence is available for the general population in Germany. By applying the concept of population-attributable fractions (PAF), we estimated the incidence of cancers attributable to excess weight, low physical activity, and unhealthy diet in people aged 35–84 years in Germany in 2018. Health professionals and politicians need such information to design and implement effective measures to reduce the prevalence of obesity, physical inactivity, and unhealthy diet.

Methods

Lifestyle factors and site-specific cancer risk

Our definitions of normal body weight, recommended level of physical activity and a healthy diet followed the cancer prevention guidelines of the World Cancer Research Fund (WCRF) (eSupplement A) (4). We considered all cancer types that have been shown to be related to those lifestyle factors in published meta-analyses of prospective studies comprising 5000 or more cancer cases (*eSupplement B–D, eTables 1–3*).

Statistical methods

In analogy to our alcohol analysis in this issue (5), we used PAFs (for details see the *Box* in Mons et al. [5], this issue) to estimate the proportion of lifestyle-associated cancers in the population aged 35 to 84 years, assuming a 10-year latency period between exposure and cancer incidence. We used prevalence data of 6962 men and women aged 25 to 74 years from the nationally representative German Health Interview and Examination Survey for Adults for the period 2008 to 2011 (DEGS1) (6) (*eSupplement*, *eTables 4–8*). We estimated the number of cancer cases attributable to each lifestyle factor by multiplying the PAF by the expected cancer incidence for the year 2018 (*eSupplement E, eTables 9–21*).

Results

Prevalence of lifestyle factors

According to DEGS1, 63% of men and women aged 25 to 74 years living in Germany were overweight (38%) or obese (25%) (*Figure 1, eTable 4*). Furthermore, 81% of the study population were insufficiently physically active (49%; 1–149 min/week of moderate to vigorous physical activity) or physically inactive (32%; 0 min/week of moderate to vigorous physical activity) (*eTable 5*). In addition, 9% of the study population reported a high red meat consumption of ≥500 g/week (*eTables 6–8*), 96% of them ate processed meat (including hamburger/kebab, bratwurst/currywurst, sausage, and ham), 76% had a high salt intake of ≥6 g/day, 72% had a low dietary fiber intake (<32 g/day), and 71% did not consume enough fruit and non-starchy vegetables (<400 g/day).

Site-specific cancer risk

Published meta-analyses revealed that obesity (as compared to normal weight) increases the risk of cancers of the stomach (by 17%), colorectum (by 33%), liver (by 83%), gallbladder (by 67%), pancreas (by 36%), breast (postmenopausal, by 20%), endometrium (by 154%), ovary (by 27%), prostate (advanced, by 14%), kidney (by 77%), bladder (by 10%), thyroid gland (by 29%), and additionally the risks of non-Hodgkin lymphoma (by 19%), multiple myeloma (by 21%), and leukemia (by 26%) (*eTable 1, eFigure 1*).

Because cohort studies of physical inactivity and cancer risk used heterogeneous physical activity assessments and categories, meta-analyses could only provide general estimates of the cancer risk among physically inactive individuals as compared to the cancer risk among individuals who were sufficiently physically active *(eTable 2)*. In DEGS1, the comparison between sufficient physical activity and physical inactivity corresponded to the comparison of engaging in an average of 248 min/week of moderate to vigorous physical activity versus not engaging in any moderate to vigorous physical activity (0 min/week). According to this interpretation, a 150 min/week decrease in moderate to vigorous physical activity is associated with risk increases of 5% for gastric cancer, 11% for colorectal cancer, 3% for pancreatic cancer, 20% for lung cancer, 7% for breast cancer, 15% for endometrial cancer, 17% for renal cancer, and 9% for bladder cancer (*eFigure 2*).

Dose–response meta-analyses of dietary factors and cancer risk reported a risk increase per 200 g/week increase in red meat consumption of 3% for colorectal cancer, 3% for pancreatic cancer, 7% for lung cancer, and 3% for breast cancer, and risk increases per 200 g/week increase in processed meat consumption of 9% for colorectal cancer and 5% for breast cancer (*eTable 3, eFigure 3*). A 2 g/day increase in salt intake increases the risk of gastric cancer by 5%. A 10 g/day decrease in dietary fiber intake is associated with an 11% increased risk of colorectal cancer and a 5% increased risk of developing breast cancer. A 200 g/day decrease in fruit and non-starchy vegetable consumption is associated with a risk increase of 2% for colorectal cancer and a 9% increase in the risk of lung cancer.

Cancers attributable to the selected lifestyle factors

We expected 440 373 incident cancers among adults aged 35 to 84 years in 2018 in Germany. Excess weight and low physical activity increased the cancer incidence substantially (excess weight: N = 30 567 cases, PAF = 7%; low physical activity: N = 27 081 cases, PAF = 6%), exerting a substantial effect on endometrial cancer (PAF for excess weight = 35%; PAF for low physical activity = 15%), renal cancer (PAF for excess weight = 25%; PAF for low physical activity = 17%), liver cancer (PAF for excess weight = 24%), and lung cancer (PAF for low physical activity = 19%) (*Figures 2–3, eTables 12–17, eFigures 4–5*).

Substantially lower contributions to total cancer risk were observed for intakes of dietary fiber, fruit, non-starchy vegetables, and processed meat (any consumption of processed meat: N = 9454, PAF = 2%; low intake of dietary fiber: N = 14 474, PAF = 3%; low consumption of fruit and non-starchy vegetables: N = 9447, PAF = 2%) (*Figure 4, eTables 18–20, eFigure 6*). Low intake of dietary fiber and the consumption of processed meat products favored the development of colorectal cancer and breast cancer (consumption of processed meat: PAF for colorectal cancer = 11 %, PAF for breast cancer = 5 %; low dietary fiber: PAF for colorectal cancer = 16 %, PAF for breast cancer = 9 %). Low consumption of fruit and non-starchy vegetables influenced the development of colorectal cancer (PAF = 4 %) and lung cancer (PAF = 14 %). High intakes of salt and red meat had considerable effects on gastric cancer (PAF for high salt intake = 9%) and lung cancer (PAF for high red meat consumption = 2%), but negligible effects on total cancer (high red meat consumption: N = 1687, PAF = 0.4%; high salt intake: N = 1204, PAF = 0.3%). We estimated that a total of 34 162 cancers (PAF = 8%) were attributable to all dietary factors combined (*Figure 4, eTable 21*).

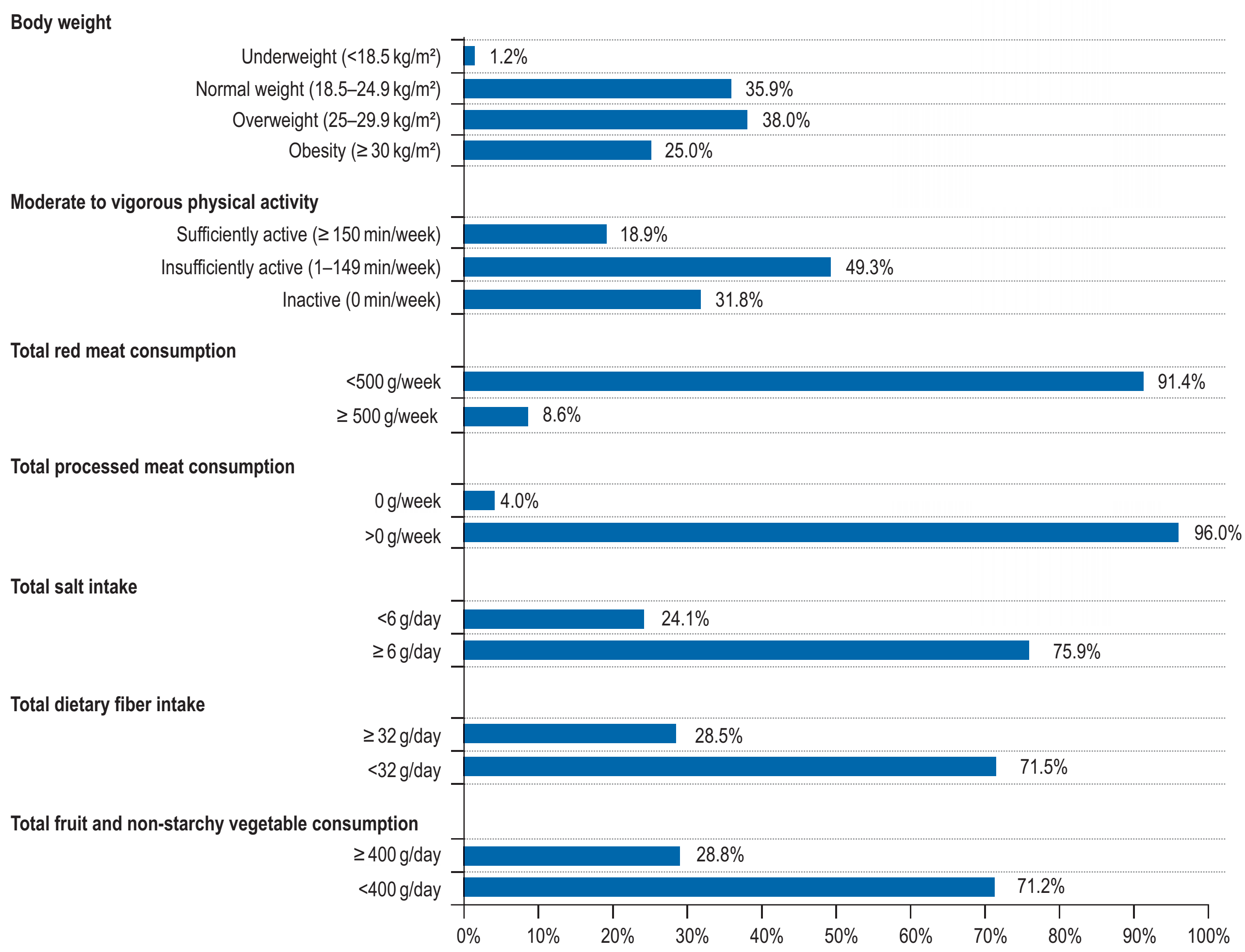
We observed no strong correlations between the individual lifestyle factors in our population, but there were moderate correlations between high consumption of processed meat and high salt intake, and between high intake of dietary fiber and high intakes of salt, fruit and non-starchy vegetables (Spearman correlation coefficients = 0.22–0.45, *eTable 22*).

Sensitivity analyses using the 95% confidence limits of risk estimates in the PAF formulae indicated an estimated range of 19 513 to 41 723 cancer cases attributable to excess weight, 19 714 to 34 857 to low physical activity, and 16 695 to 52 547 to unhealthy diet (*eTables 23–25*).

Discussion

Our study revealed a high prevalence of excess weight, low physical activity, and unhealthy diet among the

FIGURE 1



Prevalence of selected lifestyle factors among men and women aged 25–74 years (N = 6087 for body weight, N = 6696 for physical activity, N = 6129 for dietary factors) from the nationally representative DEGS1 survey, 2008 to 2011, Germany

population in Germany in the period 2008 to 2011. For the population aged 35 to 84 years in 2018 in Germany, we therefore estimated that 30 567 incident cancers will be attributable to excess weight and 27 081 to low physical activity in 2018, corresponding to 7% and 6%, respectively, of the expected total of 440 373 incident cancers in this population. 9000 to 14 000 cancers (2–3%) will be attributable to low intakes of dietary fiber, fruit and non-starchy vegetables and high consumption of processed meat, and some 1000 to 2000 cases (<1%) to high intakes of salt and red meat.

Overweight and obesity

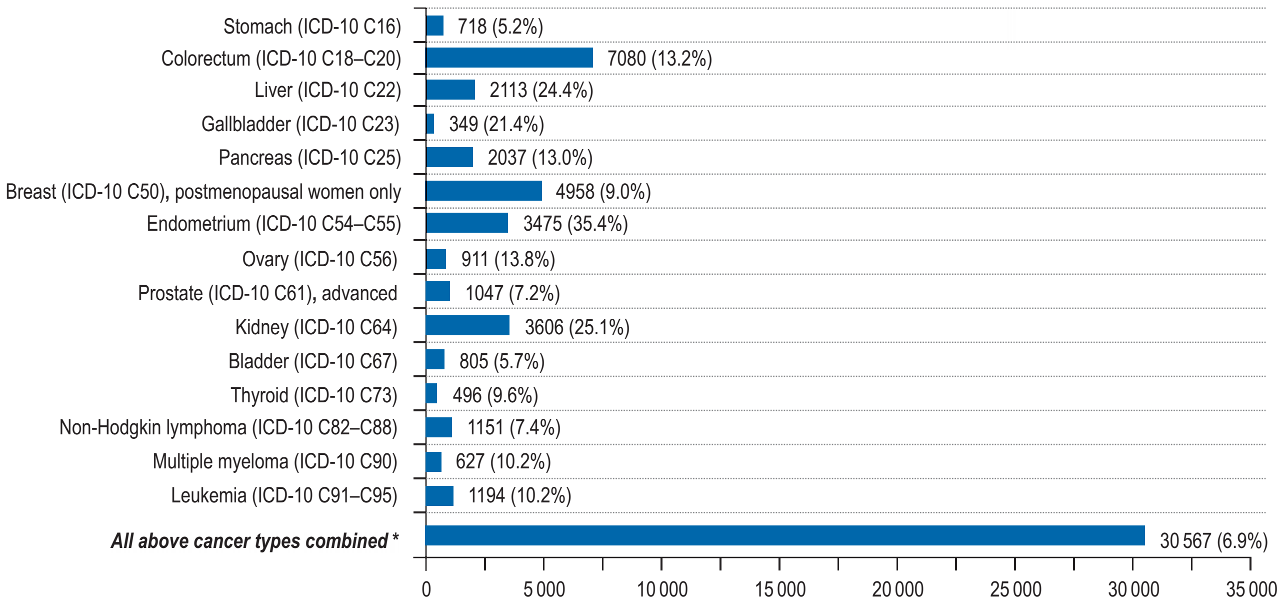
Earlier studies (7–11) estimated the cancer risk attributable to overweight and obesity under the model assumption that the natural logarithm of the relative risk depends linearly on BMI (log linearity). This assumption is not always true (12), potentially leading to distorted estimates. We therefore dispensed with this model assumption and instead used direct comparisons of the cancer risk for normal weight, overweight, and obesity. Some previous studies also used direct risk comparisons to calculate the cancer incidence attributable to overweight and obesity (13–16). Due to lower prevalence rates for overweight and obesity, those studies yielded lower attributable cancer incidence estimates for overweight and obesity than our study (13–16).

It is biologically plausible that overweight and obesity contribute to the development of cancer. Potential biological mechanisms and factors linking excess body fat to cancer incidence include insulin resistance, chronic inflammatory processes, sex hormones, and growth factors (1).

Low physical activity

Previous estimates of the cancer incidence attributable to low physical activity differ from our estimates

FIGURE 2



Estimated number of site-specific incident cancer cases attributable to excess weight (BMI≥25 kg/m²) among men and women aged 35 to 84 years in Germany for the year 2018, assuming a 10-year latency period between exposure and cancer incidence.
*The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).
ICD, International Classification of Diseases; PAF, population-attributable fraction, BMI, body mass index

because previous studies used lower physical activity target levels (13, 14), lower prevalence rates (15, 17), or lower or higher assumed cancer risks for their estimates (9, 11, 16, 18, 19).

A high level of physical activity may prevent cancer through reductions of adipose tissue and insulin resistance, through decreases in chronic inflammation, sex hormones, and growth factors, and through improved resistance to oxidative stress and DNA damage (3).

Unhealthy diet

Previous attributable cancer incidence studies reported a greater or lesser cancer prevention potential of a healthy diet because they applied more or less rigorous target intake levels than in our study (11, 20–26), because their mean intake was further away from/closer to the target level than in our study (15, 16, 20, 21), and because they used higher or lower cancer risk estimates for an unhealthy diet (11, 14, 27). Our estimate for the combined impact of dietary factors on cancer incidence was comparable to that from previous studies from other countries (28, 29).

Low intakes of red meat, processed meat, and salt and high intakes of dietary fiber, fruit, and non-starchy vegetables may contribute to the prevention of cancer through (2, 30–32):

- Reduced exposure to exogenous and endogenous carcinogens including N-nitroso compounds
- Decreased formation of cyto- and genotoxic aldehydes
- Lower levels of chronic inflammation
- Increased antioxidative capacities
- Improved DNA repair
- Modulated estrogen metabolism.

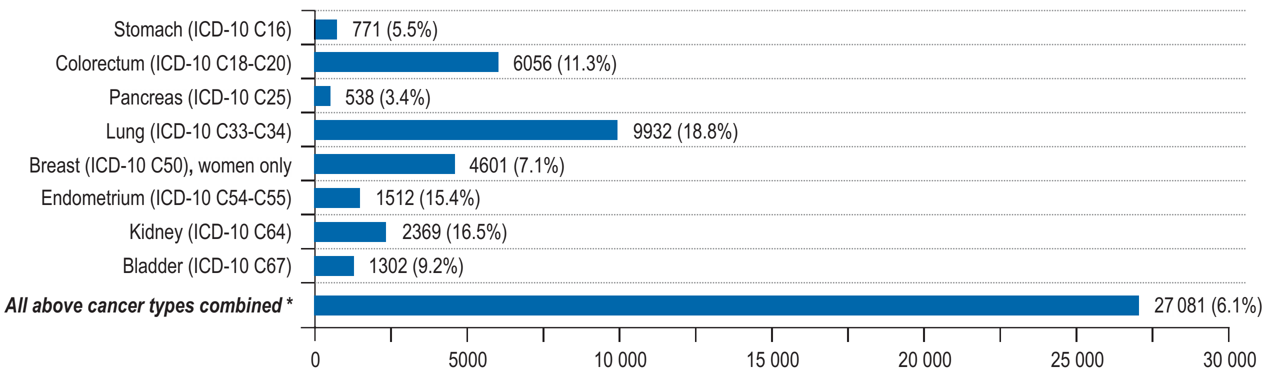
In addition, changing from diets with high intakes of energy-dense foods to diets with high intakes of dietary fiber, fruit, and vegetables may decrease cancer risk through reductions in adipose tissue, insulin levels, chronic inflammation, and circulating sex and growth hormones (2).

Strengths and limitations

The present study of attributable cancer incidence followed the methodological recommendations issued by the World Health Organization (WHO, *eSupplement F*). Our study provides up-to-date estimates of the total number of cancers attributable to excess weight, low physical activity and unhealthy diet in Germany for the year 2018, assuming a 10-year latency period, based on the latest nationally representative prevalence and cancer incidence data. As discussed above, there is sufficient biological evidence in support of a causal relationship between the selected lifestyle factors and the development of cancer.

Our comprehensive systematic literature search yielded the most recent data on the relations of lifestyle factors to site-specific cancer risk. The present study is the first to consider, in estimating the attributable cancer incidence, the relation of obesity to bladder cancer, the relations of low physical activity

FIGURE 3



Estimated number of site-specific incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) among men and women aged 35 to 84 years in Germany for the year 2018, assuming a 10-year latency period between exposure and cancer incidence.
*The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).
ICD, International Classification of Diseases; PAF, population-attributable fraction

to cancers of the stomach, lung, and bladder, and the relations of high consumption of red and processed meat and of low intake of dietary fiber to cancers of the pancreas, lung, and breast. All of these relations have been established in published meta-analyses of prospective studies including ≥5000 incident cancer cases.

As a limitation, we may have underestimated the cancer prevention potential of the selected lifestyle factors because we did not consider any potential relations of these factors to site-specific cancer risk that have not yet been confirmed in meta-analyses of prospective studies including ≥5000 incident cancer cases (*eSupplement F*).

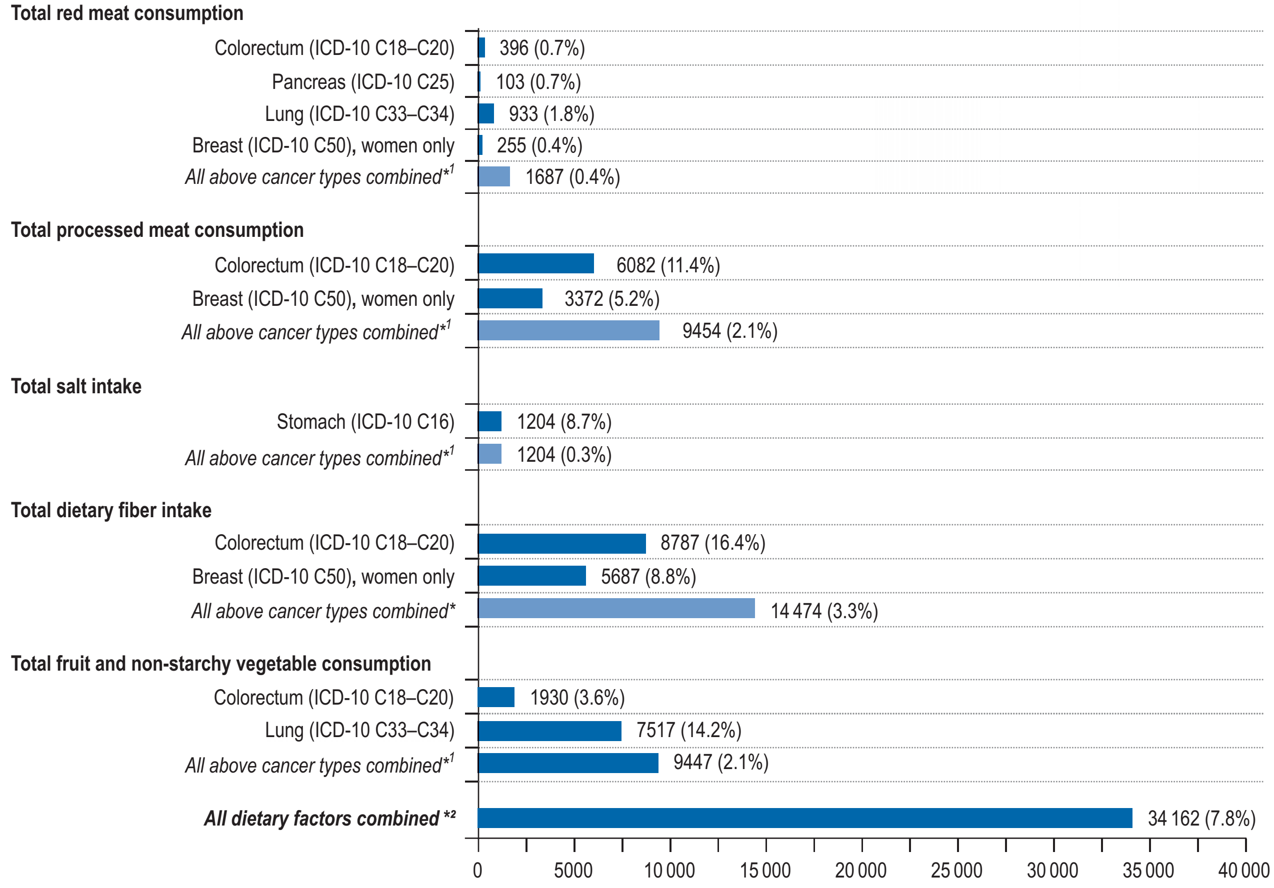
We accounted for potential confounding by age and sex, the most important predictors of cancer incidence, by stratifying our analyses by age and sex. However, we were not able to consider additional potential confounding factors, including genetic traits, medical conditions, and sociodemographic factors, because cancer registries do not provide data stratified by such factors. Unfortunately we could not calculate any PAF for combinations of lifestyle factors, because the required risk estimators were insufficiently precise (33, 34). Therefore, we were also unable to take account of the potential biological interactions among the individual lifestyle factors and the resultant potential confounding. Because the concept of PAF does not allow the summation of attributable cancer cases across individual risk factors, we used the sequential PAF formula to assess the combined impact of dietary factors on cancer incidence. That formula requires the assumption of uncorrelated dietary factors, which was approximately met in our population.

For the selected lifestyle factors, the assumed cancer latency period of 10 years is within the realistic range of 5–15 years—a range in which attributable cancer incidence estimates vary little (*eSupplement F*). In sensitivity analyses, we used the lower and upper bounds of the cancer site–specific relative risk estimates in the PAF formulas and observed substantial numbers of attributable cancer cases across all scenarios. Potential changes in prevalence of lifestyle factors in recent years are probably small and should not affect our estimates substantially.

Conclusion

The present study identified excess weight (>30 000 annual cases, 7%) and low physical activity (>27 000 annual cases, 6%) as major contributors to the current cancer incidence (>440 000 annual cases) among adults aged 35–84 years in Germany. Substantial numbers of incident cancers were also due to dietary factors, including low intake of dietary fiber (>14 000 annual cases, 3%), low consumption of fruit and non-starchy vegetables (>9000 annual cases, 2%), any consumption of processed meat (>9000 annual cases, 2%), high consumption of red meat (>1600 annual cases, 0.4%) and high salt intake (>1200 annual cases, 0.3%). These figures suggest that adherence to a healthy lifestyle is vital in cancer prevention at both the individual level and the population level. In view of the high prevalence of unhealthy lifestyle factors in the population, health professionals and politicians should increase their efforts to encourage people to lead a healthy lifestyle. According to the World Cancer Research Fund (WCRF), a cancer-preventive lifestyle should include adherence to a normal weight (BMI 18.5–24.9 kg/m²), regular physical activity (≥150 min/week of moderate to vigorous physical activity), and a healthy diet (≥32 g/day of dietary fiber, ≥400 g/day of fruit and non-starchy vegetables, 0 g/week of processed meat, <500 g/week of red meat, <6 g/day of salt). Encouragement from physicians is

FIGURE 4



Estimated number of site-specific incident cancer cases attributable to high consumption of red meat (≥500 g/week), any consumption of processed meat (>0 g/week), high intake of salt (≥6 g/day), low intake of dietary fiber (<32 g/day) and low consumption of fruit and vegetables (<400 g/day) among men and women aged 35 to 84 years in Germany for the year 2018, assuming a 10-year latency period between exposure and cancer incidence.

*[1] The PAF for the category “All above cancer types combined” was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

*[2] The PAF for the category “All dietary factors combined” was computed with the sequential PAF formula separately for each cancer type and each age group. The resulting age- and sex-specific attributable cancer cases were then summated to yield an overall estimate for the whole population and set against the total number of cancer cases (ICD-10 C00-C99 without C44; cf. *eSupplement E* and *eTable 21*).

ICD, International Classification of Diseases; PAF, population-attributable fraction

an effective means of increasing adherence to a healthy lifestyle due to the trust that patients have in their doctors’ medical advice (35). Adherence to a healthy lifestyle may be effectively supported by the creation of healthy living environments and incentives. Potential strategies to promote physical activity and reduce overweight include physical activity interventions at school and work-places, the creation of sport facilities, parks, and nature recreation areas in neighborhoods, and the development of public transport, safe bike lanes, safe sidewalks, and pleasant walking environments (36). The extension of public transportation represents a health-enhancing option because people often walk or cycle to the next public transport station (36). A healthy diet may be promoted through price policies, advertising restrictions, nutrition labeling, school and workplace interventions, information campaigns, and greater availability of healthy foodstuffs in restaurants, kiosks, and fast-food outlets (37–39).

Funding
The study was funded by German Cancer Aid (“Deutsche Krebshilfe”), grant number 70112097.

Conflict of interest statement
The authors declare that no conflict of interest exists.

Manuscript received on 16 April 2018, revised version accepted on 10 July 2018

References

1. Anderson AS, Key TJ, Norat T, et al.: European Code Against Cancer 4th Edition: obesity, body fatness and cancer. Cancer Epidemiol 2015; 39 (Suppl 1): S34–45.
2. Norat T, Scoccianti C, Boutron-Ruault MC, et al.: European Code Against Cancer 4th Edition: diet and cancer. Cancer Epidemiol 2015; 39 (Suppl 1): S56–66.

Key messages

- We estimated the proportions of new cancers among the population aged 35 to 84 years in Germany in 2018 that can be attributed to excess weight, low physical activity, and an unhealthy diet. Our estimates are based on the concept of population-attributable fractions (PAF).
- According to our calculations, more than 30 000 cancers (7% of the estimated total of 440 000 cancers in that age range) are attributable to excess weight.
- A comparably high number of cancers (>27 000, 6%) are attributable to low physical activity.
- Lower but still substantial numbers of cancers are attributable to low dietary fiber intake (>14 000, 3%), low fruit and non-starchy vegetable consumption (>9000, 2%), and high processed meat consumption (>9000, 2%).
- Our findings suggest that potentially modifiable lifestyle factors, including excess weight, low physical activity, and an unhealthy diet, contribute substantially to the development of potentially severe cancers in Germany.

3. Leitzmann M, Powers H, Anderson AS, et al.: European Code Against Cancer 4th edition: physical activity and cancer. Cancer Epidemiol 2015; 39 (Suppl 1): S46–55.
4. World Cancer Research Fund/American Institute for Cancer Research: Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington, DC: 2007. www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf (last accessed on 8 August 2017).
5. Mons U, Gredner T, Behrens G, Stock C, Brenner H: Cancers due to smoking and high alcohol consumption—estimation of the attributable cancer burden in Germany. Dtsch Arztebl Int 2018; 115: 571–7.
6. Scheidt-Nave C, Kamtsiuris P, Gosswald A, et al.: German Health Interview and Examination Survey for Adults (DEGS)—design, objectives and implementation of the first data collection wave. BMC Public Health 2012; 12: 730.
7. Renehan AG, Soerjomataram I, Tyson M, et al.: Incident cancer burden attributable to excess body mass index in 30 European countries. Int J Cancer 2010; 126: 692–702.
8. Parkin DM, Boyd L: 8. Cancers attributable to overweight and obesity in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S34–7.
9. Brenner DR: Cancer incidence due to excess body weight and leisure-time physical inactivity in Canada: implications for prevention. Prev Med 2014; 66: 131–9.
10. Kendall BJ, Wilson LF, Olsen CM, et al.: Cancers in Australia in 2010 attributable to overweight and obesity. Aust N Z J Public Health 2015; 39: 452–7.
11. Islami F, Goding Sauer A, Miller KD, et al.: Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. CA Cancer J Clin 2018; 68: 31–54.
12. Bhaskaran K, Douglas I, Forbes H, dos-Santos-Silva I, Leon DA, Smeeth L: Body-mass index and risk of 22 specific cancers: a population-based cohort study of 5.24 million UK adults. Lancet 2014; 384: 755–65.
13. Richardson A, Hayes J, Frampton C, Potter J: Modifiable lifestyle factors that could reduce the incidence of colorectal cancer in New Zealand. N Z Med J 2016; 129: 13–20.
14. Inoue M, Sawada N, Matsuda T, et al.: Attributable causes of cancer in Japan in 2005—systematic assessment to estimate current burden of cancer attributable to known preventable risk factors in Japan. Ann Oncol 2012; 23: 1362–9.
15. Brown KF, Rumgay H, Dunlop C, et al.: The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. Br J Cancer 2018; 118: 1130–41.
16. Azevedo ESG, de Moura L, Curado MP, et al.: The fraction of cancer attributable to ways of life, infections, occupation, and environmental agents in Brazil in 2020. PLoS One 2016; 11: e0148761.
17. Parkin DM: 9. Cancers attributable to inadequate physical exercise in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S38–41.
18. Friedenreich CM, Neilson HK, Lynch BM: State of the epidemiological evidence on physical activity and cancer prevention. Eur J Cancer 2010; 46: 2593–604.
19. Olsen CM, Wilson LF, Nagle CM, et al.: Cancers in Australia in 2010 attributable to insufficient physical activity. Aust N Z J Public Health 2015; 39: 458–63.
20. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to red and processed meat consumption in Alberta in 2012. CMAJ Open 2016; 4: e768-75.
21. de Vries E, Quintero DC, Henriquez-Mendoza G, Herran OF: Population attributable fractions for colorectal cancer and red and processed meats in Colombia—a macro-simulation study. Colomb Med (Cali) 2017; 48: 64–9.
22. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to insufficient fruit and vegetable consumption in Alberta in 2012. CMAJ Open 2016; 4: e760–7.
23. Nagle CM, Wilson LF, Hughes MC, et al.: Cancers in Australia in 2010 attributable to inadequate consumption of fruit, non-starchy vegetables and dietary fibre. Aust N Z J Public Health 2015; 39: 422–8.
24. Parkin DM, Boyd L: 4. Cancers attributable to dietary factors in the UK in 2010. I. Low consumption of fruit and vegetables. Br J Cancer 2011; 105 (Suppl 2): S19–23.
25. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to insufficient fibre consumption in Alberta in 2012. CMAJ Open 2017; 5: e7–13.
26. Parkin DM, Boyd L: 6. Cancers attributable to dietary factors in the UK in 2010. III. Low consumption of fibre. Br J Cancer 2011; 105 (Suppl 2): S27–30.
27. Parkin DM: 7. Cancers attributable to dietary factors in the UK in 2010. IV. Salt Br J Cancer 2011; 105 (Suppl 2): S31–3.
28. Parkin DM, Boyd L, Walker LC: 16. The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S77–81.
29. Whiteman DC, Webb PM, Green AC, et al.: Cancers in Australia in 2010 attributable to modifiable factors: summary and conclusions. Aust N Z J Public Health 2015; 39: 477–84.
30. Steppeler C, Haugen JE, Rodbotten R, Kirkhus B: Formation of nalondialdehyde, 4-hydroxynonenal, and 4-hydroxyhexenal during in vitro digestion of cooked beef, pork, chicken, and salmon. J Agric Food Chem 2016; 64: 487–96.
31. Cheng XJ, Lin JC, Tu SP: Etiology and prevention of gastric cancer. Gastrointest Tumors 2016; 3: 25–36.
32. Collins AR, Azqueta A, Langie SA: Effects of micronutrients on DNA repair. Eur J Nutr 2012; 51: 261–79.
33. Romaguera D, Vergnaud AC, Peeters PH, et al.: Is concordance with World Cancer Research Fund/American Institute for Cancer Research guidelines for cancer prevention related to subsequent risk of cancer? Results from the EPIC study. Am J Clin Nutr 2012; 96: 150–63.
34. Jankovic N, Geelen A, Winkels RM, et al.: Adherence to the WCRF/AICR dietary recommendations for cancer prevention and risk of cancer in elderly from Europe and the United States: a meta-analysis within the CHANCES project. Cancer Epidemiol Biomarkers Prev 2017; 26: 136–44.
35. Jones DE, Carson KA, Bleich SN, Cooper LA: Patient trust in physicians and adoption of lifestyle behaviors to control high blood pressure. Patient Educ Couns 2012; 89: 57–62.
36. Institute of Medicine: Physical activity: moving toward obesity solutions: workshop summary. Washington, DC: The National Academies Press 2015.

37. Capacci S, Mazzocchi M, Shankar B, et al.: Policies to promote healthy eating in Europe: a structured review of policies and their effectiveness. Nutr Rev 2012; 70: 188–200.
38. Lake AA: Neighbourhood food environments: food choice, foodscapes and planning for health. Proc Nutr Soc 2018; 77: 239–46.
39. Finkelstein EA, Strombotne KL, Zhen C, Epstein LH: Food prices and obesity: a review. Adv Nutr 2014; 5: 818–21.

Corresponding author
PD Dr. habil. med. Gundula Behrens
Klinische Epidemiologie und Alternsforschung
Deutsches Krebsforschungszentrum (DKFZ)
Im Neuenheimer Feld 581, 69120 Heidelberg, Germany
g.behrens@dkfz-heidelberg.de

► **Supplementary material**
For eReferences please refer to:
www.aerzteblatt-international.de/ref3518

eSupplement, eTables, eFigures:
www.aerzteblatt-international.de/18m0578

CLINICAL SNAPSHOT

The Differential Diagnosis of Light-Red Livor Mortis

A man was found dead at home. The body displayed advanced rigor mortis, so no attempt was made at resuscitation. At external examination of the corpse, the livor mortis was found to be light-red rather than the customary livid, bluish color *(Figure)*. Light-red livor mortis can be found soon after death and—sometimes—on exposure to cold (reoxygenation by diffusion), but also occurs with CO poisoning. Diagnosis was assisted by livor mortis in the area of the nail beds: in the event of cold exposure these would have been bluish as usual, but on CO poisoning they can be light-red (as in life). However, the typical “cherry-red” staining occurs only at a carboxyhemoglobin (COHb) concentration of 30% or more. The higher the COHb level, the lighter the lividity. To avoid further cases of—potentially deadly—CO poisoning, it is essential to find the CO source (often a defective heating system, in this case a barbecue). There were no signs of a pre-existing severe somatic disease (in which case, importantly, death would have been possible even at a low concentration of COHb, without light-red livor mortis). Owing to the obvious indications of unnatural death, the police were informed.

Dr. med. Benno Schäffer, Prof. Dr. med. Oliver Peschel, Institut für Rechtsmedizin der Ludwig-Maximilians-Universität München, benno.schaeffer@gmail.com

Conflict of interest statement: The authors declare that no conflict of interest exists.

Cite this as: Schäffer B, Peschel O: The differential diagnosis of light-red livor mortis.Dtsch Arztebl Int 2018; 115: 585. DOI: 10.3238/arztebl.2018.0585

Translated from the original German by Ethan Taub, M.D.

Supplementary material to:

Cancers Due to Excess Weight, Low Physical Activity, and Unhealthy Diet

Estimation of the Attributable Cancer Burden in Germany

by Gundula Behrens, Thomas Gredner, Christian Stock, Michael F. Leitzmann, Hermann Brenner, and Ute Mons

Dtsch Arztebl Int 2018; 115: 578–85. DOI: 10.3238/arztebl.2018.0578

eReferences

e1. WCRF/AICR: Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington DC2007. www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf (last accessed on 8 August 2017).

e2. Scheidt-Nave C, Kamtsiuris P, Gosswald A, et al.: German Health Interview and Examination Survey for Adults (DEGS)—design, objectives and implementation of the first data collection wave. BMC Public Health 2012; 12: 730.

e3. Marshall AL, Smith BJ, Bauman AE, Kaur S: Reliability and validity of a brief physical activity assessment for use by family doctors. Br J Sports Med 2005; 39: 294–7.

e4. Washburn RA, Goldfield SR, Smith KW, McKinlay JB: The validity of self-reported exercise-induced sweating as a measure of physical activity. Am J Epidemiol 1990; 132: 107–13.

e5. Kohl HW, Blair SN, Paffenbarger RS Jr, Macera CA, Kronenfeld JJ: A mail survey of physical activity habits as related to measured physical fitness. Am J Epidemiol 1988; 127: 1228–39.

e6. Siconolfi SF, Lasater TM, Snow RC, Carleton RA: Self-reported physical activity compared with maximal oxygen uptake. Am J Epidemiol 1985; 122: 101–5.

e7. Krug S, Jordan S, Mensink GB, Muters S, Finger J, Lampert T: [Physical activity: results of the German Health Interview and Examination Survey for Adults (DEGS1)]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 2013; 56: 765–71.

e8. Gruner C, Alig F, Muntwyler J: Validity of self-reported exercise-induced sweating as a measure of physical activity among patients with coronary artery disease. Swiss Med Wkly 2002; 132: 629–32.

e9. Boyle P, Koechlin A, Autier P: Sweetened carbonated beverage consumption and cancer risk: meta-analysis and review. Eur J Cancer Prev 2014; 23: 481–90.

e10. Romaguera D, Vergnaud AC, Peeters PH, et al.: Is concordance with World Cancer Research Fund/American Institute for Cancer Research guidelines for cancer prevention related to subsequent risk of cancer? Results from the EPIC study. Am J Clin Nutr 2012; 96: 150–63.

e11. Haftenberger M, Heuer T, Heidemann C, Kube F, Krems C, Mensink GB: Relative validation of a food frequency questionnaire for national health and nutrition monitoring. Nutr J 2010; 9: 36.

e12. U.S. Department of Agriculture ARS: USDA Food and Nutrient Database for Dietary Studies 2013–2014. Food Surveys Research Group Home Page 2016.

e13. Lumley T: Analysis of complex survey samples. J Stat Softw 2004; 9: 1–19.

e14. Chen Y, Liu L, Wang X, et al.: Body mass index and risk of gastric cancer: a meta-analysis of a population with more than ten million from 24 prospective studies. Cancer Epidemiol Biomarkers Prev 2013; 22: 1395–408.

e15. Ma Y, Yang Y, Wang F, et al.: Obesity and risk of colorectal cancer: a systematic review of prospective studies. PLoS One 2013; 8: e53916.

e16. Moghaddam AA, Woodward M, Huxley R: Obesity and risk of colorectal cancer: a meta-analysis of 31 studies with 70,000 events. Cancer Epidemiol Biomarkers Prev 2007; 16: 2533–47.

e17. Chen Y, Wang X, Wang J, Yan Z, Luo J: Excess body weight and the risk of primary liver cancer: an updated meta-analysis of prospective studies. Eur J Cancer 2012; 48: 2137–45.

e18. Li L, Gan Y, Li W, Wu C, Lu Z: Overweight, obesity and the risk of gallbladder and extrahepatic bile duct cancers: a meta-analysis of observational studies. Obesity (Silver Spring) 2016; 24: 1786–802.

e19. Xue K, Li FF, Chen YW, Zhou YH, He J: Body mass index and the risk of cancer in women compared with men: a meta-analysis of prospective cohort studies. Eur J Cancer Prev 2017; 26: 94–105.

e20. Munsell MF, Sprague BL, Berry DA, Chisholm G, Trentham-Dietz A: Body mass index and breast cancer risk according to postmenopausal estrogen-progestin use and hormone receptor status. Epidemiol Rev 2014; 36: 114–36.

e21. Jenabi E, Poorolajal J: The effect of body mass index on endometrial cancer: a meta-analysis. Public Health 2015; 129: 872–80.

e22. Poorolajal J, Jenabi E, Masoumi SZ: Body mass index effects on risk of ovarian cancer: a meta- analysis. Asian Pac J Cancer Prev 2014; 15: 7665–71.

e23. Xie B, Zhang G, Wang X, Xu X: Body mass index and incidence of nonaggressive and aggressive prostate cancer: a dose-response meta-analysis of cohort studies. Oncotarget 2017; 8: 97584–92.

e24. Wang F, Xu Y: Body mass index and risk of renal cell cancer: a dose-response meta-analysis of published cohort studies. Int J Cancer 2014; 135: 1673–86.

e25. Sun JW, Zhao LG, Yang Y, Ma X, Wang YY, Xiang YB: Obesity and risk of bladder cancer: a dose-response meta-analysis of 15 cohort studies. PLoS One 2015; 10: e0119313.

e26. Ma J, Huang M, Wang L, Ye W, Tong Y, Wang H: Obesity and risk of thyroid cancer: evidence from a meta-analysis of 21 observational studies. Med Sci Monit 2015; 21: 283–91.

e27. Schmid D, Ricci C, Behrens G, Leitzmann MF: Adiposity and risk of thyroid cancer: a systematic review and meta-analysis. Obes Rev 2015; 16: 1042–54.

e28. Larsson SC, Wolk A: Obesity and risk of non-Hodgkin's lymphoma: a meta-analysis. Int J Cancer 2007; 121: 1564–70.

e29. Wallin A, Larsson SC: Body mass index and risk of multiple myeloma: a meta-analysis of prospective studies. Eur J Cancer 2011; 47: 1606–15.

e30. Castillo JJ, Reagan JL, Ingham RR, et al.: Obesity but not overweight increases the incidence and mortality of leukemia in adults: a meta-analysis of prospective cohort studies. Leuk Res 2012; 36: 868–75.

e31. Gaudet MM, Kitahara CM, Newton CC, et al.: Anthropometry and head and neck cancer: a pooled analysis of cohort data. Int J Epidemiol 2015; 44: 673–81.

e32. Turati F, Tramacere I, La Vecchia C, Negri E: A meta-analysis of body mass index and esophageal and gastric cardia adenocarcinoma. Ann Oncol 2013; 24: 609–17.

e33. Sergentanis TN, Antoniadis AG, Gogas HJ, et al.: Obesity and risk of malignant melanoma: a meta-analysis of cohort and case-control studies. Eur J Cancer 2013; 49: 642–57.

e34. Niedermaier T, Behrens G, Schmid D, Schlecht I, Fischer B, Leitzmann MF: Body mass index, physical activity, and risk of adult meningioma and glioma: a meta-analysis. Neurology 2015; 85: 1342–50.

e35. Larsson SC, Wolk A: Body mass index and risk of non-Hodgkin's and Hodgkin's lymphoma: a meta-analysis of prospective studies. Eur J Cancer 2011; 47: 2422–30.

e36. Duan P, Hu C, Quan C, et al.: Body mass index and risk of lung cancer: systematic review and dose-response meta-analysis. Sci Rep 2015; 5: 16938.

e37. Hidayat K, Du X, Chen G, Shi M, Shi B: Abdominal obesity and lung cancer risk: systematic review and meta-analysis of prospective studies. Nutrients 2016; 8: 810.

e38. Chen GC, Chen SJ, Zhang R, et al.: Central obesity and risks of pre- and postmenopausal breast cancer: a dose-response meta-analysis of prospective studies. Obes Rev 2016; 17: 1167–77.

e39. Discacciati A, Orsini N, Wolk A: Body mass index and incidence of localized and advanced prostate cancer—a dose-response meta-analysis of prospective studies. Ann Oncol 2012; 23: 1665–71.

e40. Bhaskaran K, Douglas I, Forbes H, dos-Santos-Silva I, Leon DA, Smeeth L: Body-mass index and risk of 22 specific cancers: a population-based cohort study of 5.24 million UK adults. Lancet 2014; 384: 755–65.

e41. Keum N, Greenwood DC, Lee DH, et al.: Adult weight gain and adiposity-related cancers: a dose-response meta-analysis of prospective observational studies. J Natl Cancer Inst 2015; 107: pii: djv088.

e42. Allott EH, Masko EM, Freedland SJ: Obesity and prostate cancer: weighing the evidence. Eur Urol 2013; 63: 800–9.

e43. Psaltopoulou T, Ntanasis-Stathopoulos I, Tzanninis IG, Kantzanou M, Georgiadou D, Sergentanis TN: Physical activity and gastric cancer risk: a systematic review and meta-analysis. Clin J Sport Med 2016; 26: 445–64.

e44. Liu L, Shi Y, Li T, et al.: Leisure time physical activity and cancer risk: evaluation of the WHO's recommendation based on 126 high-quality epidemiological studies. Br J Sports Med 2016; 50: 372–8.

e45. Behrens G, Jochem C, Schmid D, Keimling M, Ricci C, Leitzmann MF: Physical activity and risk of pancreatic cancer: a systematic review and meta-analysis. Eur J Epidemiol 2015; 30: 279–98.

e46. Moore SC, Lee IM, Weiderpass E, et al.: Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. JAMA Intern Med 2016; 176: 816–25.

e47. Neilson HK, Farris MS, Stone CR, Vaska MM, Brenner DR, Friedenreich CM: Moderate-vigorous recreational physical activity and breast cancer risk, stratified by menopause status: a systematic review and meta-analysis. Menopause 2017; 24: 322–44.

e48. Behrens G, Leitzmann MF: The association between physical activity and renal cancer: systematic review and meta-analysis. Br J Cancer 2013; 108: 798–811.

e49. Behrens G, Jochem C, Keimling M, Ricci C, Schmid D, Leitzmann MF: The association between physical activity and gastroesophageal cancer: systematic review and meta-analysis. Eur J Epidemiol 2014; 29: 151–70.

e50. Vieira AR, Abar L, Chan D, et al.: Foods and beverages and colorectal cancer risk: a systematic review and meta-analysis of cohort studies, an update of the evidence of the WCRF-AICR Continuous Update Project. Ann Oncol 2017; 28: 1788–802.

e51. Zhao Z, Yin Z, Pu Z, Zhao Q: Association between consumption of red and processed meat and pancreatic cancer risk: a systematic review and meta-analysis. Clin Gastroenterol Hepatol 2017; 15: 486–93.

e52. Xue XJ, Gao Q, Qiao JH, Zhang J, Xu CP, Liu J: Red and processed meat consumption and the risk of lung cancer: a dose-response meta-analysis of 33 published studies. Int J Clin Exp Med 2014; 7: 1542–53.

e53. Guo J, Wei W, Zhan L: Red and processed meat intake and risk of breast cancer: a meta-analysis of prospective studies. Breast Cancer Res Treat 2015; 151: 191–8.

e54. Wu J, Zeng R, Huang J, et al.: Dietary protein sources and incidence of breast cancer: a dose-response meta-analysis of prospective studies. Nutrients 2016; 8: 730.

e55. Fang X, Wei J, He X, et al.: Landscape of dietary factors associated with risk of gastric cancer: a systematic review and dose-response meta-analysis of prospective cohort studies. Eur J Cancer 2015; 51: 2820–32.

e56. Aune D, Chan DS, Lau R, et al.: Dietary fibre, whole grains, and risk of colorectal cancer: systematic review and dose-response meta-analysis of prospective studies. BMJ 2011; 343: d6617.

e57. Aune D, Chan DS, Greenwood DC, et al.: Dietary fiber and breast cancer risk: a systematic review and meta-analysis of prospective studies. Ann Oncol 2012; 23: 1394–402.

e58. Aune D, Lau R, Chan DS, et al.: Nonlinear reduction in risk for colorectal cancer by fruit and vegetable intake based on meta-analysis of prospective studies. Gastroenterology 2011; 141: 106–18.

e59. Vieira AR, Abar L, Vingeliene S, et al.: Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis. Ann Oncol 2016; 27: 81–96.

e60. Luo J, Yang Y, Liu J, et al.: Systematic review with meta-analysis: meat consumption and the risk of hepatocellular carcinoma. Aliment Pharmacol Ther 2014; 39: 913–22.

e61. Zhang S, Wang Q, He J: Intake of red and processed meat and risk of renal cell carcinoma: a meta-analysis of observational studies. Oncotarget 2017; 8: 77942–56.

e62. Kolahdooz F, van der Pols JC, Bain CJ, et al.: Meat, fish, and ovarian cancer risk: results from 2 Australian case-control studies, a systematic review, and meta-analysis. Am J Clin Nutr 2010; 91: 1752–63.

e63. Wang A, Zhu C, Fu L, et al.: Citrus fruit intake substantially reduces the risk of esophageal cancer: a meta-analysis of epidemiologic studies. Medicine (Baltimore) 2015; 94: e1390.

e64. Lunet N, Lacerda-Vieira A, Barros H: Fruit and vegetables consumption and gastric cancer: a systematic review and meta-analysis of cohort studies. Nutr Cancer 2005; 53: 1–10.

e65. Vieira AR, Vingeliene S, Chan DS, et al.: Fruits, vegetables, and bladder cancer risk: a systematic review and meta-analysis. Cancer Med 2015; 4: 136–46.

e66. Chen GC, Lv DB, Pang Z, Liu QF: Fruits and vegetables consumption and risk of non-Hodgkin's lymphoma: a meta-analysis of observational studies. Int J Cancer 2013; 133: 190–200.

e67. Robert Koch-Institut: German Centre for Cancer Registry Data. Database query 2017. www.krebsdaten.de/Krebs/DE/Datenbankabfrage/datenbankabfrage_stufe1_node.html (last accessed on 12 December 2017).

e68. Statistisches Bundesamt: Bevölkerung Deutschlands bis 2060 – Ergebnisse der 13. koordinierten Bevölkerungsvorausberechnung. Wiesbaden, Germany, Statistisches Bundesamt 2015. www.destatis.de/DE/Publikationen/Thematisch/Bevoelkerung/VorausberechnungBevoelkerung/BevoelkerungDeutschland2060_5124202159004.pdf;jsessionid=D06F3A9634A843F70E6D0D907E659818.InternetLive1?__blob=publicationFile (last accessed on 14 December 2017).

e69. Robert Koch-Institut: Krebs in Deutschland. Berlin: Robert Koch-Institute 2017. www.krebsdaten.de/Krebs/DE/Content/Publikationen/Krebs_in_Deutschland/kid_/krebs_in_deutschland_.pdf?__blob=publicationFile (last accessed on 19 December 2017).

e70. Robert Koch-Institut: Zentrum für Krebsregisterdaten. Methoden. Vollzähligkeitsschätzung. 2017. www.krebsdaten.de/Krebs/DE/Content/Methoden/Vollzaehligkeitsschaetzung/vollzaehligkeitsschaetzung_node.html (last accessed on 4 December 2017).

e71. Parkin DM, Boyd L, Walker LC: 16. The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S77–81.

e72. Miettinen OS: Proportion of disease caused or prevented by a given exposure, trait or intervention. Am J Epidemiol 1974; 99: 325–32.

e73. James WPT, Jackson-Leach R, Ni Mhurchu C, et al.: Overweight and obesity (high body mass index). In: Ezzati M, Lopez AD, Rodgers A, Murray CJL (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 497–596.

e74. Bull FC, Armstrong TP, Dixon T, Ham S, Neiman A, Pratt M: Physical inactivity. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 729–882.

e75. Lock K, Pomerleau J, Causer L, McKee M: Low fruit and vegetable consumption. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 597–728.

e76. Murray CJL, Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S: Comparative quantification of health risks: conceptual framework and methodological issues. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 1–38.

e77. Vander Hoorn S, Ezzati M, Rodgers A, Lopez AD, Murray CJL: Estimating attributable burden of disease from exposure and hazard data. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 2129–40.

e78. Ezzati M, Vander Hoorn S, Rodgers A, Lopez AD, Mathers CD, Murray CJL: Potential health gains from reducing multiple risk factors. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL (eds.): Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization 2004; p. 2167–90.

e79. Brenner DR: Cancer incidence due to excess body weight and leisure-time physical inactivity in Canada: implications for prevention. Prev Med 2014; 66: 131–9.

e80. de Vries E, Quintero DC, Henriquez-Mendoza G, Herran OF: Population attributable fractions for colorectal cancer and red and processed meats in Colombia—a macro-simulation study. Colomb Med (Cali) 2017; 48: 64–9.

e81. Friedenreich CM, Neilson HK, Lynch BM: State of the epidemiological evidence on physical activity and cancer prevention. Eur J Cancer 2010; 46: 2593–604.

e82. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to red and processed meat consumption in Alberta in 2012. CMAJ Open 2016; 4: E768–75.

e83. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to insufficient fibre consumption in Alberta in 2012. CMAJ Open 2017; 5: E7–13.

e84. Grundy A, Poirier AE, Khandwala F, McFadden A, Friedenreich CM, Brenner DR: Cancer incidence attributable to insufficient fruit and vegetable consumption in Alberta in 2012. CMAJ Open 2016; 4: E760–767.

e85. Inoue M, Sawada N, Matsuda T, et al.: Attributable causes of cancer in Japan in 2005--systematic assessment to estimate current burden of cancer attributable to known preventable risk factors in Japan. Ann Oncol 2012; 23: 1362–9.

e86. Islami F, Goding Sauer A, Miller KD, et al.: Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. CA Cancer J Clin 2018; 68: 31–54.

e87. Kendall BJ, Wilson LF, Olsen CM, et al.: Cancers in Australia in 2010 attributable to overweight and obesity. Aust N Z J Public Health 2015; 39: 452–7.

e88. Nagle CM, Wilson LF, Hughes MC, et al.: Cancers in Australia in 2010 attributable to inadequate consumption of fruit, non-starchy vegetables and dietary fibre. Aust N Z J Public Health 2015; 39: 422–8.

e89. Nagle CM, Wilson LF, Hughes MC, et al.: Cancers in Australia in 2010 attributable to the consumption of red and processed meat. Aust N Z J Public Health 2015; 39: 429–33.

e90. Olsen CM, Wilson LF, Nagle CM, et al.: Cancers in Australia in 2010 attributable to insufficient physical activity. Aust N Z J Public Health 2015; 39: 458–63.

e91. Parkin DM, Boyd L: 4. Cancers attributable to dietary factors in the UK in 2010. I. Low consumption of fruit and vegetables. Br J Cancer 2011; 105 (Suppl 2): S19–23.

e92. Parkin DM: 5. Cancers attributable to dietary factors in the UK in 2010. II. Meat consumption. Br J Cancer 2011; 105 (Suppl 2): S24–6.

e93. Parkin DM, Boyd L: 6. Cancers attributable to dietary factors in the UK in 2010. III. Low consumption of fibre. Br J Cancer 2011; 105 (Suppl 2): S27–30.

e94. Parkin DM: 7. Cancers attributable to dietary factors in the UK in 2010. IV. Salt. Br J Cancer 2011; 105 (Suppl 2): S31–3.

e95. Parkin DM, Boyd L: 8. Cancers attributable to overweight and obesity in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S34–7.

e96. Parkin DM: 9. Cancers attributable to inadequate physical exercise in the UK in 2010. Br J Cancer 2011; 105 (Suppl 2): S38–41.

e97. Renehan AG, Soerjomataram I, Tyson M, et al.: Incident cancer burden attributable to excess body mass index in 30 European countries. Int J Cancer 2010; 126: 692–702.

e98. Richardson A, Hayes J, Frampton C, Potter J: Modifiable lifestyle factors that could reduce the incidence of colorectal cancer in New Zealand. N Z Med J 2016; 129: 13–20.

e99. Brown KF, Rumgay H, Dunlop C, et al.: The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. Br J Cancer 2018; 118: 1130–41.

e100. Azevedo ESG, de Moura L, Curado MP, et al.: The fraction of cancer attributable to ways of life, infections, occupation, and environmental agents in brazil in 2020. PLoS One 2016; 11: e0148761.

e101. Vingeliene S, Chan DS, Aune D, et al.: An update of the WCRF/AICR systematic literature review on esophageal and gastric cancers and citrus fruits intake. Cancer Causes Control 2016; 27: 837–51.

e102. WCRF/AICR: Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington DC 2007. www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf (last accessed on 8 August 2017).

e103. Parker ED, Folsom AR: Intentional weight loss and incidence of obesity-related cancers: the Iowa Women's Health Study. Int J Obes Relat Metab Disord 2003; 27: 1447–52.

e104. Mensink GB, Schienkiewitz A, Haftenberger M, Lampert T, Ziese T, Scheidt-Nave C: [Overweight and obesity in Germany: results of the German Health Interview and Examination Survey for Adults (DEGS1)]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 2013; 56: 786–94.

e105. Völzke H, Ittermann T, Schmidt CO, et al.: Prevalence trends in lifestyle-related risk factors—two cross-sectional analyses with a total of 8728 participants from the Study of Health in Pomerania from 1997 to 2001 and 2008 to 2012. Dtsch Arztebl Int 2015; 112: 185–92.

e106. Gose M, Krems C, Heuer T, Hoffmann I: Trends in food consumption and nutrient intake in Germany between 2006 and 2012: results of the German National Nutrition Monitoring (NEMONIT). Br J Nutr 2016; 115: 1498–507.

e107. Jankovic N, Geelen A, Winkels RM, et al.: Adherence to the WCRF/AICR dietary recommendations for cancer prevention and risk of cancer in elderly from Europe and the United States: a meta-analysis within the CHANCES project. Cancer Epidemiol Biomarkers Prev 2017; 26: 136–44.

e108. Lin XJ, Wang CP, Liu XD, et al.: Body mass index and risk of gastric cancer: a meta-analysis. Jpn J Clin Oncol 2014; 44: 783–91.

e109. Renehan AG, Tyson M, Egger M, Heller RF, Zwahlen M: Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. Lancet 2008; 371: 569–78.

e110. Yang P, Zhou Y, Chen B, et al.: Overweight, obesity and gastric cancer risk: results from a meta-analysis of cohort studies. Eur J Cancer 2009; 45: 2867–73.

e111. Alexander DD, Weed DL, Miller PE, Mohamed MA: Red meat and colorectal cancer: A quantitative update on the state of the epidemiologic science. J Am Coll Nutr 2015; 34: 521–43.

eSupplement

A. Definition of the selected lifestyle factors and their prevalence estimation

Our definitions of normal body weight, the recommended level of physical activity, and a healthy diet followed the cancer prevention guidelines of the World Cancer Research Fund (WCRF) (e1). We estimated the prevalence of these lifestyle factors using data on 6,962 men and women aged 25 to 74 years from the nationwide representative DEGS1 survey conducted in 2008–2011 in Germany (e2).

We defined adherence to a normal body weight by a body mass index (BMI) of 18.5 to 24.9 kg/m², and used two non-adherence groups because separate cancer risk estimates for overweight (BMI of 25 to 29.9 kg/m²) and obesity (BMI of ≥30 kg/m²) are given in the literature. Measurements of weight and height were available for 6,087 men and women.

With respect to physical activity, we distinguished between those adhering to the recommended physical activity level (≥150 min moderate to vigorous physical activity per week), those who were insufficiently physically active (1-149 min moderate to vigorous physical activity per week), and those who were physically inactive (0 min moderate to vigorous physical activity per week). The DEGS1 physical activity questionnaire, which was available for 6,696 participants aged 25 to 74 years, was similar to physical activity questionnaires of known validity (e3–e6). It assessed the average frequency and duration of physical activity sufficient to increase the respiratory rate or work up a sweat in a usual week during the previous 3 months. In line with a previous study (e7) and in line with results from sweating research (e8), we interpreted the DEGS1 physical activity questionnaire as an assessment of moderate to vigorous physical activity. Because we were not able to distinguish between moderate and vigorous physical activity, we were not able to incorporate the option of meeting the physical activity recommendation by engaging in vigorous physical activity for ≥75 min/week, which is considered equivalent to engaging in moderate physical activity for ≥150 min/week.

With respect to dietary intakes, we compared those meeting and not meeting the recommended average intakes of <500 g/week of red meat, 0 g/week of processed meat, <6 g/day of salt, ≥32 g/day of dietary fiber, and ≥400 g/day of fruits and non-starchy vegetables. We followed the wider definition of non-starchy vegetables proposed by the WCRF (e1), which included green, leafy vegetables (such as lettuce and spinach), cruciferous vegetables (the cabbage family), allium vegetables (such as onions, garlic, and leeks), non-starchy roots (such as carrots, beets, parsnips, turnips, and swedes) and fruits that are culinarily classified as vegetables (such as cucumbers, peppers, squash, aubergines, and tomatoes) (e1). We did not estimate the potential cancer burden for a high intake of energy dense food and sugary beverages, because estimates from prospective studies were based on <5,000 cases (e9, e10). We derived average daily food intakes during the previous 4 weeks from the validated 53-item food frequency questionnaire (e11), which was available for 6,129 participants aged 25 to 74 years. Red meat intake was assessed by the average frequency and portion size of meat intake explicitly including pork, beef, and venison and explicitly excluding sausages and poultry. Total processed meat intake combined separate assessments of the average intake frequency and portion size of hamburger/kebab, bratwurst/*currywurst*, sausage, and ham. We estimated total fruit and non-starchy vegetable intake using separate items on fresh fruit, cooked/canned fruit, green salad/raw vegetables, and cooked vegetables, explicitly excluding intakes of cooked/fried/roasted potatoes, potato croquettes, hash browns, French fries, fruit juices, and vegetable juices. We derived average daily salt and dietary fiber intakes from all food items using nutrient information from the USDA Food and Nutrient Database (e12).

In addition, we estimated the correlation between selected lifestyle factors (including excess weight, physical activity, dietary intakes, alcohol consumption, and current smoking) among those 5,195 men and women aged 25 to 74 years from the nationally representative DEGS1 survey for which complete information on the lifestyle factors was available using R routine svycor from the R library survey (e13).

B. Selection of cancer types, cancer risk estimates and cancer incidence estimation

We included all cancer sites that have been statistically significantly positively or inversely associated with the lifestyle factors in published meta-analyses of prospective studies (from any countries) comprising a total of 5,000 site-specific cancer cases or more. Our selection of relevant cancer sites was based on all available summary risk estimates independent of the type of risk comparison (categorical, continuous) and, for physical activity, independent of the physical activity domain (recreational physical activity, occupational physical activity, combined recreational and occupational physical activity).

In addition, for each lifestyle factor and each cancer site, we decided which summary risk estimate should be used for the calculation of the population-attributable fractions (PAFs). For our excess weight analyses, we chose summary cancer risk estimates comparing the overweight and obesity categories against the normal weight category. For our physical activity analyses, we selected summary risk estimates for recreational physical activity rather than occupational physical activity because recreational physical activity is a much more suitable target for lifestyle changes than occupational physical activity, especially because it is much easier to modify. Because sufficiently physically active DEGS1 participants spent on average 248 min/week on moderate to vigorous recreational physical activity, we interpreted the summary risk estimates for high vs. low moderate to vigorous (recreational) physical activity comparisons from published meta-analyses as summary risk estimates for our comparisons of sufficient physical activity vs. physical inactivity (corresponding to an average of 248 min/week vs. 0 min/week of moderate to vigorous recreational physical activity). This interpretation allowed us to derive summary risk estimates for our comparisons of insufficient physical activity vs. physical inactivity (corresponding to an average of 76 min/week vs. 0 min/week of moderate to vigorous recreational physical activity) by interpolation. For the interpolation, we assumed a log-linear relationship between total duration of moderate to vigorous recreational physical activity and cancer risk. For our dietary factor analyses, we chose summary risk estimates comparing continuous intake levels, which was the most common type of summary risk estimates. In addition, we used the average levels observed for those adhering to the specific recommendation for that dietary factor as health target for those not adhering to that recommendation.

If more than one summary risk estimate was available for the selected lifestyle factor and cancer risk comparisons, we chose the estimate that was based on the published meta-analysis of prospective studies with the largest number of site-specific cancer cases. We identified those meta-analyses through systematic literature searches in PubMed and Web of Science.

C. Literature search for excess weight and low physical activity

To identify cancer types related to excess weight and low physical activity, we pasted the following terms, all at once, into the PubMed search command line:

(overweight OR obesity OR adiposity OR excess weight OR physical activity OR exercise) AND (cancer OR neoplasms OR carcinoma) AND meta-analysis

That search was last updated on November 21, 2017. It yielded 1,062 hits. Two authors (GB, TG) independently screened the articles. In total, we excluded 928 irrelevant articles after screening titles and abstracts and 20 irrelevant articles after reading the manuscripts. The remaining 114 articles and one additional article of which we were aware proved relevant. We did not identify any further relevant articles when searching Web of Science and the reference lists of the identified articles.

For our cancer burden analysis of overweight and obesity, we considered all cancer sites for which there were statistically significant positive relations with obesity, in which case we also used the summary risk estimates for overweight even if the summary risk estimates for overweight were not statistically significant (see eTable 1). Those cancers included cancers of the stomach (e14), colorectum (e15, e16), liver (e17), gallbladder (e18), pancreas (e19), breast (postmenopausal) (e20), endometrium (e21), ovaries (e22), prostate (advanced) (e23), kidney (e24), bladder (e25), thyroid gland (e26, e27), non-Hodgkin lymphoma (e28), multiple myeloma (e29), and leukemia (e30). In contrast, we did not consider the statistically significant positive relations of obesity to head and neck cancer (e31), esophageal adenocarcinoma (e32), extrahepatic bile duct cancer (e18), malignant melanoma (e33), meningioma (e34), and Hodgkin lymphoma (e35) observed in meta-analyses of prospective studies because case numbers were <5,000 in those meta-analyses. We did not include the statistically significant inverse relations of obesity to lung cancer (e36) and premenopausal breast cancer (e20), because those inverse relations were not consistent with the statistically significant positive associations of waist circumference with lung cancer (e37) and premenopausal breast cancer (e38). In addition, we did not use the statistically significant inverse relation between BMI and localized prostate cancer established in linear BMI models (e39), because a linear model is not appropriate to model the non-linear relation between BMI and localized prostate cancer (e40, e41) and because it is very likely that the association between BMI and localized prostate cancer is confounded by BMI-related differences in PSA screening attendance, palpability of small prostate tumors and sensitivity of rectal biopsy (e42).

For our physical activity analysis, we considered the inverse relations of physical activity to cancers of the stomach (e43), colorectum (e44), pancreas (e45), lung (e46), breast (e47), endometrium (e46), kidney (e46, e48), and bladder (e46) (see eTable 2). In contrast, we did not consider the potentially inverse relations of physical activity to esophageal squamous cell carcinoma and esophageal adenocarcinoma, because summary risk estimates from meta-analyses of prospective studies were based on <3,000 cases (e46, e49).

D. Literature search for dietary factors

To search for diet-related cancer types, we typed the following terms, all at once, into the PubMed search command line:

(meat OR fruit OR vegetable OR fruits OR vegetables OR dietary fiber OR salt OR salted OR salt-preserved OR sodium OR sodium, dietary) AND (cancer OR carcinoma OR adenocarcinoma OR neoplasms) AND meta-analysis

That search was last updated on 21 November 2017. It yielded 594 hits. Two authors (GB, TG) independently screened the articles. In total, we removed 448 irrelevant articles after screening abstracts and titles and 21 irrelevant articles after reading the manuscripts. The remaining 125 articles were relevant. We did not find any additional relevant articles by searching Web of Science and the reference lists of the identified articles.

For our dietary factor analysis, we considered the statistically significant positive relations of high red meat intake to colorectal (e50), pancreatic (e51), lung (e52), and breast cancer (e53); of high processed meat intake to colorectal (e50) and breast cancer (e54); of high salt intake to gastric cancer (e55); of low dietary fiber intake to colorectal (e56) and breast cancer (e57); and of low fruit and vegetable intake to colorectal (e58) and lung cancer (e59) (see eTable 3). In contrast, we did not include the statistically significant positive relations of high red meat intake to liver cancer (e60), high processed meat intake to gastric (e55), renal (e61), and ovarian cancer (e62), and low fruit and vegetable intake to esophageal (e63), gastric (e64), and bladder cancer (e65) and to non-Hodgkin lymphoma (e66), because those relations were based on <5,000 cases from prospective studies.

E. Statistical methods

We estimated the number of site-specific cancers for each age and gender group for the year 2018 by multiplying the most recent age- and gender-specific cancer incidence rates available from the German cancer registries, which were those for the year 2014, by the age- and gender-specific population projections (scenario 1) for Germany for the year 2018 (e67, e68). We used the information (e69) that 26% of all prostate cancers are advanced cases (defined by tumor stage T3 to T4) to estimate the number of advanced prostate cancer cases in Germany. The German cancer registries are ≥90% complete (e70).

For each lifestyle factor, we estimated the mean exposure in those meeting the recommendations and in those not meeting the recommendations in strata defined by age (25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years, 65 to 74 years) and gender (men, women) using the data and the sample weights of the DEGS1 survey and the survey methods in SAS, version 9.4. If the lifestyle factor was positively related to cancer incidence, we defined the corresponding mean excess exposure level by the difference between the mean exposure in those adhering to the recommendations and the mean exposure in those not adhering to the recommendations

$$\text{mean excess} = \text{mean exposure under non-adherence} - \text{mean exposure under adherence} \qquad (Eq. 1)$$

Conversely, if the lifestyle factor was inversely related to cancer incidence, we defined the corresponding mean deficit exposure level by

$$\text{mean deficit}=\text{mean exposure under adherence - mean exposure under non-adherence} \quad (Eq.2)$$

For each age and gender group, we computed the log relative risk (RR) of cancer associated with the mean level of excess (or the mean level of deficit) by multiplying the mean level of excess (or the mean level of deficit) by the log RR of cancer for a one-unit increase (or one-unit decrease) in the lifestyle factor of interest:

$$\text{log RR for the mean excess}=\text{mean excess} * \text{log RR per one unit of excess} \quad (Eq.3)$$

$$\text{log RR for the mean deficit}=\text{mean deficit} * \text{log RR per one unit of deficit} \quad (Eq.4)$$

Using the exponential transformation RR=exp(log RR), we calculated the PAF for the mean level of excess (or the mean level of deficit) using Levin's formula

$$\text{PAF for mean excess}=\frac{\text{prevalence of non-adherence} * (\text{RR for the mean excess} - 1)}{[1+\text{prevalence of non-adherence} * (\text{RR for the mean excess} - 1)]} \quad (Eq.5)$$

$$\text{PAF for mean deficit}=\frac{\text{prevalence of non-adherence} * (\text{RR for the mean deficit} - 1)}{[1+\text{prevalence of non-adherence} * (\text{RR for the mean deficit} - 1)]} \quad (Eq.6)$$

The above formulae (Equations 1 to 6) were employed to estimate the PAFs for the dietary factors, for which we used one adherence group and one non-adherence group. For physical activity, we had one adherence group (group 0) and two non-adherence groups (groups 1 and 2), so that the mean deficit (Equations 1 and 2) and the corresponding log RR (Equations 2 and 3) were computed for each of the two non-adherence groups (groups 1 and 2). The PAF formula for the mean deficit in physical activity was:

$$\text{PAF for mean deficit}=\frac{\sum_{i=1,2}[\text{prevalence of non-adherence group i} * (\text{RR for the mean deficit in group i} - 1)]}{\{1+\sum_{i=1,2}[\text{prevalence of non-adherence group i} * (\text{RR for the mean deficit in group i} - 1)]\}} \quad (Eq.7)$$

For BMI, we also had one adherence group (group 0, normal weight) and two non-adherence groups (group 1, overweight, and group 2, obesity). Because RRs for risk comparisons between the overweight and the normal weight group and between the obesity and the normal weight group were readily available, we could directly use those RRs when computing the PAF for excess weight

$$\text{PAF for excess weight} = \frac{\sum_{i=1,2}[\text{prevalence of non-adherence group i} * (\text{RR for group i} - 1)]}{\{1 + \sum_{i=1,2}[\text{prevalence of non-adherence group i} * (\text{RR for group i} - 1)]\}} \quad (Eq. 8)$$

To estimate the number of incident cancers attributable to the lifestyle factors of interest, we multiplied the PAF by the expected cancer incidence for each age and gender group for the year 2018, because prevalence estimates were for the year 2008 and because we assumed that cancers incidences occurred with a 10-year latency period, i.e. we assumed that those aged 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years, and 65 to 74 years at exposure were at cancer risk 10 years later at ages 35 to 44 years, 45 to 54 years, 55 to 64 years, 65 to 74 years, and 75 to 84 years respectively.

For comparison with previous work (e71), we estimated the combined impact of the five selected dietary factors (high red meat intake, high processed meat intake, high salt intake, low dietary fiber intake, low fruit and vegetable intake) using the formula (e72)

$$\text{PAF} = 1 - \prod_i (1 - \text{PAF}_i)$$

where PAF_i represents the PAF for each individual factor for each cancer type and for each age- and sex group before summing those estimates to obtain an overall estimate of the total number of cancers attributable to all selected dietary factors. This approach yields an unbiased estimate of the combined impact of all selected dietary factors if the dietary factors are uncorrelated, which is the case for most dietary factors considered in the present study (eTable 22).

In sensitivity analyses, we examined the impact of the uncertainty in the cancer-specific relative risk estimates by comparing the total number of attributable cancers when using the point estimate, the lower limit of the corresponding 95% confidence interval, and the upper limit of the corresponding 95% confidence interval of the cancer-specific relative risk estimates in Equations 5 to 8 (eTables 23–25).

F. Methodological strengths and limitations

Our analysis of the number of cancers attributable to excess weight, low physical activity, and dietary factors followed the methodological recommendations (e73–e78) issued by the World Health Organization (WHO). In the following, we will discuss methodological strengths and limitations with respect to the selected risk factor–disease relations, the definition of health targets, the impact of long-term exposure to risk factors, the choice of latency period, the impact of changing prevalence rates over time, the potential of bias and confounding, the impact of potential correlation and biological interaction between lifestyle factors, and the variability of estimates.

We selected only established relationships between lifestyle factors and site-specific cancer risk based on results from sufficiently large meta-analyses of prospective studies which were identified in a systematic literature search. In addition, we verified that there is sufficient biological evidence in support of a causal relation of the selected lifestyle factors to site-specific cancer incidence. Our selection approach increased the generalizability of the selected estimates for the risk factor–disease relations and reduced the probability of selecting a risk factor–disease relation erroneously as a result of bias or chance.

As a particular strength, our selection approach also led to the inclusion of recently established links between lifestyle factors and cancer incidence, including the relations of obesity to bladder cancer, the relations of low physical activity to cancers of the stomach, lung and bladder and the relations of high intakes of red and processed meat and of low intakes of dietary fiber to cancers of the pancreas, lung, and breast, which have not been considered previously (e79–e100).

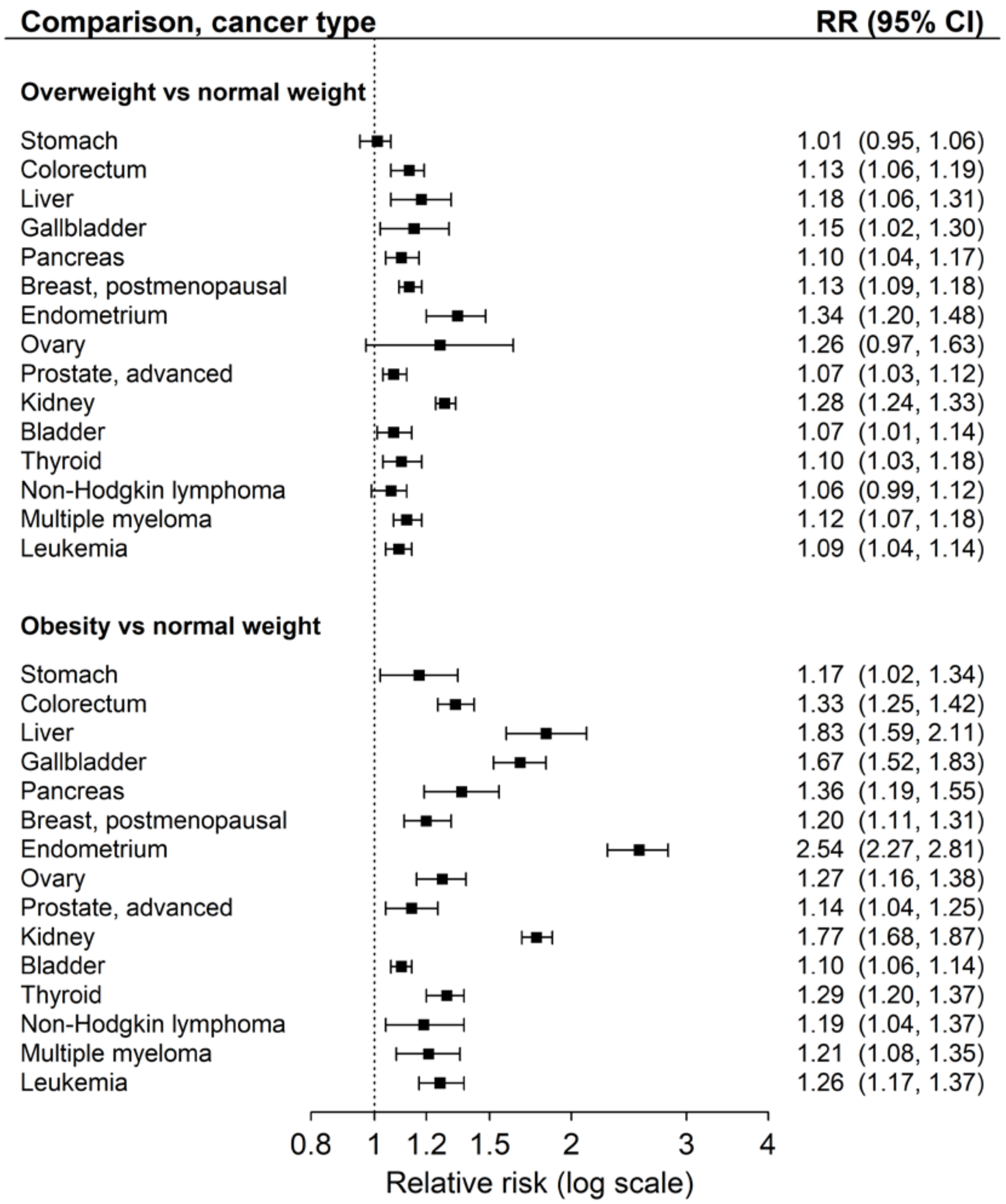
As a particular limitation, our selection approach may have led to potential underestimation of the cancer incidence attributable to the selected lifestyle factors, because we considered only established relationships between lifestyle factors and cancer incidence. In contrast to previous cancer burden studies, we did not include the relation of obesity to esophageal adenocarcinoma (e79, e87, e95, e97, e99, e100) and the relations of low fruit and vegetable intakes to oropharyngeal, gastroesophageal, and laryngeal cancer (e84, e88, e100), because summary risk estimates from meta-analyses of prospective studies were not available (oropharyngeal and laryngeal cancer) or were based on <5,000 cases (gastroesophageal cancer) (e101, e102). Similarly, due to there being <5,000 cases from prospective studies, we did not consider the potential positive relations of obesity to head and neck cancer, extrahepatic bile duct cancer, malignant melanoma, and Hodgkin lymphoma. Furthermore, we did not include the potential positive relation of low physical activity to esophageal cancer and the potential positive relations of an unhealthy diet to gastroesophageal, hepatic, ovarian, bladder, and hematologic cancers.

Our definition of health targets followed the cancer prevention guidelines of the WCRF (e1). We assumed that the subpopulation currently not meeting those guidelines would actually be capable of meeting the targets therein. This assumption is realistic. The best way of meeting the targets is to adopt them as early as possible in life (ideally in childhood/adolescence) and to maintain the appropriate behavior throughout life. In particular, healthy people may immediately change their lifestyle to meet the physical activity targets of ≥150 min/week of moderate to vigorous physical activity (brisk walking, for example) and the dietary health targets of consuming <500 g/week of red meat, no processed meat, <6 g/day of salt, ≥32 g/day of dietary fiber, ≥400 g/day of fruits and non-starchy vegetables. Weight reduction may take somewhat longer; however, regular physical activity and a diet rich in dietary fiber may accelerate that process, and it has been shown that overweight women who intentionally lost weight and reached normal weight had obesity-related cancer risks similar to those of women who had always been normal weight (e103).

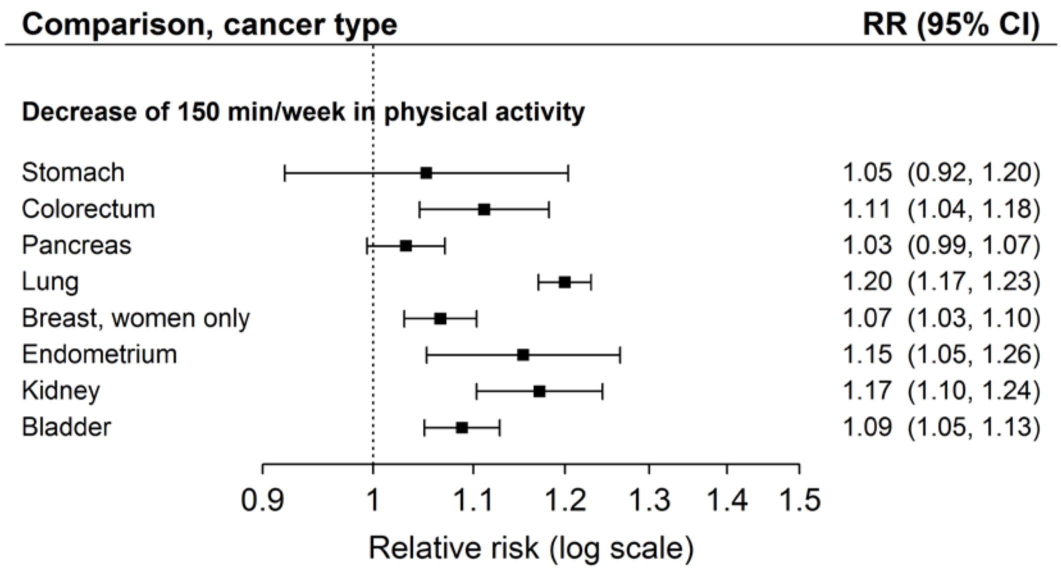
In line with many previous studies (e87–e93, e95, e96), we assumed a latency period of 10 years for all cancer sites. It has been shown that this is a realistic assumption for cancers related to obesity and physical inactivity, and that latency periods of 5 to 15 years yield comparable estimates for the attributable cancer incidence (e79, e97). In sensitivity analyses, we used the lower and upper limits of the cancer-site specific relative risk estimates to account for the uncertainty of those risk estimates when computing the PAFs. We observed that the total number of cancers attributable to the selected lifestyle factors remained substantial across all scenarios. Similarly, any potential changes in the prevalence rates of lifestyle factors during the 5-year period 2012–2016 should be small and should not affect our cancer burden estimates substantially: Previous studies observed increases (decreases) of about 5 % in obesity rates among men (women) over a period of 22 years from 1990 to 2011 (e104), decreases of about 5 % in physical inactivity over a period of 16 years from 1997 to 2012 (e105), and average decreases of 25 g fruit intakes per day over a period of 7 years from 2006 to 2012, which was not compensated by an increase in the consumption of vegetables (e106).

To reduce potential bias as far as possible, we used the nationwide representative DEGS1 data from 2008 to 2011 to estimate the prevalence exposure and the most recent data from German cancer registries to estimate the cancer incidence. Cancer registry data were ≥90% complete. Our prevalence estimates for excess weight were based on measured data, and our prevalence estimates of low physical activity and unhealthy diets were based on validated physical activity and food frequency questionnaires, which are valid and often the only choices when estimating the attributable cancer burden of lifestyle factors (e73–e75). The use of self-reported data may lead to underestimation of low physical activity and unhealthy dietary behavior, which in turn may result in a downward bias of the estimated cancer incidence attributable to those factors (e73–e75).

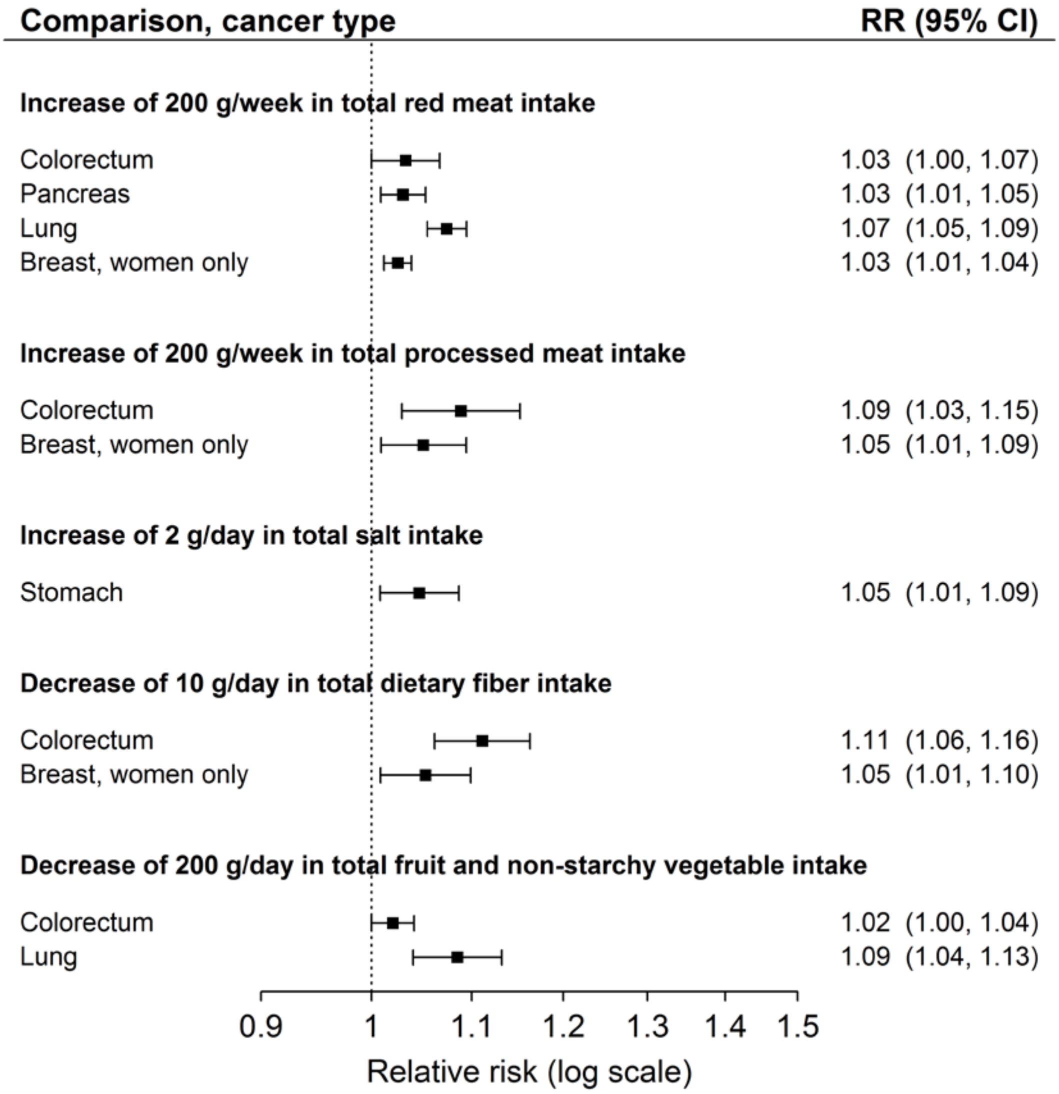
The most important potential confounders of the relation between lifestyle factors and cancer risk are age and sex. To account for potential confounding by age and sex, we stratified exposure prevalence and cancer incidence data by age and sex and used relative risk estimates that were adjusted for age and sex and potentially other confounding factors. As with previous studies (e79–e100), we were not able to stratify analyses by any additional potential confounders, including alcohol, smoking, BMI, physical activity, and dietary intakes, because cancer registries do not collect cancer incidence data stratified by those lifestyle factors. However, in our study, most lifestyle factors were uncorrelated, suggesting that the potential of confounding was low. We considered quantifying the combined impact of the selected lifestyle factors based on lifestyle scores, as recommended by the WHO, but the precision of available risk estimates was limited (e10, e107). For similar reasons, we were not able to consider potential interactions between effects or estimate the background risk of cancer among those adhering to all cancer prevention recommendations.



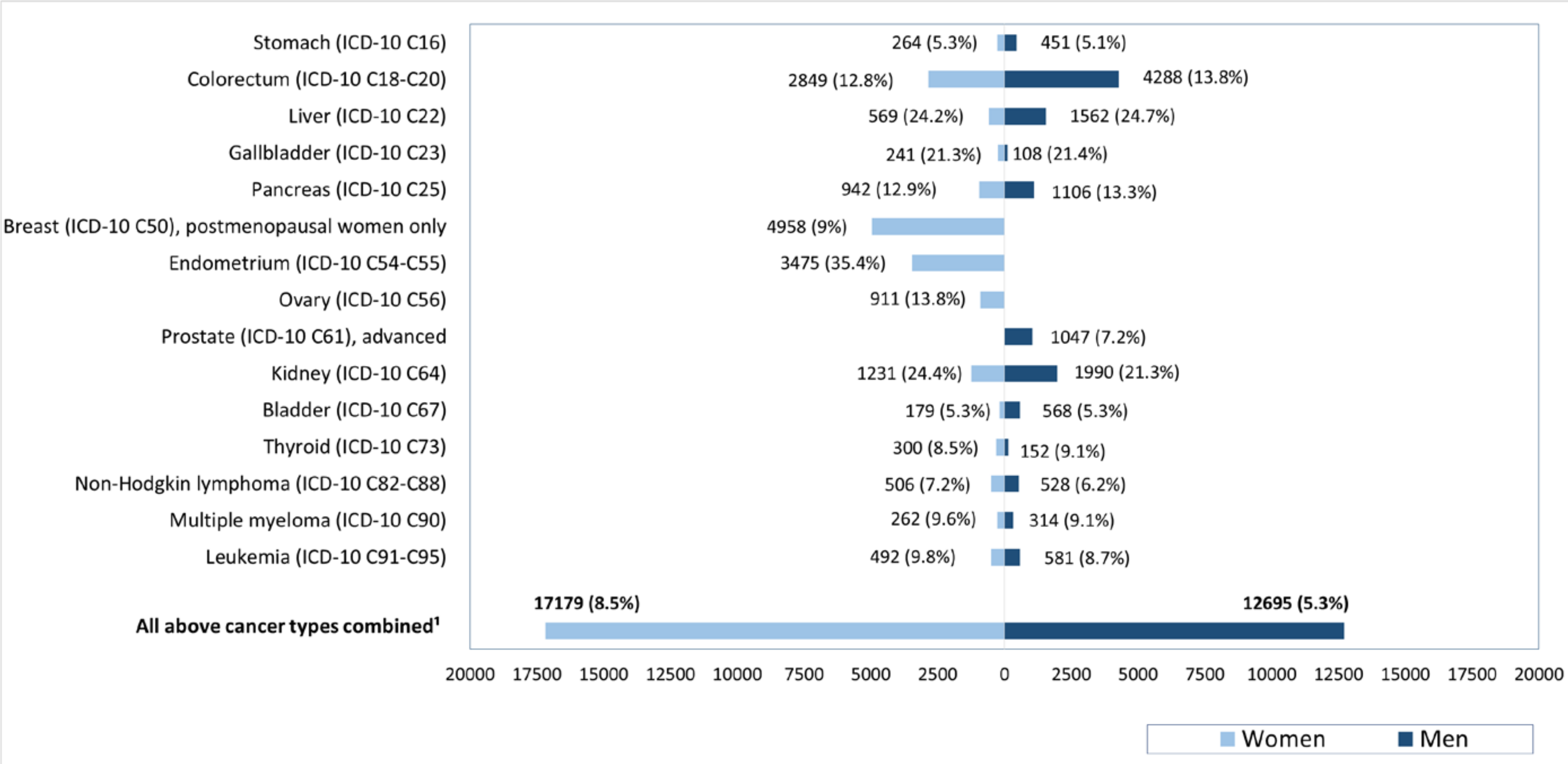
eFigure 1. Relative risks of site-specific cancer for overweight and obesity derived from published meta-analyses including ≥5,000 cases (see eSupplement B and C and eTable 1 for more information). RR=relative risk; CI=confidence interval



eFigure 2. Relative risks of site-specific cancer for decreases in physical activity levels derived from published meta-analyses including ≥5,000 cases (see eSupplement B and C and eTable 2 for more information). RR=relative risk; CI=confidence interval

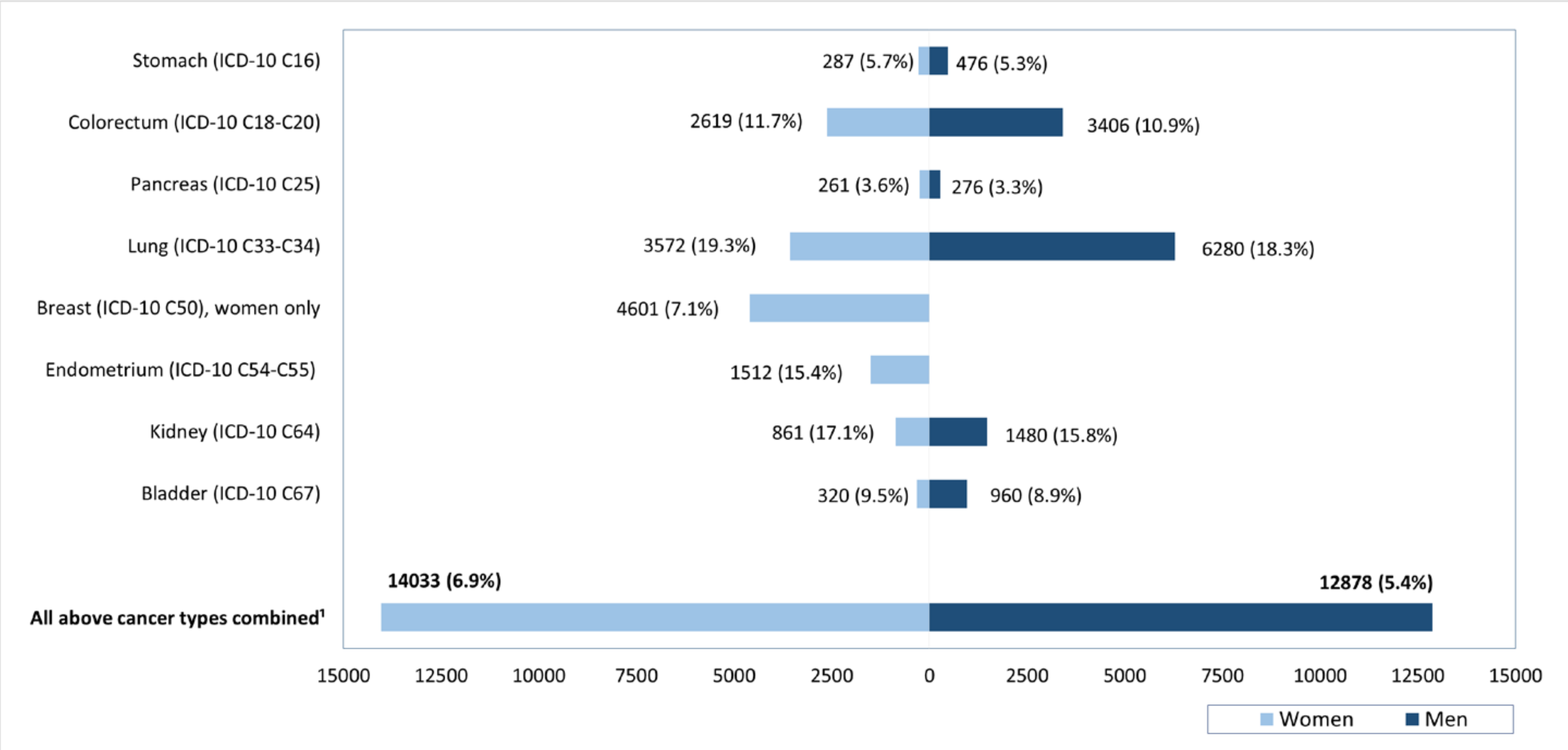


eFigure 3. Relative risks of site-specific cancer for unhealthy changes in dietary intake levels derived from published meta-analyses including ≥5,000 cases (see eSupplement B and D and eTable 3 for more information). RR=relative risk; CI=confidence interval



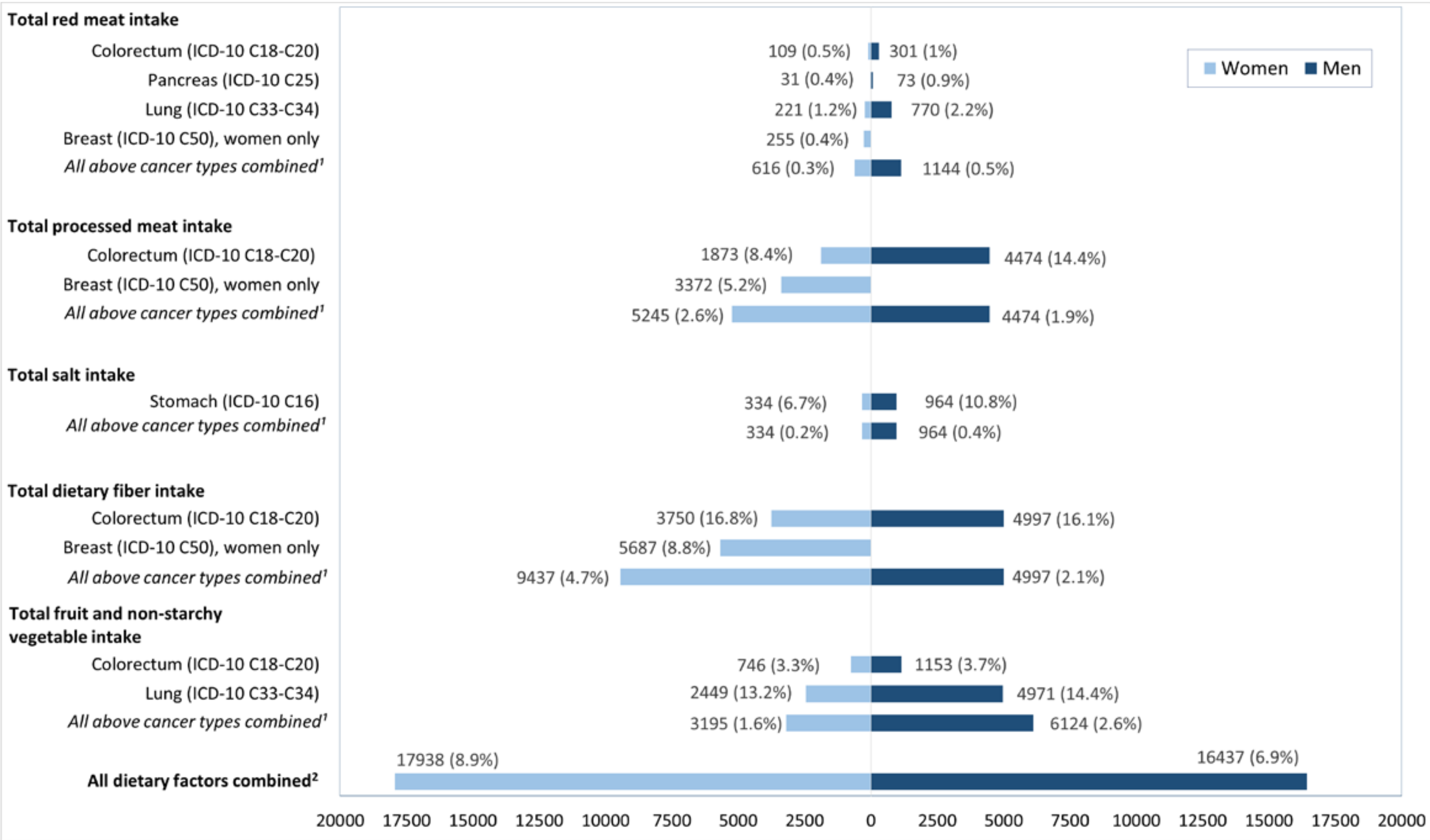
eFigure 4. Estimated number of site-specific incident cancer cases attributable to excess weight (BMI≥25 kg/m²) among men and women in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

[1] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).



eFigure 5. Estimated number of site-specific incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) among men and women in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

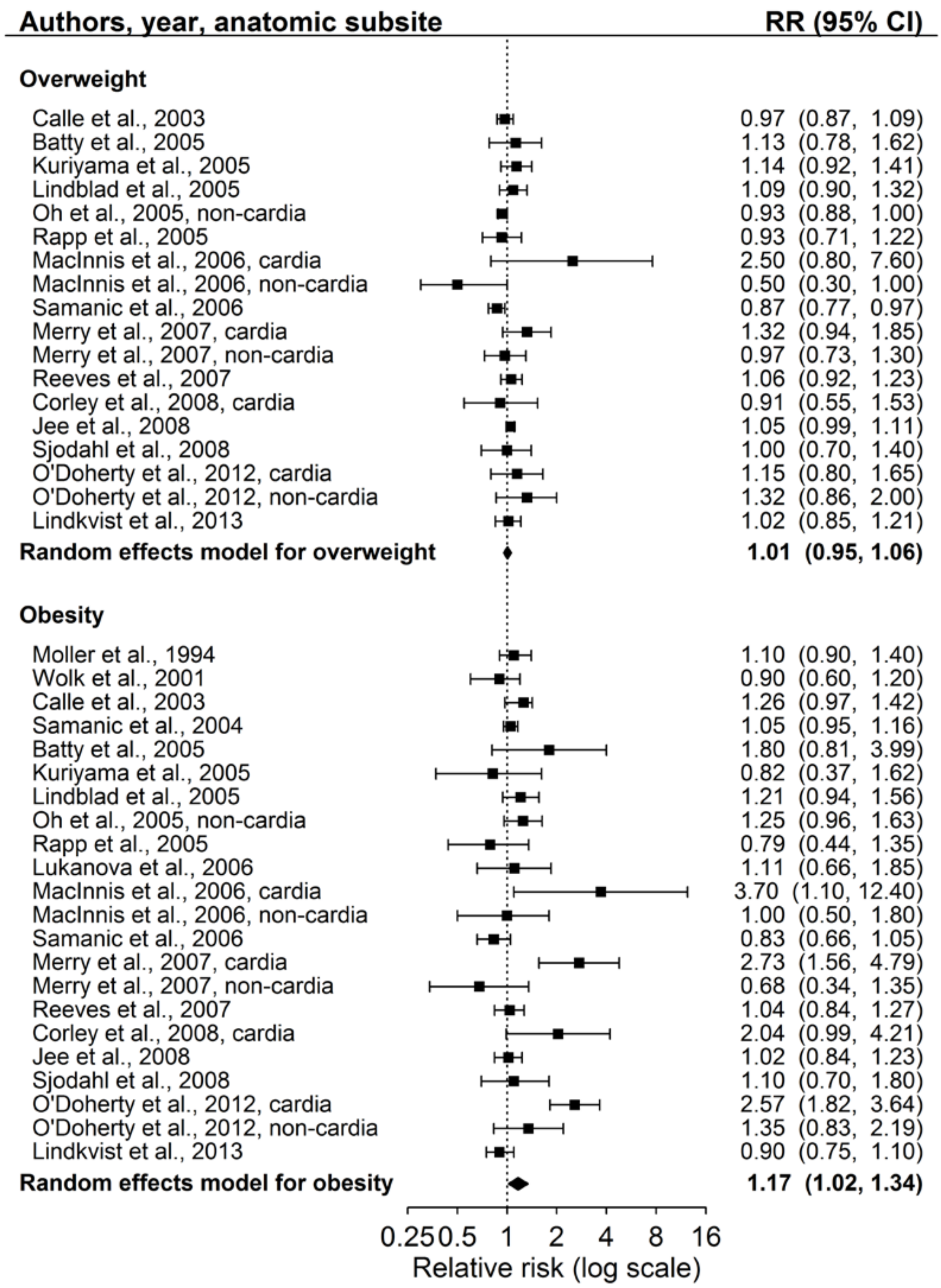
[1] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).



eFigure 6. Estimated number of site-specific incident cancer cases attributable to high intakes of red meat (≥500 g/week), any intake of processed meat (>0 g/week), high intakes of salt (≥6 g/day), low intakes of dietary fiber (<32 g/day) and low intakes of fruit and non-starchy vegetables (<400 g/day) among men and women in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

[1] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44)

[2] The total number of cancer cases attributable to all dietary factors combined was defined as the sum of all site-specific cancer cases attributable to all dietary factors combined. The site-specific estimates were based on the sequential PAF formula (see eSupplement E and eTable 21). The PAF for the category "All dietary factors combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).



eFigure 7. Random effects meta-analysis of overweight and obesity in relation to total gastric cancer incidence combining the RRs for total gastric cancer from all prospective studies for which RRs for total gastric cancer were available with the RRs for cardia and non-cardia gastric cancer from all prospective studies for which no RRs for total gastric cancer were available, using the information presented in the most recent meta-analysis (e14). This approach was in line with 3 previous meta-analyses of BMI and total gastric cancer (e108-e110) and was required to clarify the association between BMI and total gastric cancer risk for Supplementary eTable 1.

eTable 1. Summary risk estimates of overweight, obesity and site-specific cancer risk from published meta-analyses of prospective studies.

	RR (95%-CI)			
Cancer site	**Overweight**	**Obesity**	**Cases**	**Reference**
Gastric cancer[a]	1.01 (0.95-1.06)	1.17 (1.02-1.34)	41,791	(e14)
Colorectum[b]	1.13 (1.06-1.19)	1.33 (1.25-1.42)	85,935	(e15, e16)
Liver	1.18 (1.06-1.31)	1.83 (1.59-2.11)	25,337	(e17)
Gallbladder	1.15 (1.02-1.30)	1.67 (1.52-1.83)	5,279	(e18)
Pancreas[c]	1.10 (1.04-1.17)	1.36 (1.19-1.55)	10,076	(e19)
Breast, postmenopausal women only	1.13 (1.09-1.18)	1.20 (1.11-1.31)	16,180	(e20)
Endometrium	1.34 (1.20-1.48)	2.54 (2.27-2.81)	18,160	(e21)
Ovary	1.26 (0.97-1.63)	1.27 (1.16-1.38)	10,468	(e22)
Prostate, advanced[d]	1.07 (1.03-1.12)	1.14 (1.04-1.25)	13,100	(e23)
Kidney	1.28 (1.24-1.33)	1.77 (1.68-1.87)	15,144	(e24)
Bladder	1.07 (1.01-1.14)	1.10 (1.06-1.14)	38,072	(e25)
Thyroid[e]	1.10 (1.03-1.18)	1.29 (1.20-1.37)	9,529	(e26, e27)
Non-Hodgkin lymphoma	1.06 (0.99-1.12)	1.19 (1.04-1.37)	13,159	(e28)
Multiple myeloma	1.12 (1.07-1.18)	1.21 (1.08-1.35)	8,982	(e29)
Leukemia	1.09 (1.04-1.14)	1.26 (1.17-1.37)	20,813	(e30)

RR=relative risk; CI=confidence interval

[a] In line with 3 previous meta-analyses of BMI and total gastric cancer (e108-e110), we estimated the summary RRs for total gastric cancer by combining the RRs for total gastric cancer from all studies for which RRs for total gastric cancer were available with the RRs for cardia and non-cardia gastric cancer from all studies for which no RR for total gastric cancer was available, using the information presented in the most recent meta-analysis (e14) (see eFigure 7).

[b] Because Ma et al. 2013 (e15) did not present the RR for overweight, we used the RR for overweight presented in Moghaddam et al. 2007 (e16), which was based on 52,568 cases.

[c] To obtain the RRs for men and women combined, we summarized the gender-specific summary RRs presented in Xue et al. 2017 (e19) using a fixed effects model.

[d] Because Xie et al. 2017 (e23) did not present summary RRs for overweight and obesity, we derived those RRs from the summary RR for the dose-response relation between continuous BMI and risk of advanced prostate cancer (RR for a BMI increment of 5 kg/m^2=1.07, 95% CI=1.03-1.12) assuming that the comparison between overweight and normal weight corresponded to a BMI increment of 5 kg/m^2 and that the comparison between obesity and normal weight corresponded to a BMI increment of 10 kg/m^2.

[e] Because Ma et al. 2015 (e26) did not present the RR for overweight, we used the RR for overweight presented in Schmid et al. 2015 (e27), which was based on 8,420 cases.

eTable 2. Summary risk estimates of recreational physical activity and site-specific cancer risk from published meta-analyses of prospective studies.

	High vs. low recreational physical activity		
Cancer site	**RR (95%-CI)**	**Cases**	**Reference**
Stomach[a]	0.92 (0.74-1.15)	4,814	(e43)
Colorectum	0.84 (0.77-0.93)	16,613	(e44)
Pancreas[b]	0.95 (0.90-1.01)	6,002	(e45)
Lung	0.74 (0.71-0.77)	19,133	(e46)
Breast[c], women only	0.90 (0.85-0.95)	45,996	(e47)
Endometrium	0.79 (0.68-0.92)	5,346	(e46)
Kidney[d]	0.77 (0.70-0.85)	4,548	(e46)
Bladder	0.87 (0.82-0.92)	9,073	(e46)

RR=relative risk; CI=confidence interval

[a] We used the summary risk estimate for recreational physical activity and total gastric cancer, even if it was not statistically significant and based on <5,000 cases from prospective studies, because the inverse relation of high vs. low total physical activity to total gastric cancer (RR=0.83, 95% CI=0.72-0.96) has been established in a meta-analysis of prospective studies including 7,551 cases (e43).

[b] We used the summary risk estimate for recreational physical activity and pancreatic cancer, even if it was not statistically significant and based on <5,000 cases from prospective studies, because the inverse relation of high vs. low total physical activity to pancreatic cancer (RR=0.93, 95% CI=0.88-0.98) has been established in a meta-analysis of prospective studies including 8,091 cases (e45).

[c] We used the summary risk estimate for postmenopausal breast cancer for both pre- and postmenopausal women because the summary risk estimate for premenopausal breast cancer (RR=0.83, 95% CI=0.72-0.96) was comparable to the summary risk estimate for postmenopausal breast cancer (e47).

[d] We used the summary risk estimate for recreational physical activity and renal cell cancer, even if it was based on <5,000 cases from prospective studies, because the inverse relation of high vs. low total physical activity to renal cell cancer (RR=0.87, 95% CI=0.76-0.99) has been established in a meta-analysis of prospective studies including 6,104 cases (e48).

eTable 3. Summary risk estimates of selected dietary factors and site-specific cancer risk from published meta-analyses of prospective studies.

Cancer type by lifestyle factor	Unit[a] for RR	RR[b] (95% CI)	Case number for RR[b]		Reference
			Cohort	Case-control	
Total red meat intake (<500 g/week recommended)					
Colorectal cancer[c]	Per 700 g/week	1.12 (1.00-1.25)	6,662	0	(e50)
Pancreatic cancer	Per 700 g/week	1.11 (1.03-1.19)	7,970	0	(e51)
Lung cancer[d]	Per 840 g/week	1.35 (1.25-1.46)	158	11,954	(e52)
Breast cancer, women only	Per 840 g/week	1.11 (1.05-1.16)	23,930	0	(e53)
Total processed meat intake (0 g/week recommended)					
Colorectal cancer	Per 350 g/week	1.16 (1.10-1.28)	10,738	0	(e50)
Breast cancer, women only	Per 350 g/week	1.09 (1.02-1.17)	20,259	0	(e54)
Total salt intake (<6 g/day recommended)					
Gastric cancer	Per 5 g/day	1.12 (1.02-1.23)	14,850	0	(e55)
Total dietary fiber intake (≥32 g/day recommended)					
Colorectal cancer	Per 10 g/day	0.90 (0.86-0.94)	14,514	0	(e56)
Breast cancer, women only	Per 10 g/day	0.95 (0.91-0.98)	24,711	0	(e57)
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)					
Colorectal cancer[e]	Per 100 g/day	0.99 (0.98-1.00)	11,853	0	(e58)
Lung cancer	Per 100 g/day	0.96 (0.94-0.98)	9,609	0	(e59)

RR=relative risk; CI=confidence interval

[a] For red and processed meat intake, we converted g/day to g/week.

[b] RR from the dose-response meta-analysis

[c] We used the summary risk estimate for continuous total red meat intake and total colorectal cancer (RR=1.10, 95% CI=1.03-1.18), even if it was not statistically significant, because the positive relation of high vs. low total red meat intake has been established in a meta-analysis of prospective studies including 21,147 cases (e111).

[d] We used the summary risk estimate for continuous total red meat intake and total lung cancer, even if it was mainly based on cases from case-control studies, because the positive relation of high vs. low total red meat intake to total lung cancer (RR=1.21, 95% CI=1.14-1.28) has been established in a meta-analysis of prospective studies including 10,123 cases (e52).

[e] We used the summary risk estimate for continuous total fruit and non-starchy vegetable intake and total colorectal cancer, even if it was not statistically significant, because the inverse relation of high vs. low total fruit and non-starchy vegetable intake and colorectal cancer (RR=0.92, 95% CI=0.86-0.99) has been established in a meta-analysis of prospective studies including 11,853 cases (e58).

eTable 4. Prevalence of underweight, normal weight, overweight and obesity with mean BMI levels among 6,087 men and women aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

	Prevalence (%) and mean (m) for exposure categories by age at exposure											
	25-34 years		**35-44 years**		**45-54 years**		**55-64 years**		**65-74 years**		**All ages combined**	
Exposure	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**
Men and women combined (N=6,087)												
Underweight (BMI<18.5 kg/m²)	2.5	17.9	1.4	17.6	1.0	17.8	0.6	18.0	0.4	17.9	1.2	17.8
Normal weight (BMI=18.5-24.9 kg/m²)	54.8	22.2	42.9	22.6	34.7	22.6	25.3	22.9	21.1	23.2	35.9	22.6
Overweight (BMI=25.0-29.9 kg/m²)	27.1	27.2	35.9	27.2	38.7	27.2	44.7	27.4	43.6	27.5	38.0	27.3
Obesity (BMI≥30 kg/m²)	15.6	33.8	19.9	33.9	25.6	34.1	29.3	34.2	35.0	33.7	25.0	34.0
Overall	100.0	25.3	100.0	26.4	100.0	27.3	100.0	28.2	100.0	28.7	100.0	27.2
Men (N=2,906)												
Underweight (BMI<18.5 kg/m²)	0.9	18.1	0.1	18.3	0.4	18.1	0.3	17.9	0.1	18.9	0.3	18.1
Normal weight (BMI=18.5-24.9 kg/m²)	47.0	22.7	32.6	23.1	24.4	22.9	19.1	23.2	16.0	23.6	27.9	23.0
Overweight (BMI=25.0-29.9 kg/m²)	35.0	27.3	45.3	27.2	49.2	27.3	51.5	27.4	52.5	27.4	46.8	27.3
Obesity (BMI≥30 kg/m²)	17.1	33.6	22.0	33.0	26.0	33.5	29.2	33.8	31.4	33.1	25.0	33.4
Overall	100.0	26.2	100.0	27.2	100.0	27.8	100.0	28.5	100.0	28.6	100.0	27.6
Women (N=3,181)												
Underweight (BMI<18.5 kg/m²)	4.2	17.8	2.8	17.6	1.6	17.7	1.0	18.0	0.6	17.9	2.0	17.7
Normal weight (BMI=18.5-24.9 kg/m²)	62.8	21.8	53.5	22.2	45.4	22.5	31.4	22.7	25.6	23.1	43.8	22.3
Overweight (BMI=25.0-29.9 kg/m²)	19.0	27.1	26.1	27.2	27.8	27.1	38.1	27.3	35.6	27.5	29.3	27.2
Obesity (BMI≥30 kg/m²)	14.1	34.2	17.7	35.0	25.2	34.8	29.5	34.7	38.2	34.2	24.9	34.6
Overall	100.0	24.4	100.0	25.6	100.0	26.8	100.0	27.9	100.0	28.9	100.0	26.7

BMI=body mass index

eTable 5. Prevalence of moderate to vigorous physical activity with mean levels among 6,696 men and women aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

	Prevalence (%) and mean (m) for exposure categories by age at exposure											
	25-34 years		**35-44 years**		**45-54 years**		**55-64 years**		**65-74 years**		**All ages combined**	
Exposure	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**
Men and women combined (N=6,696)												
Physical activity (min/week of MVPA)												
Inactive (0 min/week)	25.1	0	30.3	0	29.1	0	34.4	0	41.8	0	31.8	0
Insufficiently active (1-149 min/week)	54.7	77	50.2	78	50.8	74	47.5	78	42.4	76	49.3	76
Sufficiently active (≥150 min/week)	20.2	248	19.5	248	20.1	245	18.1	249	15.8	248	18.9	248
Overall	100.0	92	100.0	88	100.0	87	100.0	82	100.0	71	100.0	84
Men (N=3,156)												
Physical activity (min/week of MVPA)												
Inactive (0 min/week)	18.9	0	25.8	0	28.2	0	31.3	0	39.7	0	28.4	0
Insufficiently active (1-149 min/week)	52.8	78	50.5	77	48.6	72	49.2	79	42.1	75	48.8	76
Sufficiently active (≥150 min/week)	28.3	248	23.7	250	23.3	248	19.5	244	18.2	247	22.8	248
Overall	100.0	112	100.0	98	100.0	93	100.0	87	100.0	76	100.0	94
Women (N=3,540)												
Physical activity (min/week of MVPA)												
Inactive (0 min/week)	31.5	0	34.9	0	30.0	0	37.3	0	43.7	0	35.1	0
Insufficiently active (1-149 min/week)	56.8	76	49.9	80	53.1	75	45.9	78	42.7	77	49.8	77
Sufficiently active (≥150 min/week)	11.8	249	15.2	245	16.9	241	16.8	254	13.7	250	15.0	247
Overall	100.0	72	100.0	77	100.0	80	100.0	78	100.0	67	100.0	75

MVPA=moderate to vigorous physical activity

eTable 6. Prevalence of adherence to the recommended intake levels of red and processed meat, salt, dietary fiber, fruits and non-starchy vegetables with mean intake levels among 6,129 men and women aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

	Prevalence (%) and mean[a] (m) for exposure categories by age at exposure											
	25-34 years		**35-44 years**		**45-54 years**		**55-64 years**		**65-74 years**		**All ages combined**	
Exposure	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**
Men and women combined (N=6,129)												
Total red meat intake (<500 g/week recommended)												
Recommendation met	87.5	184	90.2	204	91.1	209	94.1	199	94.3	185	91.4	198
Recommendation not met	12.5	1002	9.8	960	8.9	839	5.9	785	5.7	814	8.6	901
Overall	100.0	287	100.0	278	100.0	265	100.0	234	100.0	220	100.0	258
Total processed meat intake (0 g/week recommended)												
Recommendation met	4.7	0	3.9	0	3.4	0	4.0	0	4.0	0	4.0	0
Recommendation not met	95.3	392	96.1	378	96.6	337	96.0	289	96.0	260	96.0	333
Overall	100.0	374	100.0	363	100.0	325	100.0	277	100.0	249	100.0	320
Total salt intake (<6 g/day recommended)												
Recommendation met	25.7	4	21.3	4	20.8	5	27.5	5	26.8	4	24.1	4
Recommendation not met	74.3	11	78.7	10	79.2	10	72.5	10	73.2	9	75.9	10
Overall	100.0	9	100.0	9	100.0	9	100.0	8	100.0	8	100.0	9
Total dietary fiber intake (≥32 g/day recommended)												
Recommendation met	19.2	47	25.5	48	29.1	45	31.3	44	37.6	44	28.5	45
Recommendation not met	80.8	19	74.5	19	70.9	20	68.7	20	62.4	21	71.5	20
Overall	100.0	24	100.0	27	100.0	27	100.0	28	100.0	30	100.0	27
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Recommendation met	22.3	692	26.1	723	26.7	731	35.7	710	34.2	767	28.8	727
Recommendation not met	77.7	170	73.9	180	73.3	189	64.3	206	65.8	214	71.2	190
Overall	100.0	286	100.0	322	100.0	334	100.0	386	100.0	403	100.0	345

[a] Means are presented as g/week for intakes of red and processed meat and as g/day for intakes of salt, dietary fiber and fruit and non-starchy vegetables.

eTable 7. Prevalence of adherence to the recommended intake levels of red and processed meat, salt, dietary fiber, fruits and non-starchy vegetables with mean intake levels among 2,921 men aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

	Prevalence (%) and mean[a] (m) for exposure categories by age at exposure											
	25-34 years		**35-44 years**		**45-54 years**		**55-64 years**		**65-74 years**		**All ages combined**	
Exposure	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**
Men (N=2,921)												
Total red meat intake (<500 g/week recommended)												
Recommendation met	79.7	220	86.0	233	87.8	233	93.4	225	92.5	205	87.7	224
Recommendation not met	20.3	1049	14.0	1010	12.2	872	6.6	789	7.5	821	12.3	946
Overall	100.0	388	100.0	342	100.0	311	100.0	262	100.0	251	100.0	313
Total processed meat intake (0 g/week recommended)												
Recommendation met	3.4	0	2.5	0	2.7	0	2.6	0	3.7	0	2.9	0
Recommendation not met	96.6	524	97.5	492	97.3	431	97.4	359	96.3	330	97.1	431
Overall	100.0	506	100.0	480	100.0	419	100.0	349	100.0	318	100.0	418
Total salt intake (<6 g/day recommended)												
Recommendation met	14.2	4	16.6	4	14.3	4	22.1	4	18.4	4	16.9	4
Recommendation not met	85.8	11	83.4	12	85.7	11	77.9	10	81.6	10	83.1	11
Overall	100.0	10	100.0	10	100.0	10	100.0	9	100.0	9	100.0	10
Total dietary fiber intake (≥32 g/day recommended)												
Recommendation met	18.3	51	27.3	50	32.4	44	31.8	43	39.6	44	29.8	46
Recommendation not met	81.7	18	72.7	19	67.6	20	68.2	20	60.4	21	70.2	19
Overall	100.0	24	100.0	27	100.0	28	100.0	27	100.0	30	100.0	27
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Recommendation met	13.8	622	18.8	688	18.4	663	26.2	669	28.2	716	20.7	676
Recommendation not met	86.2	151	81.2	170	81.6	181	73.8	194	71.8	201	79.3	178
Overall	100.0	216	100.0	267	100.0	270	100.0	318	100.0	346	100.0	281

[a] Means are presented as g/week for intakes of red and processed meat and as g/day for intakes of salt, dietary fiber and fruit and non-starchy vegetables.

eTable 8. Prevalence of adherence to the recommended intake levels of red and processed meat, salt, dietary fiber, fruits and non-starchy vegetables with mean intake levels among 3,208 women aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

	Prevalence (%) and mean[a] (m) for exposure categories by age at exposure											
	25-34 years		**35-44 years**		**45-54 years**		**55-64 years**		**65-74 years**		**All ages combined**	
Exposure	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**	**%**	**m[a]**
Women (N=3,208)												
Total red meat intake (<500 g/week recommended)												
Recommendation met	95.6	154	94.6	177	94.5	185	94.8	175	96.0	168	95.0	173
Recommendation not met	4.4	785	5.4	828	5.5	763	5.2	781	4.0	802	5.0	791
Overall	100.0	182	100.0	213	100.0	217	100.0	206	100.0	193	100.0	204
Total processed meat intake (0 g/week recommended)												
Recommendation met	6.0	0	5.4	0	4.2	0	5.4	0	4.3	0	5.0	0
Recommendation not met	94.0	253	94.6	256	95.8	239	94.6	220	95.7	196	95.0	233
Overall	100.0	238	100.0	242	100.0	229	100.0	208	100.0	188	100.0	222
Total salt intake (<6 g/day recommended)												
Recommendation met	37.6	4	26.3	5	27.5	5	32.6	5	34.3	4	31.3	5
Recommendation not met	62.4	10	73.7	9	72.5	9	67.4	9	65.7	9	68.7	9
Overall	100.0	8	100.0	8	100.0	8	100.0	8	100.0	7	100.0	8
Total dietary fiber intake (≥32 g/day recommended)												
Recommendation met	20.1	43	23.6	45	25.7	46	30.9	44	35.8	45	27.1	45
Recommendation not met	79.9	19	76.4	20	74.3	20	69.1	21	64.2	21	72.9	20
Overall	100.0	24	100.0	26	100.0	26	100.0	28	100.0	29	100.0	27
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Recommendation met	31.0	723	33.7	743	35.2	768	45.0	733	39.5	799	36.8	755
Recommendation not met	69.0	193	66.3	193	64.8	199	55.0	221	60.5	228	63.2	206
Overall	100.0	358	100.0	378	100.0	399	100.0	452	100.0	453	100.0	408

[a] Means are presented as g/week for intakes of red and processed meat and as g/day for intakes of salt, dietary fiber and fruit and non-starchy vegetables.

eTable 9. Estimated number of cancers at selected anatomic sites among men and women combined in 2018 in Germany by age based on the population projections for the year 2018 (Federal Office of Statistics, 2015) and the most recent cancer incidence rates (German cancer registry data, 2014).

Cancer site	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	All ages combined
Men and women combined						
Stomach (ICD-10 C16)	310	1,260	3,000	3,794	5,546	13,910
Colorectum (ICD-10 C18-C20)	993	4,269	10,993	15,520	21,673	53,448
Liver (ICD-10 C22)	89	530	2,015	2,800	3,236	8,670
Gallbladder (ICD-10 C23)	17	73	248	415	880	1,633
Pancreas (ICD-10 C25)	187	1,077	3,195	4,769	6,384	15,612
Lung (ICD-10 C33-C34)	521	4,637	14,493	17,493	15,770	52,914
Breast (ICD-10 C50), women only	4,450	13,481	16,500	15,442	14,581	64,454
Breast (ICD-10 C50), postmenopausal women only	--	8,449	16,500	15,442	14,581	54,972
Endometrium (ICD-10 C54-C55)	207	1,134	2,856	2,781	2,831	9,809
Ovary (ICD-10 C56)	275	1,008	1,548	1,718	2,040	6,589
Prostate[a] (ICD-10 C61), advanced	18	630	3,370	5,725	4,819	14,562
Kidney (ICD-10 C64)	460	1,610	3,639	4,167	4,518	14,394
Bladder (ICD-10 C67)	121	869	2,534	4,207	6,449	14,180
Thyroid (ICD-10 C73)	990	1,364	1,368	913	545	5,180
Non-Hodgkin lymphoma (ICD-10 C82-C88)	589	1,665	3,336	4,358	5,615	15,563
Multiple myeloma (ICD-10 C90)	107	492	1,230	1,782	2,555	6,166
Leukemia (ICD-10 C91-C95)	421	1,106	2,287	3,229	4,646	11,689
Total cancer (ICD-10 C00-C99 without C44)	15,774	50,252	104,889	128,663	140,797	440,373

[a] We assumed that 26% of all prostate cancer cases were advanced prostate cancer cases (defined as tumor stage T3-T4) as reported in the most recent cancer report (e69).

eTable 10. Estimated number of cancers at selected anatomic sites among men in 2018 in Germany by age based on the population projections for the year 2018 (Federal Office of Statistics, 2015) and the most recent cancer incidence rates (German cancer registry data, 2014).

Cancer site	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	All ages combined
Men						
Stomach (ICD-10 C16)	161	797	2,067	2,535	3,352	8,912
Colorectum (ICD-10 C18-C20)	532	2,464	6,841	9,476	11,807	31,120
Liver (ICD-10 C22)	50	375	1,555	2,139	2,198	6,317
Gallbladder (ICD-10 C23)	7	23	78	135	261	504
Pancreas (ICD-10 C25)	95	643	1,918	2,652	3,011	8,319
Lung (ICD-10 C33-C34)	248	2,642	9,135	11,493	10,891	34,409
Prostate[a] (ICD-10 C61), advanced	18	630	3,370	5,725	4,819	14,562
Kidney (ICD-10 C64)	334	1,143	2,553	2,690	2,637	9,357
Bladder (ICD-10 C67)	84	645	1,961	3,260	4,849	10,799
Thyroid (ICD-10 C73)	247	427	449	336	203	1,662
Non-Hodgkin lymphoma (ICD-10 C82-C88)	367	924	1,876	2,405	2,919	8,491
Multiple myeloma (ICD-10 C90)	60	301	724	1,023	1,335	3,443
Leukemia (ICD-10 C91-C95)	233	614	1,398	1,885	2,554	6,684
Total cancer (ICD-10 C00-C99 without C44)	5,525	20,888	57,303	76,161	78,301	238,177

[a] We assumed that 26% of all prostate cancer cases were advanced prostate cancer cases (defined as tumor stage T3-T4) as reported in the most recent cancer report (e69).

eTable 11. Estimated number of cancers at selected anatomic sites among women in 2018 in Germany by age based on the population projections for the year 2018 (Federal Office of Statistics, 2015) and the most recent cancer incidence rates (German cancer registry data, 2014).

Cancer site	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	All ages combined
Women						
Stomach (ICD-10 C16)	149	463	933	1,259	2,194	4,998
Colorectum (ICD-10 C18-C20)	461	1,805	4,152	6,044	9,866	22,328
Liver (ICD-10 C22)	39	155	460	661	1,038	2,353
Gallbladder (ICD-10 C23)	10	50	170	280	619	1,129
Pancreas (ICD-10 C25)	92	434	1,277	2,117	3,373	7,293
Lung (ICD-10 C33-C34)	273	1,995	5,358	6,000	4,879	18,505
Breast (ICD-10 C50), women only	4,450	13,481	16,500	15,442	14,581	64,454
Breast (ICD-10 C50), postmenopausal women only	--	8,449	16,500	15,442	14,581	54,972
Endometrium (ICD-10 C54-C55)	207	1,134	2,856	2,781	2,831	9,809
Ovary (ICD-10 C56)	275	1,008	1,548	1,718	2,040	6,589
Kidney (ICD-10 C64)	126	467	1,086	1,477	1,881	5,037
Bladder (ICD-10 C67)	37	224	573	947	1,600	3,381
Thyroid (ICD-10 C73)	743	937	919	577	342	3,518
Non-Hodgkin lymphoma (ICD-10 C82-C88)	222	741	1,460	1,953	2,696	7,072
Multiple myeloma (ICD-10 C90)	47	191	506	759	1,220	2,723
Leukemia (ICD-10 C91-C95)	188	492	889	1,344	2,092	5,005
Total cancer (ICD-10 C00-C99 without C44)	10,249	29,364	47,587	52,502	62,497	202,197

eTable 12. Estimated number of site-specific incident cancer cases attributable to excess weight (BMI≥25 kg/m²) among men and women combined in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined												
Stomach (ICD-10 C16)	9	2.9	45	3.6	136	4.5	196	5.2	333	6.0	718	5.2
Colorectum (ICD-10 C18-C20)	79	8.0	431	10.1	1,305	11.9	2,082	13.4	3,183	14.7	7,080	13.2
Liver (ICD-10 C22)	13	14.6	99	18.7	443	22.0	685	24.5	872	26.9	2,113	24.4
Gallbladder (ICD-10 C23)	2	11.8	11	15.1	46	18.5	87	21.0	203	23.1	349	21.4
Pancreas (ICD-10 C25)	14	7.5	104	9.7	370	11.6	623	13.1	925	14.5	2,037	13.0
Breast (ICD-10 C50), postmenopausal women only	--	--	539	6.4	1,313	8.0	1,512	9.8	1,593	10.9	4,958	9.0
Endometrium (ICD-10 C54-C55)	45	21.7	300	26.5	929	32.5	1,025	36.9	1,175	41.5	3,475	35.4
Ovary (ICD-10 C56)	22	8.0	104	10.3	190	12.3	261	15.2	334	16.4	911	13.8
Prostate (ICD-10 C61), advanced	1	5.6	38	6.0	227	6.7	416	7.3	366	7.6	1,047	7.2
Kidney (ICD-10 C64)	75	16.3	325	20.2	851	23.4	1,083	26.0	1,271	28.1	3,606	25.1
Bladder (ICD-10 C67)	4	3.3	37	4.3	127	5.0	241	5.7	396	6.1	805	5.7
Thyroid (ICD-10 C73)	67	6.8	117	8.6	139	10.2	105	11.5	69	12.7	496	9.6
Non-Hodgkin lymphoma (ICD-10 C82-C88)	26	4.4	93	5.6	224	6.7	332	7.6	476	8.5	1,151	7.4
Multiple myeloma (ICD-10 C90)	7	6.5	38	7.7	112	9.1	184	10.3	285	11.2	627	10.2
Leukemia (ICD-10 C91-C95)	26	6.2	86	7.8	210	9.2	337	10.4	535	11.5	1,194	10.2
All above cancer types combined[a]	390	2.5	2,367	4.7	6,622	6.3	9,169	7.1	12,016	8.5	30,567	6.9

The estimates were based on the age-specific incidence and prevalence data for men and women combined.

[a] The PAF for the category “All above cancer types combined” was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 13. Estimated number of site-specific incident cancer cases attributable to excess weight (BMI≥25 kg/m²) among men in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men												
Stomach (ICD-10 C16)	5	3.1	32	4.0	97	4.7	132	5.2	186	5.5	451	5.1
Colorectum (ICD-10 C18-C20)	49	9.2	286	11.6	891	13.0	1,330	14.0	1,732	14.7	4,288	13.8
Liver (ICD-10 C22)	9	18.0	78	20.8	363	23.3	537	25.1	576	26.2	1,562	24.7
Gallbladder (ICD-10 C23)	1	14.3	4	17.4	15	19.2	29	21.5	59	22.6	108	21.4
Pancreas (ICD-10 C25)	8	8.4	71	11.0	240	12.5	359	13.5	428	14.2	1,106	13.3
Prostate (ICD-10 C61), advanced	1	5.6	38	6.0	227	6.7	416	7.3	366	7.6	1,047	7.2
Kidney (ICD-10 C64)	62	18.6	261	22.8	645	25.3	283	10.5	738	28.0	1,990	21.3
Bladder (ICD-10 C67)	3	3.6	33	5.1	112	5.7	110	3.4	309	6.4	568	5.3
Thyroid (ICD-10 C73)	19	7.7	42	9.8	50	11.1	15	4.5	25	12.3	152	9.1
Non-Hodgkin lymphoma (ICD-10 C82-C88)	19	5.2	60	6.5	137	7.3	68	2.8	244	8.4	528	6.2
Multiple myeloma (ICD-10 C90)	4	6.7	27	9.0	74	10.2	56	5.5	152	11.4	314	9.1
Leukemia (ICD-10 C91-C95)	16	6.9	55	9.0	141	10.1	78	4.1	292	11.4	581	8.7
All above cancer types combined[a]	196	3.5	987	4.7	2,992	5.2	3,413	4.5	5,107	6.5	12,695	5.3

The estimates were based on the age-specific incidence and prevalence data for men.

[a] The PAF for the category “All above cancer types combined” was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 14. Estimated number of site-specific incident cancer cases attributable to excess weight (BMI≥25 kg/m²) among women in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Women												
Stomach (ICD-10 C16)	4	2.7	15	3.2	41	4.4	64	5.1	141	6.4	264	5.3
Colorectum (ICD-10 C18-C20)	31	6.7	152	8.4	442	10.6	774	12.8	1,450	14.7	2,849	12.8
Liver (ICD-10 C22)	5	12.8	25	16.1	95	20.7	158	23.9	286	27.6	569	24.2
Gallbladder (ICD-10 C23)	1	10.0	7	14.0	30	17.6	57	20.4	146	23.6	241	21.3
Pancreas (ICD-10 C25)	6	6.5	36	8.3	135	10.6	267	12.6	498	14.8	942	12.9
Breast (ICD-10 C50), postmenopausal	--	--	539	6.4	1,313	8.0	1,512	9.8	1,593	10.9	4,958	9.0
Endometrium (ICD-10 C54-C55)	45	21.7	300	26.5	929	32.5	1,025	36.9	1,175	41.5	3,475	35.4
Ovary (ICD-10 C56)	22	8.0	104	10.3	190	12.3	261	15.2	334	16.4	911	13.8
Kidney (ICD-10 C64)	18	14.3	81	17.3	232	21.4	370	25.1	531	28.2	1,231	24.4
Bladder (ICD-10 C67)	1	2.7	8	3.6	24	4.2	50	5.3	95	5.9	179	5.3
Thyroid (ICD-10 C73)	42	5.7	67	7.2	84	9.1	63	10.9	44	12.9	300	8.5
Non-Hodgkin lymphoma (ICD-10 C82-C88)	8	3.6	35	4.7	88	6.0	143	7.3	232	8.6	506	7.2
Multiple myeloma (ICD-10 C90)	2	4.3	12	6.3	40	7.9	74	9.7	134	11.0	262	9.6
Leukemia (ICD-10 C91-C95)	10	5.3	32	6.5	74	8.3	134	10.0	243	11.6	492	9.8
All above cancer types combined[a]	195	1.9	1,413	4.8	3,717	7.8	4,952	9.4	6,902	11.0	17,179	8.5

The estimates were based on the age-specific incidence and prevalence data for women.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 15. Estimated number of site-specific incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) among men and women combined in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined												
Stomach (ICD-10 C16)	16	5.2	67	5.3	158	5.3	208	5.5	323	5.8	771	5.5
Colorectum (ICD-10 C18-C20)	105	10.6	463	10.8	1,183	10.8	1,736	11.2	2,569	11.9	6,056	11.3
Pancreas (ICD-10 C25)	6	3.2	35	3.2	104	3.3	162	3.4	230	3.6	538	3.4
Lung (ICD-10 C33-C34)	92	17.7	843	18.2	2,612	18.0	3,271	18.7	3,114	19.7	9,932	18.8
Breast (ICD-10 C50), women only	335	7.5	952	7.1	1,131	6.9	1,089	7.1	1,094	7.5	4,601	7.1
Endometrium (ICD-10 C54-C55)	35	16.9	173	15.3	423	14.8	424	15.2	457	16.1	1,512	15.4
Kidney (ICD-10 C64)	71	15.4	256	15.9	575	15.8	683	16.4	783	17.3	2,369	16.5
Bladder (ICD-10 C67)	10	8.3	76	8.7	220	8.7	379	9.0	617	9.6	1,302	9.2
All above cancer types combined[a]	670	4.2	2,865	5.7	6,406	6.1	7,952	6.2	9,187	6.5	27,081	6.1

The estimates were based on the age-specific incidence and prevalence data for men and women combined.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 16. Estimated number of site-specific incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) among men in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men												
Stomach (ICD-10 C16)	7	4.3	40	5.0	105	5.1	135	5.3	189	5.6	476	5.3
Colorectum (ICD-10 C18-C20)	51	9.6	251	10.2	711	10.4	1,033	10.9	1,360	11.5	3,406	10.9
Pancreas (ICD-10 C25)	3	3.2	20	3.1	60	3.1	88	3.3	105	3.5	276	3.3
Lung (ICD-10 C33-C34)	41	16.5	453	17.1	1,594	17.4	2,097	18.2	2,094	19.2	6,280	18.3
Kidney (ICD-10 C64)	43	12.9	172	15.0	390	15.3	430	16.0	445	16.9	1,480	15.8
Bladder (ICD-10 C67)	7	8.3	53	8.2	164	8.4	286	8.8	450	9.3	960	8.9
All above cancer types combined[a]	152	2.8	989	4.7	3,024	5.3	4,069	5.3	4,643	5.9	12,878	5.4

The estimates were based on the age-specific incidence and prevalence data for men.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 17. Estimated number of site-specific incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) among women in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Women												
Stomach (ICD-10 C16)	9	6.0	26	5.6	51	5.5	71	5.6	131	6.0	287	5.7
Colorectum (ICD-10 C18-C20)	57	12.4	207	11.5	462	11.1	693	11.5	1,200	12.2	2,619	11.7
Pancreas (ICD-10 C25)	3	3.3	15	3.5	43	3.4	74	3.5	125	3.7	261	3.6
Lung (ICD-10 C33-C34)	60	22.0	382	19.1	997	18.6	1,148	19.1	986	20.2	3,572	19.3
Breast (ICD-10 C50)	335	7.5	952	7.1	1,131	6.9	1,089	7.1	1,094	7.5	4,601	7.1
Endometrium (ICD-10 C54-C55)	35	16.9	173	15.3	423	14.8	424	15.2	457	16.1	1,512	15.4
Kidney (ICD-10 C64)	24	19.0	78	16.7	177	16.3	248	16.8	334	17.8	861	17.1
Bladder (ICD-10 C67)	4	10.8	21	9.4	51	8.9	88	9.3	157	9.8	320	9.5
All above cancer types combined[a]	527	5.1	1,854	6.3	3,335	7.0	3,835	7.3	4,484	7.2	14,033	6.9

The estimates were based on the age-specific incidence and prevalence data for women.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 18. Estimated number of site-specific incident cancer cases attributable to an unhealthy diet among men and women combined in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined												
Total red meat intake (<500 g/week recommended)												
Colorectum (ICD-10 C18-C20)	17	1.7	54	1.3	104	0.9	90	0.6	131	0.6	396	0.7
Pancreas (ICD-10 C25)	3	1.6	12	1.2	28	0.9	25	0.5	35	0.6	103	0.7
Lung (ICD-10 C33-C34)	21	4.1	137	2.9	318	2.2	235	1.3	222	1.4	933	1.8
Breast (ICD-10 C50), women only	16	0.4	62	0.5	67	0.4	62	0.4	48	0.3	255	0.4
All above cancer types combined[a]	57	0.4	265	0.5	517	0.5	412	0.3	436	0.3	1,687	0.4
Total processed meat intake (0 g/week recommended)												
Colorectum (ICD-10 C18-C20)	146	14.7	611	14.3	1,420	12.9	1,727	11.1	2,178	10.1	6,082	11.4
Breast (ICD-10 C50), women only	254	5.7	781	5.8	906	5.5	772	5.0	659	4.5	3,372	5.2
All above cancer types combined[a]	400	2.5	1,392	2.8	2,326	2.2	2,499	1.9	2,837	2.0	9,454	2.1
Total salt intake (<6 g/day recommended)												
Stomach (ICD-10 C16)	32	10.5	130	10.3	281	9.4	302	8.0	459	8.3	1,204	8.7
All above cancer types combined[a]	32	0.2	130	0.3	281	0.3	302	0.2	459	0.3	1,204	0.3
Total dietary fiber intake (≥32 g/day recommended)												
Colorectum (ICD-10 C18-C20)	220	22.1	884	20.7	1,934	17.6	2,481	16.0	3,268	15.1	8,787	16.4
Breast (ICD-10 C50), women only	424	9.5	1,275	9.5	1,606	9.7	1,235	8.0	1,147	7.9	5,687	8.8
All above cancer types combined[a]	644	4.1	2,159	4.3	3,540	3.4	3,716	2.9	4,415	3.1	14,474	3.3
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Colorectum (ICD-10 C18-C20)	40	4.0	170	4.0	434	3.9	501	3.2	785	3.6	1,930	3.6
Lung (ICD-10 C33-C34)	81	15.6	718	15.5	2,229	15.4	2,238	12.8	2,251	14.3	7,517	14.2
All above cancer types combined[a]	121	0.8	888	1.8	2,663	2.5	2,739	2.1	3,036	2.2	9,447	2.1

The estimates were based on the age-specific incidence and prevalence data for men and women combined.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 19. Estimated number of site-specific incident cancer cases attributable to an unhealthy diet among men combined in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men												
Total red meat intake (<500 g/week recommended)												
Colorectum (ICD-10 C18-C20)	15	2.8	45	1.8	89	1.3	59	0.6	93	0.8	301	1.0
Pancreas (ICD-10 C25)	2	2.6	11	1.7	23	1.2	15	0.6	22	0.7	73	0.9
Lung (ICD-10 C33-C34)	16	6.6	113	4.3	276	3.0	166	1.4	199	1.8	770	2.2
All above cancer types combined[a]	33	0.6	169	0.8	388	0.7	240	0.3	314	0.4	1,144	0.5
Total processed meat intake (0 g/week recommended)												
Colorectum (ICD-10 C18-C20)	103	19.4	455	18.5	1,116	16.3	1,306	13.8	1,494	12.7	4,474	14.4
All above cancer types combined[a]	103	1.9	455	2.2	1,116	1.9	1,306	1.7	1,494	1.9	4,474	1.9
Total salt intake (<6 g/day recommended)												
Stomach (ICD-10 C16)	21	13.3	103	12.9	244	11.8	245	9.7	351	10.5	964	10.8
All above cancer types combined[a]	21	0.4	103	0.5	244	0.4	245	0.3	351	0.4	964	0.4
Total dietary fiber intake (≥32 g/day recommended)												
Colorectum (ICD-10 C18-C20)	136	25.6	549	22.3	1,105	16.2	1,516	16.0	1,691	14.3	4,997	16.1
All above cancer types combined[a]	136	2.5	549	2.6	1,105	1.9	1,516	2.0	1,691	2.2	4,997	2.1
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Colorectum (ICD-10 C18-C20)	21	4.0	102	4.2	266	3.9	330	3.5	434	3.7	1,153	3.7
Lung (ICD-10 C33-C34)	38	15.5	424	16.0	1,377	15.1	1,566	13.6	1,566	14.4	4,971	14.4
All above cancer types combined[a]	59	1.1	526	2.5	1,643	2.9	1,896	2.5	2,000	2.6	6,124	2.6

The estimates were based on the age-specific incidence and prevalence data for men.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

eTable 20. Estimated number of site-specific incident cancer cases attributable to an unhealthy diet among women in Germany for the year 2018, stratified by age and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Women												
Total red meat intake (<500 g/week recommended)												
Colorectum (ICD-10 C18-C20)	2	0.5	11	0.6	22	0.5	32	0.5	42	0.4	109	0.5
Pancreas (ICD-10 C25)	0[b]	0.4	2	0.6	6	0.5	10	0.5	13	0.4	31	0.4
Lung (ICD-10 C33-C34)	3	1.1	28	1.4	67	1.2	74	1.2	49	1.0	221	1.2
Breast (ICD-10 C50), women only	16	0.4	62	0.5	67	0.4	62	0.4	48	0.3	255	0.4
All above cancer types combined[a]	21	0.2	103	0.4	162	0.3	178	0.3	152	0.2	616	0.3
Total processed meat intake (0 g/week recommended)												
Colorectum (ICD-10 C18-C20)	44	9.6	177	9.8	385	9.3	512	8.5	755	7.7	1,873	8.4
Breast (ICD-10 C50), women only	254	5.7	781	5.8	906	5.5	772	5.0	659	4.5	3,372	5.2
All above cancer types combined[a]	298	2.9	958	3.3	1,291	2.7	1,284	2.4	1,414	2.3	5,245	2.6
Total salt intake (<6 g/day recommended)												
Stomach (ICD-10 C16)	11	7.5	36	7.7	65	7.0	81	6.4	141	6.4	334	6.7
All above cancer types combined[a]	11	0.1	36	0.1	65	0.1	81	0.2	141	0.2	334	0.2
Total dietary fiber intake (≥32 g/day recommended)												
Colorectum (ICD-10 C18-C20)	87	18.8	338	18.7	799	19.3	967	16.0	1,559	15.8	3,750	16.8
Breast (ICD-10 C50), women only	424	9.5	1,275	9.5	1,606	9.7	1,235	8.0	1,147	7.9	5,687	8.8
All above cancer types combined[a]	511	5.0	1,613	5.5	2,405	5.1	2,202	4.2	2,706	4.3	9,437	4.7
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)												
Colorectum (ICD-10 C18-C20)	17	3.6	66	3.6	153	3.7	170	2.8	340	3.5	746	3.3
Lung (ICD-10 C33-C34)	39	14.3	285	14.3	777	14.5	679	11.3	669	13.7	2,449	13.2
All above cancer types combined[a]	56	0.5	351	1.2	930	2.0	849	1.6	1,009	1.6	3,195	1.6

The estimates were based on the age-specific incidence and prevalence data for women.

[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).

[b] The zero case number is due to rounding to the next integer.

eTable 21. Estimated number of site-specific incident cancer cases attributable to all selected unhealthy dietary factors combined, including a high total red meat intake of ≥500 g/week, any total processed meat intake of >0 g/week, a high salt intake of ≥6 g/day, a low dietary fiber intake of <32 g/day and a low fruit and non-starchy vegetable intake of <400 g/day, in Germany for the year 2018, stratified by age and gender and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cancer cases by age at outcome											
	35-44 years		**45-54 years**		**55-64 years**		**65-74 years**		**75-84 years**		**All ages combined**	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined												
All dietary factors combined												
Colorectum (ICD-10 C18-C20)	371	37.4	1,519	35.6	3,487	31.7	4,371	28.2	5,814	26.8	15,562	29.1
Pancreas (ICD-10 C25)	3	1.6	12	1.2	28	0.9	25	0.5	35	0.6	103	0.7
Lung (ICD-10 C33-C34)	99	19.0	833	18.0	2,498	17.2	2,443	14.0	2,442	15.5	8,315	15.7
Breast (ICD-10 C50), women only	667	15.0	2,035	15.1	2,481	15.0	2,000	13.0	1,795	12.3	8,978	13.9
Stomach (ICD-10 C16)	32	10.5	130	10.3	281	9.4	302	8.0	459	8.3	1,204	8.7
All above cancer types combined[a]	1,172	7.4	4,529	9.0	8,775	8.4	9,141	7.1	10,545	7.5	34,162	7.8
Men												
All dietary factors combined												
Colorectum (ICD-10 C18-C20)	234	44.0	995	40.4	2,288	33.4	2,893	30.5	3,362	28.5	9,772	31.4
Pancreas (ICD-10 C25)	2	2.6	11	1.7	23	1.2	15	0.6	22	0.7	73	0.9
Lung (ICD-10 C33-C34)	52	21.0	519	19.6	1,612	17.6	1,709	14.9	1,736	15.9	5,628	16.4
Stomach (ICD-10 C16)	21	13.3	103	12.9	244	11.8	245	9.7	351	10.5	964	10.8
All above cancer types combined[a]	309	5.6	1,628	7.8	4,167	7.3	4,862	6.4	5,471	7.0	16,437	6.9
Women												
All dietary factors combined												
Colorectum (ICD-10 C18-C20)	137	29.6	537	29.7	1,238	29.8	1,551	25.7	2,491	25.3	5,954	26.7
Pancreas (ICD-10 C25)	0[b]	0.4	2	0.6	6	0.5	10	0.5	13	0.4	31	0.4
Lung (ICD-10 C33-C34)	42	15.2	309	15.5	834	15.6	745	12.4	711	14.6	2,641	14.3
Breast (ICD-10 C50)	667	15.0	2,035	15.1	2,481	15.0	2,000	13.0	1,795	12.3	8,978	13.9
Stomach (ICD-10 C16)	11	7.5	36	7.7	65	7.0	81	6.4	141	6.4	334	6.7
All above cancer types combined[a]	857	8.4	2,919	9.9	4,624	9.7	4,387	8.4	5,151	8.2	17,938	8.9

The estimates for men and women combined were based on the age-specific incidence and prevalence data for men and women combined. The estimates for men were based on the age-specific incidence and prevalence data for men. The estimates for women were based on the age-specific incidence and prevalence data for women.
[a] The PAF for the category "All above cancer types combined" was computed with respect to total cancer incidence (ICD-10 C00-C99 without C44).
[b] The zero case number is due to rounding to the next integer.

eTable 22. Spearman correlation coefficients between selected healthy lifestyle factors among 5,195 men and women aged 25-74 years of the nationally representative DEGS1 survey, 2008-2011, Germany.

Healthy lifestyle factor	**Normal BMI[a]**	**High MVPA[b]**	**Low red meat intake[c]**	**No processed meat intake[d]**	**Low salt intake[e]**	**High dietary fiber intake[f]**	**High fruit/ non-starchy veg. intake[g]**	**Low alcohol intake[h]**	**No current smoking[i]**
Men and women combined									
Normal BMI[a]	1.00	0.05	0.00	0.00	-0.01	0.02	0.02	0.03	-0.09
High MVPA[b]		1.00	-0.01	-0.02	0.00	-0.01	-0.02	-0.03	-0.03
Low red meat intake[c]			1.00	0.05	0.13	-0.03	0.04	-0.03	0.03
No processed meat intake[d]				1.00	0.22	-0.03	0.03	0.01	0.01
Low salt intake[e]					1.00	-0.29	-0.09	-0.01	0.00
High dietary fiber intake[f]						1.00	0.45	-0.01	0.01
High fruit/non-starchy veg. intake[g]							1.00	-0.05	0.02
Low alcohol intake[h]								1.00	0.08
No current smoking[i]									1.00

BMI=body mass index; int.=intake; MVPA=moderate to vigorous physical activity; veg.=vegetable

[a] BMI=18.5-25 kg/m²

[b] MVPA≥150 min/week

[c] Red meat intake<500 g/week

[d] Processed meat intake=0 g/week

[e] Salt intake<6 g/day

[f] Dietary fiber intake≥32 g/day

[g] Fruit and non-starchy vegetable intake≥400 g/day

[h] Alcohol intake (women: <10 g/day; men: <20 g/day),

[i] Explicitly includes no current smoking of cigarrettes/cigars/pipes/water pipes

eTable 23. Sensitivity analyses of the estimated number of all incident cancer cases attributable to excess weight (BMI≥25 kg/m²) in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cases for all ages combined					
	Main analysis		**Sensitivity analysis: lower confidence limits of relative risks**		**Sensitivity analysis: upper confidence limits of relative risks**	
Excess weight (BMI≥25 kg/m²)	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined	30,567	6.9	19,513	4.4	41,723	9.5
Men	12,695	5.3	7,625	3.2	17,689	7.4
Women	17,179	8.5	11,351	5.6	23,170	11.5

The estimates for men and women combined were based on the age-specific incidence and prevalence data for men and women combined. The estimates for men were based on the age-specific incidence and prevalence data for men. The estimates for women were based on the age-specific incidence and prevalence data for women.

eTable 24. Sensitivity analyses of the estimated number of all incident cancer cases attributable to low physical activity (<150 min/week of moderate to vigorous physical activity) in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cases for all ages combined					
	Main analysis		**Sensitivity analysis: lower confidence limits of relative risks**		**Sensitivity analysis: upper confidence limits of relative risks**	
Low physical activity	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined	27,081	6.1	19,714	4.5	34,857	7.9
Men	12,878	5.4	8,481	3.6	17,580	7.4
Women	14,033	6.9	7,827	3.9	20,317	10.0

The estimates for men and women combined were based on the age-specific incidence and prevalence data for men and women combined. The estimates for men were based on the age-specific incidence and prevalence data for men. The estimates for women were based on the age-specific incidence and prevalence data for women.

eTable 25. Sensitivity analyses of the estimated number of all incident cancer cases attributable to all selected unhealthy dietary factors in Germany for the year 2018, stratified by gender and assuming a 10-year latency period between exposure and cancer incidence.

	Total and relative number of attributable site-specific incident cases for all ages combined					
	Main analysis		Sensitivity analysis: lower confidence limits of relative risks		Sensitivity analysis: upper confidence limits of relative risks	
Exposure	**N**	**%**	**N**	**%**	**N**	**%**
Men and women combined						
Total red meat intake (<500 g/week recommended)	1,687	0.4	823	0.2	2,565	0.6
Total processed meat intake (0 g/week recommended)	9,454	2.1	4,778	1.1	15,752	3.6
Total salt intake (<6 g/day recommended)	1,204	0.3	217	<0.1	2,143	0.5
Total dietary fiber intake (≥32 g/day recommended)	14,474	3.3	7,555	1.7	22,471	5.1
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)	9,447	2.1	3,805	0.9	14,957	3.4
All dietary factors combined	34,162	7.8	16,695	3.8	52,547	11.9
Men						
Total red meat intake (<500 g/week recommended)	1,144	0.5	580	0.2	1,737	0.7
Total processed meat intake (0 g/week recommended)	4,474	1.9	2,953	1.2	7,083	3.0
Total salt intake (<6 g/day recommended)	964	0.4	176	0.1	1,695	0.7
Total dietary fiber intake (≥32 g/day recommended)	4,997	2.1	2,996	1.3	6,991	2.9
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)	6,124	2.6	2,530	1.1	9,604	4.0
All dietary factors combined	16,437	6.9	8,902	3.7	24,076	10.1
Women						
Total red meat intake (<500 g/week recommended)	616	0.3	286	0.1	936	0.5
Total processed meat intake (0 g/week recommended)	5,245	2.6	2,010	1.0	9,047	4.5
Total salt intake (<6 g/day recommended)	334	0.2	59	<0.1	600	0.3
Total dietary fiber intake (≥32 g/day recommended)	9,437	4.7	4,534	2.2	15,425	7.6
Total fruit and non-starchy vegetable intake (≥400 g/day recommended)	3,195	1.6	1,231	0.6	5,135	2.5
All dietary factors combined	17,938	8.9	7,953	3.9	28,735	14.2

The estimates for men and women combined were based on the age-specific incidence and prevalence data for men and women combined. The estimates for men were based on the age-specific incidence and prevalence data for men. The estimates for women were based on the age-specific incidence and prevalence data for women.