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Original Research

## Red and processed meat consumption and breast cancer: UK Biobank cohort study and meta-analysis



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### KEYWORDS

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**Abstract** *Aim:* Red and processed meat may be risk factors for breast cancer due to their iron content, administration of oestrogens to cattle or mutagens created during cooking. We studied the associations in UK Biobank and then included the results in a meta-analysis of published cohort studies.

*Methods:* UK Biobank, a general population cohort study, recruited participants aged 40–69 years. Incident breast cancer was ascertained via linkage to routine hospital admission, cancer registry and death certificate data. Univariate and multivariable Cox proportional hazard models were used to explore the associations between red and processed meat consumption and breast cancer. Previously published cohort studies were identified from a systematic review using PubMed and Ovid and a meta-analysis conducted using a random effects model.

*Results:* Over a median of 7 years follow-up, 4819 of the 262,195 women developed breast cancer. The risk was increased in the highest tertile (>9 g/day) of processed meat consumption (adjusted hazard ratio [HR] 1.21, 95% confidence interval [CI] 1.08–1.35,  $p = 0.001$ ). Collation with 10 previous cohort studies provided data on 40,257 incident breast cancers in 1.65 million women. On meta-analysis, processed meat consumption was associated with overall (relative risk [RR] 1.06, 95% CI 1.01–1.11) and post-menopausal (RR 1.09, 95% CI 1.03–1.15), but not pre-menopausal (RR 0.99, 95% CI 0.88–1.10), breast cancer. In UK Biobank and the meta-analysis, red meat consumption was not associated with breast cancer (adjusted HR 0.99 95% CI 0.88–1.12 and RR 1.03, 95% CI 0.99–1.08, respectively).

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**Conclusions:** Consumption of processed meat, but not red meat, may increase the risk of breast cancer.

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## 1. Introduction

In the United Kingdom, 1 in 8 women will develop breast cancer [1], but more than one-quarter of cases could be prevented by reduced exposure to exogenous oestrogens, reduced obesity, increased physical activity and breastfeeding [1]. There is a lack of consensus on whether red and processed meat consumption is a risk factor for breast cancer [2]. Four meta-analyses have produced conflicting results [3–6] due to wide inclusion criteria, resulting in the inclusion of very heterogeneous studies. We studied whether red and processed meat consumption were associated with the risk of breast cancer in UK Biobank; then included the results in a meta-analysis of prospective cohort studies using rigorous inclusion criteria.

## 2. Materials and methods

### 2.1. UK Biobank

UK Biobank recruited 273,466 women aged 40–69 years from the general population between 2007 and 2010. Baseline socioeconomic and lifestyle information were collected via a self-completed, touch-screen questionnaire and anthropometric measurements taken by trained staff. Self-reported moderate and vigorous physical activity were converted to METs·min·week<sup>-1</sup>, and dichotomised to inactive (<600 METs·min·week<sup>-1</sup>) and active (≥600 METs·min·week<sup>-1</sup>). Dietary information was collected using a self-completed food frequency questionnaire. Frequency of beef, pork and lamb intake (excluding processed meat) and frequency of processed meat intake were recorded. These were converted into probabilities of daily consumption, multiplied by normal portion sizes [7] and then weighted by size of portion: small 0.5, medium 1.0 or large 1.5. We then derived four categories of red/processed meat intake: zero intake and tertiles of consumption for those consuming some. Follow-up information (min 5.33 years and max 9.89 years) on the date of first diagnosis of cancer was obtained via linkage to three routine administrative databases: cancer registrations, death certificates and hospital admissions. Date and cause of death were obtained from death certificates held by the National Health Service (NHS) Information Centre (England and Wales) and the NHS Central Register Scotland (Scotland). Date and cause of hospital admissions were obtained from the Health Episode Statistics (HES) for England and Wales and the Scottish

Morbidity Record 01 (SMR01) for Scotland. At the time of analysis, mortality data were available up to 31 January 2016 and hospital admission and cancer registry data until 31 March 2015. Therefore, follow-up was censored at 31 January 2016 or date of death if this occurred earlier. There were 54 participants who withdrew consent from UK Biobank at the time of analysis. All databases used the International Classification of Diseases and we defined breast cancer as ICD10 code C50.

We excluded women with a record of breast cancer at baseline. Cox proportional hazard models were used to examine the associations between red/processed meat consumption and breast cancer using zero consumption as the referent category. We ran four incremental models for each: univariate, multivariable adjusted for socio-demographic factors (age, sex, ethnic group and deprivation index); multivariable also adjusted for lifestyle factors (smoking status, frequency of alcohol consumption, body mass index and physical activity) and multivariable also adjusted for potential dietary confounders (cooked vegetables, raw vegetables and type of bread). We tested for statistical interactions and, where significant, subgroup analyses were undertaken. All analyses were repeated after stratifying women into pre- and post-menopausal subgroups. In the latter, we included the use of hormone replacement therapy as a covariate in the fully adjusted model. We also conducted landmark analyses, excluding the first 2 years of follow-up. This study was performed under generic ethical approval obtained by UK Biobank from the NHS National Research Ethics Service (ref 11/NW/0382, 17 June 2011). All analyses were undertaken using Stata, version 14.

### 2.2. Meta-analysis

Two authors (JJA and NDMD) searched PubMed and Ovid using the search term breast cancer combined with meat, red meat, processed meat, preserved meat, pork, beef, veal, mutton, lamb, ham, sausage or bacon; consistent with the most recently published meta-analysis [6]. However, inclusion was restricted to prospective, general population cohort studies. We excluded case-control studies and studies that measured only beef intake. Where more than one study was conducted on the same cohort, only the most recent was included. The last search was conducted on 15 January 2017. Meta-analysis was undertaken using a random effects model; stratified by type of meat (red and processed) and outcome (pre-,

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