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Brief communication

Home remodeling and risk of childhood leukemia

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ABSTRACT

Purpose: We investigated the relationship between the risk of childhood leukemia and home remodeling, a surrogate for indoor chemical exposures.
Methods: We collected information on remodeling activities carried out between birth and diagnosis in homes of 609 acute lymphoblastic leukemia (ALL) cases, 89 acute myeloid leukemia (AML) cases, and 893 matched controls participating in the California Childhood Leukemia Study (1995–2008). We used multivariable logistic regression to estimate the risk of ALL and AML associated with six remodeling activities: construction, painting, recarpeting, reflooring, roofing, and weatherproofing. Models were adjusted for age, sex, Hispanic ethnicity, race, household annual income, and residential mobility.
Results: Construction in the home between birth and diagnosis was associated with a significant increase in ALL risk (odds ratio [OR]: 1.52, 95% confidence interval [CI]: 1.14–2.02) and a nonsignificant increase in AML risk (OR: 1.75, 95% CI: 0.98–3.15). No other remodeling activities were associated with ALL or AML risk in the main analysis. When stratifying by Hispanic ethnicity, a positive relationship between ALL risk and painting was evident in Hispanic children (OR: 1.47, 95% CI: 1.04–2.07).
Conclusions: Specific home remodeling activities appeared to be associated with increased risk of childhood ALL.

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Introduction

Leukemia is the most common childhood cancer [1], comprised primarily of acute lymphoblastic leukemia (ALL, 79%) and acute myeloid leukemia (AML, 18%) [2]. Leukemia incidence peaks between ages 2 and 4. Established risk factors including genetic conditions and ionizing radiation explain a small fraction of leukemia incidence [3,4]. Childhood exposures to chemicals may also contribute to disease development [5–7].

A variety of suspected carcinogens formerly used as constituents of building materials still remain in homes today [8] including, polychlorinated biphenyls (PCBs), used in joint sealants, glues, and plasticizers [9]; polybrominated diphenyl ethers (PBDEs), used in insulation, roofing film, and wiring [10,11]; styrene [7] and lead [12], both used in paint; and asbestos, used in insulation, shingles, and flooring [13]. Moreover, building materials are reservoirs for chemical contamination; for example, drywall absorbs semivolatile pesticides applied indoors [14]. Home remodeling can release these latent chemicals from building materials, for example, chipping, cutting, and sanding can generate lead dust [12] or disturb asbestos and PCBs [15]. In addition to releasing latent chemicals, remodeling activities also introduce new residential chemical sources, for example, installation of carpets and carpet pads containing flame retardants [16] or application of paint containing volatile organic compounds. Construction activities also disturb settled dust [15], increasing the likelihood that residents will ingest or inhale contaminated dust. Settled dust is a source of exposure to indoor pollutants, as demonstrated by relationships observed between chemical levels in blood and dust for lead [17], PBDEs [18], and PCBs [19]. Due to their tendency to make hand-to-mouth contact, young children are especially prone to ingesting contaminated dust [14].

As part of the California Childhood Leukemia Study (CCLS), we have previously demonstrated that several of the chemicals to which children may be exposed during remodeling activities,

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including PCBs [20], PBDEs [21], and indoor insecticides[5,22], are putative risk factors for childhood leukemia. Another CCLS investigation indicated that indoor painting during early childhood was associated with increased risk of ALL [7], which was confirmed in pooled analyses [23]. Moreover, a recent Chinese study reported an increased risk of childhood acute leukemia associated with home renovation after birth [24].

We hypothesize that remodeling releases chemicals into the home and that exposure to these chemicals increases the risk of childhood leukemia.

Material and methods

Study population

The CCLS is a case-control study of incident childhood leukemia (all subtypes) diagnosed at nine pediatric oncology centers in 35 California counties from 1995 to 2008. Phase I of the study (1995–1999) included 17 counties in the San Francisco Bay Area, and phase II (1999–2008) included 18 additional counties in the California Central Valley. Leukemia cases were identified within 72 hours of diagnosis and considered eligible for participation if they were younger than 15 years, not previously diagnosed with cancer, and living in the study area with an English- or Spanish-speaking parent. Based on the California Cancer Registry, the CCLS ascertained 76% of all cases diagnosed at participating and nonparticipating hospitals in the study area. Of the case families determined to be eligible, 86% consented to participate.

Controls had the same eligibility criteria as cases, including no previous history of cancer. For each case, four potential controls were randomly matched on age, sex, Hispanic ethnicity, and mother's race using birth certificates (California Office of Vital Records). Initially, two controls were enrolled per case, but, subsequently, 1:1 matching was used. Out of all potential controls searched, 12% could not be located, 20% refused to be screened for eligibility, and 68% were successfully contacted and considered for eligibility [25]. Among the eligible families, 86% agreed to participate in the study. The demographic characteristics of the participating controls were representative of the source population [26], with an income distribution similar to that of all California families with children under 18 years [27].

Children diagnosed with leukemia at less than 1 year of age were excluded ($N = 46$, 4.6%, and their 42 corresponding controls) from the analysis because most cases of infant leukemia are believed to arise in utero [6]. This analysis focuses on ALL and AML, excluding other leukemia subtypes ($N = 9$). The sample for this analysis included 609 ALL cases, 89 AML cases, and 893 controls who provided a remodeling history.

The study was approved by the University of California, Berkeley Committee for Protection of Human Subjects, the California Health and Human Services Agency Committee for Protection of Human Subjects, and the Institutional Review Boards of the participating hospitals. Written informed consent was obtained from participating parents.

Data collection

Interviews were conducted with the parent of the participating child, usually the biological mother. The median time between date of enrollment and the first interview was 4 months for cases and 14 months for controls. Residential histories were collected during an in-person interview administered by trained personnel. Respondents described remodeling activities that took place in each home occupied by the child between birth and diagnosis date (or at an equivalent reference date, for controls) including construction, painting, recarpeting, reflooring, roofing, and weatherproofing. Demographic characteristics were collected, including child's sex, race, Hispanic ethnicity, and age at diagnosis and/or reference date, as well as household annual income (six levels) maternal education (four levels), and residential mobility (number of homes inhabited).

Missing data

Some participants were unable to provide a complete remodeling history for each residence the child inhabited between birth and diagnosis. As such, 301 respondents (19%) were missing data on construction, painting, recarpeting, reflooring, and weatherproofing for at least one home, and 526 (33%) were missing data on roofing. If a respondent indicated that a child was exposed to a remodeling activity in at least one home, the child was included in the analysis of that remodeling activity, even if the remodeling history was otherwise incomplete (i.e., child treated as "exposed"). Alternatively, if the history of a particular remodeling activity was incomplete and the respondent indicated that the child was not exposed to that remodeling activity in any of the homes that were discussed, then the participant was excluded from the analysis for that remodeling activity (i.e., child's exposure status "unknown"). Because cases tended to have more missing data than controls, in sensitivity analyses, we evaluated the potential for bias due to exposure misclassification in homes with missing data. In these analyses, if the remodeling history was incomplete and the respondent indicated that the child was not exposed to a remodeling activity in any of the homes, the child was classified as "unexposed."

In addition, there was missing covariate data: 9 (1%) of the respondents did not report child's race, 2 (0.1%) did not report child's ethnicity, and 44 (3%) did not report household income. In multivariable models, missing data on child's race and ethnicity were replaced by the mother's race and ethnicity. Missing income data were replaced by the population average.

Statistical analysis

ALL and AML risks were analyzed separately because these subtypes are epidemiologically and clinically distinct [6]. Although controls were initially matched to ALL and AML cases, the matching was not maintained in the main analysis due to missing data. The combined control group was used as a comparison for both ALL and AML cases, with adjustment made in statistical analyses for matching factors, that is, age at diagnosis and/or reference date, sex, Hispanic ethnicity, and race, and for potential confounders, income and residential mobility. In complementary analyses, we used a smaller number of matched cases and controls to conduct conditional logistic regression for ALL and AML, separately. We used logistic regression to estimate the risk of ALL and AML associated with construction, indoor painting, recarpeting, reflooring, roofing, and weatherproofing using dichotomous exposure variables (odds ratio for any vs. none).

The increasing gap in ALL incidence between Hispanic and non-Hispanic children in California suggests the presence of distinct etiologic risk factors by ethnicity; as such, we evaluated ALL risk associated with home remodeling while stratifying by Hispanic ethnicity [28]. The routes by which children are exposed to indoor chemicals vary by age, so we also stratified our ALL risk analysis by age at diagnosis. Finally, because we found that income and residential mobility were potential confounders of the relationship between remodeling and ALL risk, we stratified by these factors as well. The relatively smaller number of AML cases were not sufficient to support stratified analyses.

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