Archival Report

Biological Psychiatry: GOS

Eating Disorders and Later Incidence of Cancer: A Nationwide Longitudinal Study in Denmark

Gabrielle E. Cooper, Natalie M. Papini, Katrine Holde, Cynthia M. Bulik, Zeynep Yilmaz, and Liselotte V. Petersen

ABSTRACT

BACKGROUND: We examined the incidence of cancer types among individuals with eating disorders (EDs).

METHODS: A nationwide longitudinal study of 6,807,731 individuals born between 1940 and 2015 was conducted using the Danish National Registries. Cox models with ED diagnosis as exposure and cancer diagnoses as outcomes were used to estimate hazard ratios (HRs) and 95% CIs while adjusting for sex, birth year, and comorbidities. The primary analysis comprised ICD-8 and ICD-10 codes for anorexia nervosa (AN) and other ED (OED). The secondary analysis comprised ICD-10 codes and included AN, bulimia nervosa (BN), and eating disorders not otherwise specified (EDNOS).

RESULTS: AN was associated with a reduced incidence of breast cancer while adjusting for sex and birth year (HR, 0.80; 95% CI, 0.66–0.97) and elevated incidence of respiratory (HR, 1.59; 95% CI, 1.24–2.04), cervical (HR, 1.45; 95% CI, 1.05–1.98), and esophageal (HR, 4.77; 95% CI, 2.82–8.06) cancers. OED was associated with an elevated incidence of respiratory (HR, 1.57; 95% CI, 1.20–2.06) and cervical (HR, 1.60; 95% CI, 1.20–2.14) cancers. ICD-10–only analyses confirmed the association of AN with reduced incidence of breast cancer and elevated incidence of respiratory and cervical cancers. BN was associated with reduced incidence of breast cancer in sensitivity analysis. EDNOS was associated with reduced incidence of breast cancer and elevated incidence of respiratory and cervical cancers.

CONCLUSIONS: All EDs were associated with a reduced incidence of breast cancer. All EDs except BN were associated with a higher incidence of respiratory and cervical cancers. AN was associated with a higher incidence of esophageal cancer.

https://doi.org/10.1016/j.bpsgos.2025.100483

Eating disorders (EDs) are serious psychiatric disorders that involve dysfunctional thoughts, behaviors, and attitudes toward food, eating, and body shape and size (1). Restrictive eating disorders such as anorexia nervosa (AN) are characterized by an intense fear of weight gain, excessive concern about body weight and shape, dietary restriction, and insufficient caloric intake (2). Adverse somatic and mental health conditions associated with EDs include gastroparesis, damage to liver and kidneys, increased mood disorders such as depression and anxiety, and elevated mortality (3–5). A nascent literature has also suggested an association between EDs and later cancer incidence (6–8), encouraging subsequent studies to further elucidate the nature of the relationship.

Specifically, evidence supports an association between AN and a reduced rate of breast cancer (6,9,10) but elevated rates of esophageal and liver cancers (6). In a systematic review, Michels *et al.* (8) observed elevated mortality in patients with ED for overall cancer, breast cancer, female genital cancer, and melanoma. A retrospective cohort study that utilized longitudinal health insurance data from 2 million individuals in Taiwan revealed that individuals diagnosed with AN, bulimia nervosa (BN), and eating disorder not otherwise specified (EDNOS) faced elevated rates of developing esophageal and stomach cancers in adulthood (7). Chronic self-induced vomiting in BN has been linked to a higher risk of esophageal cancer and stomach cancer (8), although examination of the contribution of BN to cancer risk has been limited. Data from hospital admissions revealed no significant associations or altered cancer rates in individuals with BN (9). It is plausible that the risk of developing various cancers may differ across EDs depending on the presence and duration of amenorrhea or oligomenorrhea (reduced breast cancer) and the presence and frequency of vomiting (elevated rate of esophageal cancer) (11,12). Accordingly, when possible, diagnostic separation may yield a clearer picture of the association between EDs and individual cancers.

The aim of this study was to examine cancer incidence in individuals with EDs using Danish population registers. An exploratory aim was to examine whether mortality rates in individuals with EDs differ within certain cancer types. Mortality is an important end point to consider because it reflects long-term health consequences of EDs, including the cumulative impact of psychiatric and physical comorbidities. Michels *et al.* (8) called for future research on EDs and cancers to include

ISSN: 2667-1743

Table 1. Definition of the ED Exposure Groups

	ICD-8 Codes	ICD-10 Codes	Criteria
Primary Analysis			
AN	306.50	F50.0, F50.1	First diagnosis after age 6 or 1969, whichever came last; not mutually exclusive, first AN and first OED diagnosis
OED	306.58, 306.59	F50.2, F50.3, F50.8, F50.9	
Secondary Analysis			
AN	–	F50.0, F50.1	Diagnosed after age 6 or 1994, whichever came last; not mutually exclusive
BN	–	F50.2, F50.3	
EDNOS	–	F50.8, F50.9	

AN, anorexia nervosa; BN, bulimia nervosa; EDNOS, eating disorder not otherwise specified; OED, other eating disorder.

large-scale studies that focus on BN and several cancer types. Therefore, we examined the occurrence of breast, esophageal, cervical, respiratory, and brain cancers in individuals with AN, BN, and other EDs (OEDs) or EDNOS using longitudinal Danish population registry data.

METHODS AND MATERIALS

Registry

All individuals born between 1940 and 2015 who were still alive and in Denmark in 1969 were included. A unique number assigned to all individuals is used in all national registers and permits linkage among them. All demographic information was collected from the Danish Civil Registration System (13). Information on ED diagnosis, cancer diagnosis, and mortality was collected from the Danish Psychiatric Central Research Register and the Danish National Patient Register (14–16). Two separate analyses were conducted; one was aimed at capturing shifts in diagnostic systems utilized throughout the studied time frame, and another was designed to accommodate a sizable cohort within the OED group, thereby facilitating the investigation of incidence of esophageal and brain cancers. The first analysis used diagnoses based on ICD-8 and ICD-10, which give the largest possible sample size. The second analysis used ICD-10 diagnoses only. This provided a smaller sample size and also enabled disaggregation of BN from other EDs because BN was not included as an independent diagnosis in ICD-8. In the primary analysis, the diagnostic groups are AN and OED whereas in the secondary analysis, the diagnostic groups are AN, BN, and EDNOS (Table 1).

Participants and Follow-Up

The primary and secondary analysis both include all individuals born between 1940 and 2015. In the primary analysis, we followed individuals from age 6 years or from the year 1969 (the Psychiatric Central Register started in 1969), whichever came last, and until the cancer of interest, death, emigration, or the end of follow-up (December 12, 2021), whichever came first. For the secondary analysis, we followed the individuals from age 6 years or the year 1994, whichever came last, and until the cancer of interest, death, emigration, or the end of follow-up (December 31, 2021), whichever came first. The AN and OED groups were not mutually exclusive; 7396 individuals were diagnosed with both AN and OED. The AN, BN, and EDNOS groups were also not mutually exclusive; 2004 individuals were diagnosed with both AN and BN; 6124 individuals were diagnosed with both AN and EDNOS; and 3303 individuals were diagnosed with BN and EDNOS. Finally, 1078 individuals were diagnosed with AN, BN, and EDNOS.

Statistical Analysis

The exposure of interest was ED diagnosis. The outcome of interest was cancer diagnosis (breast, respiratory, esophageal, cervical, and brain). The ED as exposure was handled as a time-dependent covariate in a Cox model with death as a competing risk and time until diagnosis as the underlying time scale; therefore, an individual's ED status changed from control to case at diagnosis, and the person was considered exposed from that point onward. All analyses were adjusted for sex and birth year; we also adjusted for comorbidities (disease of the circulatory system, chronic obstructive pulmonary disease [COPD], substance use disorder, mood disorder, and anxiety disorder) as time-dependent covariates (Tables 2 and 3).

Mortality analyses were conducted in which the study population was restricted to individuals diagnosed with the cancer type of interest. We performed a Cox regression to estimate the mortality rate ratio (hazard ratio [HR]) for ED exposure adjusted for birth year and sex. A threshold of >10 observations was used for all analyses.

Two sensitivity analyses were conducted, one in which the population was restricted to individuals born after 1961 to account for missed ED diagnosis and another where follow-up starts at age 20 to address the low prevalence of cancer in adolescence. For the second sensitivity analysis, we also restricted the population to individuals born after 1961 to be able to adjust for education measured at age 20 as a proxy for socioeconomic status. The percentage of missing data for educational attainment was $<5\%$, and any individuals with missing data were excluded from the analyses.

All analyses were done using R version 4.4.1.

Table 2. Definition of the Cancer Outcome Groups

Cancer Site	ICD-8 Codes	ICD-10 Codes
Breast	174	C50
Respiratory System	160–163	C30–C39
Lung	162	C33–C34
Esophageal	150	C15
Stomach	151	C16
Cervical	180	C53
Liver	155.0–155.1	C22
Brain	191	C71

Table 3. Definition of Comorbidities

Comorbidity	ICD-8 Codes	ICD-10 Codes	Criteria
Disease of the Circulatory System	390–458	I00–I99	–
COPD	490–492	J40–J44	–
Mood Disorder	296.x9 (excluding 296.89), 298.09, 298.19, 300.49, 301.19	F30–F39	Minimum age of diagnosis at 10 years
Anxiety	300.x9 (excluding 300.49), 305.x9 305.68, 307.99	F40–F48	Minimum age of diagnosis at 10 years
Diabetes	249–250	E10–E14	–
Substance Use Disorder	291.x9, 294.39, 303.x9, 303.20, 303.28, 303.90, 304.x9	F10–F19	Minimum age of diagnosis at 10 years and excluding diagnoses given in the emergency department

COPD, chronic obstructive pulmonary disease.

RESULTS

Under the ICD-8 and ICD-10 criteria, 18,377 individuals (93% female) were diagnosed with AN, and 25,841 individuals (92% female) were diagnosed with OED. Under the ICD-10–only criteria, 16,051 individuals (94% female) were diagnosed with AN, 10,792 individuals (97% female) were diagnosed with BN, and 17,702 individuals (90% female) were diagnosed with EDNOS. Demographic information collected from the Danish Civil Registration System on place of origin, age at diagnosis, year of diagnosis, education level, highest education level, and prevalence of comorbidities is presented in Table 4 for the primary analysis and in Table 5 for the secondary analysis.

ICD-8 and ICD-10 criteria were used to examine individuals with AN and OEDs. After adjusting for sex and birth year, individuals with AN had a significantly reduced rate of breast cancer (HR, 0.80; 95% CI, 0.66–0.97). Adjusting for comorbidities, individuals with AN (HR, 0.76; 95% CI, 0.63–0.92) had a significantly reduced rate of breast cancer. We observed an elevated incidence of respiratory cancer in individuals with AN (HR, 1.59; 95% CI, 1.24–2.04) and OEDs (HR: 1.57; 95% CI, 1.20–2.06) and an elevated incidence of cervical cancer in individuals with AN (HR, 1.45; 95% CI, 1.05–1.98) and OEDs (HR, 1.60; 95% CI, 1.20–2.14) after adjusting for sex and birth year. These results were no longer significant after adjusting for comorbidities. We observed a significantly elevated incidence of esophageal cancer in individuals with AN (HR, 4.77; 95% CI, 2.82–8.06). Our results remained significant after adjusting for comorbidities (HR, 3.07; 95% CI, 1.81–5.20). Fewer than 10 individuals with OED were found to have esophageal cancer, and therefore prevalence was not analyzed. We did not observe an elevated incidence of brain cancer in individuals with AN or OED (Table 6).

Next, we restricted the analyses to individuals diagnosed with ICD-10 criteria to examine AN, BN, and EDNOS. We observed a reduced incidence of breast cancer while adjusting for birth year, sex, and comorbidities in individuals with AN (HR, 0.63; 95% CI, 0.46–0.85) and EDNOS (HR, 0.75, 95% CI, 0.58–0.98). Individuals with BN did not have a significantly reduced incidence of breast cancer. We observed a significantly elevated incidence of respiratory cancer in individuals with AN (HR, 1.65; 95% CI, 1.11–2.44) and EDNOS (HR, 1.59; 95% CI, 1.11–2.28) when adjusting for sex and birth year. After adjusting for comorbidities, the results were no longer significant. Individuals with BN did not have a significantly elevated incidence of respiratory cancers. We observed a significantly elevated incidence of cervical cancer in individuals with AN (HR, 1.92; 95% CI, 1.21–2.80) and EDNOS (HR, 2.09; 95% CI, 1.44–3.03). Our results remained significant after adjustment for comorbidities. Individuals with BN did not have a significantly elevated incidence of cervical cancer. We did not observe an elevated incidence of brain cancer in individuals with AN. The observed counts of brain cancer in the BN and EDNOS cohorts were <10 and were not analyzed (Table 7).

Using ICD-8 and ICD-10 criteria, we observed a significant increase in breast cancer–related mortality in individuals diagnosed with AN (HR, 1.96; 95% CI, 1.38–2.79) and OEDs (HR, 1.71; 95% CI, 1.16–2.53). Individuals with AN diagnosed with respiratory or brain cancer did not show elevated cancer-related mortality. We did not observe elevated respiratory cancer–related mortality in individuals with OED. In a mortality analysis restricted to ICD-10 criteria, we did not observe elevated breast or respiratory cancer–related mortality in individuals with EDNOS or elevated respiratory cancer–related mortality in individuals with AN. The remaining observations were ≤ 10 and therefore were not analyzed (Tables 8 and 9).

Sensitivity analyses adjusting for sex, birth year, and education were also conducted. In analyses that included ICD-8 and ICD-10 criteria, we did not observe significantly elevated or reduced rates of breast, cervical, or respiratory cancers in individuals with AN or OED. In analyses restricted to ICD-10 criteria, we observed a significantly reduced risk of breast cancer in individuals with AN (HR, 0.62; 95% CI, 0.39–0.97), BN (HR, 0.64; 95% CI, 0.42–0.97) and EDNOS (HR, 0.59; 95% CI, 0.38–0.93). We did not observe a significant difference in the incidence of respiratory cancer for AN, BN, or EDNOS. Individuals with EDNOS were not found to have an elevated incidence of cervical cancer. The remaining observations were too low to perform mortality analysis (Tables S1 and S2).

DISCUSSION

In this large Danish population study, we examined the associations between EDs (AN, BN, and OEDs or EDNOS) and cancer rates (breast, respiratory, esophageal, cervical, and brain). After adjusting for covariates, the incidence of breast cancer among individuals with AN and EDNOS was significantly lower than among individuals without an ED diagnosis. In a sensitivity analysis, individuals with BN and individuals with AN or EDNOS had a reduced incidence of breast cancer.

Table 4. Characteristics of Individuals Diagnosed With AN or OEDs

	AN		OED	
Characteristic	Unexposed, *n* = 6,789,354	Exposed, *n* = 18,377	Unexposed, *n* = 6,781,890	Exposed, *n* = 25,841
Sex, Female	3,298,870 (49%)	17,157 (93%)	3,292,143 (49%)	23,884 (92%)
Urbanicity at Birth				
Capital	885,172 (13%)	3022 (16%)	884,350 (13%)	3844 (15%)
Capital suburb	493,975 (7.3%)	2332 (13%)	492,982 (7.3%)	3325 (13%)
Provincial city	630,994 (9.3%)	2396 (13%)	630,260 (9.3%)	3130 (12%)
Provincial town	1,542,662 (23%)	4857 (26%)	1,540,592 (23%)	6927 (27%)
Rural area	1,545,455 (23%)	4570 (25%)	1,543,538 (23%)	6487 (25%)
Outside Denmark	1,628,728 (24%)	1164 (6.3%)	1,627,810 (24%)	2082 (8.1%)
Missing	62,368 (0.9%)	36 (0.2%)	62,358 (0.9%)	46 (0.2%)
Low Educational Level at Age 20				
Yes	2,076,671 (31%)	9992 (54%)	2,071,145 (31%)	15,518 (60%)
No	712,045 (10%)	3958 (22%)	710,477 (10%)	5526 (21%)
Missing	4,000,638 (59%)	4427 (24%)	4,000,268 (59%)	4797 (19%)
Age Groups at Diagnosis, Years				
<20	–	11,108 (60%)	–	11,265 (44%)
20–29	–	5193 (28%)	–	9879 (38%)
30–39	–	1340 (7.3%)	–	2917 (11%)
40–49	–	480 (2.6%)	–	1088 (4.2%)
50–59	–	192 (1.0%)	–	464 (1.8%)
≥60	–	64 (0.3%)	–	228 (0.9%)
Year of Diagnosis				
≤1980	–	735 (4.0%)	–	106 (0.4%)
1981–1990	–	1195 (6.5%)	–	191 (0.7%)
1991–2000	–	2550 (14%)	–	3533 (14%)
2001–2010	–	4859 (26%)	–	7693 (30%)
≥2011	–	9038 (49%)	–	14,318 (55%)
Education as a Proxy for SES, Highest Educational Level the Year Prior to Diagnosis				
Elementary school	–	8202 (45%)	–	11,881 (46%)
High school/vocational school	–	3081 (17%)	–	6802 (26%)
Academic degree	–	928 (5.0%)	–	2264 (8.8%)
Missing—diagnosed prior to 1982	–	858 (4.7%)	–	117 (0.5%)
Missing[a]	–	5308 (29%)	–	4777 (18%)
Comorbidities				
Circulatory system	1,362,661 (20%)	3011 (16%)	1,361,410 (20%)	4262 (16%)
COPD	180,932 (2.7%)	456 (2.5%)	180,815 (2.7%)	573 (2.2%)
Diabetes	244,564 (3.6%)	341 (1.9%)	244,077 (3.6%)	828 (3.2%)
Substance use disorder	351,304 (5.2%)	2243 (12%)	349,941 (5.2%)	3606 (14%)
Mood disorder	307,749 (4.5%)	5394 (29%)	304,109 (4.5%)	9034 (35%)
Anxiety disorder	489,107 (7.2%)	7171 (39%)	484,617 (7.1%)	11,661 (45%)

Values are presented as *n* (%).

AN, anorexia nervosa; COPD, chronic obstructive pulmonary disease; OED, other eating disorder; SES, socioeconomic status.

[a]Missing could be due to either having no education because of age or year not being present in the register.

The incidence of respiratory cancer was significantly elevated in AN, OED, and EDNOS; however, after adjusting for comorbidities, the results were no longer significant. Individuals with AN had a 4.7-fold increased incidence of esophageal cancer. An increase in mortality was found in individuals with breast cancer diagnosed with AN or OED.

Our findings demonstrating a significantly reduced incidence of breast cancer in individuals with AN and EDNOS are consistent with previous studies that have reported this pattern in females with AN (6,8–10,17). In the sensitivity analysis, our findings are consistent with a reduced incidence of breast cancer in individuals with AN and EDNOS. We observed a reduced incidence of breast cancer in individuals with BN. This suggests that the relationship between BN and incidence of breast cancer may be influenced by birth year and education level. Factors that could contribute to reduced incidence include hormone exposure, reproductive status, and physical activity level (18). Many individuals with EDs experience

Table 5. Characteristics of Individuals Diagnosed With AN, BN, or EDNOS

	AN		BN		EDNOS	
Characteristic	Unexposed, *n* = 6,511,656	Exposed, *n* = 16,051	Unexposed, *n* = 6,516,915	Exposed, *n* = 10,792	Unexposed, *n* = 6,510,005	Exposed, *n* = 17,702
Sex, Female	3,178,401 (49%)	15,018 (94%)	3,182,921 (49%)	10,498 (97%)	3,177,408 (49%)	16,011 (90%)
Urbanicity at Birth						
Capital	858,430 (13%)	2583 (16%)	859,368 (13%)	1645 (15%)	858,510 (13%)	2503 (14%)
Capital suburb	487,388 (7.5%)	2150 (13%)	488,054 (7.5%)	1484 (14%)	487,242 (7.5%)	2296 (13%)
Provincial city	619,473 (9.5%)	2077 (13%)	620,279 (9.5%)	1271 (12%)	619,344 (9.5%)	2206 (12%)
Provincial town	1,513,726 (23%)	4112 (26%)	1,514,937 (23%)	2901 (27%)	1,513,134 (23%)	4704 (27%)
Rural area	1,516,776 (23%)	4044 (25%)	1,518,306 (23%)	2514 (23%)	1,516,227 (23%)	4593 (26%)
Outside Denmark	1,458,097 (22%)	1062 (6.6%)	1,458,195 (22%)	964 (8.9%)	1,457,793 (22%)	1366 (7.7%)
Missing	57,766 (0.9%)	23 (0.1%)	57,776 (0.9%)	13 (0.1%)	57,755 (0.9%)	34 (0.2%)
Low Educational Level at Age 20						
Yes	2,067,460 (32%)	9012 (56%)	2,069,656 (32%)	6816 (63%)	2,065,875 (32%)	10,597 (60%)
No	708,485 (11%)	3582 (22%)	709,112 (11%)	2955 (27%)	708,787 (11%)	3280 (19%)
Missing	3,735,711 (57%)	3457 (22%)	3,738,147 (57%)	1021 (9.5%)	3,735,343 (57%)	3825 (22%)
Age Groups at Diagnosis, Years						
<20	–	9823 (61%)	–	3265 (30%)	–	8629 (49%)
20–29	–	4494 (28%)	–	5677 (53%)	–	5651 (32%)
30–39	–	1076 (6.7%)	–	1355 (13%)	–	2028 (11%)
40–49	–	404 (2.5%)	–	384 (3.6%)	–	803 (4.5%)
50–59	–	191 (1.2%)	–	93 (0.9%)	–	385 (2.2%)
≥60	–	63 (0.4%)	–	18 (0.2%)	–	206 (1.2%)
Year of Diagnosis						
≤2000	–	2159 (13%)	–	2202 (20%)	–	1287 (7.3%)
2001–2010	–	4857 (30%)	–	3565 (33%)	–	4945 (28%)
≥2011	–	9035 (56%)	–	5025 (47%)	–	11,470 (65%)
Education as a Proxy for SES, Highest Educational Level the Year Prior to Diagnosis						
Elementary school	–	7571 (47%)	–	4773 (44%)	–	8311 (47%)
High school/vocational school	–	2826 (18%)	–	3936 (36%)	–	3898 (22%)
Academic degree	–	877 (5.5%)	–	1107 (10%)	–	1567 (8.9%)
Missing[a]	–	4777 (30%)	–	976 (9.0%)	–	3926 (22%)
Comorbidities						
Circulatory system	1,349,501 (21%)	2197 (14%)	1,349,874 (21%)	1824 (17%)	1,348,930 (21%)	2768 (16%)
COPD	180,123 (2.8%)	285 (1.8%)	180,246 (2.8%)	162 (1.5%)	179,992 (2.8%)	416 (2.4%)
Diabetes	242,377 (3.7%)	245 (1.5%)	242,278 (3.7%)	344 (3.2%)	242,059 (3.7%)	563 (3.2%)
Substance use disorder	339,215 (5.2%)	1736 (11%)	339,419 (5.2%)	1532 (14%)	338,465 (5.2%)	2486 (14%)
Mood disorder	303,960 (4.7%)	4850 (30%)	304,816 (4.7%)	3994 (37%)	302,423 (4.6%)	6387 (36%)
Anxiety disorder	484,227 (7.4%)	6394 (40%)	486,058 (7.5%)	4563 (42%)	482,068 (7.4%)	8553 (48%)

Values are presented as *n* (%).

AN, anorexia nervosa; BN, bulimia nervosa; COPD, chronic obstructive pulmonary disease; EDNOS, eating disorder not otherwise specified; SES, socioeconomic status.

[a]Missing could be due to either having no education because of age or year not being present in the register.

delayed menarche, amenorrhea, or oligomenorrhea due to low body mass index (BMI) and hormonal dysregulation (19,20). The mechanism that underlies the established inverse relationship between age at menarche and the incidence of breast cancer may be a reduction in the total number of reproductive years that reduces lifetime exposure to estrogen (18,21). Calorie restriction in EDs may be a contributing factor. Previous studies have shown that energy restriction reduces spontaneous mammary tumor production in mice, potentially through reduced production of epidermal growth factor, IGF-1 (insulin-like growth factor 1), and estrogen (22–25). Increased circulating levels of IGF-1 are positively associated with breast cancer in premenopausal women, and individuals with AN may have lower circulating levels of IGF-1 (26,27). Additionally, individuals with AN and BN often engage in frequent driven exercise (28,29), which, although often an intractable feature of the illnesses, may paradoxically confer a degree of protection against breast cancer occurrence (30–32). A greater number of full-term pregnancies is associated with a reduced incidence of breast cancer (33); however, individuals with EDs have been found to have reduced parity (19,34). While parity was not analyzed in this study, it is a potential mediating factor in the

Table 6. HR for Cancer in Anorexia Nervosa and Other Eating Disorders (ICD-8 and ICD-10)

	Anorexia Nervosa				Other Eating Disorder			
Cancer	Unexposed With Cancer	Exposed With Cancer	HR (95% CI)[a]	HR (95% CI)[b]	Unexposed With Cancer	Exposed With Cancer	HR (95% CI)[a]	HR (95% CI)[b]
Breast	92,542	105	0.80 (0.66–0.97)	0.76 (0.63–0.92)	92,523	124	0.98 (0.83–1.17)	0.93 (0.78–1.11)
Esophageal	10,088	14	4.77 (2.82–8.06)	3.07 (1.81–5.20)	10,095	<10	–	–
Cervical[c]	13,560	39	1.45 (1.05–1.98)	1.24 (0.90–1.69)	13,552	47	1.60 (1.20–2.14)	1.34 (1.00–1.79)
Respiratory	78,230	62	1.59 (1.24–2.04)	0.98 (0.76–1.26)	78,240	52	1.57 (1.20–2.06)	0.91 (0.70–1.20)
Brain	14,540	16	1.38 (0.85–2.26)	1.14 (0.70–1.86)	14,540	16	1.32 (0.81–2.16)	1.02 (0.63–1.67)

HR, hazard ratio.

[a]Adjusted for birth year and sex.

[b]Adjusted for birth year, sex, and comorbidities. Comorbidities were treated as time-dependent covariates.

[c]Cervical cancer was analyzed in females only.

relationship between ED diagnosis and cancer incidence. However, given the stronger evidence for other protective factors, such as hormonal dysregulation and physical activity, parity alone is unlikely to fully explain our findings. The relationship between body size in various life stages and the incidence of breast cancer is a complex but important consideration. A higher body mass in adolescence may be associated with a lower incidence of premenopausal breast cancer, but weight gain and obesity in adulthood is associated with an increase in postmenopausal breast cancer (35–38). Additionally, females diagnosed with an ED at a later age may have a higher BMI than those diagnosed in adolescence, and individuals diagnosed with an ED in adolescence tended to avoid weight gain in adulthood (10). Although we were unable to control for BMI, most individuals in our study were diagnosed with an ED before age 30, and over half of the individuals with AN were diagnosed before age 20 (see Tables 4 and 5). Previous studies have found a greater reduction in breast cancer incidence in females diagnosed with AN at a younger age (8,10,39). Therefore, it is possible that earlier age of onset of an ED confers additional protective factors such as reduced estrogen exposure and delayed breast development that outweigh the positive relationship between low BMI in adolescence on premenopausal breast cancer incidence. Elevated breast cancer–related mortality was found in individuals with AN and OED. Previous studies have shown an association between AN or being underweight and elevated breast cancer mortality (40–42). Well-established prognostic factors in breast cancer that were not assessed in this study include tumor markers, tumor size, lymph node involvement, and age at diagnosis (43). Future studies are needed to examine these factors in individuals with breast cancer and an ED diagnosis to better understand observed differences in mortality.

We observed an elevated incidence of respiratory cancer in individuals with AN, OED, and EDNOS and a nonsignificant increase in the rate of respiratory cancer in individuals with BN. These findings are consistent with those of previous studies (6,8,9,44). Results were no longer significant after adjusting for comorbidities. We did not observe an increase in mortality for any group, although respiratory cancer mortality observations for BN were too low to analyze. Risk factors for respiratory cancer include tobacco use, exposure to environmental pollutants, and a history of obstructive lung disease, asthma, tuberculosis, or pneumonia (45,46). We were not able to determine rates of tobacco use in our cohort; however, tobacco use is a known risk factor for COPD and lung cancer (47). Individuals with EDs tend to display a high prevalence of tobacco use (48–51). In the absence of data on smoking status, we cannot determine whether the increase in the incidence of respiratory cancer is due to smoking. The association of AN and respiratory cancer may be explained by smoking, but the causal path may start with AN because smoking is used as a method to downregulate appetite to control food intake and weight (52). While individuals with BN have especially high rates of tobacco use (53), our results found no significantly elevated rate of respiratory cancer in individuals with a BN diagnosis. Given that our results were no longer significant after adjusting for comorbidities, including COPD—a risk factor for lung cancers (45–47)—and a history of COPD, and therefore tobacco use, may explain our findings. COPD and a history of pneumonia may be more prevalent in individuals with AN (54,55); however, in our study we observed a lower prevalence of COPD in individuals with EDs than in individuals without EDs. We no longer observed an elevated incidence of respiratory cancer in a sensitivity analysis, which suggests that the relationship was influenced by birth year and education level. Lower socioeconomic status is associated with higher rates of lung cancer, although this relationship may be explained by higher rates of smoking (56). Future studies that assess which respiratory cancer subtypes are present in our population could inform the risk factors involved. For example, adenocarcinoma is the most common lung cancer found in individuals who do not smoke while squamous cell carcinoma and small cell lung cancer are more commonly found in individuals who smoke (47,57). Female sex is a favorable prognostic factor in those diagnosed with lung cancer (58), which may explain why we did not observe an increase in mortality. Additionally, lung adenocarcinoma is the most frequently diagnosed subtype in females, which makes up a majority of our cohort, and has been found to have lower a mortality rate than other types of lung cancers (46,59). Assessment of risk factors is needed to further determine the underlying mechanisms.

An elevated incidence of esophageal cancer in individuals with AN in our study is consistent with previous findings (6,7,9,60). Due to the low prevalence of esophageal cancer counts, we were unable to analyze rates of esophageal cancer

Table 7. HR for Cancer in Anorexia Nervosa, Bulimia Nervosa, and Eating Disorder Not Otherwise Specified (ICD-10 Only)

	Anorexia Nervosa				Bulimia Nervosa				Eating Disorder Not Otherwise Specified			
Cancer	Unexposed With Cancer	Exposed With Cancer	HR (95% CI)[a]	HR (95% CI)[b]	Unexposed With Cancer	Exposed With Cancer	HR (95% CI)[a]	HR (95% CI)[b]	Unexposed With Cancer	Exposed With Cancer	HR (95% CI)[a]	HR (95% CI)[b]
Breast	83,739	41	0.63 (0.46–0.85)	0.59 (0.44–0.81)	83,721	59	0.86 (0.66–1.11)	0.82 (0.63–1.06)	83,725	55	0.80 (0.62–1.05)	0.75 (0.58–0.98)
Cervical[c]	9519	27	1.92 (1.31–2.80)	1.62 (1.11–2.38)	9526	20	1.48 (0.95–2.29)	1.25 (0.81–1.95)	9518	28	2.09 (1.44–3.03)	1.68 (1.16–2.44)
Respiratory	75,083	25	1.65 (1.11–2.44)	0.96 (0.65–1.43)	75,096	12	0.79 (0.45–1.40)	0.60 (0.34–1.05)	75,078	30	1.59 (1.11–2.28)	0.88 (0.62–1.27)
Brain	12,688	11	1.75 (0.97–3.16)	1.43 (0.79–2.59)	12,691	<10	–	–	12,690	<10	–	–

HR, hazard ratio.

[a]Adjusted for birth year and sex.

[b]Adjusted for birth year, sex, and comorbidities. Comorbidities are treated as time-dependent covariates.

[c]Cervical cancer was analyzed in females only.

in other ED groups. We did not distinguish between histological subtypes of esophageal cancers (adenocarcinoma and squamous cell carcinoma). The subtype of esophageal cancer informs which risk factors may be the contributing cause. Squamous cell carcinoma is associated with tobacco and alcohol use, and adenocarcinoma is associated with gastroesophageal reflux disease (GERD) and to some degree tobacco use (61). Self-induced vomiting and purging may lead to inflammation, erosion, and metaplasia of the esophagus, which can be a risk factor for esophageal cancer (11,62). Multiple case studies have shown the development of Barrett's esophagus, a precursor to esophageal cancer, in individuals with AN and BN following years of frequent purging (63–65). Chronic exposure to acid leads to production of inflammatory factors and altered gene expression that create an environment favorable for cancer cell formation (66). Individuals with EDs may have a significantly higher prevalence of GERD (7,67), which can lead to the development of Barrett's esophagus and subsequently esophageal adenocarcinoma (68). An important factor in progression to esophageal carcinoma in individuals with frequent reflux is bile acid content (69); however, no studies have examined bile acid content in individuals with EDs. Two case studies reported the development of esophageal adenocarcinoma in individuals with BN (70,71). In contrast, a previous cohort study of individuals with AN identified cases of esophageal cancer as being the squamous cell subtype (60); therefore, the incidence of esophageal cancer may be due to other risk factors such as alcohol and tobacco use (72). Two case studies found that repeated vomiting was potentially involved in the development of squamous cell carcinoma of the esophagus in individuals with self-induced vomiting (73,74), although further exploration into this association is needed. It remains unclear whether self-induced vomiting and reflux or tobacco and alcohol use are causes of the elevated incidence of esophageal cancer in individuals with AN. A larger sample size is needed to determine whether an elevated rate of esophageal cancer also exists in other ED subtypes.

In contrast with previous work that demonstrated a reduced incidence of cervical cancer in individuals with AN (5,75), we found an elevated incidence of cervical cancer in individuals with AN, OED, and EDNOS but no difference in BN. After adjusting for comorbidities, our results remained significant in the ICD-10–only analysis in individuals with AN and EDNOS. In the sensitivity analysis, we did not find a similar result. This may mean that the relationship between EDs and cervical cancer rates is mediated by birth year and education level. We were unable to assess cervical cancer–related mortality due to low numbers. Risk factors for cervical cancer include increased sexual activity, a greater number of full-term pregnancies, and cigarette use (76,77). There may be an increase in engagement in risky sexual behaviors and number of new sexual partners in individuals with EDs (78,79). Having more than 4 full-term pregnancies is associated with an increased risk of human papillomavirus (HPV) and subsequent development of cervical cancer (76); however, individuals with EDs may have reduced parity (19,34). Cigarette smoking is associated with elevated risk of squamous cell cervical cancer (77); therefore, tobacco use may be a contributing factor in our cohort. Improvements in screening and HPV vaccination have led to decreased rates

Table 8. Cancer Mortality Rates in Anorexia Nervosa and Other Eating Disorders (ICD-8 and ICD-10)

	Anorexia Nervosa			Other Eating Disorder		
Cancer	Exposed With Cancer	Deaths	HR (95% CI)[a]	Exposed With Cancer	Deaths	HR (95% CI)[a]
Breast	105	31	1.96 (1.38–2.79)	124	25	1.71 (1.16–2.53)
Respiratory	62	43	1.16 (0.86–1.56)	52	35	1.11 (0.79–1.54)
Brain	16	11	1.32 (0.73–2.40)	16	<10	–

HR, hazard ratio.
[a]Adjusted for birth year and sex.

of cervical cancer worldwide (80). We do not have data on engagement in cervical cancer prevention in individuals with EDs; however, given that individuals with EDs may engage in more risky sexual behavior (78,79), there may be less engagement with preventive care. A larger sample size to allow for additional sensitivity analysis is needed to determine whether an elevated incidence of cervical cancer really exists in individuals with AN, OED, and EDNOS.

Our study found no significant increase in the prevalence of brain cancer in individuals with AN and OEDs. In the ICD-10–only analysis, brain cancer counts were too low to analyze in the BN and EDNOS groups. Only one previous study found an elevated incidence of brain cancer in men with EDs (6). Brain cancer is most common in older adults (81), and our study only follows individuals through December 31, 2021, thereby limiting identification of later-life cancer incidence. Brain cancer is also more common in males (81), and our study is comprised mostly of females. Genetic factors also seem to be stronger predictors of brain cancer occurrence than lifestyle factors (82,83). Nevertheless, the low occurrence of brain cancer is a limitation of our findings.

Strengths and Limitations

Our study has the advantage of including over 30,000 individuals with EDs with information on cancer diagnosis spanning 4 decades. Additionally, the large sample size afforded analysis of cancer incidence among multiple ED diagnoses. The comprehensive data in the National Registries are representative of the Danish population given universal free and accessible health care. This and the standardization of register data minimize detection bias and other potential biases that can distort associations.

Several limitations of the current study merit consideration. First, we could not account for the smoking status of individuals in the registry, which is unfortunate given that several of the observed associations may be related to smoking behavior. Tobacco use is a known risk factor for respiratory, esophageal, and cervical cancers (61,77,84,85), and because nicotine reduces appetite and decreases food consumption, smoking is sometimes used to control weight and appetite in individuals with EDs (86,87). We also could not adjust for other lifestyle factors including physical activity level and BMI. Extensions of this work using different data sources should incorporate important lifestyle factors that may contribute to cancer incidence in individuals with EDs. Second, although we followed individuals from age 6 until cancer occurrence, death, emigration, or the end of follow-up (December 31, 2021), a longer follow-up period to capture later-life cancer outcomes would be ideal. We were underpowered to examine other cancers including stomach and liver cancer. After separating BN from EDNOS and focusing only on ICD-10 diagnoses, counts were too low to examine esophageal cancer across ED groups. More population-level research is needed to ensure an adequately powered sample size to study how certain EDs could influence liver, esophageal, and stomach cancer incidence. We also recognize that the shift from ICD-8 to ICD-10 might have introduced some variability in the diagnosis of EDs by health care providers. Lastly, we were unable to conduct sensitivity analysis in individuals with only one ED diagnosis due to the limited number of cancer cases.

Conclusions

This study contributes to what is known regarding cancer occurrence of multiple organ systems across AN, OEDs, BN, and EDNOS. While our findings support previous evidence of a reduced incidence of breast cancer in individuals with AN, we also observed a similar trend in individuals with BN, although power limitations warrant cautious interpretation of these findings. A significantly elevated incidence of esophageal cancer was found in individuals with AN, although estimates for these cancers in individuals with BN were limited by low power. A significantly elevated incidence of respiratory cancer was observed in individuals with AN, OEDs, and EDNOS, and these findings may be explained by comorbidities and lifestyle factors. Finally, a modest but significant elevated incidence of cervical cancer was found in individuals with AN, OED, and

Table 9. Cancer Mortality Rates in Anorexia Nervosa, Bulimia Nervosa, and Eating Disorder Not Otherwise Specified (ICD-10 Only)

	Anorexia Nervosa			Bulimia Nervosa			Eating Disorder Not Otherwise Specified		
Cancer	Exposed With Cancer	Deaths	HR (95% CI)[a]	Exposed With Cancer	Deaths	HR (95% CI)[a]	Exposed With Cancer	Deaths	HR (95% CI)[a]
Breast	41	<10	–	59	<10	–	55	13	1.70 (0.99–2.93)
Respiratory	25	17	1.44 (0.89–2.31)	12	<10	–	30	20	1.03 (0.66–1.60)

HR, hazard ratio.
[a]Adjusted for birth year and sex.

EDNOS. These results illustrate long-term morbidities associated with EDs. Further research is needed to elucidate the mechanisms, possibly related to hormone exposure and caloric deficiency, that contribute to the reduction in incidence of breast cancer. Consideration should be given to reducing esophageal and respiratory cancer incidence. Providers who encounter patients with esophageal cancer in the absence of other common risk factors may benefit from inquiring about past and current EDs. Individuals who treat EDs, especially with long duration of illness and exposure to damaging behaviors such as vomiting and binge eating, should remain vigilant for emerging cancer symptoms and provide psychoeducation to patients about elevated cancer incidence to bolster motivation for treatment and recovery.

ACKNOWLEDGMENTS AND DISCLOSURES

LVP was supported for this work by the Novo Nordisk Foundation (Grant No. NNF20OC0064993). CMB is supported by the National Institute of Mental Health (NIMH) (Grant Nos. R56MH129437, R01MH120170, R01MH124871, R01MH119084, R01MH118278, and R01MH124871); Swedish Research Council (Award No. 538-2013-8864); and Lundbeck Foundation (Grant No. R276-2018-4581). ZY acknowledges grant support from NIMH (Grant No. R01MH136156), the Independent Research Fund Denmark (Grant Nos. 1052-00029B and 3166-00063B), and the Lundbeck Foundation (Grant No. R434-2023-269).

CMB receives royalties from Pearson Education Inc. All other authors report no biomedical financial interests or potential conflicts of interest.

ARTICLE INFORMATION

From the Department of Psychiatry, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (GEC, NMP, CMB, ZY); School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (GEC); Department of Health Sciences, Northern Arizona University, Flagstaff, Arizona (NMP); National Centre for Register-Based Research, Aarhus University, Aarhus, Denmark (KH, ZY, LVP); Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden (CMB, ZY); Department of Nutrition, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (CMB); and Department of Biomedicine, Aarhus University, Aarhus, Denmark (ZY).

Address correspondence to Liselotte V. Petersen, Ph.D., at llp.ncrr@au.dk.

Received Sep 10, 2024; revised Jan 20, 2025; accepted Mar 1, 2025.

Supplementary material cited in this article is available online at https://doi.org/10.1016/j.bpsgos.2025.100483.

REFERENCES

1. Zipfel S, Giel KE, Bulik CM, Hay P, Schmidt U (2015): Anorexia nervosa: Aetiology, assessment, and treatment. Lancet Psychiatry 2:1099–1111.
2. American Psychiatric Association (2013): Diagnostic and Statistical Manual of Mental Disorders, 5th ed. Arlington, VA: American Psychiatric Publishing.
3. Crow SJ, Peterson CB, Swanson SA, Raymond NC, Specker S, Eckert ED, Mitchell JE (2009): Increased mortality in bulimia nervosa and other eating disorders. Am J Psychiatry 166:1342–1346.
4. Kärkkäinen U, Mustelin L, Raevuori A, Kaprio J, Keski-Rahkonen A (2018): Do disordered eating behaviours have long-term health-related consequences? Eur Eat Disord Rev 26:22–28.
5. Mehler PS, Brown C (2015): Anorexia nervosa – Medical complications. J Eat Disord 3:11.
6. Mellemkjaer L, Papadopoulos FC, Pukkala E, Ekbom A, Gissler M, Christensen J, Olsen JH (2015): Cancer incidence among patients with anorexia nervosa from Sweden, Denmark and Finland. PLoS One 10: e0128018.
7. Yeh HW, Chien WC, Chung CH, Chang HA, Kao YC, Tzeng NS (2021): Eating disorders and the risk of esophageal and stomach cancers-A nationwide, population-based cohort study in Taiwan. Int J Eat Disord 54:959–968.
8. Michels N, De Backer F, Dimakopoulou M, Mane K, Indave I, Huybrechts I (2021): Eating disorders and the risk of developing cancer: A systematic review. Eat Weight Disord 26:1021–1035.
9. Catalá-López F, Forés-Martos J, Driver JA, Page MJ, Hutton B, Ridao M, *et al.* (2019): Association of anorexia nervosa with risk of cancer: A Systematic Review and Meta-analysis. JAMA Netw Open 2:e195313.
10. O'Brien KM, Whelan DR, Sandler DP, Weinberg CR (2017): Eating disorders and breast cancer. Cancer Epidemiol Biomarkers Prev 26:206–211.
11. Anderson L, Shaw JM, McCargar L (1997): Physiological effects of bulimia nervosa on the gastrointestinal tract. Can J Gastroenterol 11:451–459.
12. Citronberg JS, Hardikar S, Phipps A, Figueiredo JC, Newcomb P (2018): Laxative type in relation to colorectal cancer risk. Ann Epidemiol 28:739–741.
13. Pedersen CB (2011): The Danish civil registration system. Scand J Public Health 39(suppl 7):22–25.
14. Helweg-Larsen K (2011): The Danish register of causes of death. Scand J Public Health 39(suppl 7):26–29.
15. Lynge E, Sandegaard JL, Rebolj M (2011): The Danish national patient register. Scand J Public Health 39(suppl 7):30–33.
16. Mors O, Perto GP, Mortensen PB (2011): The Danish psychiatric central research register. Scand J Public Health 39(suppl 7):54–57.
17. Seminog O, Thakrar DB, James AC, Goldacre MJ (2023): Low risk of some common cancers in women with anorexia nervosa: Evidence from a national record-linkage study. Acta Psychiatr Scand 148:71–80.
18. Falkenberry SS, Legare RD (2002): Risk factors for breast cancer. Obstet Gynecol Clin North Am 29:159–172.
19. Michels KB, Ekbom A (2004): Caloric restriction and incidence of breast cancer. JAMA 291:1226–1230.
20. Misra M, Klibanski A (2014): Endocrine consequences of anorexia nervosa. Lancet Diabetes Endocrinol 2:581–592.
21. Collaborative Group on Hormonal Factors in Breast Cancer (2012): Menarche, menopause, and breast cancer risk: Individual participant meta-analysis, including 118 964 women with breast cancer from 117 epidemiological studies. Lancet Oncol 13:1141–1151.
22. Dirx MJM, Zeegers MPA, Dagnelie PC, van den Bogaard T, van den Brandt PA (2003): Energy restriction and the risk of spontaneous mammary tumors in mice: A meta-analysis. Int J Cancer 106: 766–770.
23. Engelman RW, Owens UE, Bradley WG, Day NK, Good RA (1995): Mammary and submandibular gland epidermal growth factor expression is reduced by calorie Restriction1. Cancer Res 55:1289–1295.
24. Ruggeri BA, Klurfeld DM, Kritchevsky D, Furlanetto RW (1989): Caloric restriction and 7,12-dimethylbenz(a)anthracene-induced mammary tumor growth in rats: Alterations in circulating insulin, insulin-like growth factors I and II, and epidermal growth factor. Cancer Res 49:4130–4134.
25. Spady TJ, Harvell DME, Lemus-Wilson A, Strecker TE, Pennington KL, Vander Woude EA, *et al.* (1999): Modulation of estrogen action in the rat pituitary and mammary glands by dietary energy consumption. J Nutr 129:587S–590S.
26. Hankinson SE, Willett WC, Colditz GA, Hunter DJ, Michaud DS, Deroo B, *et al.* (1998): Circulating concentrations of insulin-like growth factor-I and risk of breast cancer. Lancet 351:1393–1396.
27. Støving RK, Chen J-W, Glintborg D, Brixen K, Flyvbjerg A, Hørder K, Frystyk J (2007): Bioactive insulin-like growth factor (IGF) I and IGF-binding Protein-1 in anorexia nervosa. J Clin Endocrinol Metab 92:2323–2329.
28. Dalle Grave R, Calugi S, Marchesini G (2008): Compulsive exercise to control shape or weight in eating disorders: Prevalence, associated features, and treatment outcome. Compr Psychiatry 49:346–352.
29. Rizk M, Mattar L, Kern L, Berthoz S, Duclos J, Viltart O, Godart N (2020): Physical activity in eating disorders: A systematic review. Nutrients 12:183.

30. Fuemmeler BF, Pendzich MK, Tercyak KP (2009): Weight, dietary behavior, and physical activity in childhood and adolescence: Implications for adult cancer risk. Obes Facts 2:179–186.
31. Luoto R, Latikka P, Pukkala E, Hakulinen T, Vihko V (2000): The effect of physical activity on breast cancer risk: A cohort study of 30,548 women. Eur J Epidemiol 16:973–980.
32. Slattery ML, Edwards S, Murtaugh MA, Sweeney C, Herrick J, Byers T, *et al.* (2007): Physical activity and breast cancer risk among women in the southwestern United States. Ann Epidemiol 17:342–353.
33. Wohlfahrt J, Melbye M (2001): Age at any birth is associated with breast cancer risk. Epidemiology 12:68–73.
34. Linna MS, Raevuori A, Haukka J, Suvisaari JM, Suokas JT, Gissler M (2013): Reproductive health outcomes in eating disorders. Int J Eat Disord 46:826–833.
35. Coates RJ, Uhler RJ, Hall HI, Potischman N, Brinton LA, Ballard-Barbash R, *et al.* (1999): Risk of breast cancer in young women in relation to body size and weight gain in adolescence and early adulthood. Br J Cancer 81:167–174.
36. Friedenreich CM (2001): Review of anthropometric factors and breast cancer risk. Eur J Cancer Prev 10:15–32.
37. Magnusson C, Baron J, Persson I, Wolk A, Bergström R, Trichopoulos D, Adami HO (1998): Body size in different periods of life and breast cancer risk in post-menopausal women. Int J Cancer 76:29–34.
38. Le Marchand LL, Kolonel LN, Earle ME, Mi MP (1988): Body size at different periods of life and breast cancer risk. Am J Epidemiol 128:137–152.
39. Papadopoulos FC, Karamanis G, Brandt L, Ekbom A, Ekselius L (2013): Childbearing and mortality among women with anorexia nervosa. Int J Eat Disord 46:164–170.
40. Bens A, Papadopoulos FC, Pukkala E, Ekbom A, Gissler M, Mellemkjær L (2018): Worse survival after breast cancer in women with anorexia nervosa. Breast Cancer Res Treat 168:495–500.
41. Flegal KM, Graubard BI, Williamson DF, Gail MH (2005): Excess deaths associated with underweight, overweight, and obesity. JAMA 293:1861–1867.
42. Moon HG, Han W, Noh DY (2009): Underweight and breast cancer recurrence and death: A report from the Korean Breast Cancer Society. J Clin Oncol 27:5899–5905.
43. Soerjomataram I, Louwman MWJ, Ribot JG, Roukema JA, Coebergh JWW (2008): An overview of prognostic factors for long-term survivors of breast cancer. Breast Cancer Res Treat 107:309–330.
44. Karamanis G, Skalkidou A, Tsakonas G, Brandt L, Ekbom A, Ekselius L, Papadopoulos FC (2014): Cancer incidence and mortality patterns in women with anorexia nervosa. Int J Cancer 134:1751–1757.
45. Cohen AJ, Brauer M, Burnett R, Anderson HR, Frostad J, Estep K, *et al.* (2017): Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the Global Burden of Diseases Study 2015. Lancet 389:1907–1918.
46. Schabath MB, Cote ML (2019): Cancer progress and priorities: Lung cancer. Cancer Epidemiol Biomarkers Prev 28:1563–1579.
47. Huang R, Wei Y, Hung RJ, Liu G, Su L, Zhang R, *et al.* (2015): Associated links among smoking, chronic obstructive pulmonary disease, and small cell lung cancer: A pooled analysis in the international lung cancer consortium. EBiomedicine 2:1677–1685.
48. Castro-Fornieles J, Díaz R, Goti J, Calvo R, Gonzalez L, Serrano L, Gual A (2010): Prevalence and factors related to substance use among adolescents with eating disorders. Eur Addict Res 16:61–68.
49. Devoe DJ, Dimitropoulos G, Anderson A, Bahji A, Flanagan J, Soumbasis A, *et al.* (2021): The prevalence of substance use disorders and substance use in anorexia nervosa: A systematic review and meta-analysis. J Eat Disord 9:161.
50. Krug I, Treasure J, Anderluh M, Bellodi L, Cellini E, di Bernardo M, *et al.* (2008): Present and lifetime comorbidity of tobacco, alcohol and drug use in eating disorders: A European multicenter study. Drug Alcohol Depend 97:169–179.
51. Mann AP, Accurso EC, Stiles-Shields C, Capra L, Labuschagne Z, Karnik NS, Le Grange D (2014): Factors associated with substance use in adolescents with eating disorders. J Adolesc Health 55:182–187.
52. Audrain-McGovern J, Benowitz NL (2011): Cigarette smoking, nicotine, and body weight. Clin Pharmacol Ther 90:164–168.
53. Solmi M, Veronese N, Sergi G, Luchini C, Favaro A, Santonastaso P, *et al.* (2016): The association between smoking prevalence and eating disorders: A systematic review and meta-analysis. Addiction 111:1914–1922.
54. Cook VJ, Coxson HO, Mason AG, Bai TR (2001): Bullae, bronchiectasis and nutritional emphysema in severe anorexia nervosa. Can Respir J 8:361–365.
55. Coxson HO, Chan IHT, Mayo JR, Hlynsky J, Nakano Y, Birmingham CL (2004): Early emphysema in patients with anorexia nervosa. Am J Respir Crit Care Med 170:748–752.
56. Hovanec J, Siemiatycki J, Conway DI, Olsson A, Stücker I, Guida F, *et al.* (2018): Lung cancer and socioeconomic status in a pooled analysis of case-control studies. PLoS One 13:e0192999.
57. Wang SY, Hu YL, Wu YL, Li X, Chi GB, Chen Y, Dai WS (1996): A comparative study of the risk factors for lung cancer in Guangdong, China. Lung Cancer 14(suppl 1):S99–S105.
58. Li J, Dai C-H, Chen P, Wu J-N, Bao Q-L, Qiu H, Li X-Q (2010): Survival and prognostic factors in small cell lung cancer. Med Oncol 27: 73–81.
59. Fukui T, Taniguchi T, Kawaguchi K, Fukumoto K, Nakamura S, Sakao Y, Yokoi K (2015): Comparisons of the clinicopathological features and survival outcomes between lung cancer patients with adenocarcinoma and squamous cell carcinoma. Gen Thorac Cardiovasc Surg 63:507–513.
60. Brewster DH, Nowell SL, Clark DN (2015): Risk of oesophageal cancer among patients previously hospitalised with eating disorder. Cancer Epidemiol 39:313–320.
61. Wheeler JB, Reed CE (2012): Epidemiology of esophageal cancer. Surg Clin North Am 92:1077–1087.
62. Matsha T, Stepien A, Blanco-Blanco E, Brink LT, Lombard CJ, Van Rensburg S, Erasmus RT (2006): Self-induced vomiting — Risk for oesophageal cancer? S Afr Med J 96:209–212.
63. Gouda A, El-Kassas M (2022): Barrett's esophagus in a patient with bulimia nervosa: A case report. World J Clin Cases 10:5841–5845.
64. Lorenze A, John C, Riedel BD, Nield LS (2020): Persistent vomiting and weight loss leading to the diagnosis of Barrett's esophagus in an adolescent. Cureus 12:e7151.
65. Pacciardi B, Cargioli C, Mauri M (2015): Barrett's esophagus in anorexia nervosa: A case report. Int J Eat Disord 48:147–150.
66. Abdel-Latif MMM, Duggan S, Reynolds JV, Kelleher D (2009): Inflammation and esophageal carcinogenesis. Curr Opin Pharmacol 9: 396–404.
67. Peat CM, Huang L, Thornton LM, Von Holle AF, Trace SE, Lichtenstein P, *et al.* (2013): Binge eating, body mass index, and gastrointestinal symptoms. J Psychosom Res 75:456–461.
68. Lagergren J, Bergström R, Lindgren A, Nyrén O (1999): Symptomatic gastroesophageal reflux as a risk factor for esophageal adenocarcinoma. N Engl J Med 340:825–831.
69. Kauer WK, Peters JH, DeMeester TR, Ireland AP, Bremner CG, Hagen JA (1995): Mixed reflux of gastric and duodenal juices is more harmful to the esophagus than gastric juice alone. The need for surgical therapy re-emphasized. Ann Surg 222:525–531.
70. Navab F, Avunduk C, Gang D, Frankel K (1996): Bulimia nervosa complicated by Barrett's esophagus and esophageal cancer. Gastrointest Endosc 44:492–494.
71. Shinohara ET, Swisher-McClure S, Husson M, Sun W, Metz JM (2007): Esophageal cancer in a young woman with bulimia nervosa: A case report. J Med Case Rep 1:160.
72. Nesheli DN (2013): Risk Factors for Esophageal Squamous Cell Carcinoma [dissertation]. Ann Arbor: Karolinska Institutet.
73. Buyse S, Nahon S, Tuszynski T, Delas N (2003): Bulimia nervosa as a risk factor for squamous cell carcinoma of the esophagus? Am J Gastroenterol 98:1442–1443.
74. Dessureault S, Coppola D, Weitzner M, Powers P, Karl RC (2002): Barrett's esophagus and squamous cell carcinoma in a patient with psychogenic vomiting. Int J Gastrointest Cancer 32:57–61.

75. Mellemkjaer L, Emborg C, Gridley G, Munk-Jørgensen P, Johansen C, Tjønneland A, *et al.* (2001): Anorexia nervosa and cancer risk. Cancer Causes Control 12:173–177.
76. Bosch FX, de Sanjosé S (2007): The epidemiology of human papillomavirus infection and cervical cancer. Dis Markers 23:213–227.
77. Malevolti MC, Lugo A, Scala M, Gallus S, Gorini G, Lachi A, Carreras G (2023): Dose-risk relationships between cigarette smoking and cervical cancer: A systematic review and meta-analysis. Eur J Cancer Prev 32:171–183.
78. Castellini G, Lelli L, Cassioli E, Ricca V (2019): Relationships between eating disorder psychopathology, sexual hormones and sexual behaviours. Mol Cell Endocrinol 497:110429.
79. Fergus KB, Copp HL, Tabler JL, Nagata JM (2019): Eating disorders and disordered eating behaviors among women: Associations with sexual risk. Int J Eat Disord 52:1310–1315.
80. Baldur-Felskov B, Munk C, Nielsen TSS, Dehlendorff C, Kirschner B, Junge J, Kjaer SK (2015): Trends in the incidence of cervical cancer and severe precancerous lesions in Denmark, 1997–2012. Cancer Causes Control 26:1105–1116.
81. Ostrom QT, Bauchet L, Davis FG, Deltour I, Fisher JL, Langer CE, *et al.* (2014): The epidemiology of glioma in adults: A "state of the science" review. Neuro Oncol 16:896–913.
82. Farmanfarma KK, Mohammadian M, Shahabinia Z, Hassanipour S, Salehiniya H (2019): Brain cancer in the world: An epidemiological review. World Cancer Res J 6:1–5.
83. Ostrom QT, Adel Fahmideh M, Cote DJ, Muskens IS, Schraw JM, Scheurer ME, Bondy ML (2019): Risk factors for childhood and adult primary brain tumors. Neuro Oncol 21:1357–1375.
84. Alberg AJ, Samet JM (2003): Epidemiology of lung cancer. Chest 123(suppl 1):21S–49S.
85. Praud D, Rota M, Pelucchi C, Bertuccio P, Rosso T, Galeone C, *et al.* (2018): Cigarette smoking and gastric cancer in the Stomach Cancer Pooling (StoP) Project. Eur J Cancer Prev 27:124–133.
86. Jo YH, Talmage DA, Role LW (2002): Nicotinic receptor-mediated effects on appetite and food intake. J Neurobiol 53:618–632.
87. Mineur YS, Abizaid A, Rao Y, Salas R, Dileone RJ, Gündisch D, *et al.* (2011): Nicotine decreases food intake through activation of POMC neurons. Science 332:1330–1332.