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## Review

# Cancer and environment: Definitions and misconceptions

Laura A. McGuinn, Armen A. Ghazarian, Gary L. Ellison, Chinonye E. Harvey,  
Christine M. Kaefer, Britt C. Reid\*

Epidemiology and Genomics Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD, USA

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## ABSTRACT

**Background:** Scientific evidence supports an association between environmental exposures and cancer. However, a reliable estimate for the proportion of cancers attributable to environmental factors is currently unavailable. This may be related to the varying definitions of the term “environment.” The current review aims to determine how the reporting of the definition of the environment and of the estimates of environmentally attributable risks have changed over the past 50 years.

**Methods:** A systematic literature search was performed to retrieve all relevant publications relating to the environment and cancer from January 1960 to December 2010 using PubMed, EMBASE, Scopus, and Web of Science. Definitions of the environment and environmentally attributable risks for cancer were extracted from each relevant publication.

**Results:** The search resulted in 261 relevant publications. We found vast discrepancies in the definition of the environment, ranging from broad (including lifestyle factors, occupational exposures, pollutants, and other non-genetic factors) to narrow (including air, water, and soil pollutants). Reported environmentally attributable risk estimates ranged from 1% to 100%.

**Conclusions:** Our findings emphasize the discrepancies in reporting environmental causation of cancer and the limits of inference in interpreting environmentally attributable risk estimates. Rather than achieving consensus on a single definition for the environment, we suggest the focus be on achieving transparency for any environmentally attributable risks.

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## 1. Introduction

Substantial scientific evidence exists to support the association between the environment and cancer (Tomatis and Bartsch, 1990; Boffetta, 2006; Clapp et al., 2007). Early links between environmental exposures and cancer date back to 1761 when John Hill discovered the association between snuff and nasal cancer (Hill, 1761); and in 1775 when Sir Percival Pott observed a relationship between chimney sweeping and scrotal cancer (Pott, 1775). Centuries later, researchers continue to demonstrate and quantify this relationship, through migrant, familial, and correlational studies, as well as identification of geographical variation in cancer incidence (Higginson and Muir, 1977; Parkin, 1992; Verkasalo et al., 1999; Lichtenstein et al., 2000). From these epidemiological studies, estimates of the proportion of cancer attributable to the environment have been derived. These estimates, often referred to as environmentally attributable risk (EAR), represent the proportion

of cancers that would be eliminated if environmental factors were reduced to their lowest level (Smith et al., 1999). The general formula used to calculate an environmentally attributable risk is

$$p(RR-1)/[p(RR-1)+1]$$

where in this case,  $p$  is the proportion of the population exposed to the environmental factor, and  $RR$  is the causal risk ratio or the proportionate increase in average risk among the exposed due to the environmental exposure.

The most cited attributable risk estimate comes from John Higginson, who declared that 80–90% of all cancers are due to environmental exposures (Higginson, 1967). More recently, Doll and Peto stated that environmental factors cause only 1–3% of cancers. They also concluded that 75–80% of all cancers are ‘avoidable’ (Doll and Peto, 1981). Furthermore, in the Harvard Report on Cancer Prevention (Harvard Center for Cancer Prevention, 1996) it is estimated that about 2% of cancer deaths are attributable to environmental pollution. There are clear inconsistencies in these estimates, which may be related to the varying definitions of the term “environment.” Therefore, it is difficult to place a reliable estimate on the proportion of cancers attributable to environment factors.

\* Correspondence to: Division of Cancer Control and Population Sciences, National Cancer Institute, 6130 Executive Blvd., Rm. 5134, Bethesda, MD 20892, USA. Fax: +1 301 435 6609.

E-mail address: reidbr@mail.nih.gov (B.C. Reid).

Previous studies have attempted to illustrate this concept by broadly reviewing definitions of the environment and their relation to environmentally attributable risk estimates (Thomas, 1978; Rushton, 2003; Boffetta et al., 2007; Saracci and Vineis, 2007). In a review by Boffetta et al. (2007), the authors note that the term “environment” is frequently used in the broad sense to include all non-genetic factors, and in the narrow sense to include only air, water, soil, and food pollutants. Boffetta et al. concluded that the term environment should be abandoned and instead replaced with the terms “non-genetic” and “pollutants.” Saracci and Vineis (2007) refute this idea, and insist on keeping the term environment, while urging researchers to clearly report what components of the environment their risk estimate include.

In the current review, we built upon these prior studies and conducted a systematic literature review on both the definition of the environment and environmentally attributable risk estimates for cancer. The findings from the current review help describe the limits of interpreting environmentally attributable risk estimates, particularly in relation to cancer. Moreover, from the literature search results, we hope to uncover any potential temporal trends in estimates of the proportion of cancer attributable to the environment and to determine if these trends were related to changes in the definition of the term “environment.” Due to the ongoing controversies of the impact of the environment on human health, the current review has potential public health implications for interpreting past research, guiding future study, and informing policy-makers.

## 2. Methods

### 2.1. Data sources

We systematically searched electronic databases, including PubMed, EMBASE, Scopus, and Web of Science, for publications from January 1960 to December 2010

containing definitions of the environment and environmentally attributable risk estimates. Google Scholar was searched as well to capture any publications found in environmental journals, which might not appear in medical databases. In addition, reference lists of all publications were examined manually to identify additional relevant publications. Relevant websites were searched for documents or gray literature containing definitions of the environment and/or environmentally attributable risk estimates. Such websites include the World Health Organization, the International Agency for Research on Cancer, the National Cancer Institute, the National Institute for Environmental Health Sciences, the American Cancer Society, and the United Nations Environment Program. The titles and abstracts of all records were screened and if considered potentially relevant, a full-text copy was obtained.

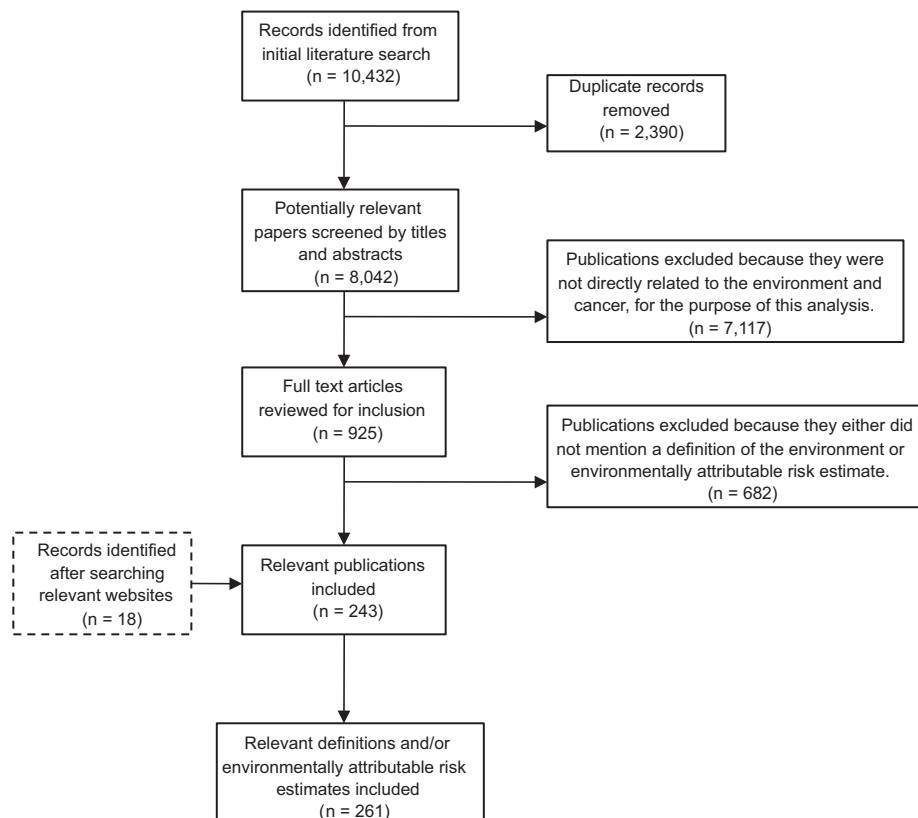
### 2.2. Inclusion criteria

To be included in our analysis, documents had to be published from January 1960 to December 2010, involve human subjects, be cancer related (though not focused on particular cancer types) and written in English. Publications were excluded if they focused on only one type of cancer and were not related to the environment and cancer for the purpose of this analysis. Definitions and environmentally attributable risk estimates were extracted from each included publication and categorized as either “broad” or “narrow” (Boffetta and Nyberg, 2003).

Definitions were categorized as narrow when they included only pollutants found in the air, water, food, and soil. All more expansive definitions were categorized as broad, for example those that may also have included diet, lifestyle, health-behavior, psychosocial, or occupational exposures, etc. Publications reporting cancer incidence were separated from those reporting cancer mortality or disability adjusted life years.

## 3. Results

The search returned 10,432 potentially relevant publications. We retrieved and excluded 2390 duplicate publications. Subsequently, the remaining 8042 publications were screened by reviewing titles and abstracts. We excluded 7117 publications that were not related to the environment and cancer for the



**Fig. 1.** Publication identification and selection process. Methodology and results from the literature analysis of cancer and the environment research articles. Databases used for the literature search were PubMed, EMBASE, Scopus, and Web of Science.

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