Evaluation of the probability of causation approach for cancer: Scoping review protocol

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Abstract

Objective: The probability of causation Introduction: The probability of causation Inclusion criteria: The probability of causation Methods: The probability of causation

Table of contents

[Background 4](#_Toc184167177)

[Research Question 6](#_Toc184167178)

[Secondary research questions 7](#_Toc184167179)

[Inclusion criteria 8](#_Toc184167180)

[Types of sources 9](#_Toc184167181)

[Methods 10](#_Toc184167182)

[References 11](#_Toc184167183)

[Appendix 1: Pilot Search Strategy (Lung Cancer) 13](#_Toc184167184)

[Appendix 2: All types of cancer 25](#_Toc184167185)

#### Type of Review

Scoping Review

#### Review Stages

This study will run in two stages: the first-stage will consist of a review of the scientific literature in three databases (PubMed-MEDLINE, EMBASE, and OpenAlex), whereas the second-stage will consist of a review of public policy documents for the application of the PoC for the financial compensation of lung cancer cases.

The stages are as follows for the review of the scientific literature:

1. Protocol
2. Search
3. Pilot Screening (50 to 100 records)
4. Pilot Extraction (10 items)
5. Preregistration update
6. Screening
7. Extraction
8. Synthesis
9. Report (first-stage completed)

For the review of public policy documents, these are the planned stages:

1. Search
2. Pilot Screening (50 to 100 records)
3. Pilot Extraction (10 items)
4. Preregistration update
5. Screening
6. Extraction
7. Synthesis
8. Report (review completed)

#### Current Review Stage

1. Search (first stage)

#### Start Date

* 28-10-2024 (actual start date)
* 1-03-2025 (second-stage, estimated start date)

#### End Date

* 28-02-2025 (first-stage, estimated end date)
* 188-8-2025 (second-stage, estimated end date)

# Background

The determination of the likelihood that an event was caused by a single exposure is of scientific, legal, philosophical, and practical interest. However, health outcomes are often multi-causal and it is practically difficult and often not possible to establish causality due to a single exposure, although examples for which assessment is relatively straight-forward exist (i.e., asbestos exposure and mesothelioma).[1](#ref-Coenen2024) In occupational health, the determination of individual causality due to exposures at the workplace has important consequences for the financial compensation of workers, but this is limited by the ability to establish a certain diagnosis, the strength of the knowledge base for the disease, among other factors reviewed by Moon and Yoo.[2](#ref-MoonYoo2021)

The probability of causation (PoC) concept has been used in the the past and present to approximate what share of a health outcome is attributable to a single exposure. For a health outcome to be “more likely than not” caused by the exposure under investigation, the probability that it is responsible for the outcome should be greater than 0.5. In one of its simplest forms, the PoC of occupational contact dermatitis due to a work-related exposure is greater than 0.5 when at least half (4 out of 7) Mathias criteria are met.[3](#ref-Mathias1989) In other cases, the attributable fraction (AF) is used to estimate whether there is a doubling in the relative risk (RR) for the outcome in the exposed compared to the non-exposed (RR = 2).[4](#ref-GreenlandPoC1999) This, however, is a population-level estimate that seldom considers the individual exposure level. The preferred approach is the derivation of the quantitative exposure level above which the PoC is greater than 0.5, which can be derived from the exposure-response curve in epidemiological studies and systematic reviews with meta-regression.[5](#ref-Siemiatycki2014)

There are numerous examples of the use of the PoC for the financial compensation of workers who develop cancer. In the United Kingdom, partial or full financial compensation due to radiation exposure was informed by using PoC thresholds to the benefit of the claimant, starting at values lower than 0.5 to account for uncertainties such as error (systematic and random) and unknown generalizability of epidemiological estimates in different populations.[6](#ref-Wakeford1998) In the United States[7](#ref-NCICDCreport2003) and Canada[8](#ref-Armstrong1988), upper confidence intervals have been used to establish a PoC = 0.5 threshold to compensate workers exposed to radiation.

Despite its use in worker compensation schemes, there have been criticisms to the PoC approach, such as it not accounting for accelerated outcome occurrence (i.e., the disease would have occurred at a later time without the exposure) or the modifications in PoC due to varying background risk.[4](#ref-GreenlandPoC1999),[9](#ref-Greenland2015) Thus, further examination of the use of the PoC in the scientific literature and health policy is relevant. A preliminary search of MEDLINE was conducted and no current or underway systematic reviews or scoping reviews on the topic were identified. The most closely related review is a scoping review of factors related to misdiagnosis in occupational and environmental health, with a brief overview of causality assessment with the PoC principle.[2](#ref-MoonYoo2021) This review covers general aspects in an appendix, such as formulas applied for the PoC calculation but does not review studies and policy documents applying PoC and related calculations.

# Research Question

How has the probability of causation (PoC) principle been applied to assess occupational exposures and their contribution to lung cancer in workplace environments?

# Secondary research questions

* What are the type of outcomes that have been applied for the PoC in lung cancer studies?
* What are the exposures of interest in lung cancer studies that have used the PoC?
* What are the causal assumptions for the underlying models?
* What are the study designs that have used the PoC in lung cancer studies?
* What mathematical formulas are used to calculate the PoC?
* Which policy or legal frameworks have used the PoC for the financial compensation of lung cancer cases?
* What alternatives are there to the PoC?

# Inclusion criteria

Written according to the (Participants, Concept, Context) PCC framework.

#### Population

Adults of both sexes with a relevant exposure at the workplace environment.

#### Concept

The application of the probability of causation (PoC) principle.

#### Context

The main outcome of interest is lung cancer. Depending on the number of results, the search strategy may be broadened to include other types of cancer or to scope for the application of the PoC for other multi-causal disease.

# Types of sources

This scoping review will consider both experimental (randomized controlled trials and non-randomized studies) and observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies. Descriptive observational study designs (case series, descriptive cross-sectional studies, ecological studies) will also be considered for inclusion. Public policy documents, editorials, and opinion papers will be included if they contain information on the application of the PoC principle. Both peer-reviewed and non-peer reviewed literature will be considered for inclusion.

# Methods

## Search strategy

The search strategy aims to find published and unpublished studies in English, Dutch, and Spanish. An initial limited search of MEDLINE and JBI Evidence Synthesis was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy for MEDLINE (PubMed) (see Appendix 1). The search strategy, including all identified keywords and index terms, will be adapted for each included information source. The reference lists of all studies selected for critical appraisal will be screened for additional studies.

## Screening

The machine learning asisted learning tool ASReview will be used in the screening stage.[10](#ref-Vandeschoot2021)

# References

1. Coenen P, Kezic S, Heederik DJJ, Peters S, Molen HF van der. Applying a ‘presumably plausible’ principle in a new one-time financial compensation system for occupational diseases in the Netherlands. *Occupational and Environmental Medicine*. Published online September 20, 2024. doi:[10.1136/oemed-2024-109533](https://doi.org/10.1136/oemed-2024-109533)

2. Moon J, Yoo H. Misdiagnosis in occupational and environmental medicine: a scoping review. *Journal of Occupational Medicine and Toxicology*. 2021;16(1):33. doi:[10.1186/s12995-021-00325-z](https://doi.org/10.1186/s12995-021-00325-z)

3. Toby Mathias CG. Contact dermatitis and workers’ compensation: Criteria for establishing occupational causation and aggravation. *Journal of the American Academy of Dermatology*. 1989;20(5, Part 1):842-848. doi:[10.1016/S0190-9622(89)70096-7](https://doi.org/10.1016/S0190-9622(89)70096-7)

4. Greenland S. Relation of probability of causation to relative risk and doubling dose: a methodologic error that has become a social problem. *American Journal of Public Health*. 1999;89(8):1166-1169. doi:[10.2105/AJPH.89.8.1166](https://doi.org/10.2105/AJPH.89.8.1166)

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6. Wakeford R, Antell BA, Leigh WJ. A Compensation Scheme for Nuclear Industry Workers in the United Kingdom: *Health Physics*. 1998;74(1):1-9. doi:[10.1097/00004032-199801000-00001](https://doi.org/10.1097/00004032-199801000-00001)

7. Land C, Gilbert E, Smith JM. *Report of the NCI-CDC Working Group to Revise the 1985 NIH Radioepidemiological Tables*.; 2003:118. <https://www.govinfo.gov/app/details/GOVPUB-HE20-PURL-LPS47231>

8. Armstrong B, Tremblay C, Theriault G. Compensating Bladder Cancer Victims Employed in Aluminum Reduction Plants. *Journal of Occupational and Environmental Medicine*. 1988;30(10):771-775. doi:[10.1097/00043764-198810000-00004](https://doi.org/10.1097/00043764-198810000-00004)

9. Greenland S. Concepts and pitfalls in measuring and interpreting attributable fractions, prevented fractions, and causation probabilities. *Annals of Epidemiology*. 2015;25(3):155-161. doi:[10.1016/j.annepidem.2014.11.005](https://doi.org/10.1016/j.annepidem.2014.11.005)

10. Van De Schoot R, De Bruin J, Schram R, et al. An open source machine learning framework for efficient and transparent systematic reviews. *Nature Machine Intelligence*. 2021;3(2):125-133. doi:[10.1038/s42256-020-00287-7](https://doi.org/10.1038/s42256-020-00287-7)

# Appendix 1: Pilot Search Strategy (Lung Cancer)

An exploratory search of the literature was conducted in MEDLINE (PubMed), EMBASE, Policy Commons, Overton, and OpenAlex. A summary of records is presented bellow:

Table 1: Summary of records for lung cancer

|  | Records | |
| --- | --- | --- |
| Database | Lung Cancer | Last 10 years |
| MEDLINE (PubMed) | 210 | 51 |
| EMBASE | 289 | 96 |
| OpenAlex | 299 | 124 |
| Policy Commons | 1867 | 974 |
| Overton | 7627 | 4617 |

The following terms were used for the search strategies and adapted for each database:

### **Population**

**Mesh Terms / Mesh Major Topic**

* “Workplace”[MeSH Terms]
* “Working Conditions”[MeSH Terms]
* “Employment”[MeSH Terms]
* “Occupational Exposure”[MeSH Terms]
* “Occupational Diseases”[MeSH Terms]
* “occupational exposure/analysis”[MeSH Major Topic]
* “occupational diseases/chemically induced”[MeSH Terms]
* “occupational diseases/epidemiology”[MeSH Terms]
* “occupational exposure/adverse effects”[MeSH Major Topic]
* “workers compensation/economics”[MeSH Major Topic]
* “workers compensation/statistics and numerical data”[MeSH Major Topic]
* “workers compensation”[MeSH Terms]

### **Concept**

**Entry Terms**

* Probability of causation
* Probabilistic causation
* Balance of probabilities
* Aetiological fraction
* Etiologic fraction
* Causal fraction
* Attributable risk
* Attributable proportion
* Attributable fraction
* Proportional liability
* Causation
* Risk model
* Stochastic model
* Work attribution
* Assigned share

### **Context**

**Entry Terms**

* Neoplasms
* Cancer
* Carcinogens

**Mesh Terms / Mesh Major Topic**

* “Carcinogens”[MeSH Major Topic]
* “neoplasms/epidemiology”[MeSH Major Topic]
* “neoplasms/etiology”[MeSH Terms]
* “neoplasms/mortality”[MeSH Major Topic]

### **Additional Context**

**Entry Terms**

* Lung
* Lung Diseases
* Lung Cancer
* Pulmonary
* Bronchial
* Tracheal

**Mesh Terms / Mesh Major Topic**

* “Lung”[Mesh]
* “Lung Diseases”[Mesh]
* “Lung Neoplasms”[MeSH Major Topic]

#### PubMed (Medline)

Population

("Workplace"[tiab] OR "Working Conditions"[tiab] OR "Employment"[tiab] OR "Occupational Exposure"[tiab] OR "Occupational Diseases"[tiab] OR "occupational exposure/analysis"[tiab] OR "occupational diseases/chemically induced"[tiab] OR "occupational diseases/epidemiology"[tiab] OR "occupational exposure/adverse effects"[tiab] OR "Workplace"[MeSH Terms] OR "Working Conditions"[MeSH Terms] OR "Employment"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "occupational exposure/analysis"[MeSH Major Topic] OR "occupational diseases/chemically induced"[MeSH Terms] OR "occupational diseases/epidemiology"[MeSH Terms] OR "occupational exposure/adverse effects"[MeSH Major Topic] OR "workers compensation/economics"[MeSH Major Topic] OR "workers compensation/statistics and numerical data"[MeSH Major Topic] OR "workers compensation"[MeSH Terms] OR "workers compensation"[tiab])

Concept

("Probability of causation"[tiab] OR "Probabilistic causation"[tiab] OR "Balance of probabilities"[tiab] OR "Aetiological fraction"[tiab] OR "Etiologic fraction"[tiab] OR "Causal fraction"[tiab] OR "Attributable risk"[tiab] OR "Attributable proportion"[tiab] OR "Attributable fraction"[tiab] OR "Proportional liability"[tiab] OR "Causation"[tiab] OR "Risk model"[tiab] OR "Stochastic model"[tiab] OR "Work attribution"[tiab] OR "Assigned share"[tiab])

Context

("neoplasms"[tiab] OR "Cancer"[tiab] OR "Carcinogens"[tiab] OR "neoplasms/epidemiology"[tiab] OR "neoplasms/etiology"[tiab] OR "neoplasms/mortality"[tiab] OR "Carcinogens"[MeSH Major Topic] OR "neoplasms/epidemiology"[MeSH Major Topic] OR "neoplasms/etiology"[MeSH Terms] OR "neoplasms/mortality"[MeSH Major Topic])

Context (Additional)

("Lung"[Mesh] OR "Lung Diseases"[Mesh] OR lung[tiab] OR lungs[tiab] OR pulmonar\*[tiab] OR bronchop\*[tiab] OR bronchu\*[tiab] OR bronchi\*[tiab] OR trache\*[tiab])

Full search string

(((("Workplace"[tiab] OR "Working Conditions"[tiab] OR "Employment"[tiab] OR "Occupational Exposure"[tiab] OR "Occupational Diseases"[tiab] OR "occupational exposure/analysis"[tiab] OR "occupational diseases/chemically induced"[tiab] OR "occupational diseases/epidemiology"[tiab] OR "occupational exposure/adverse effects"[tiab] OR "Workplace"[MeSH Terms] OR "Working Conditions"[MeSH Terms] OR "Employment"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "occupational exposure/analysis"[MeSH Major Topic] OR "occupational diseases/chemically induced"[MeSH Terms] OR "occupational diseases/epidemiology"[MeSH Terms] OR "occupational exposure/adverse effects"[MeSH Major Topic] OR "workers compensation/economics"[MeSH Major Topic] OR "workers compensation/statistics and numerical data"[MeSH Major Topic] OR "workers compensation"[MeSH Terms] OR "workers compensation"[tiab])) AND (("Probability of causation"[tiab] OR "Probabilistic causation"[tiab] OR "Balance of probabilities"[tiab] OR "Aetiological fraction"[tiab] OR "Etiologic fraction"[tiab] OR "Causal fraction"[tiab] OR "Attributable risk"[tiab] OR "Attributable proportion"[tiab] OR "Attributable fraction"[tiab] OR "Proportional liability"[tiab] OR "Causation"[tiab] OR "Risk model"[tiab] OR "Stochastic model"[tiab] OR "Work attribution"[tiab] OR "Assigned share"[tiab]))) AND (("neoplasms"[tiab] OR "Cancer"[tiab] OR "Carcinogens"[tiab] OR "neoplasms/epidemiology"[tiab] OR "neoplasms/etiology"[tiab] OR "neoplasms/mortality"[tiab] OR "Carcinogens"[MeSH Major Topic] OR "neoplasms/epidemiology"[MeSH Major Topic] OR "neoplasms/etiology"[MeSH Terms] OR "neoplasms/mortality"[MeSH Major Topic]))) AND (("Lung"[Mesh] OR "Lung Diseases"[Mesh] OR lung[tiab] OR lungs[tiab] OR pulmonar\*[tiab] OR bronchop\*[tiab] OR bronchu\*[tiab] OR bronchi\*[tiab] OR trache\*[tiab]))

Number of records: 210

Restricting to last 10 years

(((("Workplace"[tiab] OR "Working Conditions"[tiab] OR "Employment"[tiab] OR "Occupational Exposure"[tiab] OR "Occupational Diseases"[tiab] OR "occupational exposure/analysis"[tiab] OR "occupational diseases/chemically induced"[tiab] OR "occupational diseases/epidemiology"[tiab] OR "occupational exposure/adverse effects"[tiab] OR "Workplace"[MeSH Terms] OR "Working Conditions"[MeSH Terms] OR "Employment"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "occupational exposure/analysis"[MeSH Major Topic] OR "occupational diseases/chemically induced"[MeSH Terms] OR "occupational diseases/epidemiology"[MeSH Terms] OR "occupational exposure/adverse effects"[MeSH Major Topic] OR "workers compensation/economics"[MeSH Major Topic] OR "workers compensation/statistics and numerical data"[MeSH Major Topic] OR "workers compensation"[MeSH Terms] OR "workers compensation"[tiab])) AND (("Probability of causation"[tiab] OR "Probabilistic causation"[tiab] OR "Balance of probabilities"[tiab] OR "Aetiological fraction"[tiab] OR "Etiologic fraction"[tiab] OR "Causal fraction"[tiab] OR "Attributable risk"[tiab] OR "Attributable proportion"[tiab] OR "Attributable fraction"[tiab] OR "Proportional liability"[tiab] OR "Causation"[tiab] OR "Risk model"[tiab] OR "Stochastic model"[tiab] OR "Work attribution"[tiab] OR "Assigned share"[tiab]))) AND (("neoplasms"[tiab] OR "Cancer"[tiab] OR "Carcinogens"[tiab] OR "neoplasms/epidemiology"[tiab] OR "neoplasms/etiology"[tiab] OR "neoplasms/mortality"[tiab] OR "Carcinogens"[MeSH Major Topic] OR "neoplasms/epidemiology"[MeSH Major Topic] OR "neoplasms/etiology"[MeSH Terms] OR "neoplasms/mortality"[MeSH Major Topic]))) AND (("Lung"[Mesh] OR "Lung Diseases"[Mesh] OR lung[tiab] OR lungs[tiab] OR pulmonar\*[tiab] OR bronchop\*[tiab] OR bronchu\*[tiab] OR bronchi\*[tiab] OR trache\*[tiab])) AND ("2014"[dp] : "2024"[dp])

Number of records (Last 10 years): 51

#### EMBASE

(workplace:ti,ab OR 'working conditions':ti,ab OR employment:ti,ab OR 'occupational exposure':ti,ab OR 'occupational diseases':ti,ab OR 'occupational exposure'/exp OR 'occupational diseases'/exp OR 'occupational exposure/analysis' OR 'occupational diseases/chemically induced' OR 'occupational diseases/epidemiology' OR 'occupational exposure/adverse effects' OR 'workers compensation'/exp OR 'workers compensation/economics' OR 'workers compensation/statistics') AND ('probability of causation':ti,ab OR 'probabilistic causation':ti,ab OR 'balance of probabilities':ti,ab OR 'aetiological fraction':ti,ab OR 'etiologic fraction':ti,ab OR 'causal fraction':ti,ab OR 'attributable risk':ti,ab OR 'attributable proportion':ti,ab OR 'attributable fraction':ti,ab OR 'proportional liability':ti,ab OR causation:ti,ab OR 'risk model':ti,ab OR 'stochastic model':ti,ab OR 'work attribution':ti,ab OR 'assigned share':ti,ab) AND ('neoplasms':ti,ab OR cancer:ti,ab OR carcinogens:ti,ab OR 'neoplasm'/exp OR 'carcinogen'/exp OR 'neoplasms/epidemiology' OR 'neoplasms/etiology' OR 'neoplasms/mortality' OR 'carcinogen'/mj) AND ('lung'/exp OR 'lung diseases'/exp OR lung:ti,ab OR lungs:ti,ab OR pulmonar\*:ti,ab OR bronchop\*:ti,ab OR bronchu\*:ti,ab OR bronchi\*:ti,ab OR trache\*:ti,ab)

Number of records: 289

Restricting to last 10 years

(workplace:ti,ab OR 'working conditions':ti,ab OR employment:ti,ab OR 'occupational exposure':ti,ab OR 'occupational diseases':ti,ab OR 'occupational exposure'/exp OR 'occupational diseases'/exp OR 'occupational exposure/analysis' OR 'occupational diseases/chemically induced' OR 'occupational diseases/epidemiology' OR 'occupational exposure/adverse effects' OR 'workers compensation'/exp OR 'workers compensation/economics' OR 'workers compensation/statistics') AND ('probability of causation':ti,ab OR 'probabilistic causation':ti,ab OR 'balance of probabilities':ti,ab OR 'aetiological fraction':ti,ab OR 'etiologic fraction':ti,ab OR 'causal fraction':ti,ab OR 'attributable risk':ti,ab OR 'attributable proportion':ti,ab OR 'attributable fraction':ti,ab OR 'proportional liability':ti,ab OR causation:ti,ab OR 'risk model':ti,ab OR 'stochastic model':ti,ab OR 'work attribution':ti,ab OR 'assigned share':ti,ab) AND ('neoplasms':ti,ab OR cancer:ti,ab OR carcinogens:ti,ab OR 'neoplasm'/exp OR 'carcinogen'/exp OR 'neoplasms/epidemiology' OR 'neoplasms/etiology' OR 'neoplasms/mortality' OR 'carcinogen'/mj) AND ('lung'/exp OR 'lung diseases'/exp OR lung:ti,ab OR lungs:ti,ab OR pulmonar\*:ti,ab OR bronchop\*:ti,ab OR bronchu\*:ti,ab OR bronchi\*:ti,ab OR trache\*:ti,ab) AND [2014-2024]/py

Number of records (last 10 years): 96

#### OpenAlex

https://api.openalex.org/works?filter=title\_and\_abstract.search:((("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation") AND ("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share") AND ("neoplasms" OR "cancer" OR "carcinogens") AND ("lung" OR "lungs" OR "pulmonary" OR "bronchopulmonary" OR "bronchus" OR "bronchi" OR "trachea")))

Number of records (title and abstract): 299

Number of records (title and abstract, last 10 years): 124

Number of records (full-text): 11290

Number of records (full-text, last 10 years): 3951

#### Policy Commons

Restricting to lung cancer only

("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation") AND ("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share") AND ("neoplasms" OR "cancer" OR "carcinogens") AND ("lung" OR "lungs" OR "pulmonary" OR "bronchopulmonary" OR "bronchus" OR "bronchi" OR "trachea")

Number of records: 1867

Number of records (last 10 years): 974

#### Overton

("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation")   
AND   
("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share")   
AND   
("neoplasms" OR "cancer" OR "carcinogens")   
AND   
("lung" OR "lungs" OR "pulmonary" OR "bronchopulmonary" OR "bronchus" OR "bronchi" OR "trachea")

Number of records: 7627

Number of records (last 10 years): 4617

# Appendix 2: All types of cancer

Table 2: Summary of records for all types of cancer

|  | Records | |
| --- | --- | --- |
| Database | All types of cancer | Last 10 years |
| MEDLINE (PubMed) | 412 | 120 |
| EMBASE | 559 | 209 |
| OpenAlex | 629 | 276 |
| Policy Commons | 3971 | 2155 |
| Overton | 13130 | 8018 |

#### PubMed

((("Workplace\*"[tiab] OR "Working Conditions"[tiab] OR "Employment"[tiab] OR "Occupational Exposure"[tiab] OR "Occupational Diseases"[tiab] OR "occupational exposure/analysis"[tiab] OR "occupational diseases/chemically induced"[tiab] OR "occupational diseases/epidemiology"[tiab] OR "occupational exposure/adverse effects"[tiab] OR "Workplace"[MeSH Terms] OR "Working Conditions"[MeSH Terms] OR "Employment"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "occupational exposure/analysis"[MeSH Major Topic] OR "occupational diseases/chemically induced"[MeSH Terms] OR "occupational diseases/epidemiology"[MeSH Terms] OR "occupational exposure/adverse effects"[MeSH Major Topic] OR "workers compensation/economics"[MeSH Major Topic] OR "workers compensation/statistics and numerical data"[MeSH Major Topic] OR "workers compensation"[MeSH Terms] OR "workers compensation"[tiab])) AND (("Probability of causation"[tiab] OR "Probabilistic causation"[tiab] OR "Balance of probabilities"[tiab] OR "Aetiological fraction"[tiab] OR "Etiologic fraction"[tiab] OR "Causal fraction"[tiab] OR "Attributable risk"[tiab] OR "Attributable proportion"[tiab] OR "Attributable fraction"[tiab] OR "Proportional liability"[tiab] OR "Causation"[tiab] OR "Risk model"[tiab] OR "Stochastic model"[tiab] OR "Work attribution"[tiab] OR "Assigned share"[tiab]))) AND (("neoplasms"[tiab] OR "Cancer"[tiab] OR "Carcinogens"[tiab] OR "neoplasms/epidemiology"[tiab] OR "neoplasms/etiology"[tiab] OR "neoplasms/mortality"[tiab] OR "Carcinogens"[MeSH Major Topic] OR "neoplasms/epidemiology"[MeSH Major Topic] OR "neoplasms/etiology"[MeSH Terms] OR "neoplasms/mortality"[MeSH Major Topic]))

Number of records: 412

Restricting to last 10 years

((("Workplace\*"[tiab] OR "Working Conditions"[tiab] OR "Employment"[tiab] OR "Occupational Exposure"[tiab] OR "Occupational Diseases"[tiab] OR "occupational exposure/analysis"[tiab] OR "occupational diseases/chemically induced"[tiab] OR "occupational diseases/epidemiology"[tiab] OR "occupational exposure/adverse effects"[tiab] OR "Workplace"[MeSH Terms] OR "Working Conditions"[MeSH Terms] OR "Employment"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "occupational exposure/analysis"[MeSH Major Topic] OR "occupational diseases/chemically induced"[MeSH Terms] OR "occupational diseases/epidemiology"[MeSH Terms] OR "occupational exposure/adverse effects"[MeSH Major Topic] OR "workers compensation/economics"[MeSH Major Topic] OR "workers compensation/statistics and numerical data"[MeSH Major Topic] OR "workers compensation"[MeSH Terms] OR "workers compensation"[tiab])) AND (("Probability of causation"[tiab] OR "Probabilistic causation"[tiab] OR "Balance of probabilities"[tiab] OR "Aetiological fraction"[tiab] OR "Etiologic fraction"[tiab] OR "Causal fraction"[tiab] OR "Attributable risk"[tiab] OR "Attributable proportion"[tiab] OR "Attributable fraction"[tiab] OR "Proportional liability"[tiab] OR "Causation"[tiab] OR "Risk model"[tiab] OR "Stochastic model"[tiab] OR "Work attribution"[tiab] OR "Assigned share"[tiab]))) AND (("neoplasms"[tiab] OR "Cancer"[tiab] OR "Carcinogens"[tiab] OR "neoplasms/epidemiology"[tiab] OR "neoplasms/etiology"[tiab] OR "neoplasms/mortality"[tiab] OR "Carcinogens"[MeSH Major Topic] OR "neoplasms/epidemiology"[MeSH Major Topic] OR "neoplasms/etiology"[MeSH Terms] OR "neoplasms/mortality"[MeSH Major Topic])) AND ("2014"[dp] : "2024"[dp])

Number of records (last 10 years): 120

#### EMBASE

(workplace:ti,ab OR 'working conditions':ti,ab OR employment:ti,ab OR 'occupational exposure':ti,ab OR 'occupational diseases':ti,ab OR 'occupational exposure'/exp OR 'occupational diseases'/exp OR 'occupational exposure/analysis' OR 'occupational diseases/chemically induced' OR 'occupational diseases/epidemiology' OR 'occupational exposure/adverse effects' OR 'workers compensation'/exp OR 'workers compensation/economics' OR 'workers compensation/statistics') AND ('probability of causation':ti,ab OR 'probabilistic causation':ti,ab OR 'balance of probabilities':ti,ab OR 'aetiological fraction':ti,ab OR 'etiologic fraction':ti,ab OR 'causal fraction':ti,ab OR 'attributable risk':ti,ab OR 'attributable proportion':ti,ab OR 'attributable fraction':ti,ab OR 'proportional liability':ti,ab OR causation:ti,ab OR 'risk model':ti,ab OR 'stochastic model':ti,ab OR 'work attribution':ti,ab OR 'assigned share':ti,ab) AND ('neoplasms':ti,ab OR cancer:ti,ab OR carcinogens:ti,ab OR 'neoplasm'/exp OR 'carcinogen'/exp OR 'neoplasms/epidemiology' OR 'neoplasms/etiology' OR 'neoplasms/mortality' OR 'carcinogen'/mj)

Number of records: 559

Restricting to last 10 years

(workplace:ti,ab OR 'working conditions':ti,ab OR employment:ti,ab OR 'occupational exposure':ti,ab OR 'occupational diseases':ti,ab OR 'occupational exposure'/exp OR 'occupational diseases'/exp OR 'occupational exposure/analysis' OR 'occupational diseases/chemically induced' OR 'occupational diseases/epidemiology' OR 'occupational exposure/adverse effects' OR 'workers compensation'/exp OR 'workers compensation/economics' OR 'workers compensation/statistics') AND ('probability of causation':ti,ab OR 'probabilistic causation':ti,ab OR 'balance of probabilities':ti,ab OR 'aetiological fraction':ti,ab OR 'etiologic fraction':ti,ab OR 'causal fraction':ti,ab OR 'attributable risk':ti,ab OR 'attributable proportion':ti,ab OR 'attributable fraction':ti,ab OR 'proportional liability':ti,ab OR causation:ti,ab OR 'risk model':ti,ab OR 'stochastic model':ti,ab OR 'work attribution':ti,ab OR 'assigned share':ti,ab) AND ('neoplasms':ti,ab OR cancer:ti,ab OR carcinogens:ti,ab OR 'neoplasm'/exp OR 'carcinogen'/exp OR 'neoplasms/epidemiology' OR 'neoplasms/etiology' OR 'neoplasms/mortality' OR 'carcinogen'/mj) AND [2014-2024]/py

Number of records: 209

#### OpenAlex

https://api.openalex.org/works?filter=title\_and\_abstract.search:((("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation") AND ("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share") AND ("neoplasms" OR "cancer" OR "carcinogens")))

Number of records (title and abstract): 629

Number of records (title and abstract, last 10 years): 276

Number of records (full-text): 22992

Number of records (full-text, last 10 years): 8835

#### Policy Commons

("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation") AND ("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share") AND ("neoplasms" OR "cancer" OR "carcinogens") AND ("lung" OR "lungs" OR "pulmonary" OR "bronchopulmonary" OR "bronchus" OR "bronchi" OR "trachea")

Number of records: 3971

Number of records (last 10 years): 2155

#### Overton

("workplace" OR "working conditions" OR "employment" OR "occupational exposure" OR "occupational diseases" OR "workers compensation")   
AND   
("probability of causation" OR "probabilistic causation" OR "balance of probabilities" OR "aetiological fraction" OR "etiologic fraction" OR "causal fraction" OR "attributable risk" OR "attributable proportion" OR "attributable fraction" OR "proportional liability" OR "causation" OR "risk model" OR "stochastic model" OR "work attribution" OR "assigned share")   
AND   
("neoplasms" OR "cancer" OR "carcinogens")

Number of records: 13130

Number of records (last 10 years): 8018