International Journal of Occupational and Environmental Health

ISSN: 1077-3525 (Print) 2049-3967 (Online) Journal homepage: http://www.tandfonline.com/loi/yjoh20

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**To cite this article:** Jonathan Hofmann, Jorge Guardado, Matthew Keifer & Catharina Wesseling (2006) Mortality among a Cohort of Banana Plantation Workers in Costa Rica, International Journal of Occupational and Environmental Health, 12:4, 321-328, DOI: 10.1179/oeh.2006.12.4.321

**To link to this article:** http://dx.doi.org/10.1179/oeh.2006.12.4.321

# Mortality among a Cohort of Banana Plantation Workers in Costa Rica

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The nematocide 1,2-dibromo-3-chloropropane (DBCP), widely used in Costa Rica during the late 1960s and 1970s, causes sterility in men and is a possible carcinogen. Mortality among a cohort of Costa Rican banana plantation workers was investigated. The cohort included 40,959 individuals who worked on banana plantations between 1972 and 1979. Employment records were linked with the Costa Rican Mortality Registry to determine outcomes through 1999. Standardized mortality ratios (SMRs) were calculated for all causes of death. Poisson regression was also used to calculate mortality risk estimates by duration of employment, but provided no additional insight. All-causes SMRs were 0.77 for men (95% CI 0.75–0.80) and 0.90 for women (95% CI 0.80–1.02) relative to national mortality rates. Mortality from septicemia was significantly higher than expected. Nonsignificant increases in mortality were also observed for testicular cancer, penile cancer, Hodgkin's disease, and Parkinson's disease in men, and for cervical cancer and lung cancer in women. *Key words*: 1,2-dibromo-3-chloropropane (DBCP); banana plantations; Costa Rica; occupational cohort; standardized mortality ratio (SMR); pesticides.

**INT J OCCUP ENVIRON HEALTH 2006;12:321–328**



Banana production plays a major role in the economy of Costa Rica where approximately 40,000—50,000 individuals are employed each year on banana plantations.[1] Most banana plantations are located in the Limón province on the Atlantic coast. The work is strenuous; long work days, intense tropical heat and humidity, and arduous manual activity as well as unstable employment and low salaries are likely to affect the risk of morbidity and mortality among laborers.

In addition to these factors, high pesticide exposure among banana workers is a particular concern. During the late 1960s and 1970s, the nematocide 1,2-dibromo-3-chloropropane (DBCP) was widely used in Costa Rica and in many other developing countries. It is estimated that over 5 million kg of DBCP were applied on banana plantations in Costa Rica between 1963 and 1979.[2] The U.S. Environmental Protection Agency banned domestic use of DBCP in 1977, and Costa Rican officials stopped DBCP imports by 1979.[2,3]

On Costa Rican banana plantations, DBCP was applied with a manually operated soil injector near the roots of banana plants or, less frequently, by adding it to the water that was used for irrigation. In particular, workers who applied DBCP through soil injection often suffered severe skin contamination.[2] The extent of DBCP exposure and its health impact among banana plantation workers have been well established in studies of male sterility.[4,5]

Beyond its association with male sterility, exposure to DBCP is also thought to be associated with toxicity to the female reproductive system, liver and kidney toxicity, central nervous system depression, and irritation of the skin, eyes, and respiratory system, based on evidence from animal and human studies.[6] The International Agency for Research on Cancer (IARC) classifies DBCP as a possible carcinogen based on sufficient evidence of carcinogenicity for multiple sites in several animal species.[7] Thus far research on carcinogenicity in humans has been inconclusive. Several studies have shown that exposure to DBCP may be associated with increased risks of various cancers, particularly lung cancer.[8–11] However, results from these studies are inconclusive as a result of small sample sizes and potential confounding by exposures to multiple chemicals and cigarette smoking.

A previous analysis of cancer incidence was conducted among workers included in the cohort that was studied in this investigation.[12] Elevated incidence rates of melanoma and penile cancer were observed among male workers, and excess cases of cervical cancer and leukemia were observed among female workers. Lung cancer incidence was elevated among men in the stratum with the longest duration of employment on banana plantations.

Few epidemiologic studies have looked at mortality from causes other than cancer. An increased occurrence of diseases of the circulatory system has been reported among factory workers.[11] The existence of a

Received from the Departments of Epidemiology (JH) and Environmental and Occupational Health Sciences (MK), University of Washington, Seattle, Washington, and the Central American Institute for Studies on Toxic Substances (IRET), Universidad Nacional, Heredia, Costa Rica (JG, CW). Supported in part by Fogarty International Center Grant D43 TW0642.

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nationwide Mortality Registry in Costa Rica facilitated the investigation of mortality outcomes in this cohort, but the registration of deaths and ascertainment of causes of death in the Registry has never been evaluated. The main goal of this retrospective cohort study was to determine whether employment on banana plantations during the period when DBCP was widely used was associated with excess mortality. We anticipated that DBCP exposure might be associated with elevated risks of mortality from various kinds of cancer as well as diseases of the circulatory system, liver, and kidneys. Additionally, this investigation allowed us to assess the value of Costa Rican Mortality Registry data for potential use in future epidemiologic studies.

## METHODS

This study was retrospective. Procedures for enumeration of the cohort are described elsewhere.[12] Briefly, banana plantation workers were identified on monthly employment records maintained by the Social Security of Costa Rica (CCSS). Because of high job turnover in the banana industry, many workers appeared on the payrolls of multiple employers over the study period. A computerized algorithm based on worker names and identification numbers was used to integrate available information into one record per worker with first dates and numbers of months on the payrolls of banana plantations. To be included in the cohort, the worker's identity had to be confirmed through the Civil Registry. For the previous cancer risk assessment, over 7,000 records were excluded for: 1) workers with missing identification numbers, including foreign workers and children, and 2) a small number of workers with unknown date of birth. Under-ascertainment of deaths was evident in this analysis.[12] In subsequent years, the Civil Registry of Costa Rica substantially improved the computerized database of the Mortality Registry. We linked our entire Social Security payroll database to the Electoral Roll and the Mortality Registry and increased manual checking of possibly matching IDs. Since the previous analysis of cancer incidence in this cohort, over 6,000 additional workers had been identified. The follow-up was extended from 1992 to 1999.

Vital status was determined for all study subjects through December 31, 1999, through the Electoral Rolls and the Mortality Registry database. Death certificates were retrieved from the Mortality Registry. Causes of death were coded by a trained nosologist according to the 8th, 9th, or 10th Revisions of the *International Classification of Diseases* using the codes in effect at the time of death. The nosologist was familiar with the criteria used for coding in the Costa Rican Mortality Registry to ensure consistency between the classification of deaths in the cohort and in population mortality data.

Cause-specific mortality rates within the cohort were compared against: 1) national mortality rates in Costa Rica; and 2) mortality rates in the Limón province, where most banana plantations are located. Population mortality data were obtained from the Centro Centroamericano de Población.[13] Standardized mortality ratios (SMRs) were calculated separately for men and women, and were adjusted for age quintile and calendar year. Cause-of-death categories were based on a working version of the National Institute for Occupational Safety and Health (NIOSH) list of 118 death categories.[14] Person-time was counted from the midpoint of the first year of employment through date of death or end of follow-up on December 31, 1999. Expected deaths were calculated using Intercooled Stata 7.0, and SMRs were calculated in Microsoft Excel. Calculations for 95% confidence intervals (95% CI) were performed on the Simple Interactive Statistical Analysis web site.[15] Confidence intervals were calculated using the normal approximation of the Poisson distribution. For categories with fewer than 20 observed deaths, exact 95% Poisson confidence intervals were used.

We also conducted stratified analyses to compare all-causes mortality and cancer mortality within the cohort with national mortality rates by duration of employment on banana plantations between 1972 and 1979, as a surrogate for cumulative DBCP exposure (≤ 12 months employment, 13–35 months employment, and 36+ months employment). Other stratified analyses were performed for risk of cancer mortality by year of first employment during the study period (1972–1975, 1976–1979) and decade of follow-up. Stratified SMRs were calculated using national mortality rates in Costa Rica as reference. For these stratified analyses, person-time and events were counted from January 1, 1980, through death or end of follow-up. Tests for trend and heterogeneity across strata were performed using methods described by Breslow and Day.[16] Lagged analyses accounting for five-, ten- and 15-year intervals since first employment were also performed to account for latency between exposure to DBCP and cancer mortality. Stratified analyses of all-causes mortality by age at death or end of follow-up were also performed. Finally, Poisson regression was performed to calculate risk estimates for all-causes mortality and cancer mortality by duration of employment.

All study procedures were approved by the Human Subject Review Committee at the University of Washington.

## RESULTS

A total of 40,959 former banana plantation workers were included in the cohort (Table 1). Most workers (57.9%) were first employed between 1976 and 1979. The median age of workers during their first year of employment was 24 years, and the median duration of employment was 14 months. There were 3,316 reported deaths during the follow-up period.

Based on both national and regional mortality rates, all-causes mortality was less than expected for both men and women (Appendices A and B). Among outcomes of a priori interest (e.g., cancers, liver and kidney toxicity), we observed male SMRs above the null value for testicular cancer (local SMR = 2.07), penile cancer (national SMR = 2.23), and Hodgkin's disease (local SMR = 1.17). Additionally, male SMRs were elevated for Parkinson's disease (local SMR = 2.39) and septicemia (national SMR = 2.96). Among women, SMRs above the null value were observed for cervical cancer (national SMR = 1.52) and lung cancer (national SMR = 1.82). However, mortality from cervical cancer was low relative to regional mortality rates (local SMR = 0.88). A small number of cases of cancer of the rectum also produced a female SMR above the null value (local SMR = 3.33, based on three cases). Mortality due to septicemia was also elevated among women (national SMR = 7.00).

Mortality from external causes was higher than expected among both men (national SMR = 1.15; 95% CI 1.08–1.23) and women (national SMR = 2.11; 95% CI 1.54–2.82). However, relative to regional mortality rates, the SMR for deaths from external causes among men was lower than expected (local SMR = 0.64). It was estimated that injurious events caused an additional 114 deaths among men and 24 deaths among women in the cohort beyond what would have been expected based on national mortality rates in Costa Rica. Excess deaths among men were largely attributable to: injuries of undetermined origin (national SMR = 4.12); drowning (national SMR = 1.31); and homicide (national SMR = 1.17). Among women, motor vehicle accidents (national SMR = 2.48) and injuries of undetermined origin (national SMR = 15.99) were the principal causes of excess mortality from external causes.

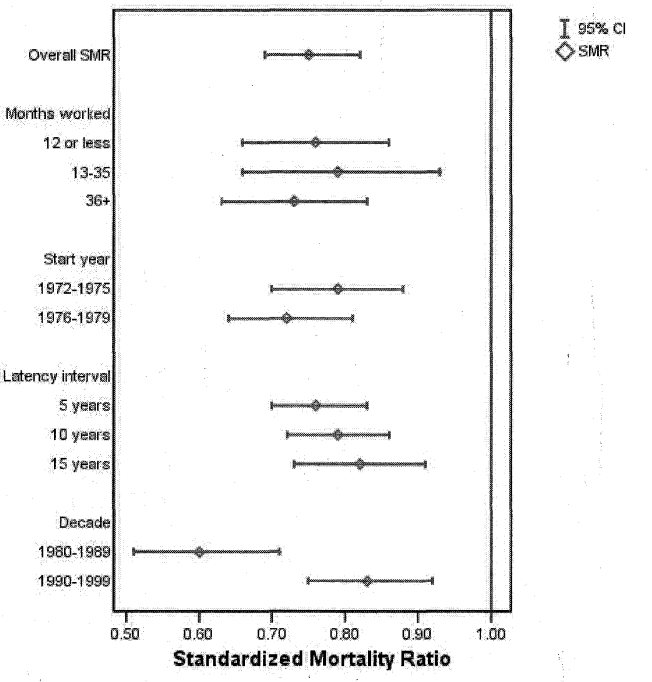


*Figure 1—Stratum-specific standardized mortality ratios for cancer mortality among men, relative to national cancer mortality rates in Costa Rica. Excludes events and person-time prior to January 1, 1980. A statistically significant difference in SMRs for cancer mortality by decade of follow-up was observed based on a test of heterogeneity (p = 0.001).*

**TABLE 1 Characteristics of the Cohort of Former Banana Plantation Workers**

| | |
|---|---|
| Number of workers | 40,959 |
| Male | 34,771 |
| Female | 6,188 |
| Vital status as of Dec 31, 1999 | |
| Alive | 37,643 (91.9%) |
| Dead | 3,316 (8.1%) |
| Year of birth | |
| Median | 1951 |
| Range† | 1900–1967 |
| Year of first employment* | |
| 1972–1975 | 17,231 (42.1%) |
| 1976–1979 | 23,719 (57.9%) |
| Duration of employment* | |
| ≤ 12 months | 19,744 (48.2%) |
| 13–35 months | 10,285 (25.1%) |
| 36+ months | 10,921 (26.7%) |
| Age at hire* | |
| Under 20 | 10,232 (25.0%) |
| 20–29 | 17,399 (42.5%) |
| 30+ | 13,319 (32.5%) |
| Duration of follow-up (years) | |
| Median | 23 |
| Range | 0–27 |

*Within the years 1972-1979
†Year of birth < 1900 was considered to be an error; data were recoded as missing for four individuals.

Among men the SMR for cancer mortality relative to national mortality rates during the 1990s was significantly higher than the SMR for cancer mortality during the 1980s ($p$ = 0.001) (Figure 1). Cancer mortality SMRs among men appeared to increase slightly as the latency interval was progressively extended up to 15 years, but did not seem to differ with respect to months employed or first year of employment. Among women there appeared to be a slight upward trend in cancer mortality SMRs with increasing duration of employment; however, this trend was not statistically significant ($p$ = 0.239) (Figure 2).

A significant decreasing trend in SMRs for all-causes mortality by duration of employment was observed among men ($p < 0.001$) (Table 2). Although SMRs for all-causes mortality among women appeared to decrease with increasing duration of employment, the test for trend was not significant ($p = 0.574$). Male SMRs for all-causes mortality also tended to decrease with increasing age at death or end of follow-up ($p < 0.001$)

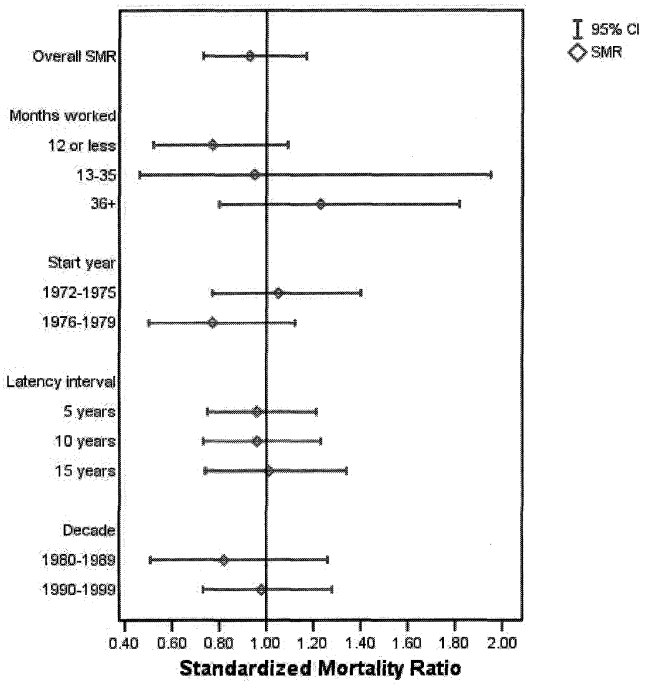


*Figure 2—Stratum-specific standardized mortality ratios for cancer mortality among women, relative to national cancer mortality rates in Costa Rica. Excludes events and person-time prior to January 1, 1980.*

(Table 3). There was a slight decrease in all-causes SMRs by age at death or end of follow-up among women, but again, this trend was nonsignificant ($p$ = 0.88). Poisson regression results were consistent with results of stratified analyses and provided no additional insight (results not shown).

## DISCUSSION

Since the previous study of cancer incidence in this cohort,[12] extending follow-up through 1999 and identifying additional workers enhanced our ability to study health outcomes among former banana plantation workers in Costa Rica. Elevated SMRs for penile cancer, Hodgkin's disease (men only), and cervical cancer are consistent with the findings of the previous study of cancer incidence. We also observed elevated SMRs for testicular cancer and Parkinson's disease among men and for lung cancer among women; these findings have not been reported previously.

Elevated SMRs for cervical cancer and penile cancer in this cohort are likely to be an artifact of regional variations in cancer mortality rates. When compared with regional mortality rates rather than national mortality rates, the SMR for penile cancer was closer to the null value (SMR = 1.40 vs 2.23) and the SMR for cervical cancer fell below the null value (SMR = 0.88 vs 1.52). Previous studies have reported higher incidence rates of invasive cervical cancer in rural banana-growing regions of Costa Rica.[17,18] Possible explanations of regional variations in mortality from cervical cancer and penile cancer include higher prevalences of sexually transmitted infections such as the human papillomavirus,[17] and lack of access to and utilization of screening programs for cervical cancer in rural areas.[18]

Similarly, Sierra and colleagues reported that individuals living in urban regions of Costa Rica may be at an increased risk of several other site-specific cancers relative to individuals living in rural areas.[18] Lower-than-expected SMRs relative to national mortality rates for stomach cancer (both men and women) and breast cancer in this cohort are consistent with previous reports.

Results for mortality from Parkinson's disease are interesting and may warrant further investigation. Relative to the local population, male banana plantation workers appeared to have an elevated risk of mortality from Parkinson's disease, although this association was based on a small number of cases ($n$ = 6) and was nonsignificant. The SMR for Parkinson's disease relative to national mortality rates was lower, although still above the null value. It is possible that exposure to other agricultural chemicals such as paraquat, mancozeb, and maneb among workers in the cohort might have contributed to this association. No deaths from Parkinson's disease were reported among women in the cohort.

**TABLE 2 Standardized Mortality Ratios for All-causes Mortality by Duration of Employment, Relative to National Mortality Rates in Costa Rica***

| Total Months Worked, 1972–1979 | Obs | Exp | SMR | 95% CI |
|---|---|---|---|---|
| Men† | | | | |
| 12 or less | 1272 | 1395.87 | 0.91 | 0.86–0.96 |
| 13 to 35 | 709 | 823.54 | 0.86 | 0.80–0.93 |
| 36+ | 863 | 1223.81 | 0.71 | 0.66–0.75 |
| Women | | | | |
| 12 or less | 128 | 124.28 | 1.03 | 0.86–1.22 |
| 13 to 35 | 52 | 54.29 | 0.96 | 0.72–1.26 |
| 36+ | 53 | 61.03 | 0.87 | 0.65–1.14 |

*Excludes events and person-time prior to January 1, 1980.
†A statistically significant decreasing trend in SMRs for all-causes mortality by duration of employment was observed among men ($p < 0.001$).

**TABLE 3 Standardized Mortality Ratios for All-causes Mortality by Age at Death or End of Follow-up, Relative to National Mortality Rates in Costa Rica***

| Age Category | Obs | Exp | SMR | 95% CI |
|---|---|---|---|---|
| Men† | | | | |
| < 40 | 702 | 778.73 | 0.90 | 0.84–0.97 |
| 40–59 | 1104 | 1440.36 | 0.77 | 0.72–0.81 |
| 60+ | 1252 | 1735.67 | 0.72 | 0.68–0.76 |
| Women | | | | |
| < 40 | 80 | 84.78 | 0.94 | 0.75–1.17 |
| 40–59 | 116 | 129.60 | 0.90 | 0.74–1.07 |
| 60+ | 62 | 71.45 | 0.87 | 0.67–1.11 |

*Excludes events and person-time prior to January 1, 1980.
†A statistically significant decreasing trend in SMRs for all-causes mortality by age at death or end of follow-up was observed among men ($p < 0.001$).



We also found that employment on banana plantations was associated with an increased risk of death from septicemia. Workers on banana plantations may be at high risk of septicemia as a result of several occupational factors. The use of machetes in, for example, harvesting bananas puts workers at risk of sustaining severe cuts. Inadequate protective clothing (e.g., lack of proper footwear, gloves, long sleeves, and long pants), outdoor work in a tropical environment, and lack of access to first aid materials may increase the likelihood of a cut's becoming infected. In addition, conditions inside packing plants can be very humid, and workers frequently suffer from chronic irritant and allergic dermatitis,[19] often leading to secondary infections.[20] Moreover, barriers to accessing health care services in rural banana-growing regions of Costa Rica may increase the risk that infections will be untreated and become systemic.

Mortality from external causes (e.g., homicides, suicides, and accidents) was significantly higher in this cohort relative to national mortality rates in Costa Rica. However, this association was attenuated for women and reversed for men when SMRs were calculated based on regional mortality rates, which suggests that these findings are likely to be related to regional differences in homicide, suicide, and accidental death rates. Lower socioeconomic status among banana plantation workers relative to the general population may also contribute to higher-than-expected SMRs for deaths from injurious events. Classification of many deaths from external causes within the cohort as "injuries of undetermined origin" made it difficult to characterize cause-specific injury deaths.

The main limitation in this study relates to misclassification of exposures. It is possible that some payroll records were assigned to the wrong individuals in the civil registry. Conversely, some banana workers might not have been identified from payroll records and would have been included in the reference population. The degree of these types of misclassification is unknown. Some of the banana plantation workers in the cohort were employed in positions with minimal DBCP exposure. Although more detailed work history information—such as job title and method of DBCP application (e.g., injection vs. chemical irrigation)—would have facilitated more precise characterization of DBCP exposure, this information was not maintained in CCSS employment records. Important misclassification of duration of employment as a surrogate for cumulative exposure to DBCP occurred, because affiliation of the workers to the Social Security was not compulsory until second half of the 1970s, and only for workers with at least three months of employment. It was a common practice to fire workers every 11 weeks to avoid social security costs. These workers were then rehired by the same or different companies and could have worked during years without Social Security records. Misclassification of durations of exposures may also have resulted from the lack of employment records prior to 1972, since DBCP had been used on some Costa Rican banana plantations in the late 1960s and early 1970s. However, the degree of misclassification as a result of employment prior to 1972 is likely to be minimal because only a small proportion of workers (8.0%) entered the study during the first two years for which records were available (1972 and 1973). These sources of exposure misclassification result in non-differential bias, pulling the SMRs towards the non-effect level and limiting our ability to detect truly existing effects.

Misclassification in the ascertainment of cause of death based on Mortality Registry data may also have limited our ability to detect associations between employment on banana plantations and cause-specific mortality outcomes. For example, the actual cause of death may have been recorded incorrectly on the death certificate, particularly if the death certificate was completed by someone other than the treating physician. It is possible that some selection bias may have resulted from non-identification of deceased banana workers in the Mortality Registry. Workers whose vital status in 1999 was unknown were excluded from the study. If there was under-ascertainment of deceased

workers, the resulting SMRs might have been spuriously low. The degree to which this selection bias affected our results is unknown.

It should be noted that this is still a relatively young cohort. At the end of follow-up in 1999, over 90% of the cohort was still alive, and the median age among these surviving cohort members was 47 years. Although we adjusted for age in all analyses, residual confounding from mortality in the highest age stratum (75+ years old) could have resulted in falsely low SMRs in this study. Extension of the follow-up period and finer age stratification among older individuals in future analyses could prevent residual confounding by age.

Confounding by other risk factors might also have affected the results of this study. In addition to DBCP, other highly toxic chemicals such as organochlorine and organophosphate insecticides, dithiocarbamate and conazole fungicides, and the herbicide paraquat were applied on banana plantations in the 1970s and in subsequent years.[21] In this study we could not distinguish between exposures to DBCP and exposures to other agricultural chemicals. Other potential confounding factors include socioeconomic status, smoking, dietary factors, and access and utilization of health care services.

The healthy-worker effect may also have led to low estimates of mortality in this cohort. Work on banana plantations is strenuous, and therefore we would expect that individuals who are able to secure and maintain employment in this industry would be relatively healthy compared with the overall population. The significant decreasing trend in SMRs for overall mortality among male banana plantation workers may be a reflection of the healthy-worker survivor effect in this cohort. That is, mortality may have been higher among individuals who were unable to maintain employment for an extended period of time relative to individuals with long-term employment.

## CONCLUSIONS

Results of this study were inconclusive for most mortality outcomes that were considered to be of interest a priori with respect to DBCP exposure. It is likely that the lack of precise exposure information and misclassification of causes of death in the Mortality Registry limited our ability to detect associations between DBCP exposure and mortality outcomes. Nonetheless, employment on banana plantations was associated with risk of death from septicemia. We also observed limited evidence of increased risks of death from testicular cancer, penile cancer, Hodgkin's disease, and Parkinson's disease in men and from cervical cancer and lung cancer in women. Future studies could employ a nested case–control design to investigate specific mortality outcomes of interest as determined from the present study.

The authors thank Harvey Checkoway, William Daniell, and Paul Demers for their advice on analytic methods and their comments on the study.

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## Appendix A

*Standardized Mortality Ratios for Selected Causes of Death among Men Employed on Banana Plantations between 1972 and 1979 (n = 34,711)*

| Cause of Death | Obs | National Population | | | Local Population | | |
|---|---|---|---|---|---|---|---|
| | | Exp | SMR | 95% CI | Exp | SMR | 95% CI |
| All causes combined | 3,058 | 3,954.76 | 0.77 | 0.75–0.80 | 4,269.44 | 0.72 | 0.69–0.74 |
| Cancers | 574 | 845.10 | 0.68 | 0.62–0.74 | 673.73 | 0.85 | 0.78–0.92 |
| Buccal cavity/pharynx | 15 | 18.80 | 0.80 | 0.45–1.32 | 16.48 | 0.91 | 0.51–1.50 |
| Esophagus | 15 | 21.45 | 0.70 | 0.39–1.15 | 18.26 | 0.82 | 0.46–1.35 |
| Stomach | 166 | 255.47 | 0.65 | 0.55–0.76 | 172.83 | 0.96 | 0.82–1.12 |
| Intestine except rectum | 24 | 34.52 | 0.70 | 0.45–1.03 | 24.75 | 0.97 | 0.62–1.44 |
| Rectum | 5 | 13.46 | 0.37 | 0.12–0.87 | 10.50 | 0.48 | 0.15–1.11 |
| Biliary passages, liver, and gallbladder | 38 | 60.73 | 0.63 | 0.44–0.86 | 42.37 | 0.90 | 0.63–1.23 |
| Pancreas | 19 | 38.55 | 0.49 | 0.30–0.77 | 20.75 | 0.92 | 0.55–1.43 |
| Peritoneum and retroperitoneum | 4 | 4.02 | 0.99 | 0.27–2.55 | 1.95 | 2.05 | 0.56–5.25 |
| Other/unspecified digestive organs | 1 | 2.16 | 0.46 | 0.01–2.58 | 1.83 | 0.55 | 0.01–3.04 |
| Larynx | 3 | 14.04 | 0.21 | 0.04–0.62 | 11.15 | 0.27 | 0.06–0.79 |
| Trachea, bronchus, and lung | 76 | 89.23 | 0.85 | 0.67–1.07 | 91.80 | 0.83 | 0.65–1.04 |
| Prostate | 56 | 71.26 | 0.79 | 0.59–1.02 | 76.60 | 0.73 | 0.55–0.95 |
| Testes | 6 | 4.15 | 1.45 | 0.53–3.15 | 2.90 | 2.07 | 0.76–4.50 |
| Penis | 6 | 2.69 | 2.23 | 0.82–4.85 | 4.29 | 1.40 | 0.51–3.04 |
| Kidney | 6 | 11.32 | 0.53 | 0.19–1.15 | 8.16 | 0.74 | 0.27–1.60 |
| Bladder | 6 | 10.45 | 0.57 | 0.21–1.25 | 7.65 | 0.78 | 0.29–1.71 |
| Bone | 3 | 6.19 | 0.48 | 0.10–1.42 | 4.11 | 0.73 | 0.15–2.13 |
| Melanoma | 5 | 6.07 | 0.82 | 0.27–1.92 | 4.82 | 1.04 | 0.34–2.42 |
| Skin, non-melanoma | 4 | 6.06 | 0.66 | 0.18–1.69 | 7.74 | 0.52 | 0.14–1.32 |
| Brain and other parts of nervous system | 16 | 30.58 | 0.52 | 0.30–0.85 | 23.79 | 0.67 | 0.38–1.09 |
| Thyroid gland | 1 | 2.29 | 0.44 | 0.01–2.43 | 2.26 | 0.44 | 0.01–2.47 |
| Other/unspecified sites | 34 | 58.15 | 0.58 | 0.40–0.82 | 53.14 | 0.64 | 0.44–0.89 |
| Hodgkin's disease | 11 | 10.54 | 1.04 | 0.52–1.87 | 9.39 | 1.17 | 0.58–2.10 |
| Non-Hodgkin's lymphoma | 16 | 22.74 | 0.70 | 0.40–1.14 | 14.94 | 1.07 | 0.61–1.74 |
| Myeloma | 8 | 13.35 | 0.60 | 0.26–1.18 | 8.42 | 0.95 | 0.41–1.87 |
| Leukemia and aleukemia | 30 | 35.32 | 0.85 | 0.57–1.21 | 31.79 | 0.94 | 0.64–1.35 |
| Other neoplasms | 23 | 13.47 | 1.71 | 1.08–2.56 | 12.75 | 1.80 | 1.14–2.71 |
| Infectious diseases | 106 | 110.14 | 0.96 | 0.79–1.16 | 175.11 | 0.61 | 0.50–0.73 |
| Septicemia | 24 | 8.11 | 2.96 | 1.90–4.40 | 14.47 | 1.66 | 1.06–2.47 |
| AIDS/HIV | 15 | 12.73 | 1.18 | 0.66–1.94 | 9.65 | 1.55 | 0.87–2.56 |
| Diseases of the blood and blood-forming organs | 10 | 13.68 | 0.73 | 0.35–1.34 | 14.80 | 0.68 | 0.32–1.24 |
| Illnesses related to the endocrine system, nutrition, and metabolism | 51 | 110.68 | 0.46 | 0.34–0.61 | 109.25 | 0.47 | 0.35–0.61 |
| Mental disorders, diseases of the nervous system and sense organs | 77 | 117.03 | 0.66 | 0.52–0.82 | 98.98 | 0.78 | 0.61–0.97 |
| Parkinson's disease | 6 | 5.41 | 1.11 | 0.41–2.41 | 2.51 | 2.39 | 0.88–5.20 |
| Diseases of the heart | 566 | 812.97 | 0.70 | 0.64–0.76 | 732.68 | 0.77 | 0.71–0.84 |
| Other diseases of the circulatory system | 234 | 320.52 | 0.73 | 0.64–0.83 | 310.02 | 0.75 | 0.66–0.86 |
| Diseases of the respiratory system | 191 | 295.39 | 0.65 | 0.56–0.75 | 281.51 | 0.68 | 0.59–0.78 |
| Diseases of the digestive system | 195 | 308.69 | 0.63 | 0.55–0.73 | 237.83 | 0.82 | 0.71–0.94 |
| Diseases of the skin and subcutaneous tissue | 12 | 19.71 | 0.61 | 0.31–1.06 | 17.85 | 0.67 | 0.35–1.17 |
| Diseases of the genitourinary system | 65 | 88.09 | 0.74 | 0.57–0.94 | 78.10 | 0.83 | 0.64–1.06 |
| Other | 92 | 151.74 | 0.61 | 0.49–0.74 | 182.48 | 0.50 | 0.41–0.62 |
| External causes combined | 862 | 747.55 | 1.15 | 1.08–1.23 | 1344.35 | 0.64 | 0.60–0.69 |
| Transportation injuries | 290 | 277.93 | 1.04 | 0.93–1.17 | 453.65 | 0.64 | 0.57–0.72 |
| Drowning | 94 | 72.03 | 1.31 | 1.05–1.60 | 199.08 | 0.47 | 0.38–0.58 |
| Accidental poisoning | 11 | 12.11 | 0.91 | 0.45–1.63 | 18.92 | 0.58 | 0.29–1.04 |
| Pesticides—accidental poisoning | 4 | 2.17 | 1.84 | 0.50–4.71 | 7.24 | 0.55 | 0.15–1.41 |
| Other accidental deaths | 62 | 53.05 | 1.17 | 0.90–1.50 | 114.98 | 0.54 | 0.41–0.69 |
| Intentional self harm | 82 | 103.59 | 0.79 | 0.63–0.98 | 150.19 | 0.55 | 0.43–0.68 |
| Assault and homicide | 109 | 92.77 | 1.17 | 0.96–1.42 | 237.65 | 0.46 | 0.38–0.55 |
| Other injury of undetermined origin | 152 | 36.93 | 4.12 | 3.49–4.82 | 71.24 | 2.13 | 1.81–2.50 |

## Appendix B

*Standardized Mortality Ratios for Selected Causes of Death among Women Employed on Banana Plantations between 1972-1979 (n = 6,188)*

| Cause of Death | Obs | National population | | | Local population | | |
|---|---|---|---|---|---|---|---|
| | | Exp | SMR | 95% CI | Exp | SMR | 95% CI |
| All causes combined | 258 | 285.83 | 0.90 | 0.80–1.02 | 340.13 | 0.76 | 0.67–0.86 |
| Cancers | 74 | 92.29 | 0.80 | 0.63–1.01 | 93.52 | 0.79 | 0.62–0.99 |
| Stomach | 6 | 13.53 | 0.44 | 0.16–0.97 | 9.93 | 0.60 | 0.22–1.32 |
| Intestine except rectum | 1 | 4.20 | 0.24 | 0.01–1.33 | 3.17 | 0.32 | 0.01–1.76 |
| Rectum | 3 | 1.41 | 2.13 | 0.44–6.21 | 0.90 | 3.33 | 0.69–9.74 |
| Biliary passages, liver, and gall bladder | 5 | 6.07 | 0.82 | 0.27–1.92 | 5.31 | 0.94 | 0.31–2.20 |
| Pancreas | 1 | 2.92 | 0.34 | 0.01–1.91 | 1.46 | 0.69 | 0.02–3.82 |
| Trachea, bronchus, and lung | 7 | 3.85 | 1.82 | 0.73–3.74 | 4.75 | 1.47 | 0.59–3.04 |
| Breast | 11 | 15.70 | 0.70 | 0.35–1.25 | 11.51 | 0.96 | 0.48–1.71 |
| Cervix uteri | 23 | 15.10 | 1.52 | 0.97–2.29 | 26.15 | 0.88 | 0.56–1.32 |
| Other/unspecified parts of uterus | 3 | 3.25 | 0.92 | 0.19–2.70 | 3.58 | 0.84 | 0.17–2.45 |
| Ovary, fallopian tube, and broad ligament | 3 | 3.03 | 0.99 | 0.20–2.89 | 2.56 | 1.17 | 0.24–3.42 |
| Kidney | 1 | 0.62 | 1.60 | 0.04–8.93 | 0.61 | 1.63 | 0.04–9.13 |
| Skin, non-melanoma | 2 | 0.37 | 5.37 | 0.65–19.38 | 0.88 | 2.26 | 0.28–8.21 |
| Other/unspecified sites | 3 | 6.19 | 0.48 | 0.10–1.42 | 7.06 | 0.42 | 0.09–1.24 |
| Non–Hodgkin's lymphoma | 1 | 1.76 | 0.57 | 0.01–3.17 | 2.12 | 0.47 | 0.01–2.63 |
| Leukemia and aleukemia | 4 | 4.65 | 0.86 | 0.23–2.20 | 5.83 | 0.69 | 0.19–1.76 |
| Infectious diseases | 11 | 7.76 | 1.42 | 0.71–2.54 | 15.95 | 0.69 | 0.34–1.23 |
| Septicemia | 6 | 0.86 | 7.00 | 2.57–15.23 | 2.33 | 2.58 | 0.95–5.60 |
| Diseases of the blood and blood-forming organs | 2 | 1.87 | 1.07 | 0.13–3.86 | 3.24 | 0.62 | 0.07–2.23 |
| Illnesses related to the endocrine system, nutrition, and metabolism | 11 | 15.89 | 0.69 | 0.35–1.24 | 21.40 | 0.51 | 0.26–0.92 |
| Diseases of the heart | 43 | 46.41 | 0.93 | 0.67–1.25 | 51.90 | 0.83 | 0.60–1.12 |
| Other diseases of the circulatory system | 20 | 26.78 | 0.75 | 0.46–1.15 | 28.73 | 0.70 | 0.43–1.08 |
| Diseases of the respiratory system | 16 | 19.88 | 0.80 | 0.46–1.31 | 23.09 | 0.69 | 0.40–1.13 |
| Diseases of the digestive system | 15 | 18.49 | 0.81 | 0.45–1.34 | 19.53 | 0.77 | 0.43–1.27 |
| Diseases of the skin and subcutaneous tissue | 3 | 4.96 | 0.61 | 0.12–1.77 | 5.43 | 0.55 | 0.11–1.61 |
| Diseases of the genitourinary system | 5 | 7.23 | 0.69 | 0.22–1.61 | 6.71 | 0.75 | 0.24–1.74 |
| Other | 13 | 23.14 | 0.56 | 0.30–0.96 | 32.38 | 0.40 | 0.21–0.69 |
| External causes combined | 45 | 21.38 | 2.11 | 1.54–2.82 | 38.53 | 1.17 | 0.85–1.56 |
| Transportation injuries | 20 | 8.07 | 2.48 | 1.51–3.83 | 13.68 | 1.46 | 0.89–2.26 |
| Drowning | 1 | 1.35 | 0.74 | 0.02–4.12 | 3.42 | 0.29 | 0.01–1.63 |
| Accidental poisoning | 2 | 0.33 | 6.06 | 0.73–21.89 | 0.48 | 4.17 | 0.50–15.05 |
| Pesticides—accidental poisoning | 1 | 0.04 | 23.60 | 0.60–131.51 | 0.39 | 2.58 | 0.06–14.29 |
| Intentional self harm | 4 | 2.87 | 1.39 | 0.38–3.57 | 6.68 | 0.60 | 0.16–1.53 |
| Assault and homicide | 3 | 2.40 | 1.25 | 0.26–3.66 | 4.45 | 0.67 | 0.14–1.97 |
| Other injury of undetermined origin | 12 | 0.75 | 15.99 | 8.26–27.93 | 1.68 | 7.16 | 3.69–12.48 |