4 Weber KT, Brilla CG. Pathological hypertrophy and cardiac interstitium: fibrosis and renin-angiotensin-aldosterone system. *Circulation* 1991; **83:** 1849–65.

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Chromosomal damage in long-term residents of houses contaminated with cobalt-60

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Chromosomal translocations in people who have lived in houses contaminated with radiation were substantially raised compared with controls. Retrospective biological dosimetry indicated cumulative exposures less than 1.0 Gy, which were lower than values derived from physical measurements.

Between 1982 and 1983 in Taiwan, cobalt-60 radiation sources were accidentally mixed with scrap metal and recycled into steel reinforcement bars used in the construction of almost 1600 apartments. By mid-1998, 6400 people had been identified as having occupied the houses for up to 16 years.[1] Dose estimates were made by surveying each apartment. The highest dose rate recorded was adjusted for radioactive decay and multiplied by residence time.[2] This calculation produced a crude and probably overestimated index of exposure since no account was taken of occupancy factors.

Phytohaemagglutinin-stimulated lymphocytes from 56 residents and 36 controls, assayed by the fluorescence in-situ hybridisation (FISH) method for reciprocal chromosomal translocations were studied for retrospective biodosimetry. Both group's ages ranged from 1 to 50 years; older individuals were excluded because of greater age-related variability in translocation background. All participants were healthy and had received no occupational or medical irradiation. Chromosomes 2, 4, and 12 were painted in different colours in 500 metaphases per person. Overall the translocation yield in the residents was five times that of the controls (table 1). Doses shown are taken from the physical surveys of the dwellings. By use of these values the residents have been further divided into three dose groups. We propose a linear dose response relation (table 2).

Translocation yields can also be compared with a linear coefficient obtained from in-vitro calibration; ideally the same chromosome probe combination should be used, and this work is in progress. In the meantime, a possible generic value for α of 0·02 full genome translocations/cell/Gy may be deduced from previous studies.[3] This value reduces to 0·007 for the probe combination used by application of a genome equivalent conversion factor of 0·336 for this mixed-sex study group. By use of 7×10^{-3} compared with a mean coefficient of $0{\cdot}94\times10^{-3}$ translocations/cell/Gy results in a cytogenetic estimate of dose a factor 7 (SE 4) lower than doses based on the physical monitoring. This finding agrees with other reports[4] in which more specific physical monitoring of selected individuals has been combined with more extensive measurements in apartments and lifestyles and occupancy factors. With the number of cells scored, and accumulated exposures suggested to be generally well below 1·0 Gy, to derive individual estimates of dose is in most instances not possible. At best one can suggest mean doses for cohorts as attempted here. With the presently obtained control values an individual dose estimate of 0·5 Gy substantially (SE 2) above zero would require about 1000 cells to be scored. Because several thousands of people have been placed at risk by this event, mass biodosimetry by FISH is impractical.

Age range (years)	Number of people	Dose range (Gy)	Mean (SE) dose (Gy)	Cells	Translocations
1–39	29	· ·	0	14 500	6
	17	<1·0	0·19 (0·05)	8500	15
	25	1–2	1·47 (0·06)	12 500	25
	4	>2·0	3·44 (0·56)	2000	4
40–50	7	· ·	0	3500	2
	3	<1·0	0·16 (0·07)	1500	4
	3	1–2	1·53 (0·17)	1500	3
	4	>2·0	2·79 (0·27)	2000	11

Table 1: **Translocations and physical estimates of dose in controls and residents of contaminated homes**

Age	c (SE)$\times10^{-4}$	α (SE)$\times10^{-3}$ Gy^{-1}	p*
1–39	8·3 (4·4)	0·71 (0·54)	0·007
40–50	9·8 (6·5)	1·44 (0·75)	0·136
1–50	8·1 (4·3)	0·94 (0·55)	0·003

A linear dose response relation (Y=c+αD) was fittted to the means of the translocation yields, Y, and mean does, D. c=background coefficient. α=induced translocation. *χ^2 test. All values of α are in excess of zero indicating a positive relation when translocations are related to the somewhat uncertain assumptions of dose.

Table 2: **Linear fit to the data in table 1**

Although our limited study is continuing, we think that for the wider population FISH should be reserved for those who live in particularly highly radioactive homes, and those who develop malignant disease for whom an estimate of dose becomes important for medicolegal reasons. Thus, a large bank of fixed culture cells should be established from many healthy exposed people and held in reserve until particular cases require more in depth investigation. 49 known accidental meltings of radioactive materials have been reported, many more have gone unreported.[5] Moreover, there have been some very serious incidents in which discarded or stolen former radiotherapy gamma ray sources have caused deaths and serious injuries in or en route to scrap yards. Four such instances occurred in Mexico in 1977, Brazil in 1987, Estonia in 1994, and Turkey in 1998. The difficulty seems to be worldwide and greater vigilance and control is necessary—eg, in the UK the installation of radiation detection instruments at major scrap yards frequently results in incoming radioactive sources, albeit small ones, being intercepted. More than 2000 similar incidents have been reported from USA and Canada.[5]

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1 Chang WP, Chan CC, Wang JD. ^{60}Co contamination in recycled steel resulting in elevated civilian radiation doses: causes and challanges. *Health Phys.* 1997; **73:** 465–72.

2 Atomic Energy Council. Contaminated rebar incident report. Taipei: Republic of China, 1994 (in Chinese).

3 Finnon P, Moquet JE, Edwards AA, Lloyd DC. The ^{60}Co gamma ray dose-response for chromosomal aberrations in human lymphocytes analysed by FISH; applicability to biological dosimetry. *Int J Radiat Biol* 1999; **75:** 1215–22.

4 Chen WL, Liao CC, Wang TT, Chen FD. Preliminary study of dose equivalent evaluation for residents in radioactivity contaminated rebar buildings. *Appl Radiat Isot* 1998; **49:** 1614–47.

5 Lubenau JO, Yusko JG. Radioactive materials in recycled metals —an update. *Health Phys* 1998; **74:** 293–99.

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