

Association Between Atopic Eczema and Cancer in England and Denmark

Kathryn E. Mansfield, PhD; Sigrún A. J. Schmidt, PhD; Bianka Darvalics, MSc; Amy Mulick, MSc; Katrina Abuabara, MD; Angel Y. S. Wong, PhD; Henrik Toft Sørensen, PhD; Liam Smeeth, PhD; Krishnan Bhaskaran, PhD; Isabel dos Santos Silva, PhD; Richard J. Silverwood, PhD; Sinéad M. Langan, PhD

[+ Supplemental content](#)

IMPORTANCE Associations between atopic eczema and cancer are unclear, with competing theories that increased immune surveillance decreases cancer risk and that immune stimulation increases cancer risk. Establishing baseline cancer risk in people with atopic eczema is important before exploring the association between new biologic drugs for atopic eczema and cancer risk.

OBJECTIVE To investigate whether atopic eczema is associated with cancer.

DESIGN, SETTING, AND PARTICIPANTS Matched cohort studies were conducted from January 2, 1998, to March 31, 2016, in England and from January 1, 1982, to June 30, 2016, in Denmark. We conducted our analyses between July 2018 and July 2019. The setting was English primary care and nationwide Danish data. Participants with atopic eczema (adults only in England and any age in Denmark) were matched on age, sex, and calendar period (as well as primary care practice in England only) to those without atopic eczema.

EXPOSURE Atopic eczema.

MAIN OUTCOMES AND MEASURES Overall cancer risk and risk of specific cancers were compared in people with and without atopic eczema.

RESULTS In England, matched cohorts included 471 970 individuals with atopic eczema (median [IQR] age, 41.1 [24.9-60.7] years; 276 510 [58.6%] female) and 2 239 775 individuals without atopic eczema (median [IQR] age, 39.8 [25.9-58.4] years; 1 301 074 [58.1%] female). In Denmark, matched cohorts included 44 945 individuals with atopic eczema (median [IQR] age, 13.7 [1.7-21.1] years; 22 826 [50.8%] female) and 445 673 individuals without atopic eczema (median [IQR] age, 13.5 [1.7-20.8] years; 226 323 [50.8%] female). Little evidence was found of associations between atopic eczema and overall cancer (adjusted hazard ratio [HR], 1.04; 99% CI, 1.02-1.06 in England and 1.05; 99% CI, 0.95-1.16 in Denmark) or for most specific cancers. However, noncutaneous lymphoma risk was increased in people with atopic eczema in England (adjusted HR, 1.19; 99% CI, 1.07-1.34 for non-Hodgkin lymphoma [NHL] and 1.48; 99% CI, 1.07-2.04 for Hodgkin lymphoma). Lymphoma risk was increased in people with greater eczema severity vs those without atopic eczema (NHL adjusted HR, 1.06; 99% CI, 0.90-1.25 for mild eczema; 1.24; 99% CI, 1.04-1.48 for moderate eczema; and 2.08; 99% CI, 1.42-3.04 for severe eczema). Danish point estimates also showed increased lymphoma risk in people with moderate to severe eczema compared with those without atopic eczema (minimally adjusted HR, 1.31; 99% CI, 0.76-2.26 for NHL and 1.35; 99% CI, 0.65-2.82 for Hodgkin lymphoma), but the 99% CIs were wide.

CONCLUSIONS AND RELEVANCE The findings from 2 large population-based studies performed in different settings do not support associations between atopic eczema and most cancers. However, an association was observed between atopic eczema and lymphoma, particularly NHL, that increased with eczema severity. This finding warrants further study as new immunomodulatory systemic therapeutics are brought to market that may alter cancer risk.

JAMA Dermatol. doi:10.1001/jamadermatol.2020.1948
Published online June 24, 2020.

Author Affiliations: Author affiliations are listed at the end of this article.

Corresponding Author: Kathryn E. Mansfield, PhD, Department of Non-communicable Disease Epidemiology, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, United Kingdom (kathryn.mansfield@lshtm.ac.uk).

Atopic eczema is the most common inflammatory skin disease, affecting 2% to 10% of adults¹⁻³ and up to 20% of children.⁴ Eczema may be associated with cancer for many reasons, including immune dysregulation related to eczema, unhealthy lifestyle choices (eg, smoking and alcohol consumption as coping mechanisms for persistent itch), stress, low self-esteem, and sleep deprivation.^{5,6} Although most eczema is managed with topical treatment, systemic treatments (eg, glucocorticoids, azathioprine, and cyclosporine) for severe disease could also affect cancer risk.⁷

Cancer is 1 of the leading causes of death globally.⁸ Skin disease is the most common reason for a new primary care practice consultation in England,^{9,10} and eczema accounts for a substantial proportion of that burden.⁹ Hence, any association between atopic eczema and cancer is potentially relevant to public health. Furthermore, as new therapeutics (that may alter cancer risk) are introduced, it is important to establish baseline cancer risk in people with atopic eczema.¹¹

A recent systematic review and meta-analysis¹² highlighted that existing evidence of cancer risk in atopic eczema is conflicting, with studies limited by lack of consideration of eczema severity and treatment and by the inability to adjust for key confounders. Studies have reported reductions in specific brain cancers and increased lymphoma risk in people with eczema.^{5,6,13-19} Two competing theories may explain the complex association between atopic eczema and cancer, namely, that increased immune surveillance decreases cancer risk and that immune stimulation increases cancer risk. Immunosuppressive therapy (including topical calcineurin inhibitors) and an impaired skin barrier may also increase risk, particularly of skin cancer, but recent findings are inconclusive.²⁰ Experimental mouse models support reduced skin cancer in individuals with atopic eczema,²¹ but population-based studies are conflicting.^{6,22-25}

We used health care data from matched cohort studies conducted in England and Denmark to address uncertainties identified by the recent systematic review and meta-analysis.¹² We explored cancer risk in persons with atopic eczema compared with those without atopic eczema, including variation in risk with eczema severity and activity.

Methods

This investigation was composed of 2 matched cohort studies conducted from January 2, 1998, to March 31, 2016, in England and from January 1, 1982, to June 30, 2016, in Denmark. We conducted our analyses between July 2018 and July 2019. Participants with atopic eczema (adults only in England and any age in Denmark) were matched on age, sex, and calendar period (as well as primary care practice in England only) to people without atopic eczema. We compared overall cancer risk and risk of specific cancers in those with and without atopic eczema. The English study was approved by the London School of Hygiene and Tropical Medicine Research Ethics Committee and by the United Kingdom Clinical Practice Research Datalink (CPRD) Independent Scientific Advisory Committee (protocol 17_108). The English trial

Key Points

Question Is atopic eczema associated with increased cancer risk?

Findings In 2 large cohort studies conducted in England (471 970 and 2 239 775 individuals with and without atopic eczema, respectively) and Denmark (44 945 and 445 673 individuals with and without atopic eczema, respectively), no evidence was found of an increased risk of most cancers among people with atopic eczema compared with those without eczema. However, atopic eczema was associated with an increased risk of lymphoma, particularly non-Hodgkin lymphoma, with risk increasing with greater eczema severity.

Meaning The findings in this study did not support an association between atopic eczema and most cancers; however, there was evidence of higher lymphoma risk with increasing eczema severity.

protocol is available at [Supplement 1](#). The Danish study was approved by the Danish Data Protection Agency (record 2015-57-0002; AU-2016-051-000001; 632). The Danish trial protocol is available at [Supplement 2](#). These are deidentified data and do not require explicit consent; individual consent for use of electronic health record data for research is implied. In England, individuals are offered the right to opt out of the use of their anonymized data. Danish legislation does not require approval by an ethical review board or informed consent from participants in registry-based studies.

Two matched cohorts of people with and without atopic eczema in England and Denmark were identified ([Table 1](#) and [Figure 1](#)). We did not include children in the English study (unlike the Danish study, in which we did not restrict age) because of limited power to study childhood cancers. Childhood cancer is rare, and the median follow-up in the CPRD is only 5 years.²⁶

Data Sources

In England, electronic health records of adults attending primary care practices contributing to the CPRD GOLD were used along with linked hospital admissions (Hospital Episode Statistics [HES]) and death registration (Office for National Statistics [ONS]) data. The CPRD includes data from participating primary care practices covering 7% of the UK population.²⁶⁻²⁸ The HES covers all admissions for National Health Service-funded patients treated in England.²⁹ Most English primary care practices contributing to the CPRD (75%) are linked to the HES.²⁶ The ONS mortality data include cause of death for all deaths in the UK.

In Denmark, linked nationwide data from the Danish National Patient Registry (hospital admissions, outpatient clinic appointments, and emergency department contacts),^{30,31} the Danish Cancer Registry (incident cancers),³² the Civil Registration System (demographics),³³ the Danish National Prescription Registry (prescriptions filled at community pharmacies),³⁴ and socioeconomic data were used. The socioeconomic data included highest educational level and gross personal income gathered by Statistics Denmark.^{35,36}

Morbidity code lists and additional details of all variable definitions are provided in eAppendix 1 and eTables 16, 17, and

Table 1. Summary of English and Danish Study Designs

| Variable | England | Denmark |
|--------------------------------|---|---|
| Sampling frame | Individuals ≥ 18 y registered with primary care practices contributing to the CPRD GOLD and eligible for linkage with hospital record data between January 2, 1998, and March 31, 2016. The CPRD is broadly representative of the whole population. We did not include children in the English study (unlike the Danish study, in which we did not restrict on age) because of limited power to study childhood cancers (childhood cancer is rare, and the median follow-up in the CPRD is only 5 y ²⁶). | All individuals (no age restriction) born and living in Denmark between January 1, 1982, and June 30, 2016 |
| Atopic eczema definition | Atopic eczema identified based on a record of 1 atopic eczema diagnostic code recorded in primary or secondary care and ≥ 2 primary care records (diagnosis code or prescription) for atopic eczema therapy | Atopic eczema identified based on an atopic eczema diagnosis, recorded as part of a hospital admission, emergency department contact, or an outpatient appointment. Therefore, the Danish cohort included people with more severe disease than the English cohort because it was based on hospital diagnoses only. |
| Comparison population | A cohort of individuals without atopic eczema matched on age (within 15 y), sex, calendar period, and primary care practice. We randomly matched (without replacement) up to 5 individuals without atopic eczema for every individual with atopic eczema in calendar date order (ie, individuals in the matched cohort were assigned first to those with earliest cohort entry to avoid time-related bias). Individuals were censored and no longer included in the comparison population on the date of their first atopic eczema diagnosis (they were subsequently included in the atopic eczema cohort if they also had ≥ 2 records for atopic eczema therapies). | A cohort of up to 10 individuals matched (with replacement) on sex and exact birth year to each individual with atopic eczema. Individuals included in the matched cohort were Danish residents who were born in Denmark and had no previous atopic eczema diagnosis on the date of the first recorded atopic eczema diagnosis (index date) of their matched atopic eczema-exposed individual. In Denmark, we were able to match with up to 10 individuals (rather than up to 5 in England) because we matched with replacement and did not match on primary care practice. |
| Cohort entry date (index date) | Prevalent cohort of atopic eczema-exposed individuals entered the cohort (index date) on the latest of 1 y after the date of registration with their primary care practice, the date that the practice met CPRD quality control standards, the start of the study (January 2, 1998), their 18th birthday, or 12 mo from the date of atopic eczema diagnosis (to limit potential reverse causality) | New hospital diagnosis cohort individuals entered the cohort (index date) on the date of their first atopic eczema diagnosis, recorded either as part of a hospital admission or an outpatient appointment |
| Cohort exit date | Earliest of the following events: death, individual no longer registered with the practice, practice no longer contributing data to the CPRD, end of study (March 31, 2016), diagnosis of atopic eczema (matched cohort only), or first-ever cancer diagnosis (excluding nonmelanoma skin cancer) | Earliest of the following events: death, emigration, diagnosis of atopic eczema (matched cohort only), first-ever cancer diagnosis (excluding nonmelanoma skin cancer), or end of study (June 30, 2016) |
| Cancer definition | Identified based on morbidity codes recorded in primary care (CPRD) or as part of a hospital admission (HES) and cause of death coding in ONS data | Identified based on diagnosis codes recorded in the Danish Cancer Registry |
| Confounders considered | Age, sex, calendar period, and IMD (as a proxy for socioeconomic deprivation) | Age and sex. Highest educational level, partner status, and gross personal income were used as proxies for socioeconomic status in people 30 y or older only (because these measures are likely to be incomplete for those aged <30 y). |
| Mediators considered | Lifestyle factors, including BMI, smoking, and harmful alcohol use | Because data on lifestyle variables were not available in Denmark, we used diagnoses or treatments for diseases associated with lifestyle factors as proxies, including chronic obstructive pulmonary disease, hyperlipidemia, hypertension, alcohol-related conditions, ischemic heart disease, hospital-diagnosed obesity, and type 2 diabetes |

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CPRD, Clinical Practice Research Datalink; HES, Hospital Episode Statistics; IMD, Index of Multiple Deprivation; ONS, Office for National Statistics.

18 in Supplement 3. Complete code lists for all variables used in the English study are available online.³⁷

Study Cohorts, Exposure, and Outcomes

England

All adults (aged ≥ 18 years) registered with primary care practices contributing data meeting CPRD quality control standards between 1998 and 2016 were eligible for inclusion (Figure 1 and eAppendix 2 in Supplement 3). Individuals needed at least 1 year of registration before cohort entry. Individuals with atopic eczema were identified based on a previously validated algorithm (eAppendix 1 in Supplement 3).³⁸ We randomly selected an individually matched cohort (without replacement) of up to 5 people for each individual with atopic eczema by age, sex, and primary care practice (eAppendix 2 in Supplement 3).

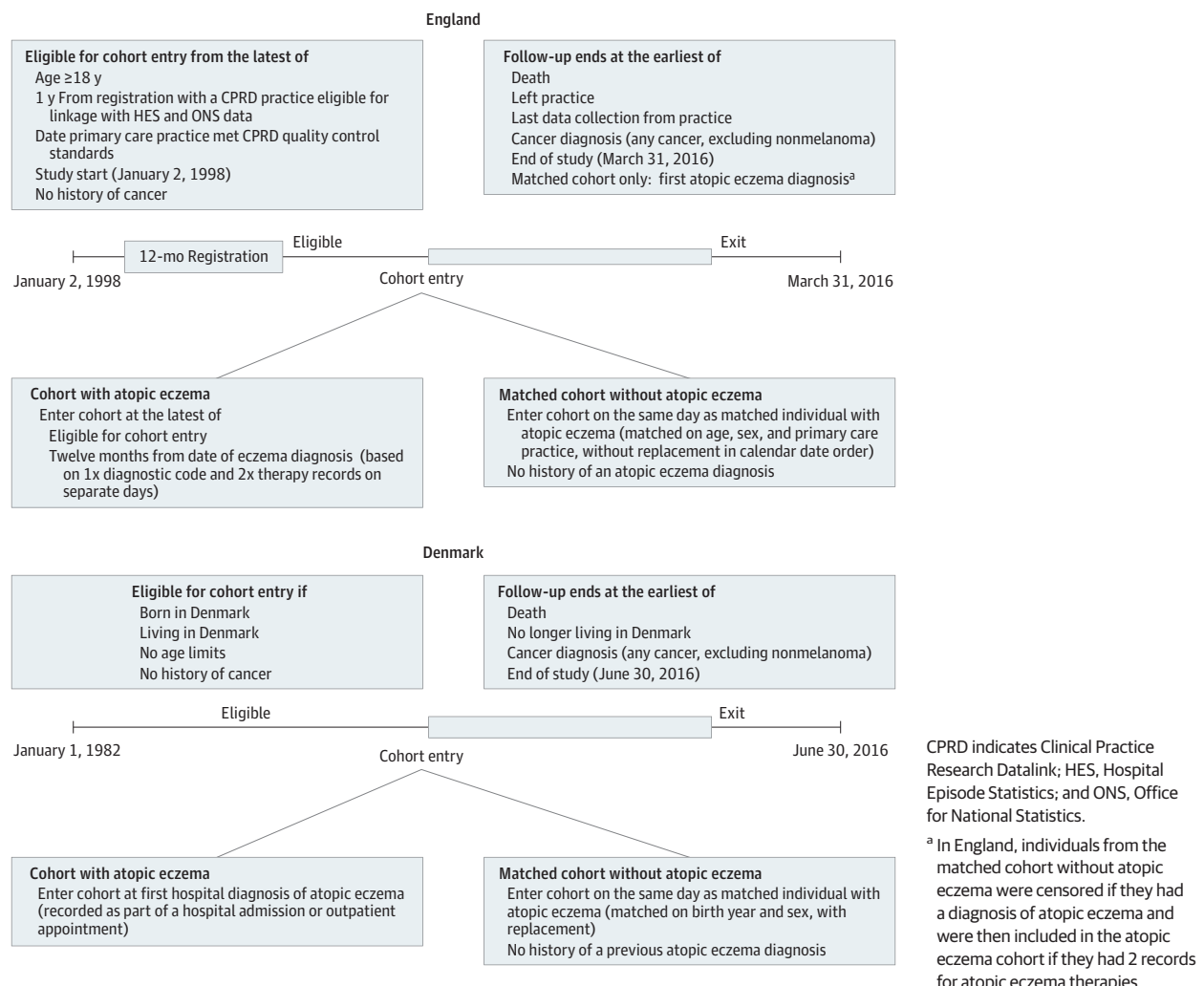
Denmark

All individuals (any age) born in Denmark with a hospital-based (outpatient and inpatient records) diagnosis of atopic eczema (mostly moderate to severe eczema) between 1982 and 2016 were identified (Figure 1 and eAppendix 2 in Supplement 3). Also identified was a comparison cohort (with replacement) of up to 10 people without atopic eczema matched to each individual with atopic eczema by sex and exact birth year.³⁹

Exclusions

In England and Denmark, we excluded individuals with any history of cancer (except nonmelanoma skin cancer [NMSC] or keratinocyte cancer). In analyses focused specifically on skin cancer, we further excluded individuals with a previous NMSC record.

Figure 1. Two Matched Cohorts of People With vs Without Atopic Eczema in England and Denmark



Outcomes

We investigated the association between atopic eczema and cancer, overall and the site-specific cancers (Figure 2), chosen a priori because they are common or were previously associated with atopic eczema or atopy.⁵ Overall cancer excluded NMSCs because of possible ascertainment bias (frequent skin examinations in atopic eczema) and possible poor capture because NMSCs may be treated topically (eg, photodynamic therapy) without histological confirmation.⁴⁰ We excluded cutaneous lymphomas from lymphoma definitions to reduce ascertainment bias because of frequent skin examinations or misdiagnosis of cutaneous lymphoma as eczema. In site-specific cancer analyses, we censored individuals at diagnosis of any cancer (excluding NMSC) and additionally at first NMSC diagnosis in skin cancer analyses.

Covariates

We considered the following variables as potential confounders: age, sex, calendar period, and socioeconomic status. In England, we used the Index of Multiple Deprivation (IMD) as a measure of socioeconomic deprivation of residential

neighborhood.⁴¹⁻⁴³ In Denmark, we used highest educational level, partner status, and gross personal income as measures of socioeconomic status.

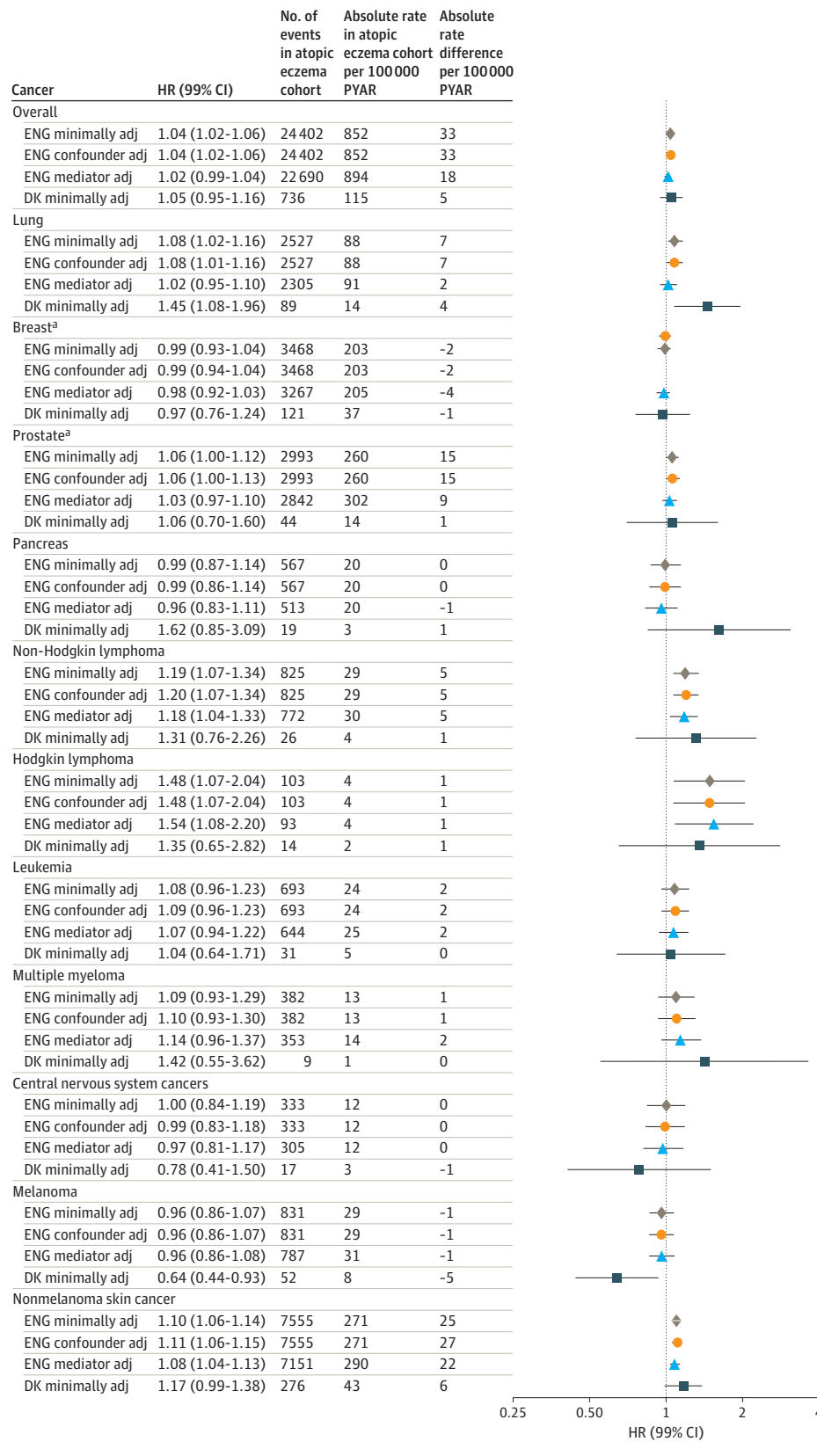
Also considered were factors potentially on the pathway between atopic eczema and cancer (ie, potential mediators), specifically body mass index (BMI), smoking, and harmful alcohol use (in England). Data on these variables were not available in Denmark; we relied instead on diagnoses or treatments for diseases associated with lifestyle factors as proxies, including chronic obstructive pulmonary disease, hyperlipidemia, hypertension, alcohol-related conditions, ischemic heart disease, hospital-diagnosed obesity, and type 2 diabetes.

Statistical Analysis

Main Analysis

We considered descriptive characteristics for individuals with and without atopic eczema. We used Cox proportional hazards regression, stratified by matched set, to estimate hazard ratios (HRs) comparing overall cancer risk and risk of specific cancers in people with and without atopic eczema. In

Figure 2. Associations Between Atopic Eczema and Cancer Outcomes in England and Denmark in People With vs Without Atopic Eczema



All models implicitly adjusted for sex, primary care practice (England [ENG] only) and date at cohort entry (because of stratification by matched set), and age (because of the underlying timescale). Confounders: Index of Multiple Deprivation (IMD) and calendar period. Potential mediators: body mass index, smoking, and harmful alcohol use. Adj indicates adjusted; DK, Denmark; HR indicates hazard ratio; and PYAR, person-years at risk.

^a Analysis of breast cancer was limited to women. Analysis of prostate cancer was limited to men.

England, we used age as the underlying timescale. In Denmark, because those with atopic eczema entered the cohort at first hospital atopic eczema diagnosis, we used time since first atopic eczema diagnosis for individuals with atopic eczema and the corresponding cohort entry date for matched individuals.

The minimally adjusted models implicitly accounted for matching and timescale factors, including age, sex, cohort entry date, and (in England only) primary care practice. In England, we followed with sequential models adjusting for (1) confounders (IMD and calendar period) to estimate the potential association between atopic eczema and cancer and then (2) potential mediators that might be on the pathway between atopic eczema and cancer. Sequential models, adjusting first for confounders and then for potential mediators, allowed us to differentiate between possible direct (eg, inflammatory) and indirect (ie, via mediating variables [eg, lifestyle factors]) associations of atopic eczema with cancer.⁴⁴ In Denmark, we were only able to adjust for potential confounders (ie, socioeconomic status) in sensitivity analyses restricted to individuals 30 years or older at cohort entry (socioeconomic status may be unreliable in younger people, who are less likely to have attained their highest educational level and have partner status and gross personal income recorded).

We repeated our main analyses in a series of sensitivity analyses assessing the robustness of our findings. Details are listed in eTable 1 in [Supplement 3](#).

Secondary Analyses

In our secondary analyses, we investigated whether the association between atopic eczema and cancer was (1) more pronounced in individuals with severe or active atopic eczema (unfeasible in Denmark because of small event numbers) and (2) modified by age, sex, or presence of asthma. Details are available in eAppendix 3 in [Supplement 3](#).

We assessed the proportional hazards assumption using Schoenfeld residual plots. In all analyses, as per our approved protocols (listed in the Methods section), we used 99% CIs to reduce the risk of type I error in the context of multiple analyses.⁴⁵ For data management and analyses, Stata, version 15 (StataCorp LLC), and SAS, version 9.4 (SAS Institute Inc), were used.

Results

In England, 2 629 640 individuals remained in valid matched sets and were included in analyses (eFigure 1 and eTable 2 in [Supplement 3](#)). The matched cohorts in England included 471 970 individuals with atopic eczema (median [IQR] age, 41.1 [24.9-60.7] years; 276 510 [58.6%] female) and 2 239 775 individuals without atopic eczema (median [IQR] age, 39.8 [25.9-58.4] years; 1 301 074 [58.1%] female).

In Denmark, 490 618 individuals remained in valid matched sets and were included in the analyses (eFigure 2 in [Supplement 3](#)). The Danish matched cohorts included 44 945 individuals with atopic eczema (median [IQR] age, 13.7 [1.7-21.1] years; 22 826 [50.8%] female) and 445 673 individuals

without atopic eczema (median [IQR] age, 13.5 [1.7-20.8] years; 226 323 [50.8%] female).

In England, the median follow-up was 4.5 years (IQR, 1.7-9.0 years). The cohorts with and without atopic eczema had broadly similar age, sex, and IMD ([Table 2](#)). Prevalence of smoking or overweight/obesity was higher in individuals with atopic eczema than in those without (46.7% vs 43.5% for smoking and 44.6% vs 40.7% for overweight/obesity). However, smoking and BMI data were less likely to be missing in people with atopic eczema compared with those without, and those with missing BMI or smoking status were more likely to be young and male (eTable 2 in [Supplement 3](#)).

In Denmark, the median follow-up was 14.3 years (IQR, 6.3-20.8 years). Distribution of age and sex was equal, and comorbidities at baseline were rare in both groups ([Table 2](#)). Among individuals aged 30 years at cohort entry, higher educational level and being single were more common in those with atopic eczema (eTable 3 in [Supplement 3](#)) than in those without atopic eczema.

Main Analysis

In both countries, little evidence was found of any association between atopic eczema and overall cancer ([Figure 2](#) and eTable 4 and eTable 5 in [Supplement 3](#)). Hazard ratios (HRs) comparing cancer risks in people with and without atopic eczema were close to 1, showing evidence of only a minor, clinically unimportant increase in minimally adjusted estimates (HR, 1.05; 99% CI, 0.95-1.16 in Denmark) and confounder-adjusted estimates (HR, 1.04; 99% CI, 1.02-1.06 in England). After further adjusting for potential mediators, estimates moved slightly closer to the null. For all specific cancer sites, only small differences in absolute cancer risk were seen between individuals with and without atopic eczema.

For most site-specific cancers, English and Danish analyses showed no strong evidence of an association with atopic eczema ([Figure 2](#)). For the following cancers, HRs comparing cancer risk in people with and without atopic eczema were close to the null: breast, prostate, pancreas, leukemia, multiple myeloma, and central nervous system cancers. There were decreases in melanoma risk and small increases in NMSC risk.

We found evidence of larger increases in lymphoma risk in people with atopic eczema compared with those without atopic eczema. In England, non-Hodgkin lymphoma (NHL) risk was 20% higher (HR, 1.20; 99% CI, 1.07-1.34) and Hodgkin lymphoma risk was 48% higher (HR, 1.48; 99% CI, 1.07-2.04) in people with atopic eczema compared with those without atopic eczema after adjusting for confounders ([Figure 2](#)). Although Danish point estimates for lymphoma were less precise than English estimates, they showed similar increased risk (minimally adjusted HR, 1.31; 99% CI, 0.76-2.26 for NHL and 1.35; 99% CI, 0.65-2.82 for Hodgkin lymphoma), but the 99% CIs were wide.

An initial small increased lung cancer risk was observed in people with atopic eczema vs those without (confounder-adjusted HR, 1.08; 99% CI, 1.01-1.16 in England and minimally adjusted HR, 1.45; 99% CI, 1.08-1.96 in Denmark) ([Figure 2](#)). However, risk attenuated after further adjusting for potential mediators (including smoking or smoking-related

Table 2. Characteristics of the English and Danish Study Populations at Cohort Entry^a

| Variable | England | | Denmark | |
|--|----------------------------------|---------------------------------------|---------------------------------|-------------------------------------|
| | With atopic eczema (n = 471 970) | Without atopic eczema (n = 2 239 775) | With atopic eczema (n = 44 945) | Without atopic eczema (n = 445 673) |
| Follow-up | | | | |
| Total person-years | 2 864 446 | 12 601 393 | 639 121 | 6 358 286 |
| Duration of follow-up, median (IQR), y | 4.8 (1.9-9.2) | 4.2 (1.7-8.6) | 14.3 (6.3-20.8) | 14.3 (6.3-20.8) |
| Female sex | 276 510 (58.6) | 1 301 074 (58.1) | 22 826 (50.8) | 226 323 (50.8) |
| Age, y | | | | |
| <18 | NA | NA | 31 772 (70.2) | 316 396 (71.0) |
| 18-44 | 262 119 (55.5) | 1 292 565 (57.7) | 9875 (22.0) | 98 181 (22.0) |
| 45-64 | 115 510 (24.5) | 563 375 (25.2) | 2418 (5.4) | 23 308 (5.2) |
| ≥65 | 94 341 (20.0) | 383 835 (17.1) | 880 (2.0) | 7788 (1.7) |
| IMD quintile ^b | | | | |
| 1, Least deprived | 113 598 (24.1) | 531 707 (23.7) | NA | NA |
| 2 | 107 613 (22.8) | 509 274 (22.7) | NA | NA |
| 3 | 92 864 (19.7) | 441 451 (19.7) | NA | NA |
| 4 | 90 112 (19.1) | 428 193 (19.1) | NA | NA |
| 5, Most deprived | 67 783 (14.4) | 329 150 (14.7) | NA | NA |
| BMI ^c | | | | |
| Underweight, <20 | 34 065 (7.2) | 165 212 (7.4) | NA | NA |
| Normal, 20-24 | 153 822 (32.6) | 721 037 (32.2) | NA | NA |
| Overweight, 25-29 | 127 144 (26.9) | 570 179 (25.5) | NA | NA |
| Obese, ≥30 | 83 169 (17.6) | 341 122 (15.2) | NA | NA |
| Missing | 73 770 (15.6) | 442 225 (19.7) | NA | NA |
| Smoking ^c | | | | |
| Nonsmoker | 239 072 (50.7) | 1 132 798 (50.6) | NA | NA |
| Current smoker or ex-smoker | 220 331 (46.7) | 975 355 (43.5) | NA | NA |
| Missing | 12 567 (2.7) | 131 622 (5.9) | NA | NA |
| Harmful alcohol use ^d | | | | |
| | 12 812 (2.7) | 49 844 (2.2) | NA | NA |
| Lifestyle-related diseases | | | | |
| Chronic obstructive pulmonary disease | NA | NA | 555 (1.2) | 1568 (0.4) |
| Hyperlipidemia | NA | NA | 533 (1.2) | 4389 (1.0) |
| Hypertension | NA | NA | 2012 (4.5) | 16 601 (3.7) |
| Alcohol-related conditions | NA | NA | 591 (1.3) | 4747 (1.1) |
| Ischemic heart disease | NA | NA | 274 (0.6) | 2011 (0.5) |
| Hospital-diagnosed obesity | NA | NA | 474 (1.1) | 3733 (0.8) |
| Type 2 diabetes | NA | NA | 248 (0.6) | 2325 (0.5) |

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); IMD, Index of Multiple Deprivation; IQR, interquartile range; NA, not applicable.

^a Unless otherwise specified, data are given as No. (%). Individuals could contribute data as both atopic eczema exposed and unexposed. Further characteristics for the English study population (including ethnicity and comorbidities) for the overall cohort, individuals included in the model additionally adjusting for potential mediators (ie, with no missing BMI or smoking status data), and for individuals with missing BMI or smoking status data are listed in eTable 2 in Supplement 3. Further characteristics for the Danish study population and socioeconomic variables (highest educational level, partner status, and gross personal income) among those 30 years or older are listed in eTable 3 in Supplement 3.

^b Based on individual-level data (from 2007) if available, supplemented with practice-level data (from 2010) if individual-level data were not available.

^c Based on records closest to the index date.

^d Based on records on or before cohort entry. We defined harmful alcohol use based on primary care morbidity codes suggesting harmful or heavy alcohol use (including alcohol dependency codes and codes associated with physical or psychological harm associated with alcohol use) or a prescription for drugs used to maintain abstinence (acamprosate calcium, disulfiram, or nalmefene hydrochloride).

disease) (HR, 1.02; 99% CI, 0.95-1.10 in England and 1.21; 99% CI, 0.88-1.65 in Denmark) (eTable 5 in Supplement 3).

Our sensitivity analyses yielded similar results (including analyses restricted to individuals with a 3-year cancer-free window after eczema diagnosis to limit reverse causality as an explanation for our findings). These results are summarized in eTable 6 and eTable 7 in Supplement 3.

Atopic Eczema Severity

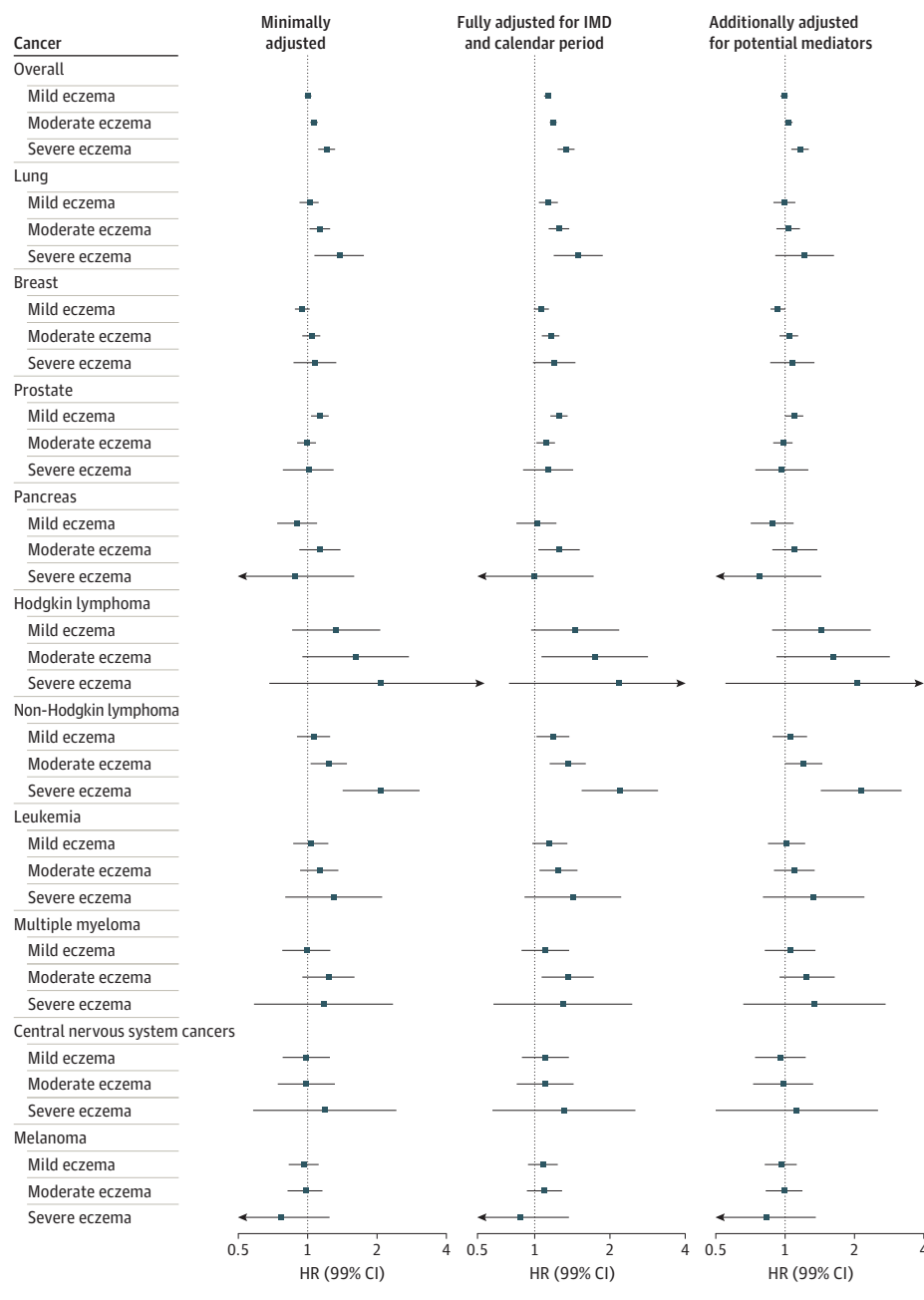
In England, we generally found no evidence of different overall cancer or site-specific cancer risk in severe eczema (Figure 3 and eTable 8 in Supplement 3). An exception was lymphoma, particularly NHL, for which the observed increased risk be-

came more pronounced with increasing eczema severity. The NHL confounder-adjusted HRs compared with those without atopic eczema were 1.06 (99% CI, 0.90-1.25) for mild eczema, 1.24 (99% CI, 1.04-1.48) for moderate eczema, and 2.08 (99% CI, 1.42-3.04) for severe eczema (eTable 8 in Supplement 3).

Atopic Eczema Activity

In England, we saw limited evidence of an association between atopic eczema activity and most site-specific cancers (eFigure 3 and eTable 9 in Supplement 3). Notably, there were higher risks of NHL in people with more active atopic eczema (confounder-adjusted HR compared with those with no atopic eczema, 1.07; 99% CI, 0.83-1.38 for never active

Figure 3. In England, Comparison of Cancer Rates at Each Level of Eczema Severity in People With vs Without Atopic Eczema



Estimated hazard ratios are from Cox proportional hazards regression with current age as the underlying timescale, stratified by matched set (matched on age at cohort entry, sex, primary care practice, and date at cohort entry). All models were fitted to individuals with complete data for all variables included in each model and from valid matched sets, including 1 individual with atopic eczema and at least 1 individual without atopic eczema. All models implicitly adjusted for sex, primary care practice, and date at cohort entry because of stratification by matched set and for age because of the underlying timescale. Fifty-two percent of those with severe eczema were classified as having severe eczema based on a prescription for systemic drugs, 1.5% based on a record for phototherapy, 28.0% due to specialist dermatology referral, and 18.0% as a result of a hospital admission for atopic eczema. Potential mediators were body mass index, smoking, and harmful alcohol use. Specific central nervous system tumors (meningioma, brain neoplasm, and others) were too rare to consider individually. HR indicates hazard ratio; IMD, Index of Multiple Deprivation. Population counts are listed in eTable 4 and eTable 5 in Supplement 3.

eczema; 1.08; 99% CI, 0.92-1.26 for moderately active eczema; and 1.58; 99% CI, 1.28-1.94 for very active eczema) and higher overall cancer risk in people with more active eczema (confounder-adjusted HR, 1.11; 99% CI, 1.07-1.15) (eTable 9 in Supplement 3).

Effect Modification

Little evidence was found of effect modification by age, sex, or presence of asthma. These results are summarized in eTables 10, 11, 12, 13, 14, and 15 in Supplement 3.

Discussion

In 2 matched cohort studies from England and Denmark, no evidence was found of an association between atopic eczema and most cancers. However, increased risk of lymphoma, particularly NHL, was seen among people with atopic eczema, specifically those with more severe or active disease. In England, we observed a 23% increased risk of lymphoma overall (similar to Danish estimates), with a 100% increase in NHL risk in

people with severe eczema, although absolute risk differences were small.

Findings in Context

A recent systematic review and meta-analysis¹² of cancer risk in people with atopic eczema highlighted the heterogeneity and limitations of existing data. Overall, our findings generally confirm those reported in prior smaller studies.^{12,14,16,19,23,46-54}

Our study is one of the few longitudinal studies^{12,14,16,23,46,47,52} to adjust for numerous potential confounders and mediators and to address the role of eczema severity and activity in 2 cohorts with complementary strengths and limitations. Our results suggest that the overall cancer risk among individuals with atopic eczema is small. This baseline risk is particularly important to establish as many new immunomodulatory systemic therapeutics are brought to market.

Previous studies assessing the association between atopic eczema and site-specific cancers have had conflicting results.¹² A discussion follows for brain cancer, solid-organ cancers, melanoma, and noncutaneous lymphomas.

Brain Cancer

A recent systematic review and meta-analysis⁴⁶ reported a 23% reduction in brain cancer risk in people with atopic eczema. However, this protective association was not observed with more specific atopic eczema diagnostic criteria, and there was substantial heterogeneity ($I^2 > 75%$) between studies. We could not reliably assess the risk of brain cancer subtypes because of low statistical power.

Solid-Organ Cancers

Some prior cohort and case-control studies⁴⁷⁻⁵¹ that assessed other solid-organ cancers found an increased risk of lung cancer associated with atopic diseases. Although we initially observed a small increased lung cancer risk in individuals with atopic eczema, this association disappeared after adjusting for possible mediators, suggesting that the increased risk may be attributable to smoking among people with atopic eczema.

Melanoma

The observation of a potentially protective association of atopic eczema with melanoma is of interest. Our findings are consistent with observations from mouse models²¹ and may reflect sun avoidance in people with atopic eczema or increased immune surveillance (further studies would be required to elucidate biologic mechanisms). Having atopic eczema might have led to more skin examinations, resulting in ascertainment bias and either an increased skin cancer risk (as seen for NMSC in this study and in other studies^{23,47,51,52}) or an apparently decreased risk because of better detection of melanoma in situ (with consequent lower invasive cancer risk). If ascertainment leads to increased melanoma detection, we would expect to see an even larger risk reduction in advanced melanoma; additional studies could examine this hypothesis.

Noncutaneous Lymphomas

The association between atopic eczema and lymphoma is consistent with previous findings in a systematic review and

meta-analysis¹⁶ of an overall relative risk of lymphoma of 1.43, as well as the finding in a CPRD-based case-control study¹⁹ of an association between Hodgkin lymphoma and allergic disease (asthma, eczema, and allergic rhinitis). The association of eczema severity with lymphoma has previously been assessed in only 1 cohort study⁵⁵ and 2 case-control studies.^{53,54} Although the cohort study⁵⁵ used data from Medicaid, a US administrative database, and focused on psoriasis, it demonstrated a 2-fold increased lymphoma risk among individuals with severe eczema in a limited secondary analysis. However, because NHL and Hodgkin lymphoma have different risk factor profiles,⁵⁶ our findings in this study might suggest detection bias (because of the use of chest radiographs in people with comorbid asthma) or residual confounding, perhaps because of immunosuppression⁵⁷ (although sensitivity analyses adjusting for immunosuppression in the present study were similar to our main analysis results).

Previous studies attempting to clarify whether topical calcineurin inhibitors (used in our study to identify moderate eczema severity) increase lymphoma risk in people with atopic eczema have failed to convincingly demonstrate an association, although most analyses were limited by low statistical power and confounding by severity.¹⁶ A low proportion of individuals with atopic eczema treated in primary care receive calcineurin inhibitors because these agents are recommended for specialist use only.⁵⁸

Implications for Future Research

In this study, we found an increased lymphoma risk in individuals with atopic eczema, especially for those with severe eczema; however, absolute differences were small, and there was little evidence of an increased risk of other cancers. This finding may be because of reverse causation (ie, atopic eczema could be an early sign of lymphoma), but a sensitivity analysis extending the cancer-free lag period to 3 years did not show any evidence of this hypothesis (eTable 6 in Supplement 3). Future research could explore underlying mechanisms for the associations observed for lymphoma, particularly NHL, including studies assessing Epstein-Barr virus in people with atopic eczema, as well as addressing the therapeutic implications (associated with existing and novel immunosuppressive treatments) of our findings in individuals with severe eczema.

Strengths and Limitations

This study has strengths and limitations. A major strength of this study is the use of prospectively collected data from large representative population-based databases from 2 countries with free health care access.^{26,30,59} Our results reflect real-world clinical practice and are likely to be generalizable to other settings. Although the Danish findings are unlikely to apply to individuals with mild eczema because the Danish data were restricted to hospital-based atopic eczema diagnoses, the Danish results are consistent with those for individuals with moderate to severe eczema in England. Therefore, combining the English and Danish population-based data lends credence to the study conclusions by virtue of triangulation.⁶⁰

It is possible that atopic eczema was misclassified in our study. Although we used a validated algorithm to identify atopic eczema in England and the validity of diagnoses in a dermatology department was found to be high in Denmark (positive predictive value, 99%⁶¹), we may have missed atopic eczema diagnoses (likely unrelated to cancer risk), which could have underestimated the magnitude of any association between atopic eczema and cancer.

The quality of diagnoses in the Danish Cancer Registry is excellent: reporting is mandatory, diagnoses stem from a range of sources, the proportion of histologically verified tumors is high (>90% for major cancers), and few diagnoses are based only on death certificates (0.1%).^{32,62,63} In England, most nationally registered cancer cases (>90%) can be identified in the CPRD; by including the HES and ONS data, we further improved cancer identification.⁶⁴ Nevertheless, we cannot exclude ascertainment bias; cancers may be diagnosed more frequently in individuals with atopic eczema because of frequent skin examinations for skin cancer, regular blood test monitoring for systemic immunosuppressive drugs (in severe eczema only), or chest radiographs for concomitant asthma or before drug initiation in severe eczema (eg, cyclosporine).

Potential misclassification of covariates may have led to residual confounding, biasing the estimates of direct associations in mediation analyses. However, increasing adjustment made little change to our HR estimates. In Denmark, we

were only able to adjust for potential confounders (ie, socioeconomic status) in sensitivity analyses, but the results of these sensitivity analyses were similar to those of the main analysis. However, matching with replacement in the Danish cohort may have resulted in mild misleadingly narrow 99% CIs.

A limitation that is common to many dermatological conditions lacking quantitative measures is reliance on treatments to classify disease severity and activity. In Denmark, sample sizes were insufficient for eczema severity and activity analyses; however, we note that, by definition, most individuals had moderate to severe eczema. Atopic eczema was identified in hospital records because we had no access to data from Danish primary care, where mild eczema is managed. The study also had limited power to examine certain cancers, specifically brain cancer subtypes.

Conclusions

In this study, no evidence was found that people with atopic eczema are at increased risk of most cancers. An exception is the observed association between atopic eczema and lymphoma, particularly NHL, that increased with eczema severity. This finding warrants further study as new immunomodulatory systemic therapeutics are brought to market that may alter cancer risk.

ARTICLE INFORMATION

Accepted for Publication: April 28, 2020.

Published Online: June 24, 2020.
doi:10.1001/jamadermatol.2020.1948

Open Access: This is an open access article distributed under the terms of the [CC-BY License](#).
© 2020 Mansfield KE et al. *JAMA Dermatology*.

Author Affiliations: Department of Non-communicable Disease Epidemiology, London School of Hygiene and Tropical Medicine, London, United Kingdom (Mansfield, Mulick, Wong, Smeeth, Bhaskaran, dos Santos Silva, Langan); Department of Clinical Epidemiology, Aarhus University Hospital, Aarhus N, Denmark (Schmidt, Darvalics, Sørensen); Department of Dermatology, Aarhus University Hospital, Aarhus N, Denmark (Schmidt); Department of Dermatology, University of California, San Francisco (Abuabara); Department of Medical Statistics, London School of Hygiene and Tropical Medicine, London, United Kingdom (Silverwood); Centre for Longitudinal Studies, Department of Social Science, University College London, London, United Kingdom (Silverwood); Health Data Research UK, London, United Kingdom (Langan).

Author Contributions: Drs Mansfield and Schmidt had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Drs Mansfield and Schmidt contributed equally as co-first authors.
Concept and design: Mansfield, Schmidt, Darvalics, Abuabara, Smeeth, Bhaskaran, Langan.
Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Mansfield, Schmidt.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Mansfield, Darvalics, Mulick, Silverwood.

Obtained funding: Schmidt, Langan.

Administrative, technical, or material support: Mansfield, Sørensen, Bhaskaran.

Supervision: Schmidt, Abuabara, Sørensen, Smeeth, Bhaskaran, Langan.

Conflict of Interest Disclosures: Dr Mansfield and Ms Mulick reported being funded under a Wellcome Trust grant awarded to Dr Langan. Dr Abuabara reported receiving personal fees from TARGET-DERM and receiving grants from Pfizer. Dr Sørensen reported that the Department of Clinical Epidemiology, Aarhus University Hospital, receives funding for other studies from companies in the form of research grants to (and administered by) Aarhus University. Dr Smeeth reported receiving grants from the Wellcome Trust, Medical Research Council, National Institute for Health Research, GlaxoSmithKline, British Heart Foundation, and Diabetes UK and being a trustee of the British Heart Foundation. Dr Bhaskaran reported receiving grants from the Wellcome Trust, Royal Society, Medical Research Council, British Heart Foundation, and Diabetes UK. Dr Langan reported receiving grants from the Wellcome Trust and from IMI Horizon 2020 funding BIOMAP. No other disclosures were reported.

Funding/Support: Dr Bhaskaran was supported by a Sir Henry Dale Fellowship from the Wellcome Trust and the Royal Society (107731/Z/15/Z). Dr Langan was supported by a Wellcome Trust Senior Clinical Fellowship (205039/Z/16/Z). The

Danish study was funded by the Dagmar Marshalls Fund and the Aase and Ejnar Danielsen's Fund.

Role of the Funder/Sponsor: The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Additional Information: This article used data provided by patients and collected by the United Kingdom National Health Service as part of their care and support.

REFERENCES

- Barbarot S, Auziere S, Gadkari A, et al. Epidemiology of atopic dermatitis in adults: results from an international survey. *Allergy*. 2018;73(6):1284-1293. doi:10.1111/all.13401
- Silverberg JI, Hanifin JM. Adult eczema prevalence and associations with asthma and other health and demographic factors: a US population-based study. *J Allergy Clin Immunol*. 2013;132(5):1132-1138. doi:10.1016/j.jaci.2013.08.031
- Hay RJ, Johns NE, Williams HC, et al. The global burden of skin disease in 2010: an analysis of the prevalence and impact of skin conditions. *J Invest Dermatol*. 2014;134(6):1527-1534. doi:10.1038/jid.2013.446
- Asher MI, Montefort S, Björkstén B, et al; ISAAC Phase Three Study Group. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys [published correction appears in *Lancet*. 2007;370(9593):1128]. *Lancet*.

- 2006;368(9537):733-743. doi:10.1016/S0140-6736(06)69283-0
5. Deckert S, Kopkow C, Schmitt J. Nonallergic comorbidities of atopic eczema: an overview of systematic reviews. *Allergy*. 2014;69(1):37-45. doi:10.1111/all.12246
6. Wedgeworth E, Powell AM, Flohr C. Eczema and cancer risk: a critical appraisal and review of the literature. *Br J Dermatol*. 2011;165(3):457-462. doi:10.1111/j.1365-2133.2011.10542.x
7. Sørensen HT, Mellekjær L, Nielsen GL, Baron JA, Olsen JH, Karagas MR. Skin cancers and non-Hodgkin lymphoma among users of systemic glucocorticoids: a population-based cohort study. *J Natl Cancer Inst*. 2004;96(9):709-711. doi:10.1093/jnci/djh118
8. Naghavi M, Abajobir AA, Abbafati C, et al; GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390(10100):1151-1210. doi:10.1016/S0140-6736(17)32152-9
9. Schofield JK, Fleming D, Grindlay D, Williams H. Skin conditions are the commonest new reason people present to general practitioners in England and Wales. *Br J Dermatol*. 2011;165(5):1044-1050. doi:10.1111/j.1365-2133.2011.10464.x
10. Moth G, Vedsted P, Olesen F. *The Pattern of Contact and Illness in General Practice: KOS 2008* [in Danish]. Forskningsenheden for Almen Praksis; 2010.
11. Bosma AL, Spuls PI, Garcia-Doval I, et al. Treatment of Atopic Eczema (TREAT) Registry Taskforce: protocol for a European safety study of dupilumab and other systemic therapies in patients with atopic eczema. *Br J Dermatol*. Published online August 24, 2019. doi:10.1111/bjd.18452
12. Wang L, Bierbrier R, Drucker AM, Chan AW. Noncutaneous and cutaneous cancer risk in patients with atopic dermatitis: a systematic review and meta-analysis. *JAMA Dermatol*. Published online December 11, 2019. doi:10.1001/jamadermatol.2019.3786
13. Burki TK. Association between allergies and reduced risk of glioma. *Lancet Oncol*. 2016;17(3):e94. doi:10.1016/S1470-2045(16)00087-5
14. Linos E, Raine T, Alonso A, Michaud D. Atopy and risk of brain tumors: a meta-analysis. *J Natl Cancer Inst*. 2007;99(20):1544-1550. doi:10.1093/jnci/djm170
15. Wang M, Chen C, Qu J, et al. Inverse association between eczema and meningioma: a meta-analysis. *Cancer Causes Control*. 2011;22(10):1355-1363. doi:10.1007/s10552-011-9808-6
16. Legendre L, Barnette T, Mazereeuw-Hautier J, Meyer N, Murrell D, Paul C. Risk of lymphoma in patients with atopic dermatitis and the role of topical treatment: a systematic review and meta-analysis. *J Am Acad Dermatol*. 2015;72(6):992-1002. doi:10.1016/j.jaad.2015.02.1116
17. Linabery AM, Jurek AM, Duval S, Ross JA. The association between atopy and childhood/adolescent leukemia: a meta-analysis. *Am J Epidemiol*. 2010;171(7):749-764. doi:10.1093/aje/kwq004
18. Margolis DJ, Abuabara K, Hoffstad OJ, Wan J, Raimondo D, Bilker WB. Association between malignancy and topical use of pimecrolimus. *JAMA Dermatol*. 2015;151(6):594-599. doi:10.1001/jamadermatol.2014.4305
19. Rafiq M, Hayward A, Warren-Gash C, et al. Allergic disease, corticosteroid use and risk of Hodgkin's lymphoma: a United Kingdom nationwide case-control study. *J Allergy Clin Immunol*. 2020;145(3):868-876. doi:10.1016/j.jaci.2019.10.033
20. Castellsague J, Kuiper JG, Pottegård A, et al. A cohort study on the risk of lymphoma and skin cancer in users of topical tacrolimus, pimecrolimus, and corticosteroids (Joint European Longitudinal Lymphoma and Skin Cancer Evaluation-JOELLE study). *Clin Epidemiol*. 2018;10:299-310. doi:10.2147/CLEP.S146442
21. Cipolat S, Hoste E, Natsuga K, Quist SR, Watt FM. Epidermal barrier defects link atopic dermatitis with altered skin cancer susceptibility. *eLife*. 2014;3:e01888. doi:10.7554/eLife.01888
22. Margolis DJ, Hoffstad O, Bilker W. Lack of association between exposure to topical calcineurin inhibitors and skin cancer in adults. *Dermatology*. 2007;214(4):289-295. doi:10.1159/000100879
23. Jensen AO, Svaerke C, Körmeniné Farkas D, Olesen AB, Kragballe K, Sørensen HT. Atopic dermatitis and risk of skin cancer: a Danish nationwide cohort study (1977-2006). *Am J Clin Dermatol*. 2012;13(1):29-36. doi:10.2165/11593280-000000000-00000
24. Cheng J, Zens MS, Duell E, Perry AE, Chapman MS, Karagas MR. History of allergy and atopic dermatitis in relation to squamous cell and basal cell carcinoma of the skin. *Cancer Epidemiol Biomarkers Prev*. 2015;24(4):749-754. doi:10.1158/1055-9965.EPI-14-1243
25. Gandini S, Stanganelli I, Palli D, De Giorgi V, Masala G, Caini S. Atopic dermatitis, naevi count and skin cancer risk: a meta-analysis. *J Dermatol Sci*. 2016;84(2):137-143. doi:10.1016/j.jdermsci.2016.07.009
26. Herrett E, Gallagher AM, Bhaskaran K, et al. Data resource profile: Clinical Practice Research Datalink (CPRD). *Int J Epidemiol*. 2015;44(3):827-836. doi:10.1093/ije/dyv098
27. Mathur R, Bhaskaran K, Chaturvedi N, et al. Completeness and usability of ethnicity data in UK-based primary care and hospital databases. *J Public Health (Oxf)*. 2014;36(4):684-692. doi:10.1093/pubmed/ftd116
28. Bhaskaran K, Forbes HJ, Douglas I, Leon DA, Smeeth L. Representativeness and optimal use of body mass index (BMI) in the UK Clinical Practice Research Datalink (CPRD). *BMJ Open*. 2013;3(9):e003389. doi:10.1136/bmjopen-2013-003389
29. NHS Digital. Hospital Episode Statistics (HES). Accessed June 25, 2015. <http://www.hscic.gov.uk/hes>
30. Schmidt M, Schmidt SAJ, Sandegaard JL, Ehrenstein V, Pedersen L, Sørensen HT. The Danish National Patient Registry: a review of content, data quality, and research potential. *Clin Epidemiol*. 2015;7:449-490. doi:10.2147/CLEP.S91125
31. Schmidt M, Schmidt SAJ, Adelborg K, et al. The Danish health care system and epidemiological research: from health care contacts to database records. *Clin Epidemiol*. 2019;11:563-591. doi:10.2147/CLEP.S179083
32. Gjerstorff ML. The Danish Cancer Registry. *Scand J Public Health*. 2011;39(7)(suppl):42-45. doi:10.1177/1403494810393562
33. Schmidt M, Pedersen L, Sørensen HT. The Danish Civil Registration System as a tool in epidemiology. *Eur J Epidemiol*. 2014;29(8):541-549. doi:10.1007/s10654-014-9930-3
34. Pottegård A, Schmidt SAJ, Wallach-Kildemoes H, Sørensen HT, Hallas J, Schmidt M. Data resource profile: the Danish National Prescription Registry. *Int J Epidemiol*. 2017;46(3):798-798f. doi:10.1093/ije/dyw213
35. Jensen VM, Rasmussen AW. Danish education registers. *Scand J Public Health*. 2011;39(7)(suppl):91-94. doi:10.1177/1403494810394715
36. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. *Scand J Public Health*. 2011;39(7)(suppl):103-105. doi:10.1177/1403494811405098
37. London School of Hygiene and Tropical Medicine. LSHTM data compass. Last modified January 2020. Accessed May 25, 2020. <https://datacompass.lshtm.ac.uk/>
38. Abuabara K, Magyari AM, Hoffstad O, et al. Development and validation of an algorithm to accurately identify atopic eczema patients in primary care electronic health records from the UK. *J Invest Dermatol*. 2017;137(8):1655-1662. doi:10.1016/j.jid.2017.03.029
39. Heide-Jørgensen U, Adelborg K, Kahlert J, Sørensen HT, Pedersen L. Sampling strategies for selecting general population comparison cohorts. *Clin Epidemiol*. 2018;10:1325-1337. doi:10.2147/CLEP.S164456
40. Stefoski Mikeljevic J, Johnston C, Adamson PJ, et al. How complete has skin cancer registration been in the UK? a study from Yorkshire. *Eur J Cancer Prev*. 2003;12(2):125-133. doi:10.1097/00008469-200304000-00006
41. Deas I, Robson B, Wong C, Bradford M. Measuring neighbourhood deprivation: a critique of the Index of Multiple Deprivation. *Environ Plann C Gov Policy*. 2003;21(6):883-903. doi:10.1068/c0240
42. Noble M, Wright G, Smith G, Dibben C. Measuring multiple deprivation at the small-area level. *Environ Plann A*. 2006;38(1):169-185. doi:10.1068/a37168
43. Department for Communities and Local Government. The English Indices of Deprivation 2015: frequently asked questions (FAQs). Updated December 5, 2016. Accessed July 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/579151/English_Indices_of_Deprivation_2015_-_Frequently_Asked_Questions_Dec_2016.pdf
44. Lederer D, Bell S, Branson R, et al. Control of confounding and reporting of results in causal inference studies: guidance for authors from editors of respiratory, sleep, and critical care journals. *Ann Am Thorac Soc*. 2019;16(1):22-28. doi:10.1513/AnnalsATS.201808-564PS
45. Ioannidis JPA. The proposal to lower P value thresholds to .005. *JAMA*. 2018;319(14):1429-1430. doi:10.1001/jama.2018.1536
46. Halling-Overgaard AS, Ravnborg N, Silverberg JI, Egeberg A, Thyssen JP. Atopic dermatitis and cancer in solid organs: a systematic review and meta-analysis. *J Eur Acad Dermatol Venereol*. 2019;33(2):e81-e82. doi:10.1111/jdv.15230
47. Hagströmer L, Ye W, Nyrén O, Emtestam L. Incidence of cancer among patients with atopic

- dermatitis. *Arch Dermatol*. 2005;141(9):1123-1127. doi:10.1001/archderm.141.9.1123
48. Wang H, Rothenbacher D, Löw M, Stegmaier C, Brenner H, Diepgen TL. Atopic diseases, immunoglobulin E and risk of cancer of the prostate, breast, lung and colorectum. *Int J Cancer*. 2006;119(3):695-701. doi:10.1002/ijc.21883
49. Castaing M, Youngson J, Zaridze D, et al. Is the risk of lung cancer reduced among eczema patients? *Am J Epidemiol*. 2005;162(6):542-547. doi:10.1093/aje/kwi241
50. Ruff S, Egeberg A, Andersen YMF, Gislason G, Skov L, Thyssen JP. Prevalence of cancer in adult patients with atopic dermatitis: a nationwide study. *Acta Derm Venereol*. 2017;97(9):1127-1129. doi:10.2340/00015555-2703
51. Olesen AB, Engholm G, Storm HH, Thestrup-Pedersen K. The risk of cancer among patients previously hospitalized for atopic dermatitis. *J Invest Dermatol*. 2005;125(3):445-449. doi:10.1111/j.0022-202X.2005.23839.x
52. Arana A, Wentworth CE, Fernández-Vidaurre C, Schlienger RG, Conde E, Arellano FM. Incidence of cancer in the general population and in patients with or without atopic dermatitis in the U.K. *Br J Dermatol*. 2010;163(5):1036-1043. doi:10.1111/j.1365-2133.2010.09887.x
53. Arellano FM, Arana A, Wentworth CE, Fernández-Vidaurre C, Schlienger RG, Conde E. Lymphoma among patients with atopic dermatitis and/or treated with topical immunosuppressants in the United Kingdom. *J Allergy Clin Immunol*. 2009;123(5):1111-1116, 116.e1-116.e13. doi:10.1016/j.jaci.2009.02.028
54. Arellano FM, Wentworth CE, Arana A, Fernández C, Paul CF. Risk of lymphoma following exposure to calcineurin inhibitors and topical steroids in patients with atopic dermatitis. *J Invest Dermatol*. 2007;127(4):808-816. doi:10.1038/sj.jid.5700622
55. Margolis D, Bilker W, Hennessy S, Vittorio C, Santanna J, Strom BL. The risk of malignancy associated with psoriasis. *Arch Dermatol*. 2001;137(6):778-783.
56. Cogliano VJ, Baan R, Straif K, et al. Preventable exposures associated with human cancers. *J Natl Cancer Inst*. 2011;103(24):1827-1839. doi:10.1093/jnci/djr483
57. Engels EA, Pfeiffer RM, Fraumeni JF Jr, et al. Spectrum of cancer risk among US solid organ transplant recipients. *JAMA*. 2011;306(17):1891-1901. doi:10.1001/jama.2011.1592
58. Surveillance report 2016: atopic eczema in under 12s: diagnosis and management (2007). NICE guideline CG57. Published July 21, 2016. Accessed July 2019. <https://www.ncbi.nlm.nih.gov/books/NBK552070/>
59. Rothman KJ. Six persistent research misconceptions. *J Gen Intern Med*. 2014;29(7):1060-1064. doi:10.1007/s11606-013-2755-z
60. Lawlor DA, Tilling K, Davey Smith G. Triangulation in aetiological epidemiology. *Int J Epidemiol*. 2016;45(6):1866-1886. doi:10.1093/ije/dyw314
61. Schmidt SAJ, Olsen M, Schmidt M, et al. Atopic dermatitis and risk of atrial fibrillation or flutter: a 35-year follow-up study. *J Am Acad Dermatol*. Published online August 20, 2019. doi:10.1016/j.jaad.2019.08.039
62. Pedersen SA, Schmidt SAJ, Klausen S, et al. Melanoma of the skin in the Danish Cancer Registry and the Danish Melanoma Database. *Epidemiology*. 2018;29(3):442-447. doi:10.1097/EDE.0000000000000802
63. Friis S, Jørgensen T, Mellekjær L. Validation of the Danish Cancer Registry and Selected Clinical Cancer Databases. Danish Cancer Society; 2012:1-2.
64. Boggon R, van Staa TP, Chapman M, Gallagher AM, Hammad TA, Richards MA. Cancer recording and mortality in the General Practice Research Database and linked cancer registries. *Pharmacoepidemiol Drug Saf*. 2013;22(2):168-175. doi:10.1002/pds.3374