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Serum concentrations of hexachlorobenzene in family members of workers in an electrochemical factory

by Ferran Ballester, MD, Maria Sala, MD, Jordi Sunyer, MD, Joan Grimalt, PhD

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Objectives This study analyzed the effect of living in the same household with a worker employed in an electrochemical factory on the hexachlorobenzene (HCB) concentrations of serum in the general population of Flix, Spain.

Methods A total of 608 subjects from the general population (response rate 42%) completed a questionnaire about residence, occupation, life-styles, and medical history and provided blood samples. Among them, 412 had never worked in the electrochemical factory. Information about the occupation of the family members was completed, and the subjects were classified with the degree of relationship with the worker having been taken into account. A multiple linear regression analysis was conducted to model HCB serum for nonfactory workers.

Results Having a spouse who worked in the factory was associated with elevated HCB concentrations in serum. The adjusted relative increases were 1.28 (P=0.0004) and 1.23 (P=0.0022) times the corresponding value of people not living with workers of the factory, respectively for spouses of current and past workers. Relatives other than spouses did not show any increase.

Conclusions The results of this study suggest that, among nonworkers, living with a worker of the electrochemical factory in Flix is associated with an increase in concentrations of HCB in blood. These findings may suggest a source of exposure to HCB that has thus far not been studied and that could be important in populations not occupationally exposed to organochlorines.

Key terms home contamination, organochlorine compounds, para-occupational exposure, serum concentrations.
with a worker of the electrochemical factory on the HCB serum concentrations of people who had never worked in this factory.

**Subjects and methods**

A cross-sectional study was carried out on the 4178 inhabitants over 14 years of age in Flix in June of 1994. The details have been reported elsewhere (7). Briefly, subjects from a random sample of this general population (N=777) were asked to provide blood samples and to answer a questionnaire about residence, occupation, life-style and medical history. The questionnaire was completed by 549 subjects (70.5% response rate), and 328 of the 549 gave blood samples (42.1% response rate). In addition, from the rest of this general population, 1251 subjects completed the questionnaire, 280 of whom also provided biological samples voluntarily. No differences were seen in the socioeconomic and occupational variables or the occurrence of chronic diseases between the subjects from the random samples with and without biological samples (eg, mean age 50.1 and 47.9 years, respectively) nor in the HCB serum concentrations between the 328 subjects of the random sample and the 280 volunteers (eg, geometric mean of HCB 16.9 ng/ml and 16.6 ng/ml, respectively). The present study was based on the 608 subjects who provided blood samples. Of them, 412 had never worked in the electrochemical factory, and 190 did not live with any worker of the factory.

Information about the occupation of the family members or subjects living with the 412 subjects included in the study was obtained through the questionnaire, and in 268 cases (64%) it was validated against information obtained from the Primary Health Care Center and the Labor Union Committee of the factory. The agreement between these 2 sources classifying employment status in the electrochemical factory was fairly good (kappa index 0.78, P<0.0001, for agreement in 3 categories (current worker, past worker, never worker) and 0.83, P<0.0001, for agreement in 2 categories (ever worker, never worker). We classified the subjects who had never worked in the factory according to the degree of relationship with the worker and the occupational situation (spouse of a current worker, spouse of a former worker, other relatives of a current worker, other relatives of a former worker, with not living with a worker of the factory as the reference category). When a person lived with more than one worker (N=13, 12 with 2 relatives and 1 with 4) of the factory, the category of closest relationship was considered (the closest category being the spouse of a current worker).

The HCB serum concentrations were analyzed by a gas chromatograph coupled to an electron capture detector as previously described (8). The initial descriptive statistical parameters were computed. Because the distribution of the HCB serum concentrations was skewed to the right, natural logarithmic transformations were used in the analysis. A multiple linear regression analysis was conducted to model HCB serum for the nonworkers. On the basis of previous results on the determinants of HCB exposure in this population (9), the variables taken into account included gender, age (in years plus 2 dummy variables: >64 and <26 years), body mass index (in kilograms per square meter), loss of weight in the last 12 months (yes or no), consumption of fish caught in the local river (yes or no), residence (living closer than 1500

| Table 1. Concentration of hexachlorobenzene (HCB) in serum in a population (N=608) living near an electrochemical factory. |
| --- |
| **N** | **Age (years)** | **HCB concentration (ng/ml)** |
| | Mean | SD | Geometric mean | Maximum value | 25 | 50 | 75 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| General population | | | | | | | |
| Male | 249 | 50.2 | 17.7 | 21.5 | 1485 | 9.8 | 19.0 | 36.3 |
| Female | 359 | 48.0 | 17.2 | 14.4 | 180 | 9.9 | 15.7 | 22.0 |
| All | 608 | 48.9 | 17.4 | 17.0 | 1485 | 9.8 | 16.5 | 24.7 |
| Non-factory workers | | | | | | | |
| Male | 80 | 39.8 | 18.2 | 8.1 | 57.3 | 3.6 | 8.6 | 14.6 |
| Female | 332 | 47.9 | 17.3 | 14.3 | 180 | 9.5 | 15.5 | 21.8 |
| All | 412 | 46.3 | 17.7 | 12.6 | 180 | 8.2 | 14.4 | 20.8 |
| Living with a worker of the factory | | | | | | | |
| No | 190 | 46.8 | 18.4 | 11.2 | 92.3 | 7.6 | 12.3 | 17.3 |
| Yes | 222 | 46.0 | 17.2 | 14.4 | 180 | 9.4 | 15.9 | 23.2 |
| Spouse of a current worker | 73 | 39.3 | 8.5 | 15.0 | 180 | 10.8 | 14.4 | 21.1 |
| Spouse of a former worker | 101 | 60.6 | 9.3 | 21.1 | 101 | 16.8 | 21.4 | 27.0 |
| Relative other than spouse of a current worker | 17 | 20.4 | 3.6 | 5.3 | 10.8 | 3.5 | 6.3 | 8.0 |
| Relative other than spouse of a former worker | 31 | 27.8 | 13.6 | 6.3 | 23.0 | 3.7 | 6.5 | 9.2 |
Adjusted coefficient of determination: 0.45, 0.58, 0.58.

Considering people not living with workers of the factory for spouses of workers, the concentrations were higher in the women than in the men, with a geometric mean of 1.28 and 1.23 times the corresponding value of people not working in the factory. The final model for the HCB concentrations (adjusted relative increase of 1.49, P<0.001). Among the women, the analysis stratifying by age group showed that the relationship was strongest among wives of current workers younger than 45 years of age (adjusted relative increase of 1.49, P<0.001). The same analysis for men was not possible due to the small numbers. Finally, the stratified analysis by sample group (random or nonrandom) showed similar results for both groups.

Discussion

In this study we found an association between spouses living with workers of an electrochemical factory in Flix (Spain) and the HCB concentration in their blood serum. When a series of predictors of the HCB concentration were taken into account, the association was higher for spouses of current workers than for those of former workers. Other members of the family did not have an elevated HCB concentration in their blood. This finding suggests that important life-style factors, such as food, may not be an explanation for this finding. One hypothesis is that exhaled breath may be a cause of exposure to organic compounds (10).

Table 2 presents the results of the multiple linear regression for the HCB concentration in the serum of people not working in the factory. The final model for the men and women together explained 58% of the variability of the HCB serum concentrations. Being a spouse of a worker of the factory was significantly associated with the highest concentrations (adjusted relative increase of 1.49, P<0.001). The same analysis for men was not possible due to the small numbers. Finally, the stratified analysis by sample group (random or nonrandom) showed similar results for both groups.

Table 2. Association between living with a worker of an electrochemical factory and the concentration of hexachlorobenzene (HCB) (in In) in serum — multiple linear regression.

| Relationship with workers in same household | Males | Females | Males and females combined |
|--------------------------------------------|-------|---------|---------------------------|
| N  | Coefficient | SE | P-value | N  | Coefficient | SE | P-value | N  | Coefficient | SE | P-value |
| Spouse of a current worker | 1    | 1.44   | 0.69  | 0.0399 | 72  | 0.23  | 0.07  | 0.0005 | 73  | 0.25  | 0.07  | 0.0004 |
| Spouse of a former worker | 2    | 0.89   | 0.56  | 0.1179 | 99  | 0.18  | 0.06  | 0.0031 | 101 | 0.21  | 0.07  | 0.0022 |
| Relative other than spouse of a current worker | 5    | 0.23   | 0.37  | 0.5324 | 12  | -0.07 | 0.16  | 0.6327 | 17  | 0.09  | 0.15  | 0.5427 |
| Relative other than spouse of a former worker | 7    | 0.15   | 0.36  | 0.6726 | 24  | -0.10 | 0.11  | 0.3128 | 31  | -0.02 | 0.11  | 0.8503 |

- Adjusted for gender, age, body mass index, loss of weight, residence, educational level, and a dummy variable for a woman with 4 workers in her household. The use of pesticides and parity did not enter the model (P>0.2).
- Considering only the highest category of relationship for each person.
- HCB concentrations (in ln) of nonfactory workers without family members in the electrochemical factory.

Ballester et al Scand J Work Environ Health 2000, vol 26, no 1 69
Para-occupational exposure to hexachlorobenzene

The increase found represents around 25% of the average concentration in this general population of Flix, but in absolute terms it is a greater quantity than the mean of the HCB concentrations found in other general populations studied (12—14). As has been reported elsewhere (9), the serum HCB concentrations of this population, even of nonworkers, were the highest ever described. This fact may reflect inadequacies in the working processes of the factory.

No differences were observed between the subjects from the random and nonrandom samples, (7) and no differences were observed when the analysis was done separately for the 2 groups. A potential source of confounding could arise from direct exposure of spouses of workers in the buildings of the factory. Workers' relatives could enter the factory more often than nonrelatives, but this occurred rarely.

In conclusion, this study suggests that, among nonworkers, living with a worker of the electrochemical factory in Flix is associated with an increase in the HCB concentration in blood. This association is particularly notable for spouses of workers. What these results represent in terms of public health is not clear, but it merits being taken into account as a source of exposure to HCB, and probably other organochlorinated compounds, in nonoccupationally exposed populations.

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