RESEARCH ARTICLE

No Association between Egg Intake and Prostate Cancer Risk: A Meta-analysis
Bo Xie¹, Huadong He²*

Abstract

Objective: Egg consumption has been suggested to increase the risk of colorectal and some other cancers. The present study summarized and quantified the current evidence relating dietary intake of eggs and prostate cancer. Materials and methods: Literature searches were conducted to identify peer-reviewed manuscripts published up to July 2012. Twenty manuscripts from nine cohort studies and 11 case-control studies were identified. Summary risk estimates with 95% confidence intervals (CIs) were calculated for case-control and cohort studies separately. Results: Neither the case-control nor the cohort studies showed any association of prostate cancer incidence with egg consumption (case-control studies: odds ratio 1.09, 95% CI 0.86-1.31; cohort studies: relative risk 0.97, 95% CI 0.97-1.07). The results were consistent in subgroup analysis. Furthermore, no association was observed between egg consumption and prostate cancer-specific mortality. Conclusions: Our analyses provided no evidence of a significant influence of egg consumption on prostate cancer incidence and mortality. However, more studies, particularly large prospective studies, are needed.

Keywords: Eggs - prostate cancer - meta-analysis

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Introduction

Prostate cancer is the most common cancer among men in United States. It is also one of the leading causes of cancer death among men of all races (Siegel et al., 2012). Although age and family history have been established as strong risk factors for prostate cancer, the role of individual dietary factors is not well understood. The large variation in incidence across countries may also suggest the role of lifestyle and dietary factors in its cause (Yu et al., 1991). Eggs are frequently consumed worldwide, supply substantial portions of protein, fat, retinal, riboflavin and iron. Eggs are also unique among foods, given their relatively high content of several substances, such as cholesterol, choline, biotin, and avidin. There is evidence pointing to a possible role of eggs consumption on cancer etiology. A positive association has been observed between eggs consumption and risk of colorectal cancer (Steinmetz et al., 1994). For other cancer sites, there is no established association with eggs. Several studies considered the relation between eggs intake and prostate cancer. Though most of them reported no association, results were often inconsistent. With the aim to investigate the relationship between prostate cancer and eggs consumption, we carried out a meta-analysis of epidemiological studies published up to July 2012.

Materials and Methods

A systematic literature search was carried out in the Medline database, using PubMed, for all studies published in English. We used the following search string in free full-text: (egg or eggs) AND (prostate or prostatic) AND (cancer or carcinoma). The reference lists of all papers of interest were checked to obtain other pertinent publications. For inclusion in this meta-analysis, studies should assess eggs intake in relation to histologically confirmed prostate cancer with informative effect estimates. Cross-sectional and ecologic analyses were excluded.

Figure 1 showed the flowchart for selection of articles. A total of 86 publications were identified in the primary search. Seventy-two articles were excluded after screening the titles and abstracts. We included 12 studies after
reviewing reference lists of retrieved articles or preceding reviews. After closer examination of full text, four articles did not report risk estimates on the relation between eggs intake and prostate cancer and were no longer considered.

One-case-control study published partly duplicated data in three different articles, and we selected the recent one with largest sample size (Deneo-Pellegrini et al., 2012). Finally, the remaining 20 publications were retained for the meta-analysis (Snowdon et al., 1984; Mills et al., 1989; Severson et al., 1989; Hsing et al., 1990; La Vecchia et al., 1991; Le Marchand et al., 1994; Ewings et al., 1996; Gronberg et al., 1996; Jain et al., 1999; Schuurman et al., 1999; Sung et al., 1999; Allen et al., 2004; Sonoda et al., 2004; Chen et al., 2005; Ukoli et al., 2009; Tyagi et al., 2010; Allen et al., 2011; Deneo-Pellegrini et al., 2012).

We reviewed all the studies and abstracted the information as follows: the name of the first author, the year of publication, study design, country, period of enrolment (case-control studies) and/or of follow-up (cohort studies), number of subjects, covariates adjusted for in the analysis, odds ratios (ORs) or relative risks (RRs) for highest vs lowest level of consumption and exposure assessment. When available, we used multivariate-adjusted risk estimates.

We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer. We estimated the summary association between eggs consumption and prostate cancer incidence in case-control and cohort studies separately. Subgroup analyses were performed according to geographical regions, time of PSA screening (Using 1994 as the cutoff for after which time most men were screened for PSA). In addition, we performed analyses for the association of eggs consumption with high-stage and fatal prostate cancer.

Table 1. Study Characteristics of Published Cohort and Case-control Studies on Eggs Intake and Prostate Cancer

<table>
<thead>
<tr>
<th>Authors</th>
<th>Publication year</th>
<th>Study design</th>
<th>Country</th>
<th>Cases/Subjects</th>
<th>Highest vs lowest Variables of adjustment</th>
<th>Cruciferous vegetables assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowdon et al.</td>
<td>1984</td>
<td>Cohort</td>
<td>USA</td>
<td>9756765</td>
<td>Age</td>
<td>Quantitative</td>
</tr>
<tr>
<td>Mills et al.</td>
<td>1988</td>
<td>Cohort</td>
<td>Hawaii</td>
<td>1974799</td>
<td>Age</td>
<td>Quantitative</td>
</tr>
<tr>
<td>Severson et al.</td>
<td>1989</td>
<td>Cohort</td>
<td>China</td>
<td>1985855 (person-yr)</td>
<td>Age, income by proportional hazards regression</td>
<td>Interview</td>
</tr>
<tr>
<td>Hsing et al.</td>
<td>1990</td>
<td>Cohort</td>
<td>Taiwan</td>
<td>199620516</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
</tr>
<tr>
<td>La Vecchia et al.</td>
<td>1991</td>
<td>Hospital-based case-control study</td>
<td>Italy</td>
<td>96388</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
</tr>
<tr>
<td>Le Marchand et al.</td>
<td>1994</td>
<td>Cohort</td>
<td>Hawaii</td>
<td>199620516</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Ewings et al.</td>
<td>1998</td>
<td>Hospital-based case-control study</td>
<td>Italy</td>
<td>15949068</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
</tr>
<tr>
<td>Gronberg et al.</td>
<td>1998</td>
<td>Population-based case-control study</td>
<td>Sweden</td>
<td>40061624</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Sun et al.</td>
<td>1999</td>
<td>Population-based case-control study</td>
<td>Canada</td>
<td>6127224</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Allen et al.</td>
<td>1999</td>
<td>Hospital-based case-control study</td>
<td>China</td>
<td>8019796</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Schuurman et al.</td>
<td>1999</td>
<td>Hospital-based case-control study</td>
<td>Netherland</td>
<td>64256279</td>
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<td>Interview</td>
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<tr>
<td>Allen et al.</td>
<td>2000</td>
<td>Cohort</td>
<td>Japan</td>
<td>196253802 (person-yr)</td>
<td>Age, area of residence, education and BMI</td>
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<td>Bosetti et al.</td>
<td>2004</td>
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<td>Italy</td>
<td>12942745</td>
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<td>Japan</td>
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<td>Chen et al.</td>
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<td>Europe</td>
<td>272712251</td>
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<td>Interview</td>
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<tr>
<td>Ueki et al.</td>
<td>2009</td>
<td>Hospital and population-based case-control study</td>
<td>Nigeria</td>
<td>96324</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Tyagi et al.</td>
<td>2010</td>
<td>Population-based case-control study</td>
<td>India</td>
<td>3059009</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
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<tr>
<td>Richman et al.</td>
<td>2015</td>
<td>Cohort</td>
<td>Canada</td>
<td>199350615</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
</tr>
<tr>
<td>Deneo-Pellegrini et al.</td>
<td>2012</td>
<td>Hospital-based case-control study</td>
<td>Uruguay</td>
<td>3268134</td>
<td>Age, area of residence, education and BMI</td>
<td>Interview</td>
</tr>
</tbody>
</table>

Results

Table 1 reports the main characteristics of the 20 studies included in the meta-analysis. There were 11 case-control studies and 9 cohort studies. Of all studies reviewed, three cohort studies presented RR estimates for fatal prostate cancer (Snowdon et al., 1984; Hsing et al., 1990; Richman et al., 2011). Seven studies were conducted in US/Canada (Snowdon et al., 1984; Mills et al., 1989; Severson et al., 1989; Hsing et al., 1990; Le Marchand et al., 1994; Jain et al., 1999; Richman et al., 2011). Six in Europe (Le Vecchia et al., 1991; Ewings et al., 1996; Gronberg et al., 1996; Schuurman et al., 1999; Bosetti et al., 2004; Allen et al., 2008). Live in Asia (Sung et al., 1999; Allen et al., 2004; Sonoda et al., 2004; Chen et al., 2005; Tyagi et al., 2010), one in Nigeria (Ukoli et al., 2009) and one in Uruguay (Deneo-Pellegrini et al., 2012). Overall, this meta-analysis included 5791 cases of prostate cancer, and most studies suggested a non-significant relationship between eggs consumption and prostate cancer.

Case-control studies

Based on data from 11 case-cohort studies (La Vecchia et al., 1991; Ewings et al., 1996; Gronberg et al., 1996; Jain et al., 1999; Sung et al., 1999; Bosetti et al., 2004; Sonoda et al., 2004; Chen et al., 2005; Ukoli et al., 2009; Tyagi et al., 2010; Deneo-Pellegrini et al., 2012), we found no association between high intake of eggs and risk of prostate cancer (OR 1.09, 95% CI 0.89-1.31) (Figure 2). There was a significant heterogeneity between studies (p = 0.022, F = 52.2%).
Figure 3. Pooled Results for 6 Cohort Studies of Eggs Consumption and Prostate Cancer Incidence

and Egger (p = 0.151) tests, as well as visual inspection of the funnel plot (not shown), did not suggest a publication bias.

Considering the geographic area, the pooled OR was 0.90 (95% CI, 0.65–1.16) in European studies and 1.11 (95% CI 0.73–1.49) in Asian studies and 1.09 (95% CI 0.74–1.62) in Asian studies. Only one study was included in three other regions and should be interpreted cautiously.

In the subgroup analysis by PSA era, no statistical heterogeneity between studies (p = 0.142, I² = 44.6%). However, when the study (Deneo-Pellegrini et al., 2012) conducted in Uruguay with the highest effect estimates was excluded, the results became homogeneous.

Prostate cancer–specific mortality

Pooling the results of the 3 studies (Snowdon et al., 1984; Hsing et al., 1990; Richman et al., 2011) showed no association of high eggs consumption with fatal prostate cancer (RR 0.97, 95% CI 0.53-0.93).

Discussion

Previous studies have suggested that eggs consumption may increase the risk of colorectal cancer and some other cancers (Steinmetz et al., 1994; Aune et al., 2009). In the present meta-analysis, we found no statistically significant positive association between high intake of eggs and risk of prostate cancer. Furthermore, our findings for lethal prostate cancer also suggested no association with high consumption of eggs. To our knowledge, this is the first meta-analysis to evaluate the relationship between them.

Several factors contributed to the stability of our findings. First, the results were generally homogeneous. No heterogeneity was detected in cohort studies but some heterogeneity in case-control studies. However, when the study (Deneo-Pellegrini et al., 2012) conducted in Uruguay with the highest effect estimates was excluded, the results for case-control studies became homogeneous, and the pooled OR was not significantly changed. Second,
the findings were consistent across the subgroup analyses, regardless of regions and PSA screening. Third, for the two established risk factors, all studies included in this meta-analysis provided risk estimates adjusted for age, but only 2 case-control studies and 1 cohort study controlled for a family history of prostate cancer in their analyses. It is unlikely that is a strong confounder because a family history of prostate cancer is not strongly related to eggs consumption, it could not be a strong confounder for association for them.

A mechanistic role of eggs intake in the etiology of prostate cancer is plausible. Eggs are an important source of cholesterol and choline, both of which are highly concentrated in prostate cancer cells. Cholesterol homeostasis is disrupted in malignant cells, leading to accumulation of cholesterol, which is a precursor of androgen and may alter signaling pathways to promote cancer progression (Freeman et al., 2004; Dillard et al., 2008). Choline is essential for a variety of cell functions involved in cancer growth and progression. Malignant prostate cells have higher choline concentrations than do healthy cells, and choline kinase is overexpressed in prostate cancer (Glunde et al., 2006; Ramirez de Molina et al., 2008). Blood concentrations of cholesterol and choline have been positively associated with risk of advanced prostate cancer (Platz et al., 2008; Johansson et al., 2009). However, in our study, eggs consumption was associated with a lower incidence of advanced prostate cancer, and no association was observed with fatal prostate cancer, while these results need to be interpreted with caution because of the few studies available. Another plausible mechanism through which eggs could increase the risk of prostate cancer include the effect of calcium in prostatic epithelium, which was the only mineral presented a significant increased risk of prostate cancer (Gao et al., 2005; Huncharek et al., 2008).

Our study has several limitations. First, as a meta-analysis of observational data, our results are prone to recall and selection bias inherent in the original studies. Second, eggs are generally not the main focus to recall and selection bias inherent in the original analysis of observational data, our results are prone to publication bias, even though no significant evidence of publication bias was observed.

In conclusion, this meta-analysis of epidemiological studies provides evidence on the absence of any association between eggs intake and prostate cancer risk. Given the relatively small number of cohort studies included in this meta-analysis, larger prospective studies are needed to confirm this association in the future.

References


