# Cancer Death Rates in Michigan Communities With and Without Navy Bean Grain Elevators, 1970-1975

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## Summary

A comparative study of cancer death rates in Michigan communities with and without navy bean grain elevators failed to confirm an unpublished report's suggestion of a twelve-fold increase in Hodgkin's disease death rates in a community with such an elevator. Although death rates for Hodgkin's disease and other selected cancers were greater in towns with such elevators from 1970 through 1975, none of the rates were significantly greater than expected from comparable United States death rates. Secular trends or differences in migration patterns in death registration, or in demographic characteristics do not seem to explain the differences between the increased rate of Hodgkin's disease in the index community compared to the normal rate in comparable communities in this study. Either the conditions in the index community differ in other, unknown ways from those in this study's communities, or the navy bean elevator has nothing to do with the increased Hodgkin's disease death rate in the index community.

## Introduction

In an unpublished paper, Schwartz, Callen, and Silva have reported a cluster of 10 Hodgkin's disease (HD) cases in a small rural Michigan village between 1954 and 1973 (1). The age-adjusted average annual HD incidence rate for this period was 41.3 cases per 100,000 population per year (12.2 times the United States white rate), and the average annual HD death rate was 22.5 deaths per 100,000 per year (12.5 times the 1969 U.S. death rate). Because some of the cases had lived near the village's large grain elevator, the authors postulated that chronic exposure to mitogens from grains (particularly navy beans) in the elevator might have predisposed the village's residents to Hodgkin's disease.

The present report attempts to replicate their study by investigating death rates from Hodgkin's disease and other cancers in other Michigan villages with and without navy bean elevators.

## Materials and Methods

The Michigan Department of Agriculture supplied a list of navy bean processors and their addresses in a 4 county area: Bay County, Huron County, Saginaw County, and Tuscola County. Of the 19 processors listed, 2 were located in 2 cities with populations of greater than 45,000 and the rest in 14 villages with populations of less than 3,000. Only death rates in the 14 villages were analyzed because the demographic characteristics of the villages more closely resemble those of the high incidence "index" village. To assess the effect of distance from the processor on the death rates, these rates were calculated both for the villages alone (group 1) and for both the villages and their surrounding townships (group 3).

Population matched villages without navy bean processors but in the same county served as a presumably unexposed comparison group. The population

matching, based on the 1970 census, was done twice: matching only to the smaller population of the processor villages (group 2), and matching to the larger population of these villages and their surrounding townships (group 4). If the population of any of the villages was unknown, the population of its township was used instead. All 14 of the processor villages are represented in both matchings. But some of the non-processor villages in the first matching (group 2) are not represented in the second matching (group 4) because the total of their own and their township's population no longer correspond to the total population of their previously matched processor village and its township. The matching was done before the deaths from these communities were counted. Table 1 lists the communities in this study.

The Office of Vital and Health Statistics of the Michigan Department of Public Health supplied a computer list of cancer deaths from 1970 through 1975 for communities in the study area. For comparison with the results from the unpublished paper (1) and with United States death rates (2), the following cancers, listed as the underlying cause of death, were included: Hodgkin's disease, reticulum cell sarcoma, other lymphomas, multiple myeloma, leukemia, lung cancer, colonic (excluding rectal) cancer, pancreatic cancer, urinary bladder cancer, prostatic cancer, cervical cancer, female breast cancer, and all cancers.

The population and the demographic characteristics of the study communities are taken from the 1970 census (3) and from census estimates for 1975 (4). The average population at risk in these communities over the 6-year study period is the arithmetic mean of their mid-year population estimates, linearly interpolated between 1970 and 1975. Because both processor (exposed) and non-processor (unexposed) communities were more than 98% white, only white rates were calculated. The community percentages of whites and of males in 1970 was pre-

sumed to remain constant and independent of one another over the study period.

Demographic characteristics of the exposed and unexposed communities were compared by the t-test for matched pairs (5). Crude cancer death rates were compared by using a binomial proportions model (6). Confidence limits for the ratio of an observed to an expected number of deaths are calculated by assuming a Poisson distribution (7).

## Results

Table 2 compares the demographic characteristics of Michigan communities with and without navy bean elevators. No statistically significant differences between the matched communities occur with respect to total population, number of males, number of whites, percentage of total population 65 years old or older, and per capita income. The median age of those in group 1 villages with elevators is 1.4 years greater than that of those in group 2 villages without elevators (p<0.05), probably reflecting a smaller percentage of the total population less than 18 years old in the former (40.5%) than in the latter (42.5%). This significant difference does not occur in the comparison of the more populous study groups 3 and 4 (i.e., villages and their surrounding townships).

Table 3 compares the average annual crude death rates among whites from 1970 through 1975 for all cancers and selected cancers in Michigan communities with and without navy bean elevators. The 1969 United States white death rates are included in the last column as a comparison (2). In general, the crude death rates in these Michigan communities are similar to or lower than the U.S. rates. The death rates of group 1 communities are significantly greater than those of group 2 communities for all cancers, Hodgkin's disease, lung cancer, and pancreatic cancer. The death rates of group 3 communities are

significantly greater than those of group 4 communities for all cancers, pancreatic cancer, and female breast cancer. The only cancers with consistently greater death rates under both comparisons are all cancers and pancreatic cancer. Even these death rates are comparable to the U.S. rates.

Differences in the age composition of the matched communities and the consistently lower crude rates in the unexposed (groups 2 and 4) communities compared to the U.S. rates might explain the significant differences in death rates observed in table 3. Tables 4A and 4B compare the observed number of deaths in the study communities to that expected by applying 1969 United States white age group specific death rates to the populations in each age group in the study communities. These comparisons are, therefore, between each study community and the United States, rather than between the communities themselves. None of the community rates are significantly greater than the U.S. rates. Some differences between the crude rates appear due to relatively low rates in the unexposed groups (e.g., the differences in rates for Hodgkin's disease and all cancers between groups 1 and 2 and for pancreatic cancer and all cancers between groups 3 and 4). These relatively low rates in the unexposed groups do not occur and thus cannot explain other differences between the crude rates of exposed and unexposed groups (e.g., the differences in rates for lung and pancreatic cancer in groups 1 and 2 and for breast cancer in groups 3 and 4). Significantly fewer deaths from lung cancer than expected occurred in groups 3 and 4, and fewer deaths from cervical cancer in group 3.

## Discussion

This study did not confirm the significantly increased death rate from Hodgkin's disease in Michigan communities with navy bean elevators, as postulated

in an unpublished account of a Hodgkin's disease cluster in another Michigan community (the index village) with such an elevator (1). Although the Hodgkin's disease crude death rate for villages with elevators was significantly greater than that for villages without elevators, this difference did not persist when the rates for a larger, more populous area around the villages were calculated. Rather, the death rates for Hodgkin's disease were either comparable to or lower than U.S. death rates. The observed significant difference in rates may have occurred because of a lack of deaths in villages without elevators rather than an excess of deaths in villages with elevators.

Differential migration might explain why the villages with navy bean elevators in this study had Hodgkin's disease death rates comparable to the U.S. rates while the index village had much higher rates. Death rates in the study villages might not reflect incident cases of Hodgkin's disease as well because cases migrated elsewhere to die more often then cases in the index village. Although impossible to test directly, such differential migration seems unlikely because the annual emigration percentage (appendix A) in the study area is less than that of the county of the index village. Census data does not detail this information for each of the study communities or the index village, but this percentage can be calculated for the 4 county study area (excluding its 2 large cities) and the county of the index village (appendix A). The annual emigration percentage is 2.2% in the study area and 4.3% in the county of the index village, a difference opposite to that expected if the emigration of incident cases had resulted in a larger loss of deaths from the study area than from the index village.

Differential death registration might also explain why the villages with navy bean elevators had Hodgkin's disease death rates much less than that of the index village. Although again impossible to test directly, one indirect measure of less than adequate death registration is the percentage of deaths

ascribed to symptoms and other ill-defined conditions (ICDA 780-796). A much larger percentage in the study area compared to that in the index village might indicate that some Hodgkin's disease deaths might have been missed in the study areas. For the period, 1970-1974, this percentage in the study areas was 0.36%, while that in the county of the index village was 0.28%, a statistically insignificant difference (p>0.05, by difference in binomial proportions test) (9-13).

Demographic differences or secular changes might also explain the differences in Hodgkin's disease death rates. The population of the index village is smaller than the mean population of this paper's study groups (table 1), but the age distribution and the percentage of males and whites are similar. The 1969 per capita income is larger in the index village, but this gap narrows by 1974. The study period for the index village, 1954-1973, differs from that of the present study, 1970-1975. Periods of high Hodgkin's disease activity might have preceded the present study period. Two observations make this less likely. Four of the 9 cases with a definite date of onset in the index village have had onsets since 1970; 2 of the 5 deaths in this group have occurred since 1970. Twenty-one Hodgkin's disease deaths occurred in the 4-county study area (excluding the 2 large cities) from 1964 through 1969, while 28 occurred there from 1970 through 1975. Neither observation suggests periods of heightened disease activity before 1970, though this may be difficult to detect in a rare disease like Hodgkin's disease.

If these reasons cannot account for the 10-fold difference in Hodgkin's disease death rates between the index village and the study villages with navy bean elevators, either the relevant conditions around the elevator in the index village differ from those around the elevators in the study villages, or the presence of the elevator in the index village has nothing to do with the Hodgkin's disease cluster there. It is now impossible to distinguish these

hypotheses because the relevant conditions are unknown. Until they become known or another village with such a cluster is discovered, how large a risk factor residence in a community with a navy bean elevator is will remain moot.

If information on death rates or incident cases in these study communities is readily available, it would be worthwhile to expand this study. Otherwise, effort should be spent elsewhere.

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## Appendix A

The number of emigrants over a time period can be approximated from census data ($\underline{3},\underline{8},\underline{14}$) and yearly mortality over that period ($\underline{9},\underline{15}$-$\underline{19}$). The annual emigration percentage is defined as the number of emigrants divided by the baseline population and by the duration in years of the study period. For the period, 1965-1970, this may be expressed as follows:

$$E = P65(all) + I - D - P70(\geq 5)$$
$$\%E = E\ [5\ .\ P65(all)]$$

Where E = number of emigrants, 1965-1970
    P65(all) = 1965 total population
    I = number of immigrants, 1965-1970
    D = number of deaths, 1965-1970
    P70($\geq$5) = 1970 population 5 years old and older
    %E = Annual emigration percentage

The 1965 total population is estimated here as the arithmetic mean of the 1960 population ($\underline{14}$) and the 1970 population ($\underline{3}$). The number of immigrants over the period, 1965-1970, is the number of persons who lived in a different county in 1965 from their residence in 1970 ($\underline{8}$). Because the above estimate of the total 1965 population is based on an April 1 date, the number of deaths between April 1, 1965, and April 1, 1970, is defined here as the sum of the following: two-thirds of the 1965 deaths ($\underline{15}$), the 1966 deaths ($\underline{16}$), the 1967 deaths ($\underline{17}$), the 1968 deaths ($\underline{18}$), the 1969 deaths ($\underline{19}$), and one-third of the 1970 deaths ($\underline{9}$). The 1970 population 5 years old and older is available from census data ($\underline{8}$). The table below lists these values for the 4 county study area (excluding its 2 large cities) and for the county of the index village.

| Value | 4-County Study Area | Index County |
|---|---|---|
| 1965 Total Population | 251,034 | 38,129 |
| Immigrants, 1965-1970 | 37,465 | 7,306 |
| Deaths, 1965-1970 | 10,085 | 1,872 |
| 1970 population, $\geq$ 5 y.o. | 250,381 | 35,442 |
| Emigrants, 1965-1970 | 28,033 | 8,121 |
| Annual Emigration Percentage | 2.2% | 4.3% |

## Table 1

### Villages and Townships by Study Group[1]

| Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|
| ·burn | Beaver Twp | Auburn and Williams Twp | Beaver Twp & Kawkawlin Twp |
| ·nconning | Garfield Twp | Pinconning & Pinconning Twp | Fraser Twp |
| ·d Axe | Harbor Beach & Sand Beach Twp | Bad Axe, Colfax Twp. & Verona Twp | Kinde, Pt. Hope, Bloomfield Twp, Dwight Twp, Gore T[wp], Hume Twp, Huron Tw[p], Lincoln Twp, Meade[?] Twp, & Rubicon Twp |
| ·kton | Ubly | Elkton & Oliver Twp | Ubly & Bingman Twp |
| ·geon | McKinley Twp & Chandler Twp | Pigeon & Winsor Twp | Harbor Beach |
| ·th (=Sherman Twp) | Paris Twp & Sigel Twp | Ruth & Sherman Twp | Paris Twp & Sigel Tw[p] |
| ·bewaing | Owendale, Brookfield Twp, & Grant Twp | Sebewaing & Sebewaing Twp | Owendale, Brookfield Twp, Grant Twp, & Fairhaven Twp. |
| ·rrollton(=Carrollton Twp | Thomas Twp | Carrollton & Carrollton Twp | Thomas Twp |
| ·ra(=Frankenmuth Twp) | Blumfield Twp | Gera, Frankenmuth, & Frankenmuth Twp | Blumfield Twp & Taymouth Twp |
| ·eeland(=Tittaba Twp) | James Twp & Swan Creek Twp | Freeland & Tittaba-Nassee Twp | James Twp & Swan Cre[ek] Twp |
| ·mlock(=Richland Twp) | Fremont Twp & St. Charles | Hemlock & Richland Twp | Fremont Twp & St. Charles |
| ·rrill | Birch Run | Merrill & Jonesfield Twp | Brady Twp & Oakley |
| ·se | Millington | Reese & Denmark Twp | Arbela Twp |
| ·irgrove | Ellington Twp | Fairgrove & Fairgrove Twp | Gilford Twp & Wisner Twp |

[1] Group 1 consists of villages with navy bean elevators; Group 2, of villages (or townships) without such elevators matched by their 1970 total populations with those in group 1; Group 3, of group 1 villages and their surrounding townships; Group 4, of villages without navy bean elevators and their surrounding townships matched by their 1970 total population with those in group 3.

Table 3

Average Annual Crude Death Rates for Selected Cancers in
Michigan Communities with and without Navy Bean Elevators,
1970-1975, whites only

| Cancer | Group 1 | Group 2 | Group 3 | Group 4 | 1969 U.S. White Death Rate |
|---|---|---|---|---|---|
| Hodgkin's Disease | 2.0* | 0.0 | 1.2 | 0.6 | 1.8 |
| Reticulum Cell Sarcoma | 2.0 | 0.9 | 1.6 | 0.6 | 1.3 |
| Other Lymphoma | 3.9 | 2.8 | 2.5 | 2.5 | 3.6 |
| Multiple Myeloma | 2.5 | 2.3 | 1.6 | 2.8 | 2.0 |
| Leukemia | 5.9 | 7.0 | 6.5 | 4.3 | 7.6 |
| Lung | 23.2* | 14.1 | 18.3 | 17.9 | 31.3 |
| Colon (Excl. Rectum) | 12.8 | 14.1 | 12.4 | 14.5 | 18.0 |
| Pancreas | 9.7* | 3.8 | 7.4* | 4.0 | 9.0 |
| Urinary Bladder | 3.9 | 3.3 | 3.7 | 3.4 | 4.4 |
| Prostate (male) | 19.0 | 12.2 | 17.6 | 11.1 | 16.6 |
| Cervix (female) | 1.0 | 0.9 | 0.6 | 2.5 | 6.0 |
| Breast (female) | 27.2 | 18.7 | 31.2* | 21.0 | 29.1 |
| All Cancers | 146.8* | 105.2 | 135.1* | 105.8 | 163.5 |

The column header spanning Groups 1–4 reads "Study Groups[1]".

[1]See footnote to table 1

*$p < 0.05$ by one-tailed test

Table 2

Demographic Characteristics of Michigan Communities
With and Without Navy Bean Elevators[1]

| Characteristic | Study Groups[1] | | | | | |
| | Group 1 | Group 2 | Group 3 | Group 4 | Index Village | Index Township |
|---|---|---|---|---|---|---|
| Mean Population (1970) | 2321 | 2379 | 3685 | 3650 | 1257 | 2996 |
| Mean Population (1975, est.) | 2578 | 2701 | 4054 | 4084 | 1352 | 3135 |
| Number of Males (1970) | 1145 | 1188 | 1816 | 1830 | 612+ | 1458 |
| Number of Whites (1970) | 2284 | 2372 | 3642 | 3635 | 1253+ | 2986 |
| Median Age (1970) | 26.0* | 24.6 | 25.8 | 25.1 | 24.2+ | 24.2 |
| % < 18 yrs. old (1970) | 40.5* | 42.5 | 40.2 | 42.0 | 40.1+ | 40.1 |
| % ≥ 65 yrs. old (1970) | 8.4 | 7.4 | 8.7 | 7.7 | 9.2+ | 9.2 |
| Per Capita Income (1969) | 2754 | 2555 | 2683 | 2521 | 3684 | 2476 |
| Per Capita Income (1974, Est.) | 4195 | 3877 | 4136 | 3741 | 4289 | 3698 |

[1] Sources: References 2 and 3

[2] Group 1 consists of villages with navy bean elevators; Group 2, of villages (or townships) without such elevators matched by their 1970 total populations with those in group 1; Group 3, of group 1 villages and their surrounding townships; Group 4, of villages without navy bean elevators and their surrounding townships matched by their 1970 total populations with those in group 3.

* Significantly different statistically (p < 0.05) by matched pairs t-test.

+ Estimated from values in township

Table 4A

Observed and Expected Numbers of Deaths for Selected Cancers
And All Cancers Among Whites in Michigan Communities With
and Without Navy Bean Elevators, 1970-1975Δ

| Cancer | Group 1 | | | | Group 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | OBS | EXP | RR | CONF. LIMITS[σ] | OBS | EXP | RR | CONF. LIMITS[σ] |
| Hodgkin's Disease | 4 | 3.2 | 1.2 | (0.4-3.7) | 0 | 3.2 | 0.0 | + |
| Reticulum Cell Sarcoma | 4 | 2.3 | 1.7 | (0.4-3.7) | 2 | 2.3 | 0.9 | (0.3-8.3) |
| Other Lymphomas | 8 | 6.4 | 1.2 | (0.5-2.3) | 6 | 6.3 | 0.9 | (0.5-2.7) |
| Multiple Myeloma | 5 | 3.4 | 1.5 | (0.4-3.1) | 5 | 3.3 | 1.5 | (0.4-3.1) |
| Leukemia | 12 | 13.8 | 0.9 | (0.6-1.9) | 15 | 13.7 | 1.1 | (0.6-1.8) |
| Lung | 47 | 55.0 | 0.9 | (0.8-1.4) | 30 | 53.9 | 0.6 | (0.7-1.5) |
| Colon (excl. rectum) | 26 | 31.0 | 0.8 | (0.7-1.5) | 30 | 29.7 | 1.0 | (0.7-1.5) |
| Pancreas | 20 | 15.5 | 1.3 | (0.6-1.6) | 8 | 14.9 | 0.5 | (0.5-2.32) |
| Urinary Bladder | 8 | 7.5 | 1.1 | (0.5-2.3) | 7 | 7.1 | 1.0 | (0.5-2.5) |
| Prostate (Male) | 19 | 13.9 | 1.4 | (0.6-1.7) | 13 | 13.1 | 1.0 | (0.6-1.9) |
| Cervix (Female) | 1 | 5.4 | 0.2 | (0.2-39.5) | 1 | 5.4 | 0.2 | (0.2-39.5) |
| Breast (Female) | 28 | 26.1 | 1.1 | (0.7-1.5) | 20 | 25.5 | 0.8 | (0.6-1.6) |
| All Cancers | 298 | 286.3 | 1.0 | (0.9-1.1) | 224 | 278.8 | 0.8 | (0.9-1.1)* |

ΔOBS = Observed; exp = expected; rr = relative risk = obs/exp
+ The probability of observing no deaths when 3.2 deaths were expected is 0.04 under
    the Poisson distribution.
[σ]These are confidence limits for the ratio of a Poisson variable to its expectation
    (see reference 7)
*Significantly different (p < 0.025) from expected

Table 4B

Observed and Expected Numbers of Deaths for Selected Cancers
and All Cancers Among Whites in Michigan Communities With
and Without Navy Bean Elevators, 1970-1975Δ

| Cancer | Group 3 | | | | Group 4 | | | |
|---|---|---|---|---|---|---|---|---|
| | OBS | EXP | RR | CONF. LIMITS[o] | OBS | EXP | RR | CONF. LIMITS[o] |
| Hodgkin's Disease | 4 | 5.2 | 0.8 | (0.4-3.7) | 2 | 5.0 | 0.4 | (0.3-8.3) |
| Reticulum Cell Sarcoma | 5 | 3.8 | 1.3 | (0.4-3.1) | 2 | 3.6 | 0.6 | (0.3-8.3) |
| Other Lymphomas | 8 | 10.4 | 0.8 | (0.5-2.3) | 8 | 9.8 | 0.8 | (0.5-2.3) |
| Multiple Myeloma | 5 | 5.6 | 0.9 | (0.4-3.1) | 9 | 5.2 | 1.7 | (0.5-2.2) |
| Leukemia | 21 | 22.3 | 0.9 | (0.7-1.6) | 14 | 21.3 | 0.7 | (0.6-1.8) |
| Lung | 59 | 88.7 | 0.7 | (0.8-1.3)* | 58 | 83.7 | 0.7 | (0.8-1.3)* |
| Colon (excl. rectum) | 40 | 50.4 | 0.8 | (0.7-1.4) | 47 | 46.6 | 1.0 | (0.8-1.4) |
| Pancreas | 24 | 25.1 | 1.0 | (0.7-1.6) | 13 | 23.3 | 0.6 | (0.6-1.9)* |
| Urinary Bladder | 12 | 12.2 | 1.0 | (0.6-1.9) | 11 | 11.2 | 1.0 | (0.6-2.0) |
| Prostate (Male) | 28 | 22.7 | 1.2 | (0.7-1.5) | 18 | 20.9 | 0.9 | (0.6-1.7) |
| Cervix (female) | 1 | 8.7 | 0.1 | (0.2-39.5)* | 4 | 8.2 | 0.5 | (0.4-3.7) |
| Breast (female) | 51 | 42.0 | 1.2 | (0.8-1.3) | 34 | 39.3 | 0.9 | (0.7-1.4) |
| All Cancers | 435 | 462.9 | 0.9 | (0.9-1.1) | 343 | 434.2 | 0.8 | (0.9-1.1)* |

ΔOBS = Observed; Exp = Expected; RR = Relative Risk = obs/exp
[o]These are confidence limits for the ratio of a Poisson variable to its expectation
    (see reference 7).
* Significantly different ($p < 0.025$) from expected