To investigate whether use of electric blankets, one of the largest sources of electromagnetic field exposure in the home, is associated with the risk of female breast cancer, the authors analyzed data from a population-based US case-control study. The 2,199 case patients were under age 55 years and had been newly diagnosed with breast cancer between 1990 and 1992. The 2,009 controls were frequency-matched to cases by 5-year age group and geographic area. There was little or no risk associated with ever having used electric blankets, mattress pads, or heated water beds among women under age 45 years (adjusted odds ratio = 1.01, 95% confidence interval 0.86-1.18) or among women aged ≥45 years (adjusted odds ratio = 1.12, 95% confidence interval 0.87-1.43). There was no substantial variation in risk with duration of use; with whether the appliance was used only to warm the bed or used throughout the night; with menopausal status; or with the cases' hormone receptor status or stage of disease. Potential breast cancer risk factors that were associated with electric blanket use did not substantially confound the associations under investigation. These data do not support the hypothesis that electric blanket use increases breast cancer risk among women under age 55 years. Am J Epidemiol 1998; 148:556-63.
has published results of research on electric blanket use and breast cancer, and they reported a modest, nonsignificant increase for continuous use throughout the night among premenopausal (35) and postmenopausal (36) women. When the results from all women were combined, regardless of menopausal status (34), there was a modest, statistically significant 45 percent increase in risk associated with continuous use throughout the night that did not increase with greater years of use. To obtain further information on whether electric blanket use is associated with breast cancer risk, we analyzed data from a large multicenter population-based case-control study conducted among women under age 55 years.

**MATERIALS AND METHODS**

The Women's Interview Study of Health was originally undertaken to evaluate whether long term oral contraceptive use, lifetime use of alcohol, adolescent diet, or other factors were related to an increase in breast cancer risk among young women. Detailed descriptions of the study methods have been previously published (37, 38). Briefly, cases were women newly diagnosed with in situ or invasive breast cancer between May 1, 1990, and December 31, 1992, who were residents of one of three US geographic areas with a tumor registry: the metropolitan area of Atlanta, Georgia; five centrally located counties in New Jersey; and the three-county Puget Sound area surrounding Seattle, Washington. In Seattle and New Jersey, only women under age 45 years of age were eligible for the study. In Atlanta, eligibility was extended to women aged 45–54 years in order to enhance examination of age- and race-specific results in relation to oral contraceptive use. Controls were women identified through Waksberg's method of random digit dialing (39) and were frequency-matched to cases by 5-year age group and geographic area.

In-person, face-to-face interviews were completed with 2,199 cases (86.4 percent of eligible women) and 2,009 controls (78.1 percent of eligible women). With response to the random digit dialing telephone screening taken into account, the overall response rate among control women was 70.7 percent (screening response * interview response). Nonresponse among all women was primarily due to subject refusal (6.4 percent for cases and 18.5 percent for controls) and, among cases, physician refusal (5.4 percent). For comparability between cases and controls, we excluded 29 case women who did not have a telephone at the time of diagnosis and 19 control women who had been diagnosed with breast cancer prior to the date of identification.

The questionnaire, which was administered by a trained interviewer and averaged 70 minutes in length, assessed the woman's reproductive, menstrual, contraceptive, and medical histories; use of exogenous hormones, alcohol, and tobacco; family history of cancer; adolescent diet; and demographic characteristics. Measures of height and weight were also obtained, along with other information for anthropometric indices. The distributions of data on many of these factors have been previously described (37, 38). Briefly, increased risks were noted among black women, women with low body mass, and women who reported having a late age at first birth, an early age at menarche, a previous breast biopsy, or a first-degree relative with breast cancer (38).

All women were queried about whether they had ever regularly used electric blankets, electric mattress pads, or heated water beds, where regular use was not defined. A positive response referred to the aggregate use of any or all of the devices at any time in the respondent's life. Women who responded positively were then asked about whether these appliances were turned on most of the time while they slept or were used only to warm the bed; the total number of years for which the appliances had been used; and the number of months per year in which they were used. For three control respondents, information on use of electric blankets, electric mattress pads, or heated water beds was missing; thus, data from 2,170 cases and 1,987 controls were available for these analyses.

To estimate the relative risk of breast cancer in relation to use of electric blankets or similar appliances, we used unconditional logistic regression (40) to compute odds ratios and 95 percent confidence intervals. Ever use versus never use of electric blankets, electric mattress pads, or heated water beds was represented in the logistic regression models as a dichotomous variable. Among ever users, the duration of use of these devices (in months) was entered as indicator variables categorized into deciles, quintiles, or tertiles or a dichotomous variable (divided at the median value) based on the distribution among controls. These methods yielded similar results. For simplicity, only those analyses based on quintiles are shown. Indicator variables were also used to evaluate other aspects of use, such as whether the subject used the electrical device to warm the bed only or left the device on most of the time while sleeping.

Logistic regression models that were constructed to estimate odds ratios for breast cancer among women under age 45 years from all three geographic locations included geographic center (Atlanta/New Jersey/Seattle) entered as indicator variables and age (age at diagnosis for cases and age at identification for controls) entered as a continuous variable. This yielded results.
similar to those obtained from models that used indicator variables for 5-year age groups. Models that were constructed to estimate risk among Atlanta women under age 55 years included age entered as a continuous variable.

Multivariate models, along with goodness-of-fit tests (40), were utilized to adjust for potential confounding and to evaluate effect modification on a multiplicative scale. Variables that were considered as potential confounders or effect modifiers included menopausal status (premenopausal/postmenopausal [defined as no menstruation for ≥6 months prior to date of diagnosis for cases or date of identification for controls]), age at first birth (continuous variable), parity (ever/never), number of live births (continuous variable), lactation (ever/never), induced and spontaneous abortion (ever/never), education (indicator variables), family income (indicator variables), race (black/other/white), body mass index (self-reported weight [kg] divided by measured height [m] squared) at age 20 years (continuous variable), adult body mass index (continuous variable), months of oral contraceptive use (continuous variable), menopausal estrogen use (ever/never), usual alcohol consumption (≥7 drinks per week, <7 drinks per week/never drinking), smoking (ever/never), history of breast biopsy (ever/never), and family history of breast cancer in a first-degree relative (ever/never).

Polytomous logistic regression (40) was used to estimate odds ratios and corresponding confidence intervals in models with cases partitioned into categories based on stage of disease (carcinoma in situ, local invasive cancer, or regional/distant invasive cancer) or on the estrogen receptor (ER)–progesterone receptor (PR) status of the tumor (ER-positive and PR-positive, ER-positive and PR-negative, ER-negative and PR-positive, ER-negative and PR-negative, or ER or PR status unknown). The 46 case women with borderline results for either of the hormone receptor assays were excluded from these analyses.

RESULTS

Table 1 shows the odds ratios for breast cancer among women under age 45 years in Atlanta, central New Jersey, and Seattle in relation to patterns of electric blanket use. As compared with never use of electric blankets, electric mattress pads, or heated water beds, breast cancer was not associated with ever use (age- and center-adjusted odds ratio (OR) = 1.07, 95 percent confidence interval (CI) 0.92–1.24) or with whether the device was left on most of the time while sleeping (age- and center-adjusted OR = 1.09, 95 percent CI 0.93–1.27). In addition, the odds ratio did not increase significantly with increasing duration of use, even among women in the highest decile of use (for ≥144 months of use, age- and center-adjusted OR = 1.12, 95 percent CI 0.79–1.58). In an attempt to

| Never users§ | 718 | 764 | 1.00 | 1.00 |
| Ever use of electric blankets, electric mattress pads, or heated water beds | 780 | 881 | 1.07 | 0.92–1.24 | 1.01 | 0.86–1.18 |
| Mode of use¶ | | | | | |
| Used only to warm bed | 149 | 155 | 0.98 | 0.76–1.26 | 0.92 | 0.71–1.20 |
| Kept on most of the time | 630 | 726 | 1.09 | 0.93–1.27 | 1.03 | 0.88–1.22 |
| Duration of use (months)# | | | | | |
| ≤10 | 160 | 215 | 1.25 | 0.99–1.57 | 1.17 | 0.92–1.49 |
| 11–24 | 172 | 208 | 1.13 | 0.90–1.43 | 1.04 | 0.82–1.33 |
| 25–50 | 144 | 151 | 0.99 | 0.77–1.28 | 0.95 | 0.73–1.24 |
| 51–96 | 148 | 133 | 0.84 | 0.65–1.05 | 0.82 | 0.62–1.08 |
| 97–384 | 155 | 172 | 1.02 | 0.79–1.32 | 0.96 | 0.74–1.26 |

* Use of electric blankets, electric mattress pads, or heated water beds.
† OR, odds ratio; CI, confidence interval.
‡ Adjusted for age, center, marital status, education, race, adult body mass index, oral contraceptive use, alcohol consumption, and postmenopausal estrogen use. Sixty-four cases and 106 controls had missing information on at least one of the covariates.
§ Reference category.
¶ One control was missing information on mode of use.
# Two cases and one control were missing information on duration of use.
evaluate latency, we considered years of use alone (regardless of the number of months of use per year); no elevation in risk was observed (for ≥10 years of use, age- and center-adjusted OR = 1.03, 95 percent CI 0.82–1.30). Potential breast cancer risk factors that were significantly associated with use of these appliances among controls included education, race, marital status, adult body mass index, alcohol drinking, and use of oral contraceptives or menopausal estrogens (p < 0.05; data not shown). However, these factors did not substantially confound the associations under investigation (table 1). Other potential risk factors listed above (see “Materials and Methods”) also did not confound the association (data not shown).

Table 2 shows the relation between breast cancer among women under age 45 from all three geographic locations and duration of use of these electrical devices, stratified according to mode of use—whether the device was used only to warm the bed or was kept on most of the time while sleeping. The odds ratio was not substantially elevated among women who left the device on most of the time, and it did not increase with greater duration of use (for >96 months of use vs. never use, adjusted OR = 1.00, 95 percent CI 0.76–1.31). Among all women under age 45 years, effect modification was not found for menopausal status, geographic center, or other established or suspected risk factors for breast cancer listed above (data not shown).

We also evaluated the use of these devices among only Atlanta women under age 55 years, stratified by age. In the Atlanta women, no substantial elevation in the odds ratio was observed for ever use versus never use (multivariate adjusted OR = 1.02, 95 percent CI 0.84–1.23) or when the women were stratified by age (multivariate adjusted OR = 0.95 for women under age 45 and 1.07 for women aged ≥45). Risk among Atlanta women was also not associated with mode of use or duration of use, and these estimates did not vary significantly with age (data not shown).

Table 3 shows the odds ratios for Atlanta residents by age and menopausal status. The odds ratios among Atlanta women under 55 years of age did not vary substantially (p for heterogeneity > 0.05) between premenopausal (adjusted OR = 1.02, 95 percent CI 0.81–1.29) and postmenopausal (adjusted OR = 0.98, 95 percent CI 0.70–1.38) women. The estimates of effect also did not vary with menopausal status when women were stratified by age (table 3). In addition, when duration of use or mode of use was examined, there was no heterogeneity in risk by menopausal status or age (data not shown). There was little heterogeneity in the odds ratios among pre- or postmenopausal women when data were stratified according

### Table 2. Odds ratios for breast cancer according to duration of electric blanket use* (months), stratified by mode of use, among women under age 45 years in Atlanta, Central New Jersey, and Seattle, 1990–1992

<table>
<thead>
<tr>
<th>Mode and duration of use†</th>
<th>No. of controls (n = 1,498)</th>
<th>No. of cases (n = 1,645)</th>
<th>Multivariate adjusted odds ratio,§</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never users†</td>
<td>718</td>
<td>764</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Appliance used only to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>warm bed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10 months</td>
<td>51</td>
<td>59</td>
<td>1.05</td>
<td>0.70–1.57</td>
</tr>
<tr>
<td>11–24 months</td>
<td>32</td>
<td>41</td>
<td>0.98</td>
<td>0.60–1.61</td>
</tr>
<tr>
<td>25–50 months</td>
<td>31</td>
<td>23</td>
<td>0.70</td>
<td>0.40–1.24</td>
</tr>
<tr>
<td>51–66 months</td>
<td>17</td>
<td>18</td>
<td>0.94</td>
<td>0.46–1.91</td>
</tr>
<tr>
<td>97–384 months</td>
<td>18</td>
<td>14</td>
<td>0.71</td>
<td>0.35–1.47</td>
</tr>
<tr>
<td>Appliance kept on most of the time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10 months</td>
<td>108</td>
<td>156</td>
<td>1.24</td>
<td>0.94–1.63</td>
</tr>
<tr>
<td>11–24 months</td>
<td>140</td>
<td>167</td>
<td>1.06</td>
<td>0.81–1.38</td>
</tr>
<tr>
<td>25–50 months</td>
<td>113</td>
<td>128</td>
<td>1.02</td>
<td>0.76–1.36</td>
</tr>
<tr>
<td>51–66 months</td>
<td>131</td>
<td>115</td>
<td>0.80</td>
<td>0.60–1.08</td>
</tr>
<tr>
<td>97–384 months</td>
<td>137</td>
<td>158</td>
<td>1.00</td>
<td>0.76–1.31</td>
</tr>
</tbody>
</table>

* Use of electric blankets, electric mattress pads, or heated water beds.
† One control was missing information on mode of use. Two cases and one control were missing information on duration of use.
‡ Adjusted for age, center, marital status, education, race, adult body mass index, oral contraceptive use, alcohol consumption, and postmenopausal estrogen use. Sixty-four cases and 106 controls had missing information on at least one of the covariates.
§ The interaction between duration of use and temperature setting was not statistically significant (χ² = 1.866; p = 0.76).
¶ Reference category.
Table 3 shows the association between use of electric blankets, electric mattress pads, or heated water beds and breast cancer in Atlanta women when the breast cancer cases were partitioned by ER–PR status and analyses were stratified by menopausal status. Among all Atlanta women under age 55, the odds ratios varied little with hormone receptor status. The adjusted odds ratio for ER-positive and PR-positive breast cancer among premenopausal women was 1.03 (95 percent CI 0.88–1.21), and the corresponding odds ratio among postmenopausal women was 1.06 (95 percent CI 0.83–1.35). Disregarding PR status, the adjusted odds ratio for electric blanket use among cases with ER-positive tumors was 1.00 (95 percent CI 0.87–1.16) in premenopausal women and 1.10 (95 percent CI 0.88–1.36) in postmenopausal women. Results pertaining to hormone receptor status for all women under age 45 (from all three geographic centers) by menopausal status (data not shown) were similar to the results for women under age 55 from Atlanta only.

When breast cancer case patients under age 45 years from all three centers were partitioned according to stage of disease (in situ/local invasive/regional-distant invasive), the odds ratio among women diagnosed with in situ disease was modestly decreased (adjusted OR = 0.86, 95 percent CI 0.73–1.01). However, the estimate was not statistically different from that for women with local (adjusted OR = 1.02, 95 percent CI 0.92–1.21) or regional-distant (adjusted OR = 1.02, 95 percent CI 0.91–1.13) disease. Among women under age 55 years from Atlanta, similar estimates of effect were observed regardless of disease stage at diagnosis.
DISCUSSION

Results from our study do not support the hypothesis of an increased risk for breast cancer in relation to use of electric blankets, electric mattress pads, or heated water beds. We found little or no increase in risk with having ever used these devices, with continuous use during the night, or with increasing duration of use. We also did not observe risk to vary substantially with age, menopausal status, geographic center, or hormone receptor status. Our study had many methodological strengths, including a large, population-based sample of case and control women who were residents of three geographically diverse locations and a comprehensive structured questionnaire that obtained data on many established and suspected risk factors for breast cancer that could be evaluated as potential confounders and effect modifiers. However, some limitations of our data must be considered.

Investigation of whether electric blanket use increases the risk of breast cancer was not a primary hypothesis of our study. As a result, the interview included only a few questions on the use of electric blankets, electric mattress pads, and heated water beds, with some limited inquiries on patterns of use. For example, information on the age or make of electric blankets, characteristics that may affect magnetic field levels (31), was not collected, although it is likely that accurate recall of this information would be difficult. Exposure from lights left on at night, other electrical appliances, or other residential (as indicated by wire coding or other measures of geographic proximity to EMF sources) and occupational sources of EMFs was also not assessed. Failure to measure total EMF exposures has been suggested (41) as a potential source of misclassification. However, recent reviews have concluded that studies that have assessed residential geographic proximity to EMF sources have generally not shown an association with risk of female breast cancer (4, 42, 43), and those that have assessed occupational exposures in women (44, 45) and men (46) have yielded inconsistent or inconclusive results (3, 43). Use of electric blankets has been estimated by most (31-33, 47, 48) but not all (49) investigators to increase exposure to magnetic fields beyond background levels and to substantially contribute to EMF exposure. Our study included a composite measure that assessed not only electric blanket use but use of electric mattress pads and heated water beds, devices that may also contribute significantly to EMF exposure (48).

As in other case-control studies, possible bias in recall of past exposure is of some concern. Stevens (49) has hypothesized that recall of current electric blanket use is likely to be better than recall of past use among case and control subjects. The implication is
that indices of ever use or use of long duration will produce exposure misclassification and attenuated estimates of effect, whereas indices of current use will not result in misclassification. Stevens (4, 49) has also proposed that exposures incurred over the previous few years could be the most important in the pathogenic process. In our study, only total duration of use was assessed, rather than the actual calendar periods in which the electrical devices were used. Thus, our study results cannot contribute to an evaluation of this possibility.

The few other studies that have been published on the issue (34–36) have found modest increases in risk with use of electric blankets among pre- and postmenopausal women, but because there was a lack of a dose-response relationship with duration of use, the authors concluded that their results were not supportive of an association between electric blanket use and breast cancer risk. It is possible, however, that the putative association is not linear but displays a different relation. Furthermore, Stevens (49) has suggested that studies which assess electric blanket use are not useful in evaluating the hypothesis of EMFs and breast cancer; he argues that the position of the blanket relative to the head does not result in much EMF exposure to the pineal gland, the gland which produces melatonin. Although electric blanket use may not have high potential to disrupt pineal gland function, there may be other more direct mechanisms by which electric blanket use may affect breast cancer risk (50), such as direct exposure of the breast, induction of cell membrane dysfunction, or alteration of mitotic processes (6, 7).

Because of previous indications that nocturnal plasma melatonin levels were decreased among women with ER-positive breast cancer (51), suggestions have been made that any association between EMF exposure and breast cancer risk could be more pronounced among women with ER-positive breast cancer. However, our study does not support this hypothesis, at least among women younger than 55 years of age. Vena et al. (34–36) did not have information on hormone receptor status.

In summary, we did not observe a substantial association between breast cancer risk and use of electric blankets, electric mattress pads, or heated water beds among pre- and postmenopausal women under 55 years of age. Because of the sparseness of the available information on this possible association, further research is needed to improve measurement of EMFs and to continue to define the major sources of EMF exposure in the home (52). Clarification of the underlying biologic mechanism by which breast cancer risk could be influenced by these electrical devices would also be helpful.

REFERENCES