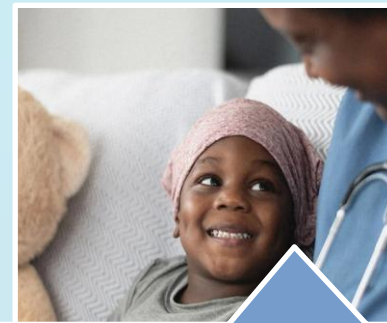


FINANCIAL DISCLOSURES

There are no financial disclosures to declare

BACKGROUND



Cancer is a leading cause of death in children and adolescents around the world. It is estimated that about 300 thousand children between 0 and 19 years are diagnosed with this disease every year (1).

Leukemia is the most common cancer in children, representing nearly a third of all pediatric cancers (1, 2).

Among childhood leukemia cases, around 80% are Acute Lymphoblastic Leukemia (ALL), and most of the remaining cases are Acute Myeloid Leukemia (AML) (2).

How Leukemia Affects the Body and Statistics

Leukemia is the most common cancer in children and adolescents, **disrupting the normal production of blood cells**, leading to anemia, bleeding disorders, and susceptibility to infections.

Approx. 23,100 deaths from the disease in 2021.

60,530 new cases is estimated to be diagnosed in 2021.

Worldwide, leukemia accounts for nearly one-third of all childhood cancers.

The five-year survival rate for people with leukemia varies widely depending on the type and stage:



OBJECTIVE

To assess the risk of developing leukemia in pediatric patients exposed to diagnostic x-ray ionizing radiation.

METHODS AND MATERIAL

Protocol and registration

This rapid review was designed using the guidance of the MOOSE group (Meta-analysis of Observational Studies in Epidemiology)

Is registered in the Prospero (International Prospective Register of Systematic Reviews) database (10, 11).

We searched the following electronic databases: PubMed, EMBASE, Web of Science, and Virtual Health Library (VHL).

In addition, we manually searched the references of the included articles and performed a citation analysis of the included studies using Google Scholar.

Search Terms



- "Child," "Leukemia," "Radiation, Ionizing," and "X-Rays"
- followed by their related entry terms
- We did not use limits for language or date when conducting the searches

Eligibility

We included full peer-reviewed publications of case-control or cohort studies, involving pediatric patients exposed to diagnostic x-ray ionizing radiation and evaluating the risk of these patients developing leukemia. We excluded conference abstracts and studies reporting duplicate population data.

Titles and abstracts of the retrieved articles were evaluated by two reviewers. Abstracts that did not provide enough information regarding the eligibility criteria were kept for full-text evaluation. Two reviewers evaluated full-text articles and determined study eligibility.

Synthesis



Descriptive analyses of studies were performed, including study characteristics and main results. A meta-analysis to evaluate the association between the number of X-rays children were exposed to and the subsequent risk of developing leukemia was conducted using the Software Review Manager

From both case and control studies, data on the total number of subjects and the number of X-rays children were exposed to were collected from studies. Data were presented as Odds Ratio (OR) and their relative 95% confidence interval (CI).

Heterogeneity was investigated using a standard χ^2 test with significance at $P < 0.05$. Pooled OR and 95% CI were calculated using a random effect model. Sensitivity analysis and funnel plot analysis were performed when high heterogeneity was observed.

The classification of heterogeneity was as follows:
- 0% to 40%: might not be important; - 30% to 60%: may represent moderate heterogeneity; - 50% to 90%: may represent substantial heterogeneity; - 75% to 100%: considerable heterogeneity.

SUMMARY OR RESULTS

Study, Year	Leukemia Type Focused	Sample Size (Cases / Controls)	X-ray Exposure Categories Assessed	Key Results and Observations
Chokkalingam et al, 2011	Acute Lymphoblastic Leukemia (ALL)	377 / 448	0-2 X-rays, 3+ X-rays	Focused on investigating the dose-response relationship. (Specific results not detailed in the excerpt)
Rajaraman et al, 2011	All leukemias	1253 / 4858	Diagnostic radiation in early infancy (0-yr and 2-yr lag)	Explored the impact of timing of exposure in early infancy. (Specific results not detailed in the excerpt)
Bailey et al, 2010	Acute lymphoid, myeloid, and chronic myeloid	389 / 876	No X-ray, 1 X-ray, >1 X-ray	Assessed risk associated with any level of exposure versus no exposure. (Specific results not detailed in the excerpt)
Bartley et al, 2010	Acute lymphoid or acute myeloid leukaemia	701 / 1107	No X-ray, 1-2 X-rays, 3+ X-rays	Investigated risk gradients with different exposure levels. (Specific results not detailed in the excerpt)
Infante-Rivard et al, 2003	Acute Lymphoblastic Leukemia (ALL)	701 / 701	No X-ray, 1 X-ray, 2+ X-rays	Increased risk of leukemia with some X-rays. The adjusted OR for two or more X-rays vs. none was 1.48 (95% CI 1.11–1.97). The region of the body exposed was not an independent risk factor. Higher risk identified in girls (OR = 1.67).
Shu et al, 2002	Acute Lymphoblastic Leukemia (ALL)	1824 / 1986	1+ X-ray	Focused on the effect of any exposure versus none. (Specific results not detailed in the excerpt)
Meinert et al, 1999	All leukemias	1184 / 2588	0 X-ray, 1-4 X-rays, 4+ X-rays	Searched for a dose-response relationship for all leukemias. (Specific results not detailed in the excerpt)
Shu et al, 1994	Acute leukemias	166 / 166	No X-ray, 1-2 X-rays, 3+ X-rays	The risk of ALL was elevated in children exposed to three or more postnatal X-rays, OR = 1.85 (95% CI 1.12 - 2.79). For B-cell ALL, any exposure (one or more X-rays) was associated with a higher risk of ALL (OR = 1.67).

Elevated Leukemia Risk Children
Exposed to diagnostic X-rays have a ~45% higher risk of developing leukemia, especially ALL

Dose-Response Evidence
Risk rises with exposure frequency: 2+ postnatal X-rays → OR ≈ 1.48, and 3+ X-rays → OR ≈ 1.85, indicating a clear dose-response relationship.

Consistent Across Studies
Results hold after sensitivity analyses and across diverse study designs. Sex-based differences noted, with higher risk in girls (OR = 1.67).

Implications for Practice
Supports ALARA principles (As Low As Reasonably Achievable). Reinforces the need for caution and justification in pediatric imaging.

CONCLUSION

In conclusion, our study found a positive association between being exposed (postnatal exposure) to one or more, two or more, and three or more X-rays and the development of leukemia. More studies, including those with large sample sizes and using data from validated sources, should be conducted to obtain conclusive results about the association between childhood X-ray ionizing radiation exposure and the subsequent development of leukemia

REFERENCES



Scan here for references



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