

The joint exposure to parental cancer and income loss during childhood and the child's socioeconomic position in early adulthood: a Danish and Norwegian register-based cohort study

Corresponding author

Stine Kjaer Urhoj; Postal address: Oster Farimagsgade 5, PO Box 2099, DK-1014 Copenhagen K
E-mail: stur@sund.ku.dk

Co-authors

Mathilde Klinte, Section of Epidemiology, Department of Public Health, University of Copenhagen, Copenhagen, Denmark. <https://orcid.org/0000-0002-9636-8373>

Åsmund Hermansen, Department of Social Work, Child Welfare and Social Policy, Faculty of Social Sciences, Oslo Metropolitan University. <https://orcid.org/0000-0002-0826-0689>

Anne-Marie Nybo Andersen, Section of Epidemiology, Department of Public Health, University of Copenhagen, Copenhagen, Denmark. <https://orcid.org/0000-0002-4296-8488>

Stine Kjaer Urhoj, Section of Epidemiology, Department of Public Health, University of Copenhagen, Copenhagen, Denmark. <https://orcid.org/0000-0002-2069-9723>

Word count (excluding title page, abstract, tables, acknowledgements, contributions, data availability statement, ethics statement and references): 3232 words.

This article has been accepted for publication in Journal of Epidemiology and Community Health, 2022] following peer review, and the Version of Record can be accessed online at <https://doi.org/10.1136/jech-2022-219374>.

© Authors. Reuse of this manuscript version (excluding any databases, tables, diagrams, photographs and other images or illustrative material included where a another copyright owner is identified) is permitted strictly pursuant to the terms of the **Creative Commons Attribution-Non Commercial 4.0 International (CC-BY-NC 4.0)** <https://creativecommons.org/licenses/by-nc/4.0/>

What is already known on this topic

- Several cancer patients experience an income loss during the illness period, but it is unknown how children are affected long-term by the joint exposure to income loss and parental cancer.

What this study adds

- We found a negative association between the joint exposure to parental cancer and income loss during childhood and the child's income and educational attainment in early adulthood.
- The association was also observed for children only exposed to an income loss or only exposed to parental cancer, though with weaker associations.
- The results showed stronger associations with lower educational attainment for severe cancer types.

How this study might affect research, practice or policy

- Although no policy implications can be taken from one study, this study points to a possible benefit of financial support for families when a parent is diagnosed with cancer, to reduce the extra burden of an income loss.

ABSTRACT

Background

Parental cancer as well as economic hardship in the family during childhood can affect the child negatively. Our aim was to examine the association between the joint exposure to parental cancer and income loss in childhood and the child's socioeconomic position in early adulthood.

Methods

We conducted a register-based prospective cohort study of children born in Denmark between 1978-1986 and in Norway between 1979-1987. The children were followed from 1 January 1994 (in Denmark) or 1995 (in Norway). Educational level and personal income were measured at age 30 years. Children who experienced parental cancer between the year they turned 8 and 16 years were identified, and exposure to income loss was measured in the same period. Adjusted multinomial logistic regression model was used to estimate relative risk ratios for the joint exposure of parental cancer and income loss during childhood.

Results

Children who experienced parental cancer and an income loss during childhood had an increased risk of low education and lower income at age 30 years. The associations were weaker for children only exposed to income loss and less clear for those only exposed to parental cancer. Further, exposure to parental cancer with a severe cancer type was associated with lower educational level.

Conclusion

The child's educational attainment and income level in early adulthood were negatively affected by exposure to income loss in childhood, and even more so if exposed to both parental cancer and income loss. The associations with educational attainment were stronger for more severe cancer types.

INTRODUCTION

An individual's health status is strongly correlated with social factors including income, education, and employment.[1] Long-term illness, such as cancer, increases the risk of getting a lower income, as the ability to work can be reduced.[2–6] Thus, health factors may also affect the social factors. Knowledge on how such mechanisms affect the children in the household in a long-term perspective is very limited.

Studies on short term consequences suggest that children affected by parental cancer may experience problems in numerous ways including increased emotional problems, behavioral problems, lower educational attainment, and worsened physical functioning.[7–11] Since parental cancer seems to affect the child's school performance, it is also very likely that the child's socioeconomic position (SEP) in early adulthood is affected, since school performance has been found to be a predictor of educational attainment and earnings in adulthood.[12]

Economic hardship has been found to be associated with negative outcomes in the children, including behavioral problems, emotional problems, poorer mental health, and lower grades.[13–17] An income loss may possibly have some of the same consequences, but the association between income loss and the child's SEP later in life have not been examined in previous studies.

Effects of different exposures can vary according to when in the life course a person is exposed[18], and previous studies have found that exposure to parental cancer have different effects at different ages.[19,20]

Our theory is that an income loss enlarges a negative association between parental cancer and the child's SEP long term because it amounts to a higher burden for the family, including the child. The primary aim of this paper was therefore to assess the joint effect of parental cancer and income loss on the child's SEP in young adulthood. Moreover, we wish to explore the association in children in both primary school and lower secondary school ages. Sickness benefits in Norway are more generous compared to Denmark in terms of replacement rate, coverage, and duration.[21] This could possibly influence the association and we therefore included both countries to see if the association differed.

METHODS

Study population

We established one Danish and one Norwegian nationwide cohort from national registers. The Danish cohort included children born in Denmark from 1978 through 1986 registered in the Danish Medical Birth Registry. The Norwegian study was pushed one year due to differences in the available register data in the two countries, and the Norwegian cohort therefore included children born in Norway from 1979 through 1987 registered in the National Registry of Norway (see Lexis diagrams in online supplementary figure 1 and 2). Unique personal identification numbers were used to link the children and parents and to link information from the various nationwide registers within the two countries. The children were followed from 1 January 1994 (in Denmark) or from 1 January 1995 (in Norway) and turned 8-16 years during the first year of the study. The children were followed until the year they turned 30 years. Children were excluded from the study if they were not alive and residing in the country by the end of follow-up or if they had emigrated before the year they turned 19. Norwegian children who had emigrated before 2017 were excluded as this was the only option to exclude those who were not in the country until the age of 19 years. Further, children were excluded if they had been exposed to parental cancer before the time of inclusion, did

not have complete information on covariates (the child's or parent's personal identification numbers, covariates, mothers yearly equivalized disposable household income) or were missing information on one or both outcomes. This resulted in two slightly different populations for each country (one for each outcome), consisting of 426,477 and 435,019 Danish children and 425,169 and 423,455 Norwegian children. Because there was no parental cancer year to determine the time for calculating the income loss for children who did not experience parental cancer, we applied the following: for each child exposed to parental cancer in the populations, ten unexposed children with the same birth year as the exposed child and without missing data on mother's income were randomly selected from the same population (see online supplementary figure 3 for illustration). This resulted in two Danish populations of 72,204 and 73,777 children and in two Norwegian populations of 79,266 and 79,013 children 1 (see Flowcharts in online supplementary figure 4 and 5). Data were stored and processed at Services for Sensitive Data (TSD) located at the University of Oslo and at Statistics Denmark and no direct identifiers were accessible.

Socioeconomic position

The child's highest attained educational level and personal yearly income at the age of 30 years were applied as measures of the child's SEP. The Danish study population turned 30 years between 2008 and 2016, and the Norwegian study population turned 30 years between 2009 and 2017. The children's educational levels were extracted from the Danish Population's Education Register available at Statistics Denmark and the National Education Database (NUDB) in Norway. The educational level was categorized into three groups using the International Standard Classification of Education (ISCED): low (ISCED 0–2), medium (ISCED 3–4) and high (ISCED 5–8). The personal income was obtained from the Income Statistics Register available at Statistics Denmark and the Income Registry in Norway and was categorized into quartiles by year.

Parental cancer

The primary exposure in this study was parental cancer during childhood (age 8-16), and the secondary exposure was income loss in the family during the same period as the parental cancer. Data on parental cancer was retrieved from the Danish National Patient Registry and the Cancer Registry of Norway and defined using ICD-8 and ICD-10 codes. Children were categorized as exposed to parental cancer if one or both parents was diagnosed with cancer for the first time between the time of inclusion and the calendar year the child turned 17 years. In the definition of parental cancer, we did not include the following ICD-10 codes: N87.9, C44, D00-09 and D10-48 (for full list see online supplementary table 1). Parental cancer was included as a binary variable in the joint exposure analyses. In additional analyses, parental cancer was categorized in three groups according to the age standardized five year survival prognosis for the cancer type[22]: good ($\geq 85\%$ survival) intermediate (50% to 85% survival) and poor ($< 50\%$ survival).

Income loss

Income loss was calculated using the mothers yearly equivalized disposable household income (hereafter household income) which is the household post-tax income adjusted for household composition using the modified OECD scale. The household income two years before and two years after a parent was diagnosed with cancer was used to calculate the income loss. Calculation of income loss for children unexposed to parental cancer was based on the calendar year the corresponding exposed child experienced parental cancer. The difference between the mean of the household incomes two years before and two years after the diagnosis was calculated. An income loss was defined as a 10% drop or more and was modelled as a binary variable.

Covariates

The following covariates were included in the analyses: maternal and paternal age at childbirth, parental education, and maternal and paternal country of origin. Parental education was defined as the educational level of the parent with the highest completed educational level measured the year the child turned five years. Maternal and paternal country of origin was categorized into two groups: Denmark/Norway or other country. The sex of the child was considered to be a possible effect modifier. Interaction analyses however showed no significant difference, and the children were therefore not divided by sex in the analyses.

Statistical analyses

Multinomial logistic regression model was used to conduct joint exposure analyses and estimate relative risk ratios (RRR) and corresponding 95% confidence intervals (CIs). Parental cancer and income loss in childhood were combined into one exposure variable with the four categories: 1) neither exposed to parental cancer or income loss, 2) only exposed to parental cancer, 3) only exposed to income loss, 4) exposed to parental cancer and income loss, with the first category being the reference group. The analyses were adjusted for the covariates mentioned above. In the analyses with educational attainment as the outcome, the reference category was high education and in the analyses with personal income as the outcome, the fourth income (highest) quartile was the reference category. All analyses were stratified into two age groups, which approximately corresponds to primary school and lower secondary school; 1) children who turned 8-13 the year they were exposed to cancer and 2) children who turned 14-16 years the year they were exposed to cancer. This stratification was made because interaction analyses showed significant difference between the two age groups.

All statistical analyses were performed in STATA V.14.2.

RESULTS

As shown in table 1 (and online supplementary table 2), the Danish and Norwegian study populations display similar tendencies. In all populations about 1% were exposed to both parental cancer and an income loss (double exposed), and approximately 8% were exposed only to parental cancer. Between 7-9% were only exposed to an income loss. Danish double exposed children more often had mothers who originated from outside Denmark. Parents of children exposed to parental cancer only or parental cancer and income loss were 2-4 years older than the unexposed, and parents of children only exposed to parental cancer had higher educational attainments. (For child's educational level see online supplementary table 3).

Table 1 Baseline characteristics of children in the Danish and Norwegian population with the outcome: Child's educational level

| Characteristics | Ages between 8-13 years* | | | | Ages between 14-16 years† | | | |
|--|---|--|--|-------------------------------------|---|--|--|-------------------------------------|
| | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) |
| Characteristics of Danish children § | | | | | | | | |
| Total | 84.0 | 8.1 | 6.9 | 0.9 | 83.0 | 7.9 | 8.0 | 1.1 |
| Child's sex | | | | | | | | |
| Male | 84.2 | 8.1 | 6.7 | 1.0 | 83.2 | 8.0 | 7.7 | 1.1 |
| Female | 83.8 | 8.2 | 7.0 | 0.9 | 82.6 | 7.9 | 8.2 | 1.2 |
| Maternal country of origin | | | | | | | | |
| Denmark | 84.1 | 8.2 | 6.8 | 0.9 | 82.9 | 8.0 | 8.0 | 1.1 |
| Other country | 82.0 | 6.7 | 9.6 | 1.8 | 84.4 | 6.4 | 7.6 | 1.6 |
| Paternal country of origin | | | | | | | | |
| Denmark | 84.0 | 8.2 | 6.8 | 0.9 | 82.9 | 8.0 | 7.9 | 1.1 |
| Other country | 84.3 | 6.6 | 8.0 | 1.2 | 84.2 | 5.5 | 8.9 | 1.4 |
| Parental educational level ‡ | | | | | | | | |
| Low | 83.5 | 7.3 | 8.0 | 1.2 | 82.6 | 7.6 | 8.6 | 1.2 |
| Medium | 84.1 | 7.6 | 7.3 | 1.0 | 83.2 | 7.4 | 8.2 | 1.2 |
| High | 84.3 | 9.5 | 5.5 | 0.7 | 82.7 | 9.1 | 7.1 | 1.1 |
| Maternal age at childbirth (mean and SD) | 27 (4.7) | 29 (5.1) | 27 (5.0) | 29 (5.9) | 27 (4.7) | 29 (5.0) | 27 (5.1) | 30 (5.2) |
| Paternal age at childbirth (mean and SD) | 30 (5.5) | 33 (6.5) | 30 (6.0) | 33 (6.8) | 30 (5.4) | 33 (6.5) | 30 (6.2) | 34 (6.7) |
| Characteristics of Norwegian children ¶ | | | | | | | | |
| Total | 82.6 | 8.0 | 8.3 | 1.0 | 82.3 | 7.9 | 8.6 | 1.2 |
| Child's sex | | | | | | | | |
| Male | 82.5 | 8.1 | 8.3 | 1.0 | 82.3 | 8.2 | 8.4 | 1.1 |
| Female | 82.6 | 8.0 | 8.3 | 1.1 | 82.3 | 7.7 | 8.7 | 1.2 |
| Maternal country of origin | | | | | | | | |
| Norway | 82.7 | 8.0 | 8.2 | 1.1 | 82.4 | 8.0 | 8.5 | 1.1 |
| Other country | 82.9 | 8.1 | 10.0 | 1.0 | 81.0 | 7.5 | 10.1 | 1.4 |
| Paternal country of origin | | | | | | | | |
| Norway | 82.7 | 8.0 | 8.2 | 1.1 | 82.5 | 8.0 | 8.5 | 1.1 |
| Other country | 80.7 | 8.4 | 9.7 | 1.2 | 80.9 | 7.7 | 10.1 | 1.4 |
| Parental educational level ‡ | | | | | | | | |
| Low | 82.0 | 6.2 | 10.7 | 1.1 | 81.5 | 6.8 | 10.5 | 1.3 |
| Medium | 83.2 | 7.9 | 8.0 | 0.90 | 83.4 | 7.6 | 8.0 | 1.0 |
| High | 82.1 | 8.9 | 7.8 | 1.20 | 81.4 | 8.8 | 8.6 | 1.2 |
| Maternal age at childbirth (mean and SD) | 27 (4.9) | 30 (5.2) | 26 (5.1) | 29 (5.5) | 27 (4.9) | 29 (5.3) | 27 (5.3) | 29 (5.9) |
| Paternal age at childbirth (mean and SD) | 30 (5.5) | 33 (6.7) | 29 (5.7) | 33 (7.0) | 30 (5.5) | 33 (6.6) | 30 (5.9) | 33 (7.6) |

* Experience of parental cancer and/or income loss between the calendar year the child turned 8 and 13 years old.

† Experience of parental cancer and/or income loss between the calendar year the child turned 14 and 16 years old.

‡ The highest of the parents' completed educational level measured the year the child turned five years old.

§ Number of Danish children exposed at ages 8-13 years are 27,841 and at ages 14-16 years are 44,363.

¶ Number of Norwegian children exposed at ages 8-13 years are 33,099 and at ages 14-16 years are 46,167.

Educational attainment at age 30 years

Table 2 shows the results from the joint exposure model. The crude and adjusted estimates did not differ substantially in most cases.

We found no clear association between exposure to parental cancer only and educational level at age 30 years apart from an indication of a higher risk of low education relative to a high education (RRR:1.33; 95%CI 1.16 to 1.52) for Danish children exposed at ages 8-13.

For children only exposed to an income loss the risk of low education, relative to high, was between 27%-46% higher than for children not exposed to parental cancer or income loss. For medium education, the association was weaker and only seemed to be present if the child was exposed at ages 8-13 years.

For double exposed children the risk of low education, relative to high, were between 42%-70% higher than unexposed children. For medium education, the risk were between 19%-38% higher. The double exposed children had a higher risk of low and medium education, relative to high, than children exposed to either parental cancer or income loss.

In an additional analysis, we found a 26-79% higher risk of low education, relative to high, if the parent's cancer type had an intermediate or poor prognosis for both age groups in both countries (table 3).

Overall no clear differences were found between the Danish and Norwegian cohorts in the analyses with educational level.

Table 2 Multinomial logistic regression with joint exposure analyses of parental cancer and income loss during childhood and educational level at age 30 years

| | Model 1 – Unadjusted* | | Model 2 – Adjusted*† | |
|---------------------------------|---------------------------------------|--|---------------------------------------|--|
| | Low education RRR (95% CI) | Medium education RRR (95% CI) | Low education RRR (95% CI) | Medium education RRR (95% CI) |
| Danish children | | | | |
| Exposed at age 8-13 (n=27,841) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.08 (0.95–1.22) | 0.95 (0.86–1.05) | 1.33 (1.16–1.52) | 1.09 (0.99–1.21) |
| – Parental cancer + Income loss | 1.60 (1.41–1.82) | 1.25 (1.13–1.39) | 1.46 (1.27–1.67) | 1.18 (1.06–1.32) |
| + Parental cancer + Income loss | 1.56 (1.10–2.21) | 1.41 (1.07–1.87) | 1.52 (1.07–2.17) | 1.42 (1.07–1.88) |
| Exposed at age 14-16 (n=44,363) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.93 (0.84–1.03) | 0.91 (0.85–0.98) | 1.10 (0.98–1.22) | 1.02 (0.94–1.10) |
| – Parental cancer + Income loss | 1.44 (1.31–1.58) | 1.10 (1.02–1.19) | 1.41 (1.27–1.56) | 1.08 (1.00–1.17) |
| + Parental cancer + Income loss | 1.28 (0.99–1.66) | 1.11 (0.91–1.36) | 1.42 (1.09–1.87) | 1.19 (0.96–1.47) |
| Norwegian children | | | | |
| Exposed at age 8-13 (n=33,099) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.91 (0.81–1.02) | 0.97 (0.89–1.07) | 1.08 (0.96–1.22) | 1.09 (0.99–1.21) |
| – Parental cancer + Income loss | 1.40 (1.26–1.55) | 1.14 (1.04–1.25) | 1.27 (1.14–1.41) | 1.10 (1.00–1.21) |
| + Parental cancer + Income loss | 1.48 (1.12–1.97) | 1.16 (0.90–1.48) | 1.70 (1.24–2.33) | 1.29 (0.99–1.68) |
| Exposed at age 14-16 (n=46,167) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.89 (0.81–0.98) | 0.91 (0.84–0.98) | 1.03 (0.93–1.14) | 0.99 (0.92–1.08) |
| – Parental cancer + Income loss | 1.46 (1.34–1.59) | 1.02 (0.94–1.10) | 1.43 (1.31–1.57) | 1.03 (0.95–1.12) |
| + Parental cancer + Income loss | 1.39 (1.10–1.75) | 1.13 (0.93–1.37) | 1.56 (1.22–1.98) | 1.25 (1.02–1.53) |

*Reference group is unexposed to parental cancer and income loss, and reference category is high educational level.

†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.

Table 3 Multinomial logistic regression with 5-year prognosis of the parent's cancer type and educational level at age 30 years

| | Model 1 – Unadjusted* | | Model 2 – Adjusted*† | |
|---------------------------------|-------------------------------|----------------------------------|-------------------------------|----------------------------------|
| | Low education RRR (95% CI) | Medium education RRR (95% CI) | Low education RRR (95% CI) | Medium education RRR (95% CI) |
| Danish children | | | | |
| Exposed at age 8-13 (n=2,531) | | | | |
| 5-year prognosis of cancer type | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.53 (1.18–1.99) | 1.28 (1.05–1.57) | 1.26 (0.95–1.68) | 1.17 (0.94–1.45) |
| Poor | 2.03 (1.53–2.69) | 1.33 (1.05–1.67) | 1.64 (1.22–2.21) | 1.19 (0.94–1.52) |
| Exposed at age 14-16 (n=4,033) | | | | |
| 5-year prognosis of cancer type | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.78 (1.42–2.22) | 1.44 (1.22–1.69) | 1.53 (1.21–1.94) | 1.34 (1.13–1.58) |
| Poor | 2.40 (1.91–3.01) | 1.57 (1.33–1.87) | 1.79 (1.40–2.28) | 1.37 (1.15–1.64) |
| Norwegian children | | | | |
| Exposed at age 8-13 (n=2,798) | | | | |
| 5-year prognosis of cancer type | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.62 (1.29–2.05) | 1.18 (0.98–1.42) | 1.57 (1.23–2.01) | 1.17 (0.97–1.42) |
| Poor | 1.73 (1.24–2.43) | 1.20 (0.90–1.61) | 1.57 (1.09–2.26) | 1.17 (0.86–1.58) |
| Exposed at age 14-16 (n=3,926) | | | | |
| 5-year prognosis of cancer type | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.51 (1.24–1.84) | 1.23 (1.05–1.43) | 1.30 (1.06–1.60) | 1.11 (0.94–1.30) |
| Poor | 1.86 (1.43–2.43) | 1.40 (1.12–1.74) | 1.39 (1.03–1.86) | 1.15 (0.92–1.46) |

*Reference group is 'good' five-year prognosis of cancer type and reference category is high education.

†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.

Personal yearly income at age 30 years

Like for educational level as the outcome, the crude and adjusted estimates did not substantially differ in most analyses with personal income at age 30 years as the outcome (table 4).

A slight tendency of higher risk of an income in the first quartile, relative to the fourth, was seen in children exposed to parental cancer only compared to unexposed children, but no clear association was found.

Children exposed to an income loss only had a 20-32% higher risk of having an income in the first quartile, relative to the fourth, compared to unexposed children.

Double exposed children had a 24-46% higher risk of having an income in the first or second income quartile, relative to the fourth, compared to unexposed children. No associations were found between being double exposed and having an income in the third, relative to the fourth, quartile.

We further found no clear differences in association between the cancer prognosis and the child's income level at age 30 years (table 5).

No distinct overall country differences were seen in the analyses with personal income.

Table 4 Multinomial logistic regression with joint exposure analyses of parental cancer and income loss during childhood and personal income level at age 30 years

| | Model 1 – Unadjusted* | | | Model 2 – Adjusted*† | | |
|------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|-----------------------------------|---------------------------------------|--------------------------------------|
| | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) |
| Danish children | | | | | | |
| Exposed at age 8-13 (n=28,567) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.12 (0.99–1.26) | 1.01 (0.89–1.14) | 0.97 (0.86–1.10) | 1.15 (1.02–1.30) | 1.07 (0.95–1.21) | 1.02 (0.90–1.16) |
| – Parental cancer + Income loss | 1.37 (1.21–1.56) | 1.12 (0.98–1.28) | 1.06 (0.92–1.21) | 1.31 (1.15–1.49) | 1.06 (0.93–1.21) | 1.02 (0.89–1.17) |
| + Parental cancer + Income loss | 1.54 (1.08–2.18) | 1.29 (0.90–1.85) | 1.05 (0.73–1.53) | 1.46 (1.03–2.08) | 1.25 (0.87–1.79) | 1.05 (0.73–1.53) |
| Exposed at age 14-16 (n=45,210) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.11 (1.01–1.22) | 0.97 (0.88–1.07) | 0.99 (0.89–1.09) | 1.14 (1.03–1.25) | 1.02 (0.92–1.12) | 1.02 (0.92–1.12) |
| – Parental cancer + Income loss | 1.35 (1.22–1.49) | 1.12 (1.01–1.23) | 1.01 (0.91–1.12) | 1.32 (1.20–1.46) | 1.10 (0.99–1.21) | 1.00 (0.90–1.11) |
| + Parental cancer + Income loss | 1.25 (0.97–1.60) | 1.08 (0.84–1.39) | 0.95 (0.74–1.23) | 1.24 (0.96–1.59) | 1.10 (0.85–1.41) | 0.96 (0.75–1.24) |
| Norwegian children | | | | | | |
| Exposed at age 8-13 (n=33,022) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.01 (0.90–1.13) | 0.99 (0.89–1.11) | 0.95 (0.84–1.06) | 1.05 (0.94–1.19) | 1.08 (0.96–1.21) | 0.97 (0.86–1.09) |
| – Parental cancer + Income loss | 1.26 (1.12–1.41) | 1.09 (0.97–1.22) | 1.02 (0.91–1.15) | 1.20 (1.08–1.35) | 1.04 (0.93–1.17) | 1.01 (0.90–1.13) |
| + Parental cancer + Income loss | 1.26 (0.92–1.72) | 1.12 (0.82–1.53) | 0.97 (0.70–1.33) | 1.28 (0.94–1.75) | 1.18 (0.86–1.62) | 0.98 (0.71–1.36) |
| Exposed at age 14-16 (n=45,991) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.94 (0.85–1.03) | 0.90 (0.82–0.99) | 0.93 (0.85–1.03) | 0.99 (0.89–1.09) | 0.97 (0.88–1.07) | 0.96 (0.87–1.06) |
| – Parental cancer + Income loss | 1.30 (1.19–1.42) | 1.08 (0.98–1.19) | 0.94 (0.85–1.03) | 1.26 (1.15–1.38) | 1.05 (0.96–1.16) | 0.93 (0.84–1.03) |
| + Parental cancer + Income loss | 1.35 (1.05–1.72) | 1.20 (0.93–1.54) | 0.95 (0.72–1.24) | 1.37 (1.07–1.76) | 1.27 (0.98–1.63) | 0.97 (0.74–1.27) |

*Reference group is unexposed to parental cancer and income loss, and reference category is the fourth personal income quartile at the age of 30 years.
†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.

Table 5 Multinomial logistic regression with the 5-year prognosis of the parent's cancer type and personal income level at age 30

| | Model 1 – Unadjusted* | | | Model 2 – Adjusted*† | | |
|---------------------------------|-----------------------------|------------------------------|-----------------------------|-----------------------------|------------------------------|-----------------------------|
| | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) |
| Danish children | | | | | | |
| Exposed at age 8-13 (n=2,597) | | | | | | |
| 5-year prognosis of cancer type | | | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 0.93 (0.72–1.20) | 1.10 (0.85–1.42) | 0.96 (0.74–1.23) | 0.85 (0.65–1.10) | 1.03 (0.79–1.33) | 0.94 (0.72–1.23) |
| Poor | 1.23 (0.93–1.63) | 1.24 (0.93–1.64) | 0.88 (0.65–1.19) | 1.12 (0.84–1.49) | 1.11 (0.83–1.48) | 0.86 (0.64–1.17) |
| Exposed at age 14-16 (n=4,110) | | | | | | |
| 5-year prognosis of cancer type | | | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.42 (1.16–1.74) | 1.27 (1.03–1.57) | 1.37 (1.11–1.69) | 1.32 (1.07–1.63) | 1.15 (0.93–1.42) | 1.31 (1.06–1.61) |
| Poor | 1.33 (1.07–1.64) | 1.13 (0.91–1.40) | 1.04 (0.83–1.29) | 1.15 (0.93–1.43) | 0.94 (0.75–1.18) | 0.96 (0.76–1.20) |
| Norwegian children | | | | | | |
| Exposed at age 8-13 (n=2,918) | | | | | | |
| 5-year prognosis of cancer type | | | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.16 (0.92–1.46) | 1.08 (0.86–1.36) | 1.00 (0.79–1.27) | 1.10 (0.87–1.39) | 1.03 (0.82–1.31) | 0.99 (0.79–1.26) |
| Poor | 1.33 (0.92–1.93) | 1.22 (0.85–1.74) | 1.11 (0.78–1.60) | 1.19 (0.82–1.73) | 1.12 (0.78–1.61) | 1.08 (0.75–1.57) |
| Exposed at age 14-16 (n=4,297) | | | | | | |
| 5-year prognosis of cancer type | | | | | | |
| Good | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Intermediate | 1.28 (1.05–1.56) | 1.14 (0.93–1.39) | 1.18 (0.97–1.44) | 1.19 (0.98–1.46) | 1.07 (0.87–1.31) | 1.14 (0.94–1.40) |
| Poor | 1.37 (1.02–1.83) | 1.37 (1.02–1.83) | 1.21 (0.90–1.63) | 1.19 (0.88–1.60) | 1.21 (0.89–1.62) | 1.15 (0.86–1.55) |

*Reference group is 'good' five-year prognosis of cancer type and reference category is high education.

†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.

DISCUSSION

In this Danish and Norwegian register-based study, the results suggest that children exposed to both parental cancer and an income loss in childhood overall had a higher risk of having a low or medium educational level and a personal income in one of the two lowest income quartiles at the age of 30 years, compared to unexposed children. These associations were in most analyses stronger than for children exposed to only parental cancer or only an income loss during childhood.

No overall distinct country differences were seen between the Danish and Norwegian cohorts, but one needs to be aware of the reference groups not being the same in the two countries. Overall no strong differences were observed between the age groups.

Studies on parental cancer in childhood have found higher risk of low stress resilience in the children around the age of 18 years, and also higher reported anxiety levels between ages 18 to 25 years.[23,24] Economic hardship in childhood have also been correlated with poorer psychological health [25,26] and emotional problems.[27] Stress and anxiety are associated with socioeconomic indicators such as low education and income,[28,29] and it is therefore possible that such problems mediate the associations between exposure to parental cancer and income loss during childhood and the child's SEP in early adulthood. For future research it would therefore be beneficial to investigate possible mediating effects of e.g. poor mental health.

In a Danish register-based study parental cancer was associated with a slightly lower grade point average in ninth grade and a higher risk of both low educational level and having an income in the lowest quartile at age 30 years.[11] The study population of this study overlap with this study's Danish populations. Financial stress during childhood have been associated with lower school readiness, school engagement, educational aspirations, and academic achievement.[16,17,30] Our results indirectly support these findings, as there is an association between school performance and SEP in adulthood.[12,31] Lower educational level and lower disposable income have also been found among children who experienced childhood poverty.[32,33]

SEP in adulthood has been found to be a good predictor of a person's health[34] and seen in this perspective, our results suggest that a child's health might be more negatively affected long term if exposed to an additional financial burden in the same period as parental cancer.

Although no policy implications can be taken from one study, this study points to a possible benefit of financial support for families when a parent is diagnosed with cancer, to reduce the extra burden of an income loss.

Strengths and limitations

Strengths of this study include the prospective design which ensured temporality between the exposures and the outcomes. The use of Danish and Norwegian nationwide registers ensured relatively large study populations and also reduced the risk of selection bias and recall bias.

Non-differential misclassification of parental cancer may arise if some children in the study do not have contact with the ill parent, which would lead to an underestimation of the association. Children without contact to their mother are possibly misclassified regarding exposure to income loss because the mother's household income was used to calculate the income loss. The same is true for children whose father experiences a loss of income without living together with the children's mother. We, however, used the mother's income because children with divorced parents on average see their mother more than their father.[35]

The stronger associations found with lower educational attainment for children exposed to severe cancer types indicates that parental death could be a part of the effect. The field would thus benefit from future studies including this factor in proper mediation analyses.

Severe illnesses other than cancer were not included in the study as these data are not available for Norway until 1997. This may attenuate the association, if other parental diagnoses have similar effect on the child's SEP in young adulthood. Parental cancer was chosen because the register data

on cancer are of high quality in Denmark and Norway, and to avoid the risk of including different types of illnesses that possibly affect children differently.

It was not possible to use a method of estimating the additive interaction effect of parental cancer and income loss because no such methods has been developed for joint exposure analyses performed using multinomial logistic regression.[36]

Due to the income loss being measured over a five-year period, it is expected that the family income on average would increase following the general trend for parents of working ages in both Denmark and Norway.[37,38] Thus, a 10% income loss could indicate a loss of expected profit that is higher than 10%. It has been shown that the association between poverty in childhood and educational attainment is stronger the lower the family income is.[32] This could indicate that the size of the income play a role in the effect of an income loss. The 10% cutoff for the income loss was chosen as this level was assumed to influence most families regardless of income level. Moreover, analyses using a cutoff of 20% showed the same tendencies as when using the 10% cutoff although some of the associations with low income and low education were weaker in both countries for the double exposed children (See data in online supplementary table 4 and 5). Among the double exposed children in this study, not all income losses were due to parental cancer. However, we did see a higher occurrence of income loss among children exposed to parental cancer.

The income level at age 30 years was included as a categorical variable to examine the risk of being in the lower categories relative to the higher and not only the average difference between the exposed and unexposed.

Due to data availability, it was not possible to include earlier exposure years than age 8-16 years or later outcome years than age 30 years. Exposures in early childhood were therefore not included as the children would not be old enough at follow-up for most of them to have completed their education.

It is possible that children who experienced parental cancer and income loss to a greater extend finished their education after the age of 30 years and thus the associations found may potentially result from a later completion of education among the exposed children. In general, educational and income levels have been found to represent different aspects of SEP and as this may be particularly relevant around age 30 years, we included both as outcome measures.[39]

We have adjusted the analysis for relevant confounders, however, there is still risk of unmeasured or residual confounding. The binary categorization of the parents' country of origin may be too coarse and could result in residual confounding. It was however not possible to divide the variable into more categories due to few observations in some groups.

Also, the risk of the associations being affected by or due to unmeasured confounding cannot be ruled out, especially because the associations in general are weak. However, several of the described biases would likely result in underestimation of the associations.

CONCLUSION

Our study showed that exposure to both parental cancer and income loss during childhood was negatively associated with the child's socioeconomic position in early adulthood measured by lower income and educational attainment. The same trend was observed for children only exposed to an income loss and to some extend also for those only exposed to parental cancer, though these

correlations were weaker. The associations with educational attainment were stronger for more severe cancer types.

Data Availability Statement

Data may be obtained from a third party and are not publicly available. The Danish data can be made available after application to the Research Service Center at Statistics Denmark (forskningsservice@dst.dk) and the Danish Health Data Authority (forsknerservice@sundhedsdata.dk), and the Norwegian data can be made available after application to Statistics Norway (mikrodata@ssb.no) and the Cancer Registry of Norway (datautlevering@krefregisteret.no).

Ethics Statement

Patient consent for publication

The investigations do not involve personal contact with patients/informants and informed consent is not required for register-based studies in Denmark or Norway.

Ethics approval

The processing and linkage of data were approved by the Danish Data Protection Agency (UCPH reference number: 514-0230/18-3000). Ethical approval or informed consent was not required for register-based studies according to Danish legislation.

Contributorship Statement

AMNA, SKU and MK developed the study and the study methods. MK and SKU conducted the Danish statistical analyses and AH conducted the Norwegian statistical analyses. MK and SKU drafted the manuscript. All authors interpreted study results and critically reviewed the manuscript. All authors approved the final manuscript as submitted.

Acknowledgements

We thank the WELLIFE group for discussion and valuable comments on the manuscript. The Danish data were accessed from The Public Health Database at Department of Public Health at University of Copenhagen and the authors acknowledge the secretariat of the database for the hard work in regards to operating and establishing project data. We also wish to thank Lise Kristine Højsgaard Schmidt for her help in constructing the Danish cohort from the administrative data.

Funding

This study was supported by NordForsk under grant agreement number 83540 (WELLIFE).

Competing interests

None declared.

REFERENCES

- 1 Braveman P, Gottlieb L. The Social Determinants of Health: It's Time to Consider the Causes of the Causes. *Public Health Rep* 2014;129(Suppl 2):19–31.
- 2 Šaltytė Benth J, Dahl FA, Lurås H, et al. A controlled study of income development for breast cancer survivors in Norway. *J Cancer Surviv* 2014;8:239–47.

- 3 Hauglann B, Benth JS, Fosså SD, et al. A controlled cohort study of long-term income in colorectal cancer patients. *Support Care Cancer* 2014;22:2821–30.
- 4 Andersen I, Kolodziejczyk C, Thielen K, et al. The effect of breast cancer on personal income three years after diagnosis by cancer stage and education: a register-based cohort study among Danish females. *BMC Public Health* 2015;15:50.
- 5 Jensen LS, Overgaard C, Bøggild H, et al. The long-term financial consequences of breast cancer: a Danish registry-based cohort study. *BMC Public Health* 2017;17:853.
- 6 Elstad JI, Hermansen Å, Brønnum-Hansen H, et al. Income security in Nordic welfare states for men and women who died when aged 55–69 years old. *Journal of International and Comparative Social Policy* 2019;35:157–76.
- 7 Visser A, Huizinga GA, van der Graaf WT, et al. The impact of parental cancer on children and the family: a review of the literature. *Cancer Treat Rev* 2004;30:683–94.
- 8 Grabiak BR, Bender CM, Puskar KR. The impact of parental cancer on the adolescent: an analysis of the literature. *Psychooncology* 2007;16:127–37.
- 9 Morris JN, Martini A, Preen D. The well-being of children impacted by a parent with cancer: an integrative review. *Support Care Cancer* 2016;24:3235–51.
- 10 Faccio F, Ferrari F, Pravettoni G. When a parent has cancer: How does it impact on children's psychosocial functioning? A systematic review. *Eur J Cancer Care (Engl)*. 2018;27:e12895.
- 11 Joergensen AC, Urhoj SK, Andersen AMN. Primary school achievement and socioeconomic attainment in individuals affected by parental cancer in childhood or adolescence: a Danish nationwide register-based study. *J Epidemiol Community Health* 2018;72:982–989.
- 12 French MT, Homer JF, Popovici I, et al. What You Do in High School Matters: High School GPA, Educational Attainment, and Labor Market Earnings as a Young Adult. *East Econ J* 2015;41:370–86.
- 13 Ponnet K. Financial stress, parent functioning and adolescent problem behavior: an actor-partner interdependence approach to family stress processes in low-, middle-, and high-income families. *J Youth Adolesc* 2014;43:1752–69.
- 14 Mistry RS, Vandewater EA, Huston AC, et al. Economic well-being and children's social adjustment: the role of family process in an ethnically diverse low-income sample. *Child Dev* 2002;73:935–51.
- 15 Dahl E, Birkelund GE. Health inequalities in later life in a social democratic welfare state. *Soc Sci Med* 1997;44:871–81.
- 16 Mistry RS, Benner AD, Tan CS, et al. Family economic stress and academic well-being among Chinese-American youth: the influence of adolescents' perceptions of economic strain. *J Fam Psychol* 2009;23:279–90.

- 17 Kiang L, Andrews K, Stein GL, et al. Socioeconomic stress and academic adjustment among Asian American adolescents: the protective role of family obligation. *J Youth Adolesc* 2013;42:837–47.
- 18 Kuh D. Life course epidemiology. *J Epidemiol Community Health*. 2003;57:778–83.
- 19 Compas BE, Worsham NL, Epping-Jordan JE, et al. When mom or dad has cancer: markers of psychological distress in cancer patients, spouses, and children. *Health Psychol* 1994;13:507–15.
- 20 Hoke LA. Psychosocial adjustment in children of mothers with breast cancer. *Psychooncology* 2001;10:361–9.
- 21 Krane L, Johnsen R, Fleten N, Nielsen CV, Stapelfeldt CM, Jensen C, et al. Sickness absence patterns and trends in the health care sector: 5-year monitoring of female municipal employees in the health and care sectors in Norway and Denmark. *Hum Resour Health*. 2014;12:37.
- 22 NORDCAN. Table by period and cancer (Survival). 2019. Available: <https://www-dep.iarc.fr/nordcan/dk/frame.asp> [Accessed 30 May 2022].
- 23 Metcalf CA, Arch JJ, Greer JA, et al. Anxiety and its correlates among young adults with a history of parental cancer. *J Psychosoc Oncol* 2017;35:597–613.
- 24 Chen R, Fall K, Czene K, et al. Impact of parental cancer on IQ, stress resilience, and physical fitness in young men. *Clin Epidemiol* 2018;10:593–604.
- 25 Lindström M, Fridh M, Rosvall M. Economic stress in childhood and adulthood, and poor psychological health: Three life course hypotheses. *Psychiatry Res* 2014;215:386–93.
- 26 Morrissey K, Kinderman P. The impact of financial hardship in childhood on depression and anxiety in adult life: Testing the accumulation, critical period and social mobility hypotheses. *SSM Popul Health* 2020;11:100592.
- 27 Conger RD, Ge X, Elder GH, et al. Economic stress, coercive family process, and developmental problems of adolescents. *Child Dev* 1994;65:541–61.
- 28 Nielsen L, Curtis T, Kristensen TS, et al. What characterizes persons with high levels of perceived stress in Denmark? A national representative study. *Scand J Public Health* 2008;36:369–79.
- 29 Hakulinen C, Elovainio M, Arffman M, et al. Mental disorders and long-term labour market outcomes: nationwide cohort study of 2 055 720 individuals. *Acta Psychiatr Scand* 2019;140:371–81.
- 30 Anderson RE. And still WE rise: Parent-child relationships, resilience, and school readiness in low-income urban Black families. *J Fam Psychol* 2018;32:60–70.
- 31 Klapp A. Does grading affect educational attainment? A longitudinal study. *Assess Educ* 2015;22:302–23.

- 32 Løken KV, Mogstad M, Wiswall M. What Linear Estimators Miss: The Effects of Family Income on Child Outcomes. *Am Econ J Appl Econ* 2012;4:1–35.
- 33 Lesner RV. The long-term effect of childhood poverty. *J Popul Econ* 2018;31:969–1004.
- 34 Glymour MM, Avendano M, Kawachi I. Socioeconomic Status and Health. In: Berkman LF, Kawachi I, Glymour MM, eds. *Social Epidemiology*. Oxford University Press 2014:17–62.
- 35 Ottosen MH, Stage SMH. Delebørn i tal: en analyse af skilsmissebørns samvær baseret på SFI's børneforløbsundersøgelse. København: *SFI-Det Nationale Forskningscenter for Velfærd*, 2012.
- 36 de Mutsert R, Jager KJ, Zoccali C, et al. The effect of joint exposures: examining the presence of interaction. *Kidney Int* 2009;75:677–81.
- 37 Statistics Denmark. INDKP106: Disposable income by income interval, age, sex, unit, region and time. *StatBank Denmark*. Available: <https://www.statistikbanken.dk/10331> [Accessed 30 May 2022].
- 38 Statistics Norway. 06248: Working income and personal income. Number of residents 17 years and older, by sex and age 1993 - 2019. Available: <https://www.ssb.no/en/statbank/table/06248> [Accessed 30 May 2022].
- 39 Galobardes B, Lynch J, Smith GD. Measuring socioeconomic position in health research. *Br Med Bull*. 2007;81–82:21–37.

SUPPLEMENTS

Figure 1: Lexis-diagram of Danish study population

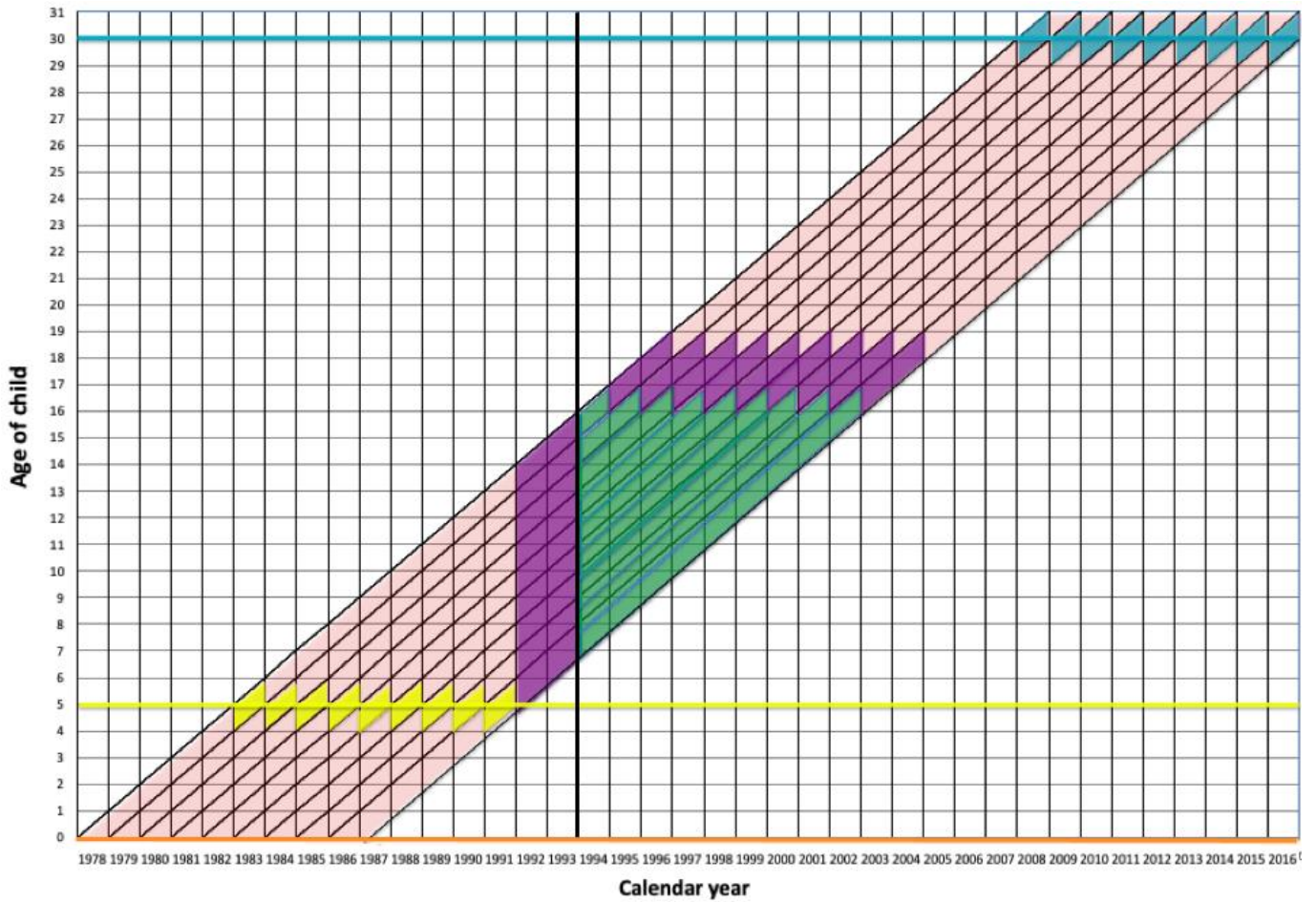


Illustration of the Danish cohort (pink area) born between 1978-1986. The time of exposure to parental cancer is illustrated by the green area, and the period where data on the mother's household income was used to calculate income loss is shown by the purple area. The vertical black line illustrates that children were included in the study from the beginning of 1994. In addition it is illustrated when the socioeconomic outcomes were measured (blue area) as well as when the confounders: parent's level of education (yellow area) and parent age (orange area) were measured.

Figure 2: Lexis-diagram of Norwegian study population

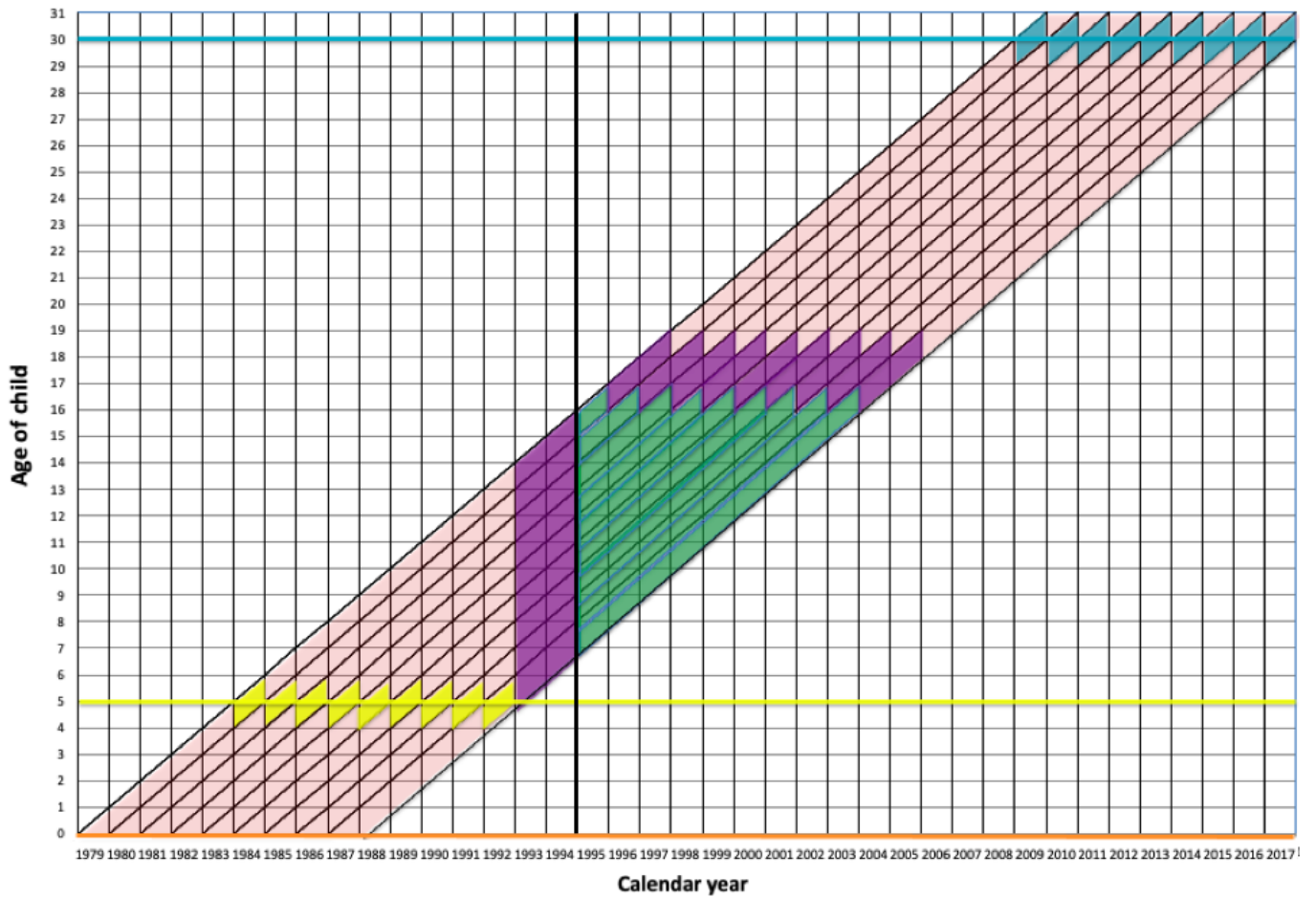
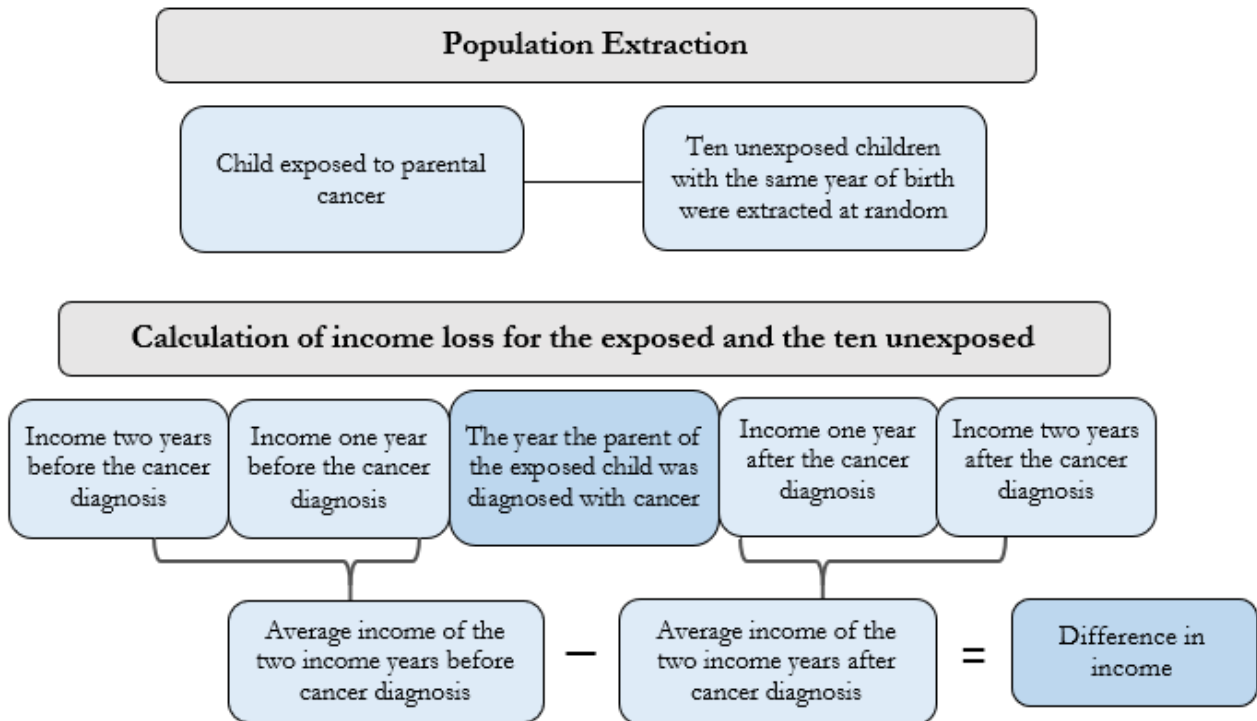


Illustration of the Norwegian cohort (pink area) born between 1979-1987. The time of exposure to parental cancer is illustrated by the green area, and the period where data on the mother's household income was used to calculate income loss is shown by the purple area. The vertical black line illustrates that children were included in the study from the beginning of 1995. In addition it is illustrated when the socioeconomic outcomes were measured (blue area) as well as when the confounders: parent's level of education (yellow area) and parent age (orange area) were measured.

Figure 3 Extraction of populations



For each child exposed to parental cancer, ten unexposed children with the same year of birth and without missing data on the mother's household income were randomly selected. The loss of income for the cancer-exposed child and the ten unexposed children was calculated based on the year the exposed child first experienced parental cancer. Difference in income was calculated based on the difference between the average of the mother's equivalent disposable household income two years before and two years after the calendar year. If the difference in income amounted to a drop of ten percent or more, it was defined as an income loss.

Figure 4: Flowchart of inclusion process for Danish populations

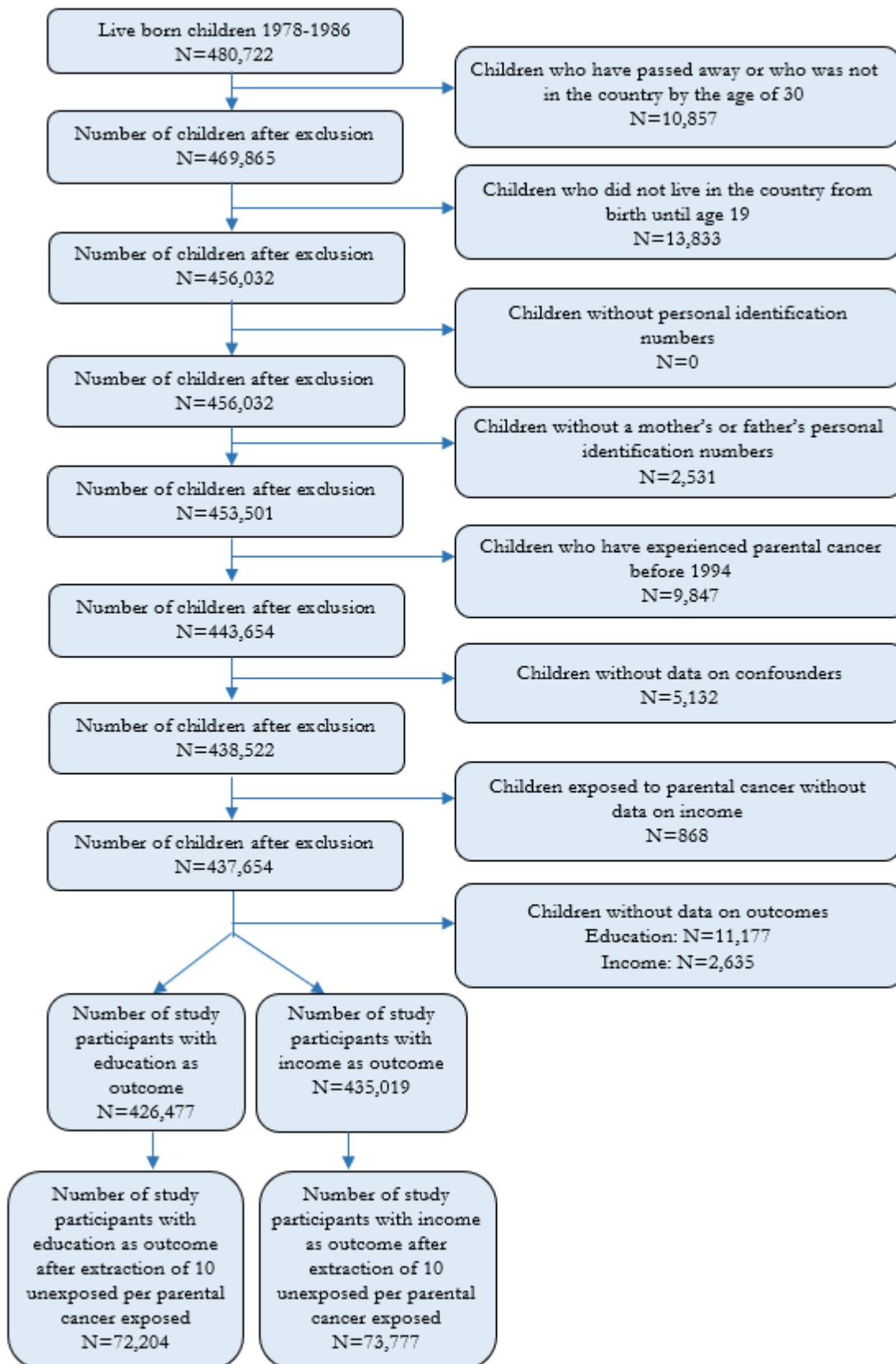
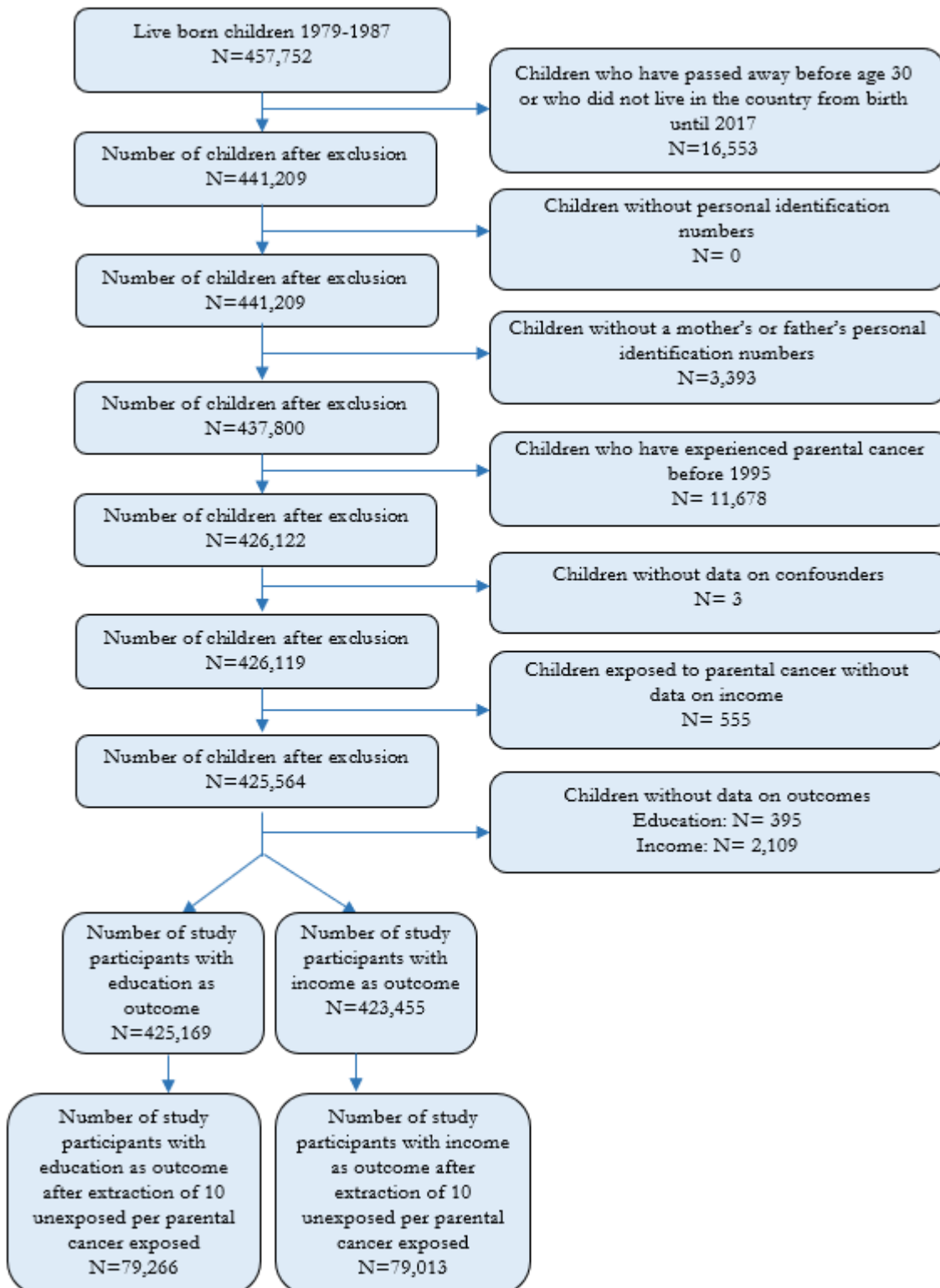


Figure 5: Flowchart of inclusion process for Norwegian populations



Supplementary Table 1 Definition of cancer (ICD-8 and ICD-10 codes)

ICD-10 codes included

C00-C97 Malignant neoplasms, except C44 Other malignant neoplasms of skin

ICD-8 codes included and translated into ICD-10 codes

140-209 Malignant neoplasms, except 173 Other malignant neoplasms of skin

Supplementary Table 2 Baseline characteristics of children in the Danish and Norwegian population with the outcome: Personal income level

| Characteristics | Ages between 8-13 years* | | | | Ages between 14-16 years† | | | |
|--|---|--|--|-------------------------------------|---|--|--|-------------------------------------|
| | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) |
| Characteristics of Danish children § | | | | | | | | |
| Total | 83.9 | 8.2 | 7.0 | 0.9 | 83.2 | 8.0 | 7.7 | 1.1 |
| Child's sex | | | | | | | | |
| Male | 84.3 | 8.0 | 6.8 | 0.9 | 83.3 | 8.1 | 7.6 | 1.1 |
| Female | 83.4 | 8.4 | 7.3 | 0.9 | 83.1 | 7.9 | 7.9 | 1.2 |
| Maternal country of origin | | | | | | | | |
| Denmark | 83.9 | 8.2 | 7.0 | 0.9 | 83.2 | 8.0 | 7.7 | 1.1 |
| Other country | 82.8 | 6.7 | 8.7 | 1.8 | 83.3 | 5.8 | 9.4 | 1.5 |
| Paternal country of origin | | | | | | | | |
| Denmark | 83.9 | 8.2 | 6.9 | 0.9 | 83.1 | 8.0 | 7.7 | 1.1 |
| Other country | 82.7 | 6.5 | 9.6 | 1.2 | 84.8 | 5.2 | 8.6 | 1.3 |
| Parental educational level ‡ | | | | | | | | |
| Low | 83.0 | 7.3 | 8.6 | 1.2 | 82.7 | 7.7 | 8.5 | 1.2 |
| Medium | 84.2 | 7.6 | 7.2 | 1.0 | 83.7 | 7.3 | 7.9 | 1.2 |
| High | 84.0 | 9.5 | 5.8 | 0.8 | 82.7 | 9.1 | 7.1 | 1.1 |
| Maternal age at childbirth (mean and SD) | 28 (4.7) | 29 (5.1) | 27 (5.0) | 29 (5.9) | 27 (4.6) | 29 (5.0) | 27 (5.1) | 30 (5.2) |
| Paternal age at childbirth (mean and SD) | 30 (5.6) | 33 (6.5) | 30 (6.0) | 33 (6.8) | 30 (5.4) | 33 (6.5) | 31 (6.5) | 34 (6.7) |
| Characteristics of Norwegian children ¶ | | | | | | | | |
| Total | 82.9 | 8.0 | 8.0 | 1.1 | 82.3 | 7.9 | 8.6 | 1.1 |
| Child's sex | | | | | | | | |
| Male | 83.0 | 8.1 | 7.8 | 1.0 | 82.2 | 8.2 | 8.5 | 1.1 |
| Female | 82.7 | 7.9 | 8.3 | 1.1 | 82.4 | 7.6 | 8.7 | 1.2 |
| Maternal country of origin | | | | | | | | |
| Norway | 83.0 | 8.0 | 7.9 | 1.1 | 82.5 | 8.0 | 8.4 | 1.1 |
| Other country | 81.4 | 8.2 | 9.4 | 1.0 | 79.9 | 7.6 | 11.1 | 1.4 |
| Paternal country of origin | | | | | | | | |
| Norway | 83.0 | 8.0 | 7.9 | 1.0 | 82.5 | 7.9 | 8.4 | 1.1 |
| Other country | 81.2 | 8.2 | 9.3 | 1.2 | 79.9 | 7.9 | 10.9 | 1.3 |
| Parental educational level ‡ | | | | | | | | |
| Low | 82.8 | 6.3 | 9.8 | 1.1 | 81.5 | 6.7 | 10.6 | 1.2 |
| Medium | 83.3 | 7.8 | 7.9 | 1.0 | 83.1 | 7.7 | 8.2 | 1.1 |
| High | 82.4 | 9.0 | 7.5 | 1.1 | 81.7 | 8.8 | 8.3 | 1.2 |
| Maternal age at childbirth (mean and SD) | 27 (4.9) | 30 (5.2) | 27 (5.1) | 29 (5.5) | 27 (4.9) | 29 (5.3) | 27 (5.3) | 29 (5.9) |
| Paternal age at childbirth (mean and SD) | 30 (5.5) | 33 (6.7) | 30 (6.1) | 33 (7.0) | 30 (5.5) | 33 (6.6) | 30 (6.0) | 33 (7.6) |

* Experience of parental cancer and/or income loss between the calendar year the child turned 8 and 13 years old.

† Experience of parental cancer and/or income loss between the calendar year the child turned 14 and 16 years old.

‡ The highest of the parents' completed educational level measured the year the child turned five years old.

§ Number of Danish children exposed at ages 8-13 years are 28,567 and at ages 14-16 years are 45,210

¶ Number of Norwegian children exposed at ages 8-13 years are 33,022 and at ages 14-16 years are 45,991.

Supplementary Table 3 Baseline characteristics of children in the Danish and Norwegian population with the outcome: Child's educational level

| Characteristics | Ages between 8-13 years* | | | | Ages between 14-16 years† | | | |
|--|---|--|--|-------------------------------------|---|--|--|-------------------------------------|
| | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) | No parental cancer and no income loss (%) | Parental cancer and no income loss (%) | No parental cancer and income loss (%) | Parental cancer and income loss (%) |
| Characteristics of Danish children § | | | | | | | | |
| Child's educational level | | | | | | | | |
| Low | 81,4% | 8,6% | 8,9% | 1,1% | 81,1% | 7,6% | 10,0% | 1,3% |
| Medium | 84,0% | 7,8% | 7,1% | 1,1% | 83,3% | 7,7% | 7,9% | 1,2% |
| High | 85,2% | 8,3% | 5,8% | 0,8% | 83,4% | 8,4% | 7,2% | 1,1% |
| Characteristics of Norwegian children ¶ | | | | | | | | |
| Child's educational level | | | | | | | | |
| Low | 81,0% | 7,4% | 10,3% | 1,3% | 80,2% | 7,3% | 11,2% | 1,4% |
| Medium | 82,4% | 8,0% | 8,5% | 1,1% | 83,1% | 7,6% | 8,1% | 1,2% |
| High | 83,2% | 8,3% | 7,5% | 0,9% | 82,7% | 8,4% | 7,9% | 1,0% |

* Experience of parental cancer and/or income loss between the calendar year the child turned 8 and 13 years old.

† Experience of parental cancer and/or income loss between the calendar year the child turned 14 and 16 years old.

§ Number of Danish children exposed at ages 8-13 years are 27,841 and at ages 14-16 years are 44,363.

¶ Number of Norwegian children exposed at ages 8-13 years are 33,099 and at ages 14-16 years are 46,167.

Supplementary Table 4 Multinomial logistic regression with joint exposure analyses of parental cancer and income loss (20%) during childhood and educational level at age 30 years

| | Model 1 – Unadjusted* | | Model 2 – Adjusted*† | |
|---------------------------------|---------------------------------------|--|---------------------------------------|--|
| | Low education RRR (95% CI) | Medium education RRR (95% CI) | Low education RRR (95% CI) | Medium education RRR (95% CI) |
| Danish children | | | | |
| Exposed at age 8-13 (n=27,841) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.09 (0.97–1.23) | 0.96 (0.88–1.06) | 1.33 (1.17–1.51) | 1.10 (1.00–1.22) |
| – Parental cancer + Income loss | 1.37 (1.15–1.64) | 1.21 (1.05–1.40) | 1.33 (1.10–1.61) | 1.19 (1.03–1.38) |
| + Parental cancer + Income loss | 1.10 (0.64–1.87) | 1.38 (0.93–2.05) | 1.13 (0.67–1.91) | 1.40 (0.96–2.04) |
| Exposed at age 14-16 (n=44,363) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.94 (0.85–1.04) | 0.92 (0.85–0.99) | 1.09 (0.98–1.22) | 1.02 (0.94–1.10) |
| – Parental cancer + Income loss | 1.27 (1.12–1.45) | 1.06 (0.95–1.18) | 1.29 (1.12–1.48) | 1.06 (0.95–1.18) |
| + Parental cancer + Income loss | 1.08 (0.76–1.53) | 1.30 (0.87–1.48) | 1.35 (0.92–1.96) | 1.30 (0.98–1.71) |
| Norwegian children | | | | |
| Exposed at age 8-13 (n=33,099) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.93 (0.84–1.04) | 0.99 (0.90–1.08) | 1.11 (0.99–1.25) | 1.11 (1.01–1.22) |
| – Parental cancer + Income loss | 1.54 (1.34–1.76) | 1.20 (1.06–1.36) | 1.41 (1.22–1.63) | 1.17 (1.03–1.33) |
| + Parental cancer + Income loss | 1.39 (0.92–2.10) | 1.01 (0.71–1.44) | 1.61 (1.04–2.48) | 1.10 (0.75–1.61) |
| Exposed at age 14-16 (n=46,167) | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.90 (0.82–0.99) | 0.91 (0.84–0.98) | 1.04 (0.94–1.15) | 1.00 (0.92–1.08) |
| – Parental cancer + Income loss | 1.35 (1.21–1.52) | 0.89 (0.80–0.99) | 1.39 (1.23–1.57) | 0.93 (0.83–1.05) |
| + Parental cancer + Income loss | 1.37 (0.98–1.91) | 1.18 (0.90–1.56) | 1.53 (1.10–2.12) | 1.30 (0.97–1.72) |

*Reference group is unexposed to parental cancer and income loss, and reference category is high educational level.

†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.

Supplementary Table 5 Multinomial logistic regression with joint exposure analyses of parental cancer and income loss (20%) during childhood and personal income level at age 30 years

| | Model 1 – Unadjusted* | | | Model 2 – Adjusted*† | | |
|------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------|-----------------------------------|---------------------------------------|--------------------------------------|
| | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) | First quartile RRR (95% CI) | Second quartile RRR (95% CI) | Third quartile RRR (95% CI) |
| Danish children | | | | | | |
| Exposed at age 8-13 (n=28,567) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.14 (1.01–1.28) | 1.01 (0.90–1.14) | 0.96 (0.85–1.09) | 1.17 (1.03–1.31) | 1.07 (0.95–1.21) | 1.01 (0.89–1.14) |
| – Parental cancer + Income loss | 1.33 (1.12–1.58) | 0.98 (0.82–1.18) | 0.92 (0.77–1.11) | 1.29 (1.09–1.54) | 0.95 (0.79–1.14) | 0.90 (0.75–1.09) |
| + Parental cancer + Income loss | 1.18 (0.71–1.98) | 1.31 (0.79–2.16) | 1.20 (0.73–1.99) | 1.18 (0.71–1.96) | 1.29 (0.79–2.12) | 1.22 (0.74–2.00) |
| Exposed at age 14-16 (n=45,210) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.11 (1.01–1.22) | 0.97 (0.89–1.07) | 0.99 (0.90–1.08) | 1.13 (1.03–1.24) | 1.02 (0.93–1.12) | 1.01 (0.92–1.12) |
| – Parental cancer + Income loss | 1.22 (1.07–1.39) | 0.97 (0.85–1.11) | 0.92 (0.80–1.06) | 1.22 (1.07–1.39) | 0.96 (0.84–1.10) | 0.92 (0.80–1.05) |
| + Parental cancer + Income loss | 1.10 (0.80–1.53) | 0.92 (0.66–1.28) | 0.88 (0.63–1.24) | 1.23 (0.81–1.56) | 0.97 (0.69–1.34) | 0.91 (0.65–1.28) |
| Norwegian children | | | | | | |
| Exposed at age 8-13 (n=33,022) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 1.00 (0.89–1.12) | 0.99 (0.89–1.11) | 0.94 (0.84–1.05) | 1.04 (0.92–1.17) | 1.08 (0.97–1.21) | 0.96 (0.86–1.08) |
| – Parental cancer + Income loss | 1.22 (1.05–1.42) | 1.03 (0.88–1.20) | 0.87 (0.74–1.02) | 1.15 (0.99–1.34) | 0.97 (0.83–1.14) | 0.86 (0.73–1.01) |
| + Parental cancer + Income loss | 1.14 (0.73–1.79) | 1.03 (0.65–1.63) | 0.88 (0.56–1.40) | 1.20 (0.77–1.87) | 1.10 (0.70–1.75) | 0.90 (0.57–1.43) |
| Exposed at age 14-16 (n=45,991) | | | | | | |
| – Parental cancer – Income loss | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| + Parental cancer – Income loss | 0.90 (0.82–0.99) | 0.88 (0.80–0.98) | 0.93 (0.84–1.02) | 0.95 (0.89–1.04) | 0.95 (0.86–1.05) | 0.96 (0.87–1.06) |
| – Parental cancer + Income loss | 1.29 (1.13–1.47) | 1.08 (0.94–1.24) | 0.97 (0.84–1.11) | 1.24 (1.09–1.42) | 1.06 (0.92–1.21) | 0.96 (0.84–1.11) |
| + Parental cancer + Income loss | 1.12 (0.79–1.60) | 1.04 (0.72–1.51) | 0.68 (0.45–1.04) | 1.17 (0.82–1.66) | 1.12 (0.78–1.62) | 0.71 (0.46–1.08) |

*Reference group is unexposed to parental cancer and income loss, and reference category is the fourth personal income quartile at the age of 30 years.

†Model 2 is adjusted for maternal country of origin, paternal country of origins, maternal age at childbirth, paternal age at childbirth, parents' highest educational level.