

CANCER DEATH RATE CHANGES NEAR OLDEST U.S. NUCLEAR PLANTS

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Introduction. The United States is home to 94 nuclear power reactors, down from a high of 111 in the early 1990s. Only two reactors (that later were not cancelled) have been ordered since 1973, and thus the current reactors are aging.

Federal regulators originally granted 40-year licenses to reactors, based on the life expectancy of the mechanical parts of reactors. Subsequently, regulators granted 20-year extensions beyond the initial 40 years to virtually all reactors still operating. Six reactors (at the Peach Bottom PA, Surry VA, and Turkey Point FL plants) have received approval for licenses up to 80 years, and more are expected (Nuclear Energy Institute, 2024).

The oldest U.S. reactors are at 17 nuclear plants that began operating from 1969-1975. There are 31 reactors operating at these plants, including 24 that started from 1969-1975, or 50 to 56 years ago. Note: These 17 plants had no prior reactor at the site (World Nuclear Association, 2025).

Reactors with over 50 years in service raise issues of whether health in local populations has been affected by routinely-emitted radioactivity into the environment. No studies of health near aging reactors exist; the only federal study of cancer near reactors covered areas near 52 power plants from the years 1950 to 1984, none of which had operated over 25 years (Jablon, 1991).

Aging reactors, plus the lack of health studies in local populations, indicate a need to analyze trends in cancer. This report will analyze cancer trends near the 17 oldest U.S. plants.

Methodology. The Wonder system of the U.S. Centers for Disease Control and Prevention (CDC) makes annual death rates available for all causes, including all forms of cancer, for each U.S. county from 1968 to 2020. An initial cancer trend analysis should include all cancers combined.

CDC age-adjusted death rates will be used in this report. Age-adjustment is a standard epidemiological technique, accounting for age distribution to allow “apples to apples” comparisons. Without age adjustment, crude rates would be highest in areas with high proportions of elderly. The 2000 U.S. standard population is used to adjust cancer death rates.

Three time periods will be used to assess mortality trends, including:

- 1968 to 1978, just before and just after nuclear plant startup (baseline)
- 1979 to 1998, the early years of nuclear plant operation
- 1999 to 2020, the later years of nuclear plant operation

For each nuclear plant, the county rate compared with the national rate will be calculated for each of the three time periods. This is also known as the Standard Mortality Ratio (SMR), which was

used in the 1990 National Cancer Institute study. Counties selected are the site of nuclear plants. The Monticello plant in Minnesota borders Sherburne and Wright Counties, so both are included.

Cancer death rates for all races and ethnic groups combined will be calculated for each of the three periods. Census data shows changes in racial/ethnic makeup of study counties over the past half century was not much different than U.S. changes – with one exception.

Miami-Dade County in Florida, the site of Turkey Point, had a large increase in Hispanic residents, from 5% to 69% of the population from 1960-2020. Because cancer death rates for Hispanics are well below Caucasians and African-Americans, the cancer mortality trend for Miami-Dade County would be affected, and thus Turkey Point is removed from the study, leaving 16 nuclear plants.

In addition to deaths from all cancers combined, this report includes deaths from all causes combined. Radiation exposure is known to be a cancer risk, but can also raise risk of other disorders. A review of 5,000 reports showed increases in incidence and mortality for multiple diseases in the two decades after the 1986 meltdown at Chernobyl reactor #4 (Yablokov, 2009).

The number of “excess” cancer deaths and total deaths for the 42 years after baseline (1979-2020) will be calculated. This calculation assumes the standard mortality ratio at baseline (1968-1978) will not change in future periods. Excess deaths are the percent increase in the ratio multiplied by the number of deaths in periods after the baseline.

From 1970 to 2020, the population in the 17 counties living near the 16 nuclear plants in the study increased from 947,741 to 1,368,709, seen on Table 1 (U.S. Census Bureau, 2025).

Results – All Cancers Combined.

In the baseline period of 1968-1978, the age-adjusted cancer death rate in the areas near the 16 plants was 6.0% below the U.S. (standard mortality ratio 0.940). In the following two periods, the local rate increased to 0.8% below the U.S. (1979-1998) and to 3.0% above the U.S. (1999-2020).

Increases after the baseline occurred in areas near 15 of 16 plants. The exception is Surry, located in Surry County VA, with a small population (6,000 in 2020).

The excess number of cancer deaths near the 16 plants was 8,476, or 7.8% of the 109,350 total cancer deaths in these areas (see below, and tables 2 and 3).

| | <u>1968-1978</u> | <u>1979-1998</u> | <u>1999-2020</u> | |
|---------------------------|------------------------|------------------|------------------|---------------|
| Standard Mortality Ratio | 0.940 | 0.992 | 1.030 | |
| % Above/Below U.S. | - 6.0% | - 0.8% | + 3.0% | |
| Excess Cancer Deaths | --- | 2,566 | 5,910 | (total 8,476) |
| Excess as % of all deaths | 8,476 / 109,350 = 7.8% | | | |

Results – All Causes Combined.

In the baseline period of 1968-1978, the age-adjusted death rate for all causes combined in the areas near the 16 plants was 0.3% below the U.S. (standard mortality ratio 0.997). In the following two periods, the local rate increased to 1.4% above the U.S. (1979-1998) and to 3.7% above the U.S. (1999-2020).

Increases after the baseline occurred in areas near 13 of 16 plants. The excess number of deaths from all causes near the 16 plants was 19,438, or 4.1% of the 479,124 total deaths in these areas (see below, and tables 4 and 5).

| | <u>1968-1978</u> | <u>1979-1998</u> | <u>1999-2020</u> | |
|--------------------------|------------------|------------------|------------------|----------------|
| Standard Mortality Ratio | 0.997 | 1.014 | 1.037 | |
| % Above/Below U.S. | - 0.3% | + 1.4% | + 3.7% | |
| Excess Total Deaths | --- | 3,636 | 15,802 | (total 19,438) |

Excess as % of all deaths $19,438 / 479,124 = 4.1\%$

Discussion. This analysis of death rates from all cancers and all causes in areas near the 16 oldest U.S. nuclear plants shows rising rates over time, compared to the U.S. rate. In the 42 years after the baseline period (1968-1978)

- the percent of deaths that was “excess” was 7.8% for all cancers, and 4.1% for all deaths
- the number of excess deaths was 8,476 for all cancers, and 19,438 for all deaths
- excess deaths were observed near 15 of 16 plants for all cancers, and near 13 of 16 plants for all deaths
- excess deaths were much greater for all cancers during the third and fourth decades of operation (5,910), compared to the first and second decades of operation (2,566)
- excess deaths were much greater for all causes during the third and fourth decades of operation (15,802), compared to the first and second decades of operation (3,636)

All findings achieved statistical significance ($p < .05$), as they involve large numbers of deaths.

While multiple factors can affect mortality, the rising rates in local areas after startup of nuclear plants documented in this report are concerning. Reactors operating for more than 50 years have no precedent, and thus should require local health trends to better understand any adverse impact. More analysis should be conducted; trends in deaths from all cancers and all causes can be tracked after 2020, as can specific causes of death, including specific cancers.

Perhaps just as important as additional studies is the need to disseminate results to officials and the public. Any future decisions on keeping aging reactors in operation, to build new reactors, or to re-start permanently closed reactors should include an assessment of local health trends.

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Table 1

Home counties and 1970 and 2020 populations

Near 16 oldest U.S. nuclear power plants still operating on January 1, 2022

| <u>Startup</u> | <u>Plant</u> | <u>County</u> | <u>1970 Pop.</u> | <u>2020 Pop.</u> |
|----------------|----------------------|---------------------|------------------|------------------|
| 1969 | Nine Mile Point | Oswego NY | 100,897 | 117,525 |
| 1970 | Ginna | Wayne NY | 79,404 | 91,283 |
| 1970 | HB Robinson | Darlington SC | 53,442 | 62,905 |
| 1970 | Point Beach | Manitowoc WI | 82,294 | 81,359 |
| 1971 | Palisades | Van Buren MI | 56,173 | 75,587 |
| 1971 | Monticello | Sherburne/Wright MN | 57,277 | 238,520 |
| 1972 | Surry | Surry VA | 5,882 | 6,561 |
| 1973 | Oconee | Oconee SC | 40,728 | 78,607 |
| 1973 | Prairie Island | Goodhue MN | 34,804 | 57,582 |
| 1973 | Quad Cities | Rock Island IL | 166,734 | 144,672 |
| 1974 | Arkansas Nuclear One | Pope AR | 28,607 | 63,381 |
| 1974 | Browns Ferry | Limestone AL | 41,699 | 103,570 |
| 1974 | Cooper | Nemaha NE | 8,976 | 7,704 |
| 1975 | Brunswick | Brunswick NC | 14,223 | 136,693 |
| 1975 | DC Cook | Berrien MI | 163,875 | 154,316 |
| 1975 | Hatch | Appling GA | 12,726 | 18,444 |
| Total | | | 947,741 | 1,368,709 |

Table 2
 Age-adjusted death rate, all cancers combined
 Home counties of 16 oldest U.S. nuclear power plants
 Three time periods (1968-1978, 1979-1998, 1999-2020)

| <u>Plant</u> | <u>Cancer Deaths/100,000 (adjusted)</u> | | | <u>Number of Cancer Deaths</u> | | |
|-----------------|---|----------------|----------------|--------------------------------|----------------|----------------|
| | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> |
| Nine Mile Point | 206.53 | 228.67 | 195.92 | 1875 | 4526 | 5647 |
| Ginna | 198.89 | 220.68 | 185.30 | 1458 | 3496 | 4513 |
| HB Robinson | 170.08 | 219.91 | 204.99 | 770 | 2464 | 3589 |
| Point Beach | 175.10 | 201.36 | 171.64 | 1543 | 3697 | 4216 |
| Palisades | 188.06 | 217.53 | 194.24 | 1098 | 2924 | 3738 |
| Monticello | 182.34 | 192.85 | 166.02 | 1053 | 3019 | 6195 |
| Surry | 250.00 | 237.45 | 201.24 | 140 | 301 | 405 |
| Oconee | 189.06 | 204.37 | 173.41 | 715 | 2285 | 3877 |
| Prairie Island | 165.37 | 188.73 | 168.66 | 719 | 1790 | 2323 |
| Quad Cities | 197.47 | 219.25 | 181.56 | 3112 | 7149 | 7612 |
| Arkansas Nucl. | 174.23 | 200.76 | 197.09 | 541 | 1706 | 2816 |
| Browns Ferry | 164.93 | 184.73 | 166.80 | 606 | 1737 | 3167 |
| Cooper | 179.24 | 196.23 | 175.51 | 209 | 427 | 397 |
| Brunswick | 165.62 | 212.45 | 169.98 | 404 | 2290 | 6345 |
| DC Cook | 207.28 | 217.17 | 188.33 | 3096 | 7069 | 8419 |
| Hatch | 160.17 | 205.88 | 187.48 | 191 | 585 | 839 |
| Total 16 plants | 191.57 | 211.39 | 180.31 | 17530 | 45465 | 64085 |
| U.S. | 203.77 | 213.09 | 175.05 | 3947589 | 9863123 | 12968466 |

Table 3
Standard mortality ratio, all cancers combined
Home counties of 16 oldest U.S. nuclear power plants
Three time periods (1968-1978, 1979-1998, 1999-2020)

| <u>Plant</u> | <u>Standard Mortality Ratio</u> | | | <u>Excess Cancer Deaths</u> | | |
|-----------------|---------------------------------|----------------|----------------|-----------------------------|----------------|----------------|
| | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1979-20</u> |
| Nine Mile Point | 1.014 | 1.073 | 1.119 | 267 | 593 | 860 |
| Ginna | 0.977 | 1.036 | 1.059 | 206 | 370 | 576 |
| HB Robinson | 0.835 | 1.032 | 1.171 | 485 | 1206 | 1691 |
| Point Beach | 0.860 | 0.945 | 0.981 | 314 | 510 | 824 |
| Palisades | 0.923 | 1.021 | 1.110 | 287 | 699 | 986 |
| Monticello | 0.895 | 0.905 | 0.948 | 30 | 328 | 358 |
| Surry | 1.237 | 1.114 | 1.150 | - 37 | -35 | - 72 |
| Oconee | 0.928 | 0.959 | 1.009 | 75 | 314 | 319 |
| Prairie Island | 0.812 | 0.886 | 0.963 | 132 | 351 | 483 |
| Quad Cities | 0.970 | 1.029 | 1.037 | 422 | 510 | 932 |
| Arkansas Nucl. | 0.855 | 0.942 | 1.126 | 148 | 763 | 911 |
| Browns Ferry | 0.810 | 0.867 | 0.953 | 99 | 453 | 552 |
| Cooper | 0.880 | 0.921 | 1.003 | 18 | 49 | 67 |
| Brunswick | 0.813 | 0.997 | 0.971 | 421 | 1003 | 1424 |
| DC Cook | 1.018 | 1.019 | 1.076 | 71 | 488 | 559 |
| Hatch | 0.786 | 1.034 | 1.071 | 105 | 239 | 344 |
| Total 16 plants | 0.940 | 0.992 | 1.030 | 2566 | 5910 | 8476 |

Table 4
 Age-adjusted death rate, all causes combined
 Home counties of 16 oldest U.S. nuclear power plants
 Three time periods (1968-1978, 1979-1998, 1999-2020)

| <u>Plant</u> | <u>Total Deaths/100,000 (adjusted)</u> | | | <u>Number of Total Deaths</u> | | |
|-----------------|--|----------------|----------------|-------------------------------|----------------|----------------|
| | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> |
| Nine Mile Point | 1268.27 | 1014.23 | 834.46 | 10792 | 19538 | 23300 |
| GINNA | 1145.08 | 950.70 | 775.57 | 8045 | 14745 | 18337 |
| HB Robinson | 1332.50 | 1162.54 | 1044.74 | 5874 | 12546 | 17413 |
| Point Beach | 1074.35 | 860.45 | 736.82 | 8535 | 15890 | 18454 |
| Palisades | 1134.52 | 957.56 | 858.50 | 6551 | 12702 | 15936 |
| Monticello | 1008.75 | 890.77 | 691.50 | 5820 | 14095 | 25102 |
| Surry | 1434.34 | 1080.84 | 835.46 | 762 | 1313 | 1577 |
| Oconee | 1263.16 | 975.64 | 854.35 | 4367 | 10174 | 17522 |
| Prairie Island | 958.91 | 851.53 | 714.28 | 4116 | 8634 | 10264 |
| Quad Cities | 1152.46 | 960.37 | 797.19 | 16919 | 30561 | 33916 |
| Arkansas Nucl. | 1066.18 | 910.87 | 880.11 | 3150 | 7628 | 12308 |
| Browns Ferry | 1169.84 | 1007.03 | 860.58 | 4047 | 9004 | 15237 |
| Cooper | 993.09 | 855.27 | 789.80 | 1168 | 1959 | 1892 |
| Brunswick | 1122.96 | 946.72 | 758.88 | 2605 | 9406 | 24457 |
| DC Cook | 1205.12 | 977.92 | 833.14 | 17183 | 30976 | 36970 |
| Hatch | 1314.76 | 1074.43 | 1020.58 | 1520 | 2933 | 4335 |
| Total 16 plants | 1160.12 | 960.63 | 803.69 | 101454 | 202104 | 277020 |
| U.S. | 1163.27 | 947.75 | 775.31 | 3947589 | 9863123 | 12968466 |

Table 5
Standard mortality ratio, all cancers combined
Home counties of 16 oldest U.S. nuclear power plants
Three time periods (1968-1978, 1979-1998, 1999-2020)

| <u>Plant</u> | <u>Standard Mortality Ratio</u> | | | <u>Excess Total Deaths</u> | | |
|-----------------|---------------------------------|----------------|----------------|----------------------------|----------------|----------------|
| | <u>1968-78</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1979-98</u> | <u>1999-20</u> | <u>1979-20</u> |
| Nine Mile Point | 1.092 | 1.070 | 1.076 | -430 | -373 | - 803 |
| Ginna | 0.986 | 1.003 | 1.000 | 251 | 257 | 508 |
| HB Robinson | 1.147 | 1.227 | 1.348 | 1004 | 3500 | 4504 |
| Point Beach | 0.925 | 0.908 | 0.950 | -270 | 461 | 191 |
| Palisades | 0.977 | 1.010 | 1.108 | 419 | 2088 | 2507 |
| Monticello | 0.868 | 0.940 | 0.892 | 1018 | 602 | 1620 |
| Surry | 1.235 | 1.141 | 1.078 | -123 | -248 | - 371 |
| Oconee | 1.087 | 1.030 | 1.102 | -580 | 263 | - 317 |
| Prairie Island | 0.825 | 0.899 | 0.921 | 639 | 985 | 1624 |
| Quad Cities | 0.992 | 1.013 | 1.028 | 642 | 1221 | 1863 |
| Arkansas Nucl. | 0.918 | 0.961 | 1.135 | 328 | 2671 | 2999 |
| Browns Ferry | 1.007 | 1.063 | 1.110 | 504 | 1569 | 2073 |
| Cooper | 0.855 | 0.903 | 1.019 | 94 | 310 | 404 |
| Brunswick | 0.967 | 0.999 | 0.979 | 289 | 293 | 582 |
| DC Cook | 1.037 | 1.032 | 1.075 | -155 | 1405 | 1250 |
| Hatch | 1.132 | 1.134 | 1.316 | 6 | 798 | 804 |
| Total 16 plants | 0.997 | 1.014 | 1.037 | 3636 | 15802 | 19,438 |