Role of Life-style and Dietary Habits in Risk of Cancer among Seventh-Day Adventists

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Summary

The Seventh-Day Adventist population abstains from smoking and drinking; about 50% follow a lacto-ovo-vegetarian diet; and most avoid the use of coffee, tea, hot condiments, and spices. Existing data on cancer mortality in Seventh-Day Adventists clearly document mortality rates that are 50 to 70% of general population rates for most cancer sites that are unrelated to smoking and drinking. Several approaches to determining whether this reduced risk is due to the unique Seventh-Day Adventist life-style or selective factors related to who chooses to become and remain a Seventh-Day Adventist are described.

A comparison of the mortality experience of Seventh-Day Adventist and non-Seventh-Day Adventist physicians shows equal cancer mortality, which is consistent with the hypothesis that the apparent reduced risk of cancer death in all Adventists may be due to selective factors. However, the results of a small case-control study of colon and breast cancer among Adventists show statistically significant relative risks for colon cancer of 2.8 for past use of meat. For current food use, the significant relative risks are 2.3 for cancer among Adventists show statistically significant relative risks for colon cancer of 2.8 for past use of meat. For current food use, the significant relative risks are 2.3 for beef, 2.7 for lamb, and 2.1 for a combined group of highly saturated fat foods. This strongly suggests that the lacto-ovo-vegetarian diet may protect against colon cancer. However, the evidence linking diet to breast cancer is less clear. Because of the marked variability in dietary habits within the Seventh-Day Adventist population, they will be a productive group for further study of diet and cancer.

Introduction

Numerous components of life-style have been suggested or demonstrated to have a relationship to the major sites of cancer in this country, but aside from the well-established relationship of smoking to risk of certain cancer sites, few of the hypothesized relationships with life-style are backed by sufficient evidence to allow firm conclusions to be made (46). Interest in studying cancer occurrence among Seventh-Day Adventists was initially generated because they are a nonsmoking and nondrinking population by Church prescription (33, 52). However, Adventists have many other unusual life-style characteristics (Table 1) which suggest that they may be a particularly fruitful study population in elucidating the role of dietary factors and possibly other life-style variables in either promoting or preventing the carcinogenic process.

Seventh-Day Adventists are an evangelical religious denomination with about 2.5 million members worldwide and about 500,000 members in North America. About 100,000 of these live in California. Aside from the lack of smoking and drinking, dietary habits appear to be the key distinguishing characteristic of the Seventh-Day Adventist life-style. Approximately one-half of the Seventh-Day Adventist population follow a lacto-ovo-vegetarian diet, and virtually all of them abstain from using pork products. They use vegetables, fruits, whole grains, and nuts abundantly and avoid the use of coffee, tea, hot condiments, and, possibly, highly refined foods. This dietary pattern has been strongly recommended among Adventists for over 100 years. With the exception of abstinence from alcohol and pork products, the degree of adherence to these dietary recommendations is somewhat variable.

Comparative data for the frequency of use of 3 types of foods hypothesized to be etiologically related to certain cancer sites (6, 7, 16, 28), have been obtained for a small sample of Adventists and non-Adventists enrolled in a study of stool bacteria, currently being carried out in collaboration with Dr. Sydney Finegold. Table 2 shows that the intake of meat and coffee among Adventists is markedly less than that among the general population. It is important to note that the Adventist population demonstrates significant variability of dietary habits. It is also worthwhile to recall that observational investigations have been unsuccessful in demonstrating a relationship between dietary habits and CHD despite the great likelihood that a significant biological association exists. Lack of significant variation in intake of the suspected causative nutrients within a single study population is the most likely explanation for failure to observe a significant association. No doubt this same difficulty will plague observational studies of dietary habits and cancer. For this reason, the significant variability of dietary habits among Adventists may provide a unique opportunity for investigating dietary determinants of cancer.

This report presents a reanalysis of data collected in a

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1 Presented at the Conference on Nutrition in the Causation of Cancer, May 19 to 22, 1975, Key Biscayne, Fla. This work was partially supported by grant number 1 ROI CA 14703-02 from National Cancer Institute and funds from The American Health Foundation.

2 The abbreviations used are: CHD, coronary heart disease; LLU, Loma Linda University; USC, University of Southern California.
R. L. Phillips

Table 1
Unique characteristics of typical Seventh-Day Adventist life-style

<table>
<thead>
<tr>
<th>Frequency of current use</th>
<th>Adventists (n = 151)</th>
<th>Non-Adventists (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat, poultry, or fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>20.5</td>
<td>0</td>
</tr>
<tr>
<td>Never (past users)</td>
<td>25.8</td>
<td>0</td>
</tr>
<tr>
<td>&lt;1 time/month</td>
<td>12.8</td>
<td>0</td>
</tr>
<tr>
<td>1-2 times/mo</td>
<td>10.3</td>
<td>0</td>
</tr>
<tr>
<td>1-2 times/wk</td>
<td>12.3</td>
<td>5.9</td>
</tr>
<tr>
<td>3-4 times/wk</td>
<td>10.8</td>
<td>8.8</td>
</tr>
<tr>
<td>5-6 times/wk</td>
<td>3.9</td>
<td>26.5</td>
</tr>
<tr>
<td>7+ times/wk</td>
<td>3.4</td>
<td>58.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never or almost never</td>
<td>43.3</td>
<td>0</td>
</tr>
<tr>
<td>&lt;1 time/wk</td>
<td>19.8</td>
<td>8.8</td>
</tr>
<tr>
<td>1-2 times/wk</td>
<td>12.0</td>
<td>64.7</td>
</tr>
<tr>
<td>3-4 times/wk</td>
<td>17.5</td>
<td>23.5</td>
</tr>
<tr>
<td>5-6 times/wk</td>
<td>4.8</td>
<td>2.9</td>
</tr>
<tr>
<td>7+ times/wk</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Coffee (cups/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>76.6</td>
<td>11.8</td>
</tr>
<tr>
<td>&lt;1</td>
<td>6.6</td>
<td>5.8</td>
</tr>
<tr>
<td>1</td>
<td>9.6</td>
<td>20.5</td>
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<tr>
<td>2-3</td>
<td>3.6</td>
<td>29.4</td>
</tr>
<tr>
<td>4-5</td>
<td>1.8</td>
<td>20.5</td>
</tr>
<tr>
<td>5+</td>
<td>1.8</td>
<td>11.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2
Percentage of persons using different amounts of meat and coffee among California Adventists and non-Adventists

Table 3
Age-sex distribution of the Adventist population at the beginning of the study, compared with the 1960 California population

Cancer Mortality in Seventh-Day Adventists

Lemon and Walden (32), and Lemon et al. (33) carefully followed a defined cohort of 35,460 Adventists living in California during 1958 to 1965 by maintaining annual contacts with each subject. They tabulated the causes of death as recorded on the death certificates. Their data show that mortality from most cancer sites in Adventists is considerably below cancer mortality in the general population. Their studies also documented reduced mortality from numerous other causes, with resultant greater life expectancy among Adventists. Table 3 shows the age-sex composition of their study population, compared with the general California population. Chart 1 summarizes the 8-year cancer mortality experience of this Seventh-Day Adventist population. The age-sex standardized cancer mortality in Adventists is one-half to two-thirds of the general population cancer mortality rates.

The obvious initial question is to what extent their abstinence from smoking and drinking accounts for the lower risk of Adventists to death from cancer. A large share of previously published study of Adventists as well as preliminary summary results of 2 other studies we have recently completed.

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this reduction in mortality is clearly due to the expected very low mortality rates of cancers known to be related to smoking and/or alcohol. However, other major sites, such as gastrointestinal and reproductive cancers, which are not strongly related to smoking and alcohol, are significantly below the general population. This suggests that other components of the Seventh-Day Adventist lifestyle may be protective for these sites. It is noteworthy that the sites that differ significantly are those most suspected of being related to dietary habits. Kidney and central nervous system cancers, as well as lymphoma, male leukemia, and all other cancers (males only) do not differ significantly from those of the general population.

Chart 2 details the Adventists’ experience by sex for selected gastrointestinal cancers. The rates are all in the vicinity of 60 to 70% of general population rates, except for gallbladder, which is not significantly below that of the general population. With the exception of pancreas cancer, no significant sex differentials are seen.

Table 4 shows the results of a recent hospital record review of a sample of Seventh-Day Adventist and non-Seventh-Day Adventist colon cancer cases discharged from 2 California hospitals during 1965 to 1974. The anatomic location within the colon was recorded using surgery, sigmoidoscopy, and pathology reports. Previous studies have suggested that colon cancers tend to occur more frequently in the right colon in low-risk populations and in the left colon and rectum in high-risk populations (9, 17, 18). The data in Table 4 provide suggestive evidence that Seventh-Day Adventists are indeed a low-risk population, since their lesions are shifted somewhat to the right, compared with those of non-Adventists, but the difference does not quite reach significance at the 5% level.

Chart 3 indicates the mortality ratios for specific reproductive cancers for 2 age groups where numbers are adequate. Postmenopausal cancer of the breast, ovary, and other uterus (endometrium and uterus cancer of unspecified type) are significantly below the general population, while prostate cancer mortality is not significantly different from that of the general population. The low rates for cancer of the cervix are probably a result of conservative sexual practices in Seventh-Day Adventists.

Selection versus Life-style

Seventh-Day Adventists are by no means a representative sample of the general population; indeed, they are a very select group of the general population. For example, the proportion of college-educated persons among Seventh-Day Adventists is twice that of the general population. Thus, before we attribute the low Adventist mortality risk for cancer sites unrelated to smoking and alcohol to some other aspect of the Adventist lifestyle, a crucial issue to be resolved is whether the reduction in risk can be explained by selective factors related to who chooses to become and remain a Seventh-Day Adventist. Selective factors such as socioeconomic status could conceivably be quite unrelated to dietary habits or other lifestyle characteristics and, yet, significantly influence cancer mortality rates (47). Clearly, the alternative explanation is that one or more components of the Adventist lifestyle are protective against cancer.

Education Adjustment. A simplistic approach to this question is to adjust the mortality ratios for educational status. Chart 4 shows that adjustment for education does not significantly change the mortality ratios, thus eliminating one very general measure of socioeconomic status as a possible explanation of the low Seventh-Day Adventist mortality rates.

Appropriate Comparison Group. Another approach would be to compare Adventists with an easily identifiable subgroup of the general population which might be more similar to Adventists and, more particularly, to Adventists...
who choose to enroll in a prospective study. There is convincing evidence that persons who enroll in large population studies by completing a questionnaire are at lower risk of death than the rest of the population, many of whom are institutionalized, etc. (48, 51). It occurred to us that such data are readily available from the published data of Hammond's prospective study (20) and that it might be quite appropriate to compare Adventists with the nonsmokers in Hammond's population. The solid bars in Chart 5 depict standardized mortality ratios for Adventists recalculated using Hammond's nonsmokers as the standard (comparison) population. Due to the age groups for which site-specific mortality rates are reported in Hammond's publication, these data are limited to the indicated sites among persons age 45 to 79. One would expect this to virtually eliminate the differential between Adventists and the general population for such sites as lung, mouth, and pharynx. However, it is fascinating to note that an apparent differential still exists, especially in females. This suggests the possibility that factors other than smoking (possibly dietary) could be related to these sites. However, the small numbers and the wide confidence limits certainly restrict any inferences.

In the lower part of Chart 5, the bars on the right, in effect, adjust for the selective factors that relate to who is willing or able to enroll in a prospective study. Stomach cancer is limited to males only because Hammond's publication did not give age-specific death rates for female stomach cancer. Stomach and uterus are the only sites for which the gradient between Seventh-Day Adventists and the general population was reduced by utilizing Hammond's nonsmokers as the comparison population. The pattern for uterus cancer is possibly explained by either the known inverse relationship of endometrial cancer to socioeconomic status (47) or by the possibility that female nonsmokers in the general population are less sexually promiscuous than smoking females (29) and thus are more like the Seventh-Day Adventists. The elimination of the gradient for male stomach cancer is consistent with the possibility that dietary factors unique to the Adventist lifestyle play only a minor role in stomach cancer or act as promoters. It may also emphasize the observation reported at this conference by Hirayama (27) that stomach cancer is related to both smoking and drinking.

The differential between Seventh-Day Adventists and the general population for all causes of death is reduced but not eliminated by using a comparable cohort of nonsmokers from the general population as the comparison group. This suggests that life-style factors other than nonsmoking may contribute to the low general mortality among Adventists.

The persistence of the differentials between Seventh-Day Adventists and the general population for cancer of the colon, breast, ovary, and prostate, as well as leukemia and lymphoma, is consistent with the hypothesis that one or more components of the Adventists life-style (other than nonsmoking) may protect against these cancer sites. Furthermore, this observation tends to weaken the hypothesis that selective factors account for the differential. However, the unique method of selection of Hammond's population is dissimilar to that of the Adventist study. It is quite conceivable that selective factors that may be related to participation in Hammond's study are entirely different from the selective factors that relate to choosing to become and remain a Seventh-Day Adventist.

**Time and Duration of Exposure to the Seventh-Day Adventists' Life-style.** Another approach to assessing the relative role of life-style in explaining the low Adventist rates is to compare those who joined the Church at different ages (Chart 6). If life-style differences are the key factor explaining the gradient between Adventists and the general population, then the earlier in life a person assumes the Adventist life-style, the lower should be his risk. Conversely, persons joining the Church late in life should have a risk more nearly equal to the general population, especially if
life-style very early in life were the critical factor. There are no significant gradients except for stomach cancer and, possibly, for all cancers. The latter is probably a reflection of the near absence of smoking-related sites among persons who joined early in life who are less likely to have smoked in the past than those who joined at a later age. The picture for stomach cancer is consistent with the importance of exposure to etiological agents early in life, as suggested by the migrant studies (19, 49). Persons who joined the Church late in life are more likely to have been exposed early in life to foods that Adventists usually avoid (meat, coffee, etc.). Alternatively, if risk of certain sites of cancer is determined more by habits in the recent past than during childhood, one would not expect a gradient by age that church membership began, as shown for colon and breast cancer in Chart 6.

Chart 7 compares life-time Adventists to recent converts, irrespective of the age at which they became members. This is consistent with the above observation for stomach cancer. The results for colon and breast, which show a lower risk for recent converts than life-time members, are quite unexpected. It can be assumed that recent converts are more zealous about adhering to the Church recommendations regarding diet and other aspects of life-style and that recent habits are more important than early life habits, this observation would be consistent with the dietary hypotheses for these sites. Although unsubstantiated by any data, long-time Adventists suspect a secular trend of an increasing proportion of vegetarians among Adventists which might also partially explain the pattern of lower risk in recent converts. However, since these assumptions are questionable, it may simply reflect the likely possibility that persons who choose to become Adventists relatively late in life are a highly select group who may already be at low risk of colon and breast cancer before they adopt the Adventist life-style, or they may indeed be living a life-style similar to that of Adventists before joining and thus are more likely to join a select group with a somewhat stringent life-style.

Because of the strong possibility that selective factors may relate more strongly to joining the Church in later life than in the teen years, Charts 6 and 7 do not provide much evidence for or against the hypothesis that life-style is a primary explanation for the low cancer mortality rates among Adventists.

Comparison of Adventist versus non-Adventist Physicians. One further approach to determining whether selective factors or life-style explains the low cancer mortality in Adventists is to compare the mortality experience of a group of Adventists and of non-Adventists who are very similar in many respects, except for certain aspects of life-style. It recently occurred to us that Adventist and non-Adventist physicians would fulfill these criteria and that existing records would allow easy follow-up of 2 such groups of physicians. We are just completing a study of the complete mortality experience of all male medical graduates of LLU (3867) and USC (2416) medical schools who graduated during the years 1914 to 1971 and 1901 to 1971, respectively. We have so far obtained death certificates on 96.5% of the 863 deaths. These 2 groups of physicians are clearly very similar in regard to socioeconomic status, medical care, knowledge of health, etc., yet they differ in other key life-style variables. We do not have information on current or past religious affiliation of these 2 groups, but we can safely assume that over 75% of the LLU graduates are Adventists and less than 5% of the USC graduates are Adventists. Thus, this is roughly a comparison of Adventist versus non-Adventist physicians.

Chart 8 shows the results of this study presented as standardized mortality ratios derived from a life table analysis. As expected, the death rates in physicians are much lower than general population rates, but the startling finding was that mortality rates in LLU and USC graduates are essentially the same for all causes and all cancer. It is interesting to note that the difference in cancer mortality between Adventist physicians and the general population is essentially the same as that observed between all Adventists and the general population (Chart 1). Thus cancer mortality in Adventist physicians is equal to the population from which they come, whereas non-Adventist physicians have a cancer mortality considerably below the general population. The higher gastrointestinal and colon-rectal cancer deaths in LLU graduates were unexpected. Differences between LLU and USC for the indicated types of cancer are not statistically significant because of small numbers. However, the direction of these differences is certainly opposed to the current dietary hypotheses for these sites, which suggest that intake of fat, meat, beef, or low-fiber foods are re-
which we will later relate to site-specific cancer incidence rates among subgroups that do and do not adhere to certain dietary patterns. However, we felt it would be worthwhile to try to get some quicker, although somewhat less reliable, information on the topic of diet and cancer from a case-control study. Preliminary results are now available from a recent interview study of 41 Adventist colon-rectal cancer and 77 Adventist breast cancer patients discharged from 2 Adventist-operated hospitals during 1969 to 1973 and 3 types of age-, sex-, and race-matched Adventist controls. The food questions used in the structured interview were specifically designed to test the hypothesis that intake of high fat, low fiber, or both are associated with risk of colon or breast cancer.

Colon Cancer. The relative risks for reported usage of food items by servings per day, week, or month among colon cancer cases and controls are shown in Table 5. For the cases listed in Table 5, the results calculated separately for the cases matched to the 3 different types of controls showed an association with colon cancer of approximately the same magnitude and direction. Thus, all controls were combined for calculation of relative risks. Using relative risk as a measure of association and \( \chi^2 \) as a test of statistical significance, it appears that any use of beef, lamb, fish, and the heavy use of dairy products other than milk and other high-fat foods are significantly related to risk of colon cancer.

While current use of meat, poultry, or fish did not show a relationship, such use 20 years ago gives one of the highest relative risks. Although it is clearly impossible quantitatively to determine frequency of food use 20 years ago, it is possible, in Seventh-Day Adventists, to reliably assess vegetarian versus nonvegetarian status in the distant past. Adventists can usually distinctly remember when they became a physician (C) may be less complex.

The fact that the cancer mortality differential between all Adventists and the general population is not seen between Adventist and non-Adventist physicians is consistent with the hypothesis that selective factors are the prime determinants of this differential. However, the diagram below indicates that 2 sets of selective factors (A and B, which may be quite different) could relate to becoming an Adventist physician, whereas the selective factors relating to an individual in the general population becoming a physician (C) may be less complex.

![Chart 8. Standardized mortality ratios (SMR) for various causes of death among all male graduates of LLU and USC medical schools. Standardized mortality ratios = \( (O/E) \times 100 \) where \( E \) = number of expected deaths derived by accumulating the yearly expected deaths obtained by applying the age-decade (1920, 1930, 1940, etc.) cause-specific death rates for white males in the United States to the corresponding 5-year age group in the physician population at risk and \( O \) = number of observed deaths during 1914 to 1971; 95% confidence limits are shown for each bar.](chart8.png)

There are presently 2 years into a 6-year prospective study of the 100,000 Adventists currently living in California. At the outset, we are collecting detailed information on diet which we will later relate to site-specific cancer incidence rates among subgroups that do and do not adhere to certain dietary patterns. However, we felt it would be worthwhile to try to get some quicker, although somewhat less reliable, information on the topic of diet and cancer from a case-control study. Preliminary results are now available from a recent interview study of 41 Adventist colon-rectal cancer and 77 Adventist breast cancer patients discharged from 2 Adventist-operated hospitals during 1969 to 1973 and 3 types of age-, sex-, and race-matched Adventist controls. The food questions used in the structured interview were specifically designed to test the hypothesis that intake of high fat, low fiber, or both are associated with risk of colon or breast cancer.

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Based on the concept that the important variable may be the total pattern of food used, rather than specific individual foods, the results for an approximate index of intake for several combined food groups are also presented in Table 5 (dairy products; fried foods; beef products = beef hamburger + beefsteak and other beef; highly saturated fat foods = cheese + cheese + eggs + all meats and poultry). The relative risks for these food groups are in the same general direction but are not significantly higher than those for individual components of the groups. Milk,* vegetarian protein products, and green leafy vegetables show a non-significant negative association with colon cancer. These are all foods that Adventist lacto-ovo-vegetarians are likely to consume in large amounts, so the observed negative associations do not necessarily indicate that these foods are protective. Vegetarian protein products are highly processed, purified, fiber-free meat analogs derived from soy or gluten protein. Many of these products contain little or no fat. Although the current pattern of food use in colon cancer cases is likely to be different from the pattern prior to diagnosis, it is quite possible

* The interview form did not determine the type of milk used and a recent diet survey shows that only 23% of the milk used by Adventists is whole milk.
Table 5

Relative risk for use of individual foods reported by Adventist colon cancer cases and Adventist controls

Forty-one colon cancer cases were each matched by age, sex, and race to 3 controls. Where possible, 2 of the controls were selected, respectively, from hospitalized cases of hernia and osteoarthritis, and the 3rd, from the general Seventh-Day Adventist population.

<table>
<thead>
<tr>
<th>Type of food</th>
<th>Relative risk*</th>
<th>Raw data (case+, case−, cont+, cont−)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dichotomy</td>
<td>High vs. low extreme*</td>
</tr>
<tr>
<td></td>
<td>(≥ X vs. &lt; X)*</td>
<td></td>
</tr>
<tr>
<td>Positively associated†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat,* any type, 20 yr ago (any vs. none)</td>
<td>2.8</td>
<td>3.6*</td>
</tr>
<tr>
<td>Food products (any vs. none)</td>
<td>2.3</td>
<td>3.1*</td>
</tr>
<tr>
<td>Beef hamburger (any vs. none)</td>
<td>2.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Lamb (any vs. none)</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Fish (any vs. none)</td>
<td>1.6</td>
<td>3.4*</td>
</tr>
<tr>
<td>Cheese (≥ 1/wk vs. &lt; 1/wk)</td>
<td>2.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Ice cream (any vs. none)</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Dairy products except milk (heavy + medium vs. light)</td>
<td>1.7</td>
<td>2.5*</td>
</tr>
<tr>
<td>High saturated fat foods (heavy + medium vs. light)</td>
<td>2.1</td>
<td>2.7*</td>
</tr>
<tr>
<td>Fried potatoes (≥ 1/wk vs. &lt; 1/wk)</td>
<td>1.9</td>
<td>2.7*</td>
</tr>
<tr>
<td>Fried foods (heavy + medium vs. light)</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Cake or pie (≥ 1/wk vs. &lt; 1/wk)</td>
<td>2.0</td>
<td>1.7</td>
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<tr>
<td>Fresh fruit (≥ 1/day vs. &lt; 1/day)</td>
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<td>White bread (most of the time)</td>
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<td>1.9</td>
</tr>
<tr>
<td>Pepper (frequent vs. seldom or never)</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Negatively associated‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk (≥ 1/day vs. &lt; 1/day)</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Vegetarian protein products (≥ 1/wk vs. &lt; 1/wk)</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Green leafy vegetables (≥ 1/wk vs. &lt; 1/wk)</td>
<td>0.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* Relative risk (RR) = ad/bc where a(c) = cases reporting higher (lower) usage, and b(d) = all controls combined reporting higher (lower) usage. A relative risk of 1.0 indicates no association (i.e., subjects with high and low usage have the same risk).

† The reported frequency of use of each food (times/week or day) was arbitrarily divided into 2 categories at the point X (indicated under each food) to approximate above and below the median of all controls except for foods reported as "never used" by a sizable group where any versus none was preferentially used on the assumption that recall was more accurate for this than for average number of times used.

‡ High and low extremes arbitrarily selected from distribution of food usage in all controls to provide adequate numbers in both categories. It approximates upper one-third vs. lower one-third.

§ Positive (negative) association = RR ≥ 1.5 (≤ 0.66) for both hospital and general population controls and ≥ 2.0 (≤ 0.5) with either type of control.

<table>
<thead>
<tr>
<th></th>
<th>Raw data (case+, case−, cont+, cont−)</th>
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(particularly among Adventists) that the pattern after diagnosis would shift toward less meat and fat consumption, which would simply decrease the likelihood of finding associations with these foods.

It is quite clear that these results are supportive of the hypothesis that beef, meat, and saturated fat or fat in general are etiologically related to colon cancer. However, it should also be noted that some highly refined but not necessarily high-fat foods also show a positive but nonsignificant relationship to colon cancer (e.g., cake, pie, and white bread). Green leafy vegetables that are quite high in fiber are negatively associated. These associations are...
consistent with Burkitt's hypothesis that low fiber intake is a primary determinant of colon cancer (4). However, the lack of statistical significance, the strong likelihood that intake of these foods in Adventists is highly correlated with low meat and low fat intake, and the strong negative correlation between fat and fiber content of most foods suggest that the association with low fiber intake may be secondary to a primary relationship with fat, meat, or beef intake. Since the use of black pepper is strongly discouraged among Adventists, its use may be somewhat of an indirect index of how well a person follows the recommended diet, which may well account for the observed association with colon cancer.

Table 6 lists individual foods and combined food groups which were not associated with colon cancer. There is a lack of association for several foods which might be predicted to show an association, on the basis of the fat or fiber hypothesis. However, the strong association with the high-fat combined food groups which include these individual high-fat foods and the lack of association with the high- or low-fiber combined food groups tends to support the relative importance and credibility of the fat hypothesis.

Breast Cancer. Table 7 shows the results for the 77 breast cancer cases and controls. Only 5 foods were associated with breast cancer, but the association with fried potatoes was highly significant ($p < 0.01$). It is important to note that the next highest relative risk was for the use of hard fat (margarine, butter, or shortening) for frying. This association together with the association with fried potatoes and fried foods in general raises the possibility that carcinogens may be produced by excessive heating of fat during frying (1, 13). The distribution of type of fat used for frying was not significantly different in heavy and light users of fried foods, so it is likely that the observed associations with fried foods and type of fat used for frying are independent. Except for the foods listed in Table 7, all the others studied in relation to colon cancer (Tables 5 and 6) were not associated with breast cancer. Four of the 5 foods associated with breast cancer are consistent with the hypothesis that fat intake is related to breast cancer. However, in comparing the data for colon and breast cancer, it seems that the evidence implicating dietary factors in the etiology of breast cancer is less convincing than that for colon cancer.

**Discussion**

Overall, the currently available evidence on cancer among Seventh-Day Adventists is consistent with the hypothesis that one or more components of the typical Adventist...
life-style account for a large portion of their apparent reduced risk of the types of cancer which are unrelated to cigarette smoking and alcohol consumption. Aside from abstinence from smoking and drinking, the most distinctive feature of the typical Adventist life-style is a unique diet whose principal feature is lacto-ovo-vegetarianism. Harding et al. (21, 22) and Sanchez et al. (44, 45) have shown that the typical lacto-ovo-vegetarian diet has about 25% less fat and 50% more fiber than the average nonvegetarian diet, and the proportion of saturated fat ratio is just about doubled.

If the relative effect of selective factors is minimal, the prospective mortality data for Adventists are clearly in agreement with the hypotheses that either fat or fiber intake is related to many gastrointestinal cancers, as well as breast, endometrial, and ovarian cancer. The case-control data would tend to favor the fat hypothesis for colon cancer, and the comparison of LLU to USC physicians does not clearly refute or confirm either hypothesis. It seems clear that additional studies on diet and cancer in the Adventist population will be productive.

Several aspects of the typical Adventist diet might affect their risk of cancer. The relatively low content of fat (especially saturated fat) and cholesterol and the relatively high content of fiber could influence other physiological or metabolic phenomena which may relate to cancer risk. Such phenomena could include rapid bowel transit time (4, 15) and lower output of bile acids potentially convertible to carcinogens (43, 25), as well as altered type and metabolic activity of intestinal bacteria (2, 14, 26, 42).

The relatively low intake of protein (23) and the possible lower frequency of obesity (8) in Seventh-Day Adventist vegetarians, which suggests a lower caloric intake, may well delay the onset of menarche (14, 31) and also influence hormone status at other periods of life (11, 12, 36, 37). If such effects were documented, they could explain all or part of the reduced risk of Adventists for breast, ovary, and endometrial cancer. The lack of coffee consumption by most Seventh-Day Adventists could account for a good share of their reduced bladder cancer risk (6, 7). Primarily on the basis of animal experiments, one could speculate that the relatively low intake of protein and fat by members of this religious group may favorably alter the body’s response to chemical carcinogens (5, 40). It is also conceivable that exposure to potentially carcinogenic food additives or contaminants among Adventists may be quite different from that of the general public. Furthermore, their response to potential carcinogens such as nitrosamines, aflatoxin, polycyclic hydrocarbons, etc., might be less detrimental because of a relatively high intake of vitamin C and vitamin A (23), both of which are potentially protective against certain chemical carcinogens (39, 41). Although relatively little is known regarding the environmental influences on the human microsomal hydroxylation enzyme system (38, 40, 50), it is worth noting that several fruits and vegetables that are abundantly used by Adventists contain compounds (such as flavones) that are potent inducers of this enzyme system which is intimately involved in the detoxification of absorbed carcinogens (40). The lower use of meats also reduces the use of backyard charcoal broilers which are capable of producing considerable benzo(a)-pyrene content in broiled meat (34, 35).

Although the evidence is quite scanty (3), it seems reasonable to assume that the Adventists’ diet might influence the functioning of the immunological system. Both humoral and cellular immunity are involved in the body’s defense against cancer, and it is quite conceivable that a very low intake of foreign animal protein could influence the ability of the immunological surveillance system to recognize and destroy small, early clones of tumor cells. This possibility is particularly attractive because of the rather general decrease in cancer mortality from almost all cancer sites in Adventists, which is more suggestive of a stronger defense system against cancer than lack of exposure to a few of the known multiple environmental carcinogens.

Our current prospective study will not be able to elucidate many of these potential mechanisms but, hopefully, our findings will help to establish priorities for which hypotheses would be most productive for further detailed epidemiological, laboratory, or clinical investigation.

References

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Role of Life-style and Dietary Habits in Risk of Cancer among Seventh-Day Adventists

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