

THE POTENTIAL IMPACT OF INCOMPLETE RADIOGRAPHY HISTORIES IN EPIDEMIOLOGIC STUDIES THAT RELY ON PREPAID HEALTH PLAN RECORDS

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Abstract—Members of prepaid health plans are often considered a group for which complete histories of exposure to medically-related risk factors are known. In a population-based case-control study of radiography as a risk factor for acute myelogenous leukemia, extensive retrospective exposure data from an average of 71% of subjects' health care providers were collected. It was determined that at least 21% of prepaid health plan members received diagnostic imaging procedures outside of their plans over the 10-y period of interest and that these "outside" procedures constituted 43% of their total red bone marrow dose from all radiographic imaging. Procedures significantly more likely to have been received outside of prepaid health plans were conventional spine x rays ($p = 0.004$) and coronary angiograms ($p < 0.0001$). All "outside" coronary angiograms and 50% of "outside" spine x rays were received at hospitals. Epidemiologic studies that restrict exposure to that received within prepaid health plans may miss a substantial portion of exposure, resulting in underestimated risk estimates and a loss of statistical power.

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AML, studies that explore its risk factors are usually retrospective and therefore must either rely on participants' recall to ascertain radiography history or must draw its subjects from a population for which all exposure from radiography is assumed to be known. One such case-control study was conducted within two prepaid health plans and found no association between radiography (received within the prepaid plans) and leukemias other than chronic lymphocytic leukemia (Boice et al. 1991).

Data from a Los Angeles County population-based case-control study of AML were used to determine the extent of incomplete radiography history over a 10-y period that resulted for members of prepaid health plans when exposure was limited to that received within their plans. This was feasible because of the extensive data collection performed in order to include a validation component as part of this study (Pogoda and Preston-Martin, in press).

INTRODUCTION

RISK OF acute myelogenous leukemia (AML) from ionizing radiation has been well-studied in heavily-exposed populations, such as A-bomb survivors (Shimizu et al. 1989). The few studies on AML risk from low-dose sources, i.e., medical radiography, have produced inconsistent findings (Stewart et al. 1962; Gunz and Atkinson 1964; Gibson et al. 1972; Linos et al. 1980; Boice et al. 1991; Yuasa et al. 1997). Because of the low incidence of

MATERIALS AND METHODS

412 matched case-control pairs were interviewed between 1987 and 1997 on their radiography histories in the past 10 years. The cases were diagnosed from January 1987 through June 1994; they represented 57% (412/726) of those originally identified through the Cancer Surveillance Program (the Los Angeles County SEER Cancer Registry) and 85% (412/487) of those invited to participate. For 201 deceased cases, proxy respondents (usually the spouse) were interviewed (comparisons between direct and proxy respondents to be published later).

Respondents were asked about specific diagnostic imaging procedures within anatomical categories (Preston-Martin and Pogoda, in press). If they reported that they had ever had a particular procedure, they were then asked the total number of occasions on which they had the procedure; the exact body part examined; the date of the procedure; the reason for the procedure; the exact

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name of the procedure; whether or not fluoroscopy was used; the type of facility at which the procedure was performed; and the name, address, and specialty of the health care provider who ordered the procedure.

Contact with every provider named in subjects' interviews was attempted using aggressive mail and phone techniques. Each provider located was asked to consult their records for the relevant subject and time period and to provide the subject's history of diagnostic imaging procedures while under their care. Institutional providers were asked to search their master records that contained patient information from all departments (i.e., not just radiology). All providers were also asked if they were aware of other providers who had treated the subject (e.g., through referrals to or from) or to whom the subject's records had been transferred. When records had been transferred from the original provider to a new provider, the new provider was asked to provide the necessary information.

An estimate of red bone marrow (RBM) radiation dose associated with each radiographic procedure reported by study participants or recorded in their medical records was developed (Preston-Martin and Pogoda, in press). Briefly, a database of RBM dose estimates for each procedure was created through literature searches and other resources (e.g., personal communications with radiology experts), and a median RBM dose was calculated for each procedure.

This report includes exposure data only from subjects' medical records. Since subjects were not specifically asked if they were members of prepaid health plans, prepaid health plan members were defined as subjects who had ever received a diagnostic imaging procedure through a prepaid health plan. Time periods of membership were based on the first and last years that diagnostic imaging procedures were received through prepaid health plans. Subjects with only one recorded plan-affiliated procedure were considered members during that year in which the procedure was performed.

Fisher's exact test was used to test for associations between subject characteristics and receiving diagnostic procedures outside of a prepaid plan. To test for associations between particular types of procedures and type of facility (through a prepaid plan vs. outside of a plan), two different methods were used: 1) Fisher's exact test and 2) generalized estimating equations to account for within-subject correlation (Zeger and Liang 1986). All tests were two-sided with a 0.05 significance level.

RESULTS

Study subjects ranged in age from 25 to 74 y; 57% were male and 77% were white; 165 subjects (20%) were

members of prepaid health plans. Of these, 35 (21%) had a total of 146 diagnostic imaging procedures from facilities outside of those operated by their prepaid health plans while they were members, constituting 5% of all procedures recorded in medical records. Disease status (AML vs. control), proxy status, age, and sex were unrelated to receiving procedures outside of prepaid health plans.

The total RBM radiation dose associated with "outside" procedures was 290 mGy, which was 18% of total RBM dose from all recorded procedures over the 10-y period of interest for all prepaid health plan members combined. Among the 35 members with "outside" procedures, the median number of "outside" procedures received was two (range = 1 to 20), representing an average of 32% (SD = 24%) of their total procedures and 43% (SD = 36%) of their total RBM dose over the 10-y period of interest. Most (62%) of the "outside" procedures were received at hospitals. The most common "outside" procedures were conventional chest, extremity, and spine x rays (30%, 16%, and 15%, respectively; Table 1). Procedures significantly more likely to have been received outside of prepaid health plans were conventional spine x rays ($p = 0.004$) and coronary angiograms ($p < 0.0001$); estimated RBM doses per examination for these procedures are 1.4 and 12.7 mGy, respectively. All "outside" coronary angiograms and 50% of "outside" conventional spine x rays were received at hospitals. Mammograms, which deliver very little RBM dose (estimated at 0.07 mGy per examination), were significantly more likely to have been received through prepaid health plans ($p = 0.01$).

After accounting for within-subject correlation, only coronary angiograms were significantly more likely to have been received outside of prepaid plans ($p = 0.009$), and only MRIs (which are non-radiographic) were significantly more likely to have been received through prepaid health plans ($p = 0.02$).

DISCUSSION

Twenty-one percent of prepaid plan members had diagnostic procedures done outside of their prepaid plans during the 10-y period of interest, accounting for 18% of total RBM dose reported in this study among all prepaid health plan members and 43% of RBM dose among those members who had outside procedures. It was assumed that a) members were in their plans continuously from the first to the last year in which a procedure was recorded by a plan-affiliated facility, and b) these first and last years coincided with the timing of plan membership. While neither of these assumptions is realistic, it is likely that their effects on amount of exposure received

Table 1. Diagnostic imaging procedures recorded in medical records of prepaid health plan members, Los Angeles County case-control study of AML, 1987–1994.

Procedure	Estimated dose (mGy) ^a	Procedures within prepaid plans (n = 1,239 ^b)		Procedures outside of prepaid plans (n = 144 ^b)		p-value
		No.	Percent	No.	Percent	
Conventional chest x ray	0.05	454	36.6	43	29.9	
Conventional extremity x ray	0.00	217	17.5	23	16.0	
Mammogram	0.07	120	9.7	5	3.5	— ^d
Conventional spine x ray	1.41	93	7.5	22	15.3	— ^e
Other conventional x ray	0.78	137	11.1	13	9.0	
GI series	5.05	50	4.0	3	2.1	
Coronary angiogram	12.67	1	0.1	10	6.9	— ^f
Arteriogram	9.95	1	0.1	0	0.0	
Venogram	2.71	3	0.2	0	0.0	
Other fluoroscopic exams	3.04	7	0.6	3	2.1	
Ultrasound ^c	0.00	41	3.3	7	4.9	
CT scan	5.50	40	3.2	7	4.9	
Nuclear medicine scan	6.62	38	3.1	3	2.1	
IVP	2.10	19	1.5	0	0.0	
MRI	0.00	8	0.6	3	2.1	— ^g
Tomogram	0.50	6	0.5	1	0.7	
Cholecystogram	1.59	3	0.2	1	0.7	
Thermogram ^c	0.00	1	0.1	0	0.0	

^a For procedure categories that contain > one type of procedure, doses were averaged over all procedures. Dose estimation methods are described in Preston-Martin and Pogoda, in press.

^b For 16 procedures within and two procedures outside of prepaid plans, the type of procedure was unknown.

^c Non-radiographic but included in this report since subjects were specifically queried on them.

^d $p < 0.05$ by Fisher's exact test (FET), non-significant by generalized estimating equations (GEE).

^e $p < 0.01$ by FET, non-significant by GEE.

^f $p < 0.0001$ by FET, 0.009 by GEE.

^g p non-significant by FET, 0.02 by GEE.

outside of prepaid plans by plan members are counter-balanced; i.e., some procedures received between the assigned first and last membership years would have been erroneously counted as “outside the plan” when in fact the subject was not a plan member at that time, and other procedures performed outside the plan that occurred outside of the range of the assigned membership years while the subject was in fact a plan member would not have been counted as “outside” procedures.

These findings suggest that a substantial portion of RBM exposure from radiography over a 10-y period might be missed if exposure histories were collected only from records of prepaid health plan providers for members of those plans. The one procedure most likely to be performed outside of prepaid plans was a coronary angiogram, among the highest-exposure diagnostic procedures. Failure to account for such high-dose procedures could result in underestimated risk estimates and a loss of statistical power in analyses of radiation effects on AML and other cancer incidence. Although restricting a study to a population of subjects and their medical records for which historical exposure has been well-documented removes some of the methodological problems associated with recall data, incomplete exposure ascertainment is likely to persist.

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