

# Tea Intake and Squamous Cell Carcinoma of the Skin: Influence of Type of Tea Beverages<sup>1</sup>

Iman A. Hakim,<sup>2</sup> Robin B. Harris, and Ute M. Weisgerber

Cancer Prevention and Control, Arizona Cancer Center, College of Medicine, University of Arizona, Tucson, Arizona 85724 [I. A. H., R. B. H.], and Unilever Health Institute Vlaardingen, 3130 AC Vlaardingen, the Netherlands [U. M. W.]

## Abstract

Differences in tea drinking habits are likely to vary by populations and could contribute to the inconsistencies found between studies comparing tea consumption and cancer risk. A population-based case-control study was used to evaluate how usual tea consumption patterns of an older population ( $n = 450$ ) varied with history of squamous cell carcinoma (SCC) of the skin. A detailed tea questionnaire was developed to assess specific tea preparation methods and patterns of drinking. In this southwestern United States population, black tea was the predominant variety of tea consumed. We found no association between the broad definition of any tea consumption and skin SCC. However, the adjusted odds ratios (ORs) for hot and iced black tea intake were 0.63 [95% confidence interval (CI), 0.36–1.10] and 1.02 (95% CI, 0.64–1.63), respectively. Controls were more likely to report usually drinking strong hot tea (OR, 0.74; 95% CI, 0.53–1.03) with increased brewing time ( $P$  for trend = 0.03). Adjusting for brewing time, the association between skin SCC and hot black tea consumption suggests a significantly lower risk in consumers of hot tea compared to nonconsumers (OR, 0.33; 95% CI, 0.12–0.87). This is one of the first studies to explore the relation between different types of tea consumption and occurrence of human cancers. Our results show that tea concentration (strength), brewing time, and beverage temperature have major influences on the potential protective effects of hot black tea in relation to skin SCC. Further studies with increased sample sizes are needed to evaluate the interrelationships between preparation techniques, tea type, and other life-style factors.

## Introduction

Tea is one of the most ancient and widely consumed liquids in the world. Tea leaves are primarily manufactured as green or black or oolong, with black tea representing ~80% of the tea products consumed. Tea is known to have various clinical merits (1), with recent laboratory studies demonstrating inhibition of tumorigenesis in different animal models by tea and tea polyphenols. The most extensively studied system is the mouse skin tumorigenesis model with UV light (2). In contrast to the consistent observations in animal models (3–9), the effect of tea consumption on human cancers is not conclusive (10). Some epidemiological studies have suggested a potentially protective effect of black or green tea consumption against human cancers of the lung (11–12), breast (13), colon and rectum (14), and prostate (15). However, lack of specific information on the type of tea consumed (*e.g.*, black or green), amount and duration of use, or method of preparation (*e.g.*, hot or iced, strong or weak) has limited all studies. Differences in the types of tea consumed and tea drinking habits are likely to vary by populations and could contribute to the inconsistencies between studies.

Although experimental studies have demonstrated inhibitory effects of tea infusions and tea polyphenols on skin carcinogenesis, no studies have examined the association between tea consumption and skin SCC<sup>3</sup> in humans. Furthermore, no studies have explored the potential for differential effects between tea preparation techniques and cancer risk.

The present study was designed to determine the usual tea consumption patterns of an older southwestern United States population and to then evaluate the association between tea consumption and risk of SCC of the skin. A detailed TQ was developed to assess specific tea preparation methods and patterns of drinking. This questionnaire was used in a subgroup of subjects who participated in a population-based case-control study of the potential relationships between environmental risk factors and SCC occurrence.

## Subjects and Methods

**Study Population.** Cases of SCC of the skin were randomly selected from persons identified through the Southeastern Arizona Skin Cancer Registry (16) as a first occurrence of SCC. Cases were eligible if they were  $\geq 30$  years of age, had a histopathologically confirmed SCC of the skin diagnosed within 4 months before the first interview, and had no prior history of a skin cancer. Only non-Hispanic (Anglo) and Hispanic white cases were eligible. Physician approvals were obtained to contact identified cases. A study interviewer contacted the person by phone to determine eligibility and invite participation. Over 83% of the cases selected from the registry were

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<sup>2</sup> To whom requests for reprints should be addressed, at Arizona Cancer Center, College of Medicine, 1515 N. Campbell Avenue, P. O. Box 245024, Tucson, AZ 85724. Phone: (520) 626-5355; Fax: (520) 626-5348; E-mail: ihakim@azcc.arizona.edu.

<sup>3</sup> SCC, squamous cell carcinoma; TQ, tea questionnaire; SEAH, Southeastern Arizona Health; OR, odds ratio; CI, confidence interval; AK, actinic keratosis.

interviewed for eligibility. Of the 531 eligible, 404 (76%) participated in the baseline study. Population-based controls were selected using random-digit dialing techniques. Phone numbers were randomly generated from the first four digits of the cases' residential telephone numbers. Controls were frequency-matched to the cases by a 10-year age category and gender, with one control per household invited to participate using modified Waksburg criteria (17). Control subjects were eligible if they had no history of any cancer within the past 5 years and met the age, gender, and ethnicity groupings. A total of 1641 persons were interviewed for eligibility; of these, 795 were eligible and 391 (49%) completed baseline interview.

Between January 1993 and December 1996, 404 cases and 391 controls were recruited to baseline study. Sixty % of these subjects ( $n = 566$ ) provided complete dietary data and constituted the population for this present study of tea consumption. These individuals were recontacted by telephone between February 1998 and November 1998. A total of 466 (86%) individuals completed the TQ (24 subjects were deceased, and 76 subjects could not be located or refused a second interview).

All participants completed a structured interview detailing personal, behavioral, and demographic characteristics. Information included: skin characteristics, sunburns and tanning history, use of suntan lotions and sunscreens, residential history, UV exposure during past year, family history of skin cancer, past medical history, tobacco and alcohol use, physical characteristics, and demographic information. Daily mean nutrient intakes were calculated using the Minnesota Nutrition Data System (version 2.9, Nutrition Coordinating Center, University of Minnesota). Interviews were conducted by trained, experienced interviewers. One interviewer conducted >90% of the personal interviews and 100% of the dietary recalls and TQs. After each interview, questionnaires were reviewed for completeness and coded. Data entry was through screen-based entry programs that included range checks.

**TQ.** The TQ asked about usual tea intake over the past year, as well as a lifetime consumption pattern and how the past year intake differed from the lifetime pattern. Detailed information was sought for the past year's tea intake for each type of tea consumed (black, green, or herbal and hot or iced). Information was sought for use of regular or decaffeinated tea products and the usual brewing strength (weak, medium, or strong). Usual or typical recipes for tea preparation were obtained, *e.g.*, number of tea bags/cup and brewing time. This questionnaire was evaluated for short- (1 week) and long-term (6 month) reliability within a randomly selected sample of men and women from the original case-control study who had not completed the 24-h dietary recalls ( $n = 40$ ). The correlation coefficients between baseline and 6-month interviews were highly significant.

**Data Analyses.** Distribution of demographic characteristics and potential risk factors were compared between cases and controls using *t* tests for continuous variables and  $\chi^2$  tests for categorical variables.  $\chi^2$  tests for trend were also calculated. Crude ORs and 95% CIs were calculated using the non-tea drinkers as the reference category. Adjusted ORs were calculated using multiple logistic regression with the initial models, including age, sex, and energy intake. Potential confounding effects were assessed for education, mean percent of kcal as fat; alcohol intake (mean alcohol intake/day); smoking history (never, former, and present smoker); body mass index ( $\text{kg}/\text{m}^2$  in  $\text{m}^2$ ); usual daily hours of sun exposure during the past year; history of actinic skin damage (self-reported physician-diagnosed AK); and self-reported ability to tan after prolonged sun exposure (no suntan, mildly tan, moderately tan, and deeply

tan). Inclusion of variables for fat intake, alcohol intake, and smoking status did not alter any of the results and were excluded from the final model. Age, sex, energy intake, inability to tan after prolonged sun exposure, and history of diagnosed and treated AK were included in the final multivariate models.

Tea consumption was defined by various methods. It was first assessed by asking participants to self-define themselves as non-tea drinkers, occasional drinkers, or regular tea drinkers. All occasional and regular tea drinkers were then asked to report their usual consumption of black tea, green tea, and herbal tea and for hot and iced tea products. Average consumption for each tea product was categorized as none, 1–3 cups/month, 1–6 cups/week, and  $\geq 1$  cup/day. Initial analyses compared all tea drinkers to non-tea drinkers. Separate analyses then compared various categories of hot and iced tea consumption with non-tea drinkers. All statistical analyses were done by using STATA computer software (Stata Corp. Stata statistical software, intercooled stata, release 5.0, Stata Corporation, College Station, TX).

## Results

### Population

A total of 270 men and 196 women who had participated in the Southeastern Arizona Skin Cancer Study completed the tea consumption questionnaire. Sixteen subjects reported drinking only herbal tea and were excluded from the present analyses. The mean time between initial interview and completion of the TQ was 2 years; whereas the mean time between the TQ and SCC diagnosis was 2 years and 9 months. The structure of the questionnaire allowed identification of subjects who reported making recent changes in their tea consumption. Twenty-nine subjects (16 cases and 13 controls) reported changes in the usual amount of tea consumed from the lifetime consumption pattern. However, only two subjects (one case and one control) reported that these changes were made within the last 2 years. Exclusion of those 29 subjects from the analyses did not affect the results, so this report includes data for all 450 subjects (234 cases and 216 controls).

Because the tea consumption questionnaire was completed in a subset of the original participants, we compared subjects who participated in the tea study ( $n = 466$ ) with those who did not participate ( $n = 329$ ). We found no statistically significant difference between the two groups in relation to case-control status, gender, education, smoking, average hours per day in the sun in the past year, and tanning ability. Participants in the tea study did report more AK history than subjects who did not participate in the study, with the increase being consistent for cases and controls.

Table 1 shows the distribution of cases and controls according to sex, age, education, reported tanning ability, history of AK, daily hours of sun exposure during the past year, and smoking status. The study population is an older, educated southwestern United States population with 68.8% of cases and 66.2% of controls having some college education. There was no difference between the cases and controls in the reported number of hours spent in the sun. There was also no difference between cases and controls in the number of years they have lived in Arizona. Only tanning ability and history of AK showed a significant difference between cases and controls ( $P < 0.001$ ).

### Pattern and Type of Tea Consumption and SCC Risk

In this Arizona population, 66.4% reported drinking tea during the past year. Black tea was the predominant variety of tea

**Table 1** Selected characteristics of skin SCC cases and controls participating in SEAH-Tea Study

|                                   | Cases (n = 234)<br>% | Controls (n = 216)<br>% | P      |
|-----------------------------------|----------------------|-------------------------|--------|
| Gender                            |                      |                         |        |
| Females                           | 41.0                 | 42.1                    |        |
| Males                             | 59.0                 | 57.9                    | 0.812  |
| Age categories (yr)               |                      |                         |        |
| ≤60                               | 19.7                 | 23.1                    |        |
| 61–70                             | 39.3                 | 38.9                    |        |
| >70                               | 41.0                 | 38.0                    | 0.634  |
| Education                         |                      |                         |        |
| <High school                      | 4.6                  | 7.0                     |        |
| High school                       | 26.5                 | 26.9                    |        |
| Some college                      | 30.3                 | 27.3                    |        |
| College                           | 37.6                 | 38.7                    | 0.53   |
| Smoking                           |                      |                         |        |
| Never                             | 36.8                 | 37.5                    |        |
| Former                            | 51.7                 | 46.8                    |        |
| Current                           | 11.5                 | 15.7                    | 0.361  |
| Actinic keratosis history         |                      |                         |        |
| No                                | 21.8                 | 63.0                    |        |
| Yes                               | 78.2                 | 37.0                    | <0.001 |
| Tanning ability <sup>a</sup>      |                      |                         |        |
| No                                | 31.2                 | 19.0                    |        |
| Yes                               | 68.8                 | 81.0                    | <0.001 |
| Sun exposure <sup>b</sup> (h/day) | 1.38 (0.08)          | 1.49 (0.08)             | 0.35   |

<sup>a</sup> Ability to tan after prolonged sun exposure (no = no suntan/mild tanning; yes = moderate or deep tanning).

<sup>b</sup> Average hours per day during past year spent outside during peak sun; expressed as mean (SD).

**Table 2** Estimated ORs and 95% CIs for the association between tea consumption in the past year and skin SCC: SEAH-Tea Study

|                           | Cases | Controls | OR <sup>a</sup> (95% CI) | OR <sup>b</sup> (95% CI) |
|---------------------------|-------|----------|--------------------------|--------------------------|
| Non-tea drinkers          | 76    | 75       | 1.0                      | 1.0                      |
| Frequency of tea drinking |       |          |                          |                          |
| Occasional                | 82    | 76       | 1.06 (0.68–1.66)         | 0.97 (0.58–1.61)         |
| Regular                   | 76    | 65       | 1.15 (0.72–1.83)         | 1.00 (0.76–1.31)         |
| Type of tea consumed      |       |          |                          |                          |
| Hot black tea             | 61    | 77       | 0.78 (0.49–1.24)         | 0.63 (0.36–1.10)         |
| Iced black tea            | 125   | 108      | 1.14 (0.75–1.72)         | 1.02 (0.64–1.63)         |

<sup>a</sup> Crude OR.

<sup>b</sup> Adjusted for age, sex, kcal, and tanning ability after prolonged sun exposure, and AK history.

consumed, with 51.8% of all subjects reporting iced black tea drinking and 30.7% reporting hot black tea use. Only 8.7% of this population reported drinking green tea. Overall, about 35% of women and 29% of men reported drinking non-herbal tea regularly (here defined as drinking tea at least once a week), whereas 27% of women and 38% of men reported no tea drinking in the past year. Frequency of tea consumption was not associated with smoking history or average daily alcohol intake. Exclusive consumption of iced tea was slightly higher in men and present smokers. There were no significant differences for any of the risk factors listed in Table 1 between subjects who reported drinking only hot tea compared to those who reported drinking only iced tea.

The association between usual pattern and type of tea consumed and risk of skin SCC is presented in Table 2. In this analysis, usual tea consumption is defined as self-reported non-tea drinker, occasional tea drinker, or regular tea drinker. There was no association between either occasional or regular

**Table 3** Estimated ORs and 95% CIs for the association between the strength, brewing time, and temperature of the hot black tea consumed and skin SCC: SEAH-Tea Study

|                                   | Cases | Controls | OR adjusted <sup>a</sup> | 95% CI    |
|-----------------------------------|-------|----------|--------------------------|-----------|
| Non-tea drinkers                  | 76    | 75       | 1.0                      |           |
| Reported strength of prepared tea |       |          |                          |           |
| Weak                              | 7     | 6        | 1.1                      | 0.54–2.65 |
| Medium                            | 51    | 57       | 0.91                     | 0.75–1.10 |
| Strong                            | 5     | 11       | 0.74                     | 0.53–1.03 |
| Usual brewing time (min)          |       |          |                          |           |
| 1 min                             | 6     | 7        | 0.89                     | 0.19–3.95 |
| 2–3 min                           | 30    | 44       | 0.72                     | 0.50–1.01 |
| 4–7 min                           | 6     | 15       | 0.74                     | 0.50–1.0  |
| Preferred temperature of hot tea  |       |          |                          |           |
| Warm                              | 7     | 6        | 1.51                     | 0.37–6.12 |
| Hot                               | 52    | 70       | 0.76                     | 0.56–1.01 |
| Tea consumption frequency         |       |          |                          |           |
| 1–3 cups/mo                       | 24    | 32       | 0.25 <sup>b</sup>        | 0.07–0.84 |
| ≥1 cup/wk                         | 37    | 45       | 0.57 <sup>b</sup>        | 0.33–0.98 |

<sup>a</sup> Adjusted for age, sex, kcal, and tanning ability after prolonged sun exposure and AK history.

<sup>b</sup> Adjusted for the above plus brewing time of hot tea.

tea drinking and risk of skin SCC. The associations between skin SCC and the specific use of hot black tea or iced black tea are also presented in Table 2. For black tea, controls were somewhat more likely to report drinking hot tea compared to cases. The adjusted OR estimate for hot tea intake was 0.63 (95% CI, 0.36–1.10). However, for iced tea, the OR was 1.02 (95% CI, 0.64–1.63). Similar patterns were seen when consumption was evaluated for winter or summer seasons separately (data not shown). Green tea consumption was not common in this population. Only 7.3% of cases and 10.2% of controls reported drinking hot green tea, and 2.1% of cases and 1.9% of controls reported drinking iced green tea. A suggestion of an inverse association was seen between consumption of hot green tea (OR, 0.82; 95% CI, 0.35–1.90) and risk of skin SCC. Decaffeinated tea consumption was not common in this population. Only 6% of cases and 8.8% of controls reported drinking decaffeinated hot tea, and 6% of cases and 5.1% of controls reported decaffeinated iced tea use. Again, an inverse association was seen between consumption of either regular hot tea (OR, 0.83; 95% CI, 0.46–1.48) or decaffeinated hot tea (OR, 0.83; 95% CI, 0.60–1.15) and risk of skin SCC.

### Tea Preparation Techniques and SCC

Because of potential differences in the association between hot tea and iced tea and skin SCC risk, these two preparations were evaluated separately.

**Hot Black Tea.** Strength of tea was defined by the question “How do you usually drink your tea,” with the categories recorded as “strong,” “medium,” or “weak.” Table 3 shows that controls were more likely to report drinking strong hot tea than were the cases (OR, 0.74; 95% CI, 0.53–1.03). Strength of the tea product was also evaluated using reported usual brewing time. There was a significant correlation between reported brewing time and reported strength of hot tea ( $r = 0.48$ ;  $P < 0.001$ ). As shown in Table 3, controls were more likely to report brewing hot tea for >3 min than were cases. There was a significant trend between brewing time of hot tea and skin SCC ( $P$  for trend = 0.03). Subjects were asked to identify the preferred temperature for consumption of the hot tea (room temperature, warm, hot, or very hot). Almost all subjects re-

**Table 4** Estimated ORs and 95% CIs for the association between the strength and preparation of the iced black tea consumed and skin SCC: SEAH-Tea Study

|                                   | Cases | Controls | OR adjusted <sup>a</sup> | 95% CI    |
|-----------------------------------|-------|----------|--------------------------|-----------|
| Non-tea drinkers                  | 76    | 75       | 1.0                      |           |
| Reported strength of prepared tea |       |          |                          |           |
| Weak                              | 7     | 3        | 1.71                     | 0.75–3.85 |
| Medium                            | 105   | 87       | 1.00                     | 0.85–1.19 |
| Strong                            | 13    | 18       | 0.95                     | 0.76–1.18 |
| Methods of preparation            |       |          |                          |           |
| Brewed only                       | 28    | 28       | 0.99                     | 0.46–2.07 |
| Sun tea only                      | 51    | 34       | 1.07                     | 0.78–1.46 |
| Instant tea only                  | 11    | 10       | 1.10                     | 0.77–1.58 |

<sup>a</sup> OR adjusted for age, sex, kcal, and tanning ability after prolonged sun exposure and history of AK.

ported drinking either hot (86.7%) or warm (9.6%) tea. There was a highly significant correlation between reported usual temperature of hot tea consumed and reported strength of hot tea ( $r = 0.94$ ;  $P < 0.001$ ) as well as reported brewing time of hot tea ( $r = 0.45$ ;  $P < 0.001$ ). Furthermore, a significant inverse association was shown between the temperature of hot tea and the risk of skin SCC ( $P = 0.05$ ).

We then evaluated the association between skin SCC and hot black tea consumption by frequency of intake, adjusting for strength of the tea, here measured as brewing time. The adjusted OR estimates for hot black tea intake were 0.33 (95% CI, 0.12–0.87) for any hot tea drinking, 0.25 (95% CI, 0.07–0.84) for occasional use of 1–3 cups/month, and 0.57 (95% CI, 0.33–0.98) for regular use of  $\geq 1$  cup/week.

**Iced Black Tea.** Table 4 describes similar comparisons between skin SCC and various preparations of iced tea consumption. Iced tea intake was categorized by strength of prepared tea and by preparation techniques. Iced tea is prepared by either brewing in hot water, or from instant tea, or as sun tea. Weak statistically nonsignificant associations between iced tea consumption and risk of SCC were observed for all tea preparation techniques and strengths.

#### Tea Consumption and Other Risk Factors for SCC Risk

The associations between hot and iced black tea intake and skin SCC were evaluated for potential effect modification by selected covariates (Table 5). A statistically significant inverse association between hot black tea consumption and the risk of skin SCC was observed among subjects in the middle age-group (61–70 years old) category (OR, 0.07; 95% CI, 0.01–0.83). The pattern was similar for other age groups, although not statistically significant. In addition, a statistically significant inverse association between black hot tea consumption and skin SCC was shown among nonsmokers (OR, 0.11; 95% CI, 0.02–0.68). Although hot black tea consumption appeared to be generally inversely associated with risk, there were no significant differences in the strata of any of the other covariates. In contrast, iced tea consumption failed to show any association with risk of skin SCC.

#### Discussion

This older Arizona population offered a unique opportunity to study potential associations between consumption of tea and risk of skin SCC. Arizona has one of the highest risks of skin SCC worldwide, and tea is a commonly consumed beverage. In this population, two-thirds reported drinking some tea during the past year, with more than half of all subjects reporting iced black tea

**Table 5** Relationship of hot black tea and iced black tea consumption with skin SCC risk for selected demographic and behavioral characteristics: SEAH-Tea Study

| Variable                     | Non-tea drinkers      |                       | Any hot black tea consumption |                       | Any iced black tea consumption |  |
|------------------------------|-----------------------|-----------------------|-------------------------------|-----------------------|--------------------------------|--|
|                              | <i>n</i> <sup>a</sup> | <i>n</i> <sup>a</sup> | OR <sup>b</sup> (95% CI)      | <i>n</i> <sup>a</sup> | OR <sup>b</sup> (95% CI)       |  |
| Gender                       |                       |                       |                               |                       |                                |  |
| Females                      | 50                    | 77                    | 0.36 (0.10–1.28)              | 50                    | 0.93 (0.41–2.08)               |  |
| Males                        | 101                   | 61                    | 0.17 (0.02–1.06)              | 95                    | 1.06 (0.59–1.89)               |  |
| Age (yr)                     |                       |                       |                               |                       |                                |  |
| $\leq 60$                    | 34                    | 26                    | 1.08 (0.17–6.70)              | 50                    | 1.50 (0.44–5.03)               |  |
| 61–70                        | 59                    | 95                    | 0.07 (0.01–0.83)              | 95                    | 0.74 (0.34–1.56)               |  |
| $> 70$                       | 58                    | 53                    | 0.41 (0.08–1.94)              | 88                    | 1.08 (0.52–2.2)                |  |
| Smoking                      |                       |                       |                               |                       |                                |  |
| Never                        | 56                    | 63                    | 0.11 (0.02–0.68)              | 83                    | 0.92 (0.42–2.02)               |  |
| Former                       | 73                    | 60                    | 0.54 (0.13–2.17)              | 117                   | 0.98 (0.51–1.85)               |  |
| Current                      | 22                    | 15                    | 0.01 (0.01–37.65)             | 33                    | 0.24 (0.02–2.95)               |  |
| AK                           |                       |                       |                               |                       |                                |  |
| No                           | 71                    | 57                    | 0.29 (0.05–1.45)              | 92                    | 0.91 (0.44–1.85)               |  |
| Yes                          | 80                    | 81                    | 0.28 (0.07–1.07)              | 141                   | 1.03 (0.55–1.93)               |  |
| Tanning ability <sup>c</sup> |                       |                       |                               |                       |                                |  |
| No                           | 38                    | 37                    | 0.23 (0.02–2.04)              | 60                    | 0.45 (0.15–1.30)               |  |
| Yes                          | 113                   | 101                   | 0.35 (0.11–1.03)              | 173                   | 1.29 (0.75–2.20)               |  |

<sup>a</sup> Number of subject in each stratum.

<sup>b</sup> Multivariate adjusted OR: iced tea adjusted for age, sex, kcal, tanning ability, and actinic keratosis history. Hot tea adjusted for all of the previous plus brewing time.

<sup>c</sup> Ability to tan after prolonged sun exposure (no = no suntan/mild tanning; yes = moderate or deep tanning).

consumption and one third reporting hot black tea use. In Arizona, iced tea was often prepared by cooling brewed tea or by prolonged (6–15 h) steeping of tea in the sun (sun tea). Over 37% of the study population reported consuming iced tea as sun tea, and 24% consumed it from brewed iced tea. Cold water-soluble instant teas, as well as tea beverages in a canned form, were used by  $< 10\%$  of all tea drinkers. The remainder consumed a mixture of either brewed iced tea or sun tea. Overall, we found no evidence for a relationship between consumption of tea when broadly defined as any use in the past year and skin SCC. However, we did find evidence of an inverse association between the risk of skin SCC and consumption of hot strong black tea.

In this study, we were able to estimate the ORs of skin SCC by frequency and preparation habits, such as strength, brewing time, preferred drinking temperature, and methods of preparation. The present study shows that consumption of strong hot tea was inversely associated with risk of skin SCC. This association was observed with multiple definitions or markers of strong tea: reported strength of tea, brewing time, and temperature. We were unable to detect a dose-response reduction in skin SCC with increasing frequency of hot tea consumption. This lack of dose-response might be explained by the fact that we did not have adequate number of subjects reporting daily hot tea consumption. Previous studies have shown that the tumor-inhibitory effect of tea may depend on its intake level (2). For example, at high concentrations, tea can effectively block endogenous formation of *N*-nitroso compounds, whereas at low levels, it may facilitate nitrosation reactions (18). In human populations, the amount of tea polyphenols ingested is determined not only by the frequency and amount of tea intake but also by the strength of tea consumed. Tealeaf concentration and brewing time may be the most important determinants of the polyphenol concentration in a cup of tea.

The difference in association with hot black tea consumption but not iced black tea may be explained by the simple fact that iced tea is likely to be consumed more diluted than hot tea.

Iced tea is prepared in larger amounts, using fewer tea bags. The usual recipe in Arizona was 6–10 bags/gallon or 0.86–1.44 g of tea leaves/240 ml. In contrast, regular hot tea is usually prepared by extracting one tea bag per one cup (2.26 g/240 ml) of hot water. Another explanation might be that the black tea flavonoids, theaflavins and thearubigins, form insoluble complexes with caffeine, the so-called “tea cream,” when tea is cooled (18, 19). These complexes precipitate in cold water and remain in the bottom of the iced tea container. Therefore, these complexes might not be ingested by iced tea drinkers, reducing the intake of the active compounds. Instant tea is known to be very low in tea flavonoids (20).

In some populations, tea drinking is associated with cigarette smoking and alcohol drinking (21, 22). This was not the case in our population, with the exception that iced tea consumption was slightly higher in men and present smokers. Although adjustments were made for these variables, the finding of a significant inverse association of hot black tea consumption with skin SCC among nonsmokers suggests that smoking may modify the effect of tea.

Some limitations and strengths of the study deserve consideration. In case-control studies, the possibilities for recall and interviewer bias are a major concern. Differential recall of diet and tea consumption between cases and controls can lead to biased estimates of effect. Furthermore, because there was a lag between diagnosis of the skin cancer and interview, there is potential for cases to have altered their behavior and to then report their recently changed behaviors. Several steps were taken to reduce potential bias. Standard questionnaires were administered to all subjects by a trained interviewer who was not aware of the case-control status of the subjects at the time of the TQ administration.

There is some evidence, however, that skin cancer cases did recently alter their behavior for risk factors they thought were related to skin cancer. For instance, they reported increased use of sunscreens in the past year, whereas there were no differences between cases and controls for sunscreen use during earlier time periods. They also reported similar past year exposure to the sun to the controls. Given that skin SCC is related to other measures of high UV exposure (*i.e.*, history of AK, history of sunburns), then the lack of a finding for a differential sun exposure history for cases and controls argues for a change in behavior since the diagnosis of the skin cancer. However, although it appears that the cases did modify some of their behaviors, there is no evidence that they recently altered their consumption of tea products. In fact, because there have been no prior studies of skin cancer occurrence and tea consumption, it is unlikely that this population would have considered tea consumption to be related to their risk of skin cancer. The difference in risk patterns between consumption of iced tea and hot tea supports the lack of differential recall between cases and controls in their reporting of tea drinking. Public perception of tea drinking has been that there would be no difference in the potential effect of tea based on temperature. Furthermore, few participants reported recent changes (within the past 2 years) in their tea drinking habits, and exclusion of these did not alter the results of the study.

This is the first study to explore the relationships between different tea consumption patterns, tea preparation techniques, and human cancer of the skin. Although this study was of moderate sample size to explore relationships within subgroups of tea consumption patterns, a statistically significant inverse association between skin SCC and hot black tea consumption was observed. Results show that tea concentration (strength), brewing time, and beverage temperature influence the potential

protective effects of hot black tea in relation to skin SCC. Further studies of increased sample sizes are needed to more completely evaluate the interrelationships between preparation techniques, tea type, and other life-style factors.

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