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MORTALITY FROM CANCER OF THE UTERUS IN CANADA AND ITS RELATIONSHIP TO SCREENING FOR CANCER OF THE CERVIX

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SUMMARY

Age-standardized death rates at ages 30-64 from cancer of the uterus in the 10 provinces of Canada have been assessed in 1950-52, 1960-62 and 1970-72, and changes in rates over these periods related to screening for cancer of the cervix and variables derived from the censuses of 1961 and 1971. Death rates at the county and census division level have also been assessed for the provinces of Nova Scotia, Quebec, Ontario, Manitoba and Alberta for 1960-62 and 1970-72 and related to screening and census-derived variables. There is little indication of a contribution of screening to the fall in death rates that occurred in eight of the 10 provinces from 1950-52 to 1960-62. There is, however, evidence of an important and significant contribution of the intensity of screening (as indicated by the numbers of cervical cytology examinations conducted in 1966 expressed as a rate per 1,000 female population aged 20 or more) to the fall in death rates at both the provincial and county or census division levels from 1960-62 to 1970-72, and this effect is not abolished by taking the census-derived variables into account. It is concluded that a significant effect of intensity of screening on the reduction in mortality from cancer of the uterus in Canada in the age-group 30-64 over the period 1960-62 to 1970-72 has been demonstrated.

A number of attempts have already been made to evaluate trends in mortality from cancer of the uterine cervix in Canada, and to infer an association with screening for cancer of the cervix.

The British Columbia group (Fidler *et al.*, 1968, 1970) have argued that the fall in both incidence and mortality from cancer of the cervix in that province was due to the screening programme which began in 1949. However, others have been less certain of a cause and effect relationship as mortality appeared to be falling in other parts of Canada either in the absence of screening or where screening programmes began later and have so far reached a smaller proportion of the population. Thus, Ahluwalia and Doll (1968) compared the changes in mortality from cancer of the cervix and uterus between British Columbia, Ontario and the rest of Canada. They were unable to demonstrate a difference in the rate of fall attributable to screening. Kinlen and Doll (1973) updated this analysis and produced suggestive evidence of a greater decline in mortality in the age-group 45-64 in British Columbia compared with the rest of Canada. However, Sellers and McLerie (1973) concluded from an analysis comparing mortality from cancer of the cervix in British Columbia and Ontario that " there seems to be little evidence of the reduction in mortality which was anticipated by many observers ".

None of these studies, however, took sufficient note of screening for cancer of the cervix in parts of Canada other than British Columbia, even though, in some parts of Ontario and elsewhere in Canada, substantial screening has already been conducted (Kulcsar, 1966; Anderson *et al.*, 1969). In addition, none attempted to relate changes in mortality to other factors.

In this study, the Canadian mortality data are re-examined, updated to 1972 and related, at both the province and county or census division levels, not only to screening activity but also to various census-derived indices of socio-economic status that are known to be indirectly associated with cancer of the cervix.

MATERIAL AND METHODS

Mortality data

Copies of all death certificates are lodged with Statistics Canada (formerly the Dominion Bureau of Statistics). These are coded to the underlying cause of death and tabulations are published annually. These tabulations formed the basis of previous studies.

For the present study, all deaths coded to cancer of the uterine cervix, cancer of the body of the uterus and cancer of the uterus, unspecified as to site, were extracted for the years 1950-52, 1960-62 and 1970-72. Only deaths occurring in women aged 30-64 were utilized in the present analysis as this age range encompasses both the majority of deaths due to cancer of the cervix and the mode of the 5-year age-specific death curve, avoids the mode for cancer of the body of the uterus and the relatively greater imprecision in death certification at older ages, and

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includes the age range in which screening for cancer of the cervix could be expected to have the greatest effect on mortality for the condition.

The time periods 1950-52, 1960-62 and 1970-72 were chosen as these years encompass the time-span during which screening for cancer of the cervix was being introduced in Canada and straddle the years of the decennial censuses of Canada (1951, 1961 and 1971) which provide the denominator data to county and census division level by sex and 5-year age-groups.

Three-year mean age-standardized rates at ages 30-64 were then calculated for the three time periods to province and census division or county levels using the 1961 Canadian population as standard.

Screening data

The Canadian Association of Cytology has published two surveys on Cervical Cytology in Canada (Kulcsar, 1966; Anderson *et al.*, 1969). The surveys were conducted by requesting information from all laboratories within each province known to perform examinations of cervical smears: provincial, hospital and private. These data were collected through regional advisors of the Society and included information on numbers of examinations performed by each laboratory each year for the period 1962 to 1967. Through the collaboration of the Society these data were made available to one of us (A.B.M.) with the exception of the data for part of Quebec for 1965-7 which were no longer available. A special request was then sent to the laboratories in Quebec for the data which were no longer available, and simultaneously a request was directed to all laboratories for information on the area served by them. Copies of maps of the county or census division within which the laboratory was situated were supplied and Directors were requested to indicate on these maps the catchment areas of their laboratories. Where areas crossed county or census division boundaries (none crossed provincial boundaries) the numbers of the examinations were allocated to different areas as indicated by the laboratory and the female population of the areas in the 1966 census.

Data on screening could not be obtained at the census division level from British Columbia as one laboratory covered the whole province. For Saskatchewan, although relevant data were obtained on screening, the only mortality data available were coded to health district area and the boundaries of these areas did not coincide with the census divisions. For New Brunswick, Prince Edward Island and Newfoundland the areas served by the laboratories covered too many counties to permit reliable attribution of numbers of examinations to these areas. For Manitoba, however, examinations were related by the provincial cytology register to the census divisions on the basis of coding of addresses in the register to census division level.

The analysis of mortality at county or census division level was therefore restricted to the provinces of Alberta, Manitoba, Ontario, Quebec and Nova Scotia, comprising 147 counties or census divisions covering 80% of the female population of Canada at the 1971 census.

The numbers of examinations per year by county or census division were related to the female population aged 20 or more in the 1966 census to give a screening rate/1,000 for each area. This is to be regarded as an " index of screening activity ", and is not equivalent either to the number of women screened up to that year or to the number of women screened in that year. Further, the ratio of first examinations to repeat examinations changes during the years, the ratio falling in inverse relationship to the time the programme has been in operation.

Census data

From the large number of variables available in the 1961 and 1971 censuses, variables were chosen for incorporation in this study which provided, at province and census division or county levels, indices of sanitation, living conditions, family income, education, ethnic background, religion, marital status and parity. Where little change in the variable had occurred between the two censuses the 1961 variable only was used, and where change had occurred, the 1961 variable and the degree of change from 1961 to 1971 were both used.

Wherever possible the same variables were used at province and county or census division levels. For birth-rates, vital statistics data for 1962 instead of 1961 were used, so that Manitoba census divisions were the same as in the 1961 and 1971 censuses. Further information is available from the publications of the 1961 and 1971 censuses and, on request, from the authors.

RESULTS

Changes in mortality at the provincial level

Table I presents the death rates for cancer of the uterus (including cervix) and cancer of the cervix uteri only, while Table II presents the ratio between these rates, for the 3-year periods 1950-52, 1960-62 and 1970-72. It is apparent from Table II that not only are there differences between provinces in the proportion of deaths due to cancer of the uterus certified as due to cancer of the cervix, but that in many provinces this proportion changes over time. As a considerable proportion of this difference is likely to be due to changes in the proportion of

TABLE I

THREE-YEAR AVERAGE TRUNCATED STANDARDIZED MORTALITY RATES; AGES 30-64

Province	Death rates due to cancer of uterus			Death rates due to cancer of cervix uteri only		
	1951	1961	1971	1951	1961	1971
Newfoundland	18.9	21.4	20.3	13.1	19.1	16.8
Prince Edward Island	18.4	23.4	19.4	14.3	19.9	12.6
Nova Scotia	27.8	24.8	19.1	17.8	21.4	16.7
New Brunswick	27.8	22.8	19.3	19.1	18.3	15.7
Quebec	34.1	23.6	16.5	15.1	13.0	10.2
Ontario	26.2	17.9	12.8	19.3	13.7	9.7
Manitoba	19.3	15.0	11.7	12.8	9.6	8.0
Saskatchewan	15.7	13.9	9.4	11.2	7.8	6.4
Alberta	24.0	16.0	9.9	15.6	12.1	6.4
British Columbia	21.2	18.8	11.0	14.6	13.9	8.3

TABLE II

RATIO BETWEEN DEATH RATES DUE TO CANCER OF THE CERVIX UTERI ONLY, AND CANCER OF THE UTERUS (INCLUDING CERVIX)

Province	1950-52	1960-62	1970-72
Newfoundland	0.69	0.89	0.83
Prince Edward Island	0.78	0.85	0.65
Nova Scotia	0.64	0.86	0.87
New Brunswick	0.69	0.80	0.81
Quebec	0.44	0.55	0.62
Ontario	0.74	0.77	0.76
Manitoba	0.66	0.64	0.68
Saskatchewan	0.71	0.56	0.68
Alberta	0.65	0.76	0.65
British Columbia	0.69	0.74	0.75

deaths due to cancer of the cervix certified to uterus unspecified, and as a decrease in this proportion over time could mask true falls in the death rates from cancer of the cervix, in the remainder of this report death rates for total uterus (including cervix) will be used.

Considering deaths due to cancer of the uterus in Table I, it is apparent that over the period 1950-52 to 1970-72 there has been no fall in mortality in Newfoundland or Prince Edward Island, but falls have occurred in every other province. The lowest death rate for each time period was in Saskatchewan, the highest for 1950-52 in Quebec, the highest for 1960-62 in Nova Scotia and the highest for 1970-72 in Newfoundland. The largest absolute fall in mortality from 1950-52 to 1970-72 occurred in Quebec, followed in rank order by Alberta, Ontario, British Columbia, Nova Scotia, New Brunswick, Manitoba and Saskatchewan.

Table III presents in detail the changes in death rates for the period 1960-62 to 1970-72, calculated as 3-year moving averages. It is apparent that in Nova Scotia, Quebec, Ontario and Manitoba, most, if not all, of the fall in mortality occurred in the latter half of the decade, while in Saskatchewan, Alberta and British Columbia, the death rate was falling in both halves of the decade. It is also apparent that comparing mortality between 1960-62 with 1970-72 will not introduce any artefacts, except for Prince Edward Island where the "fall" over the decade only occurred between 1969-71 and 1970-72 and for Manitoba where the overall fall has possibly been minimized by a sudden rise from 1969-71 to 1970-72.

The numbers of cytology screenings expressed as the rate per 1,000 women aged 20 or more for the years 1962 to 1967 are set out in Table IV. Over this period the coverage of the population has been greatest in British Columbia, though in all provinces

TABLE III

DEATHS DUE TO CANCER OF UTERUS—3-YEAR MOVING AVERAGE TRUNCATED STANDARDIZED DEATH RATES—AGES 30-64

Province	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Newfoundland	21.4	18.8	22.9	22.2	22.9	20.2	20.4	19.5	22.0	22.7	20.3
Prince Edward Island	23.4	19.4	22.6	22.3	20.7	17.0	19.0	20.1	24.7	26.5	19.4
Nova Scotia	24.8	24.4	23.3	24.0	25.7	26.3	23.1	21.7	18.7	19.6	19.1
New Brunswick	22.8	25.2	22.6	19.8	18.7	19.2	19.3	18.4	19.3	19.0	19.3
Quebec	23.6	22.4	22.1	21.3	21.1	20.3	18.5	17.6	17.0	17.9	16.5
Ontario	17.9	17.6	17.3	17.4	17.1	16.8	15.5	14.3	14.1	13.2	12.8
Manitoba	15.0	16.2	16.7	16.6	15.7	14.4	12.2	9.6	9.2	9.5	11.7
Saskatchewan	13.9	12.9	11.9	11.1	10.6	10.5	10.0	10.4	10.6	10.3	9.4
Alberta	16.0	17.1	15.9	14.3	12.9	12.4	11.7	10.1	9.4	9.1	9.9
British Columbia	18.8	19.5	18.1	16.4	15.5	13.8	14.2	12.7	12.3	11.3	11.0

TABLE IV

CYTOLOGY SCREENINGS—RATE PER 1,000 WOMEN AGED 20 AND OVER

Province	1962	1963	1964	1965	1966	1967	Total	Mean
Newfoundland	5.6	1.5	5.5	41.1	98.3	143.4	295.4	49.2
Prince Edward Island	9.3	4.9	16.2	30.6	73.4	128.0	262.4	43.7
Nova Scotia	74.0	94.4	114.6	160.6	217.7	240.6	901.9	150.3
New Brunswick	16.7	13.9	22.8	33.5	79.2	129.8	295.9	49.3
Quebec	34.2	50.2	68.9	91.7	113.4	134.8	493.2	82.2
Ontario	32.6	50.8	74.4	124.5	171.1	219.9	673.3	112.2
Manitoba	66.5	128.5	168.0	205.5	255.7	329.6	1,153.8	192.3
Saskatchewan	6.5	9.0	38.2	123.4	182.6	238.9	598.6	99.8
Alberta	45.3	91.7	136.5	206.8	246.3	271.8	998.4	166.4
British Columbia	229.7	261.9	300.0	339.7	367.9	410.6	1,909.9	318.3

there has been a substantial increase in the proportion of the population examined, especially in Manitoba, Saskatchewan and Alberta and to a lesser extent in Nova Scotia and Ontario.

In Figure 1 the percentage fall in mortality over the period 1950-52 to 1960-62 is plotted, related to the screening rate in 1962, the earliest index available of screening in the preceding decade. It is apparent

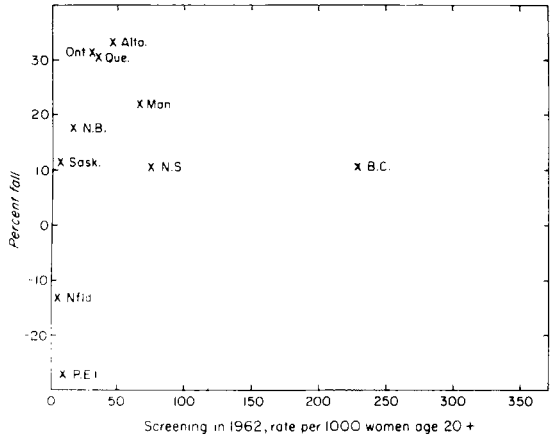

FIGURE 1

Fall in mortality from cancer of the uterus, 1950-52 to 1960-62, related to screening in 1962. Three-year average age-standardized rates, females aged 30-64.

that there is little association, if any. In Figure 2, however, the percentage fall in mortality over the period 1960-62 to 1970-72 is related to the screening rate in 1966. It is apparent that an association is present. For the remainder of this report the screening rate in 1966 will be the index of screening intensity used in the correlation and multivariate analyses, as the mid-point of the decade of interest.

In Table V the Pearson correlation coefficients for the census-derived variables with mortality in 1960-62 and 1970-72 are tabulated. In 1960-62 the mortality

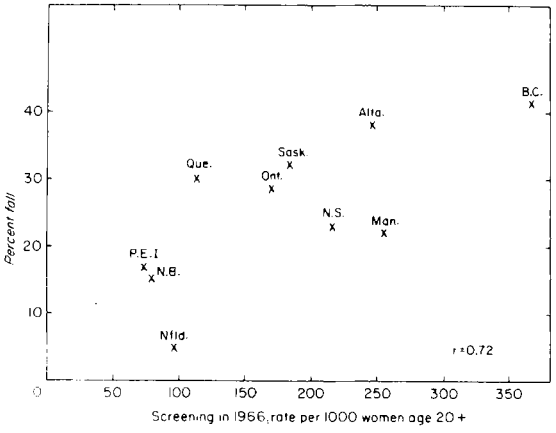

FIGURE 2

Fall in mortality from cancer of the uterus, 1960-62 to 1970-72, related to screening in 1966. Three-year average age-standardized rates, females aged 30-64.

at the provincial level was positively correlated with the 1961 population density, the percentage of Roman Catholic women, the number of children born per 1,000 women ever married and the percentage of women working in managerial and technical occupations, and was negatively correlated with the percentage of women aged 15 or more ever married, the percentage of women of other ethnic origin and the percentage of women of all other religions. In 1970-72 the mortality level was positively correlated with the 1961 population density, the number of children born in 1961 per 1,000 ever-married women, the percentage of women working in managerial and technical occupations in 1961 and the change in the percentage of women ever married from 1961 to 1971, and was negatively correlated with the 1961 average income of families, the percentage of women aged 15 or more ever married in 1961, the percentage of women aged 15 or more who attended grade 13 before 1961, the percentage of women of other ethnic

origin in 1961, and the 1956-61 female immigrants as a percentage of the female population. Some of the census-derived variables are intercorrelated; for example, the percentage of women of French origin in 1961 and the percentage of Roman Catholic women in 1961, while some are negatively correlated; for example, the percentage of women of other ethnic origin in 1961 and percentage of women of British or of French origin, and too many variables have been examined for conventional levels of statistical significance to be valid. Nevertheless, it is apparent that at both time periods some association between mortality from cancer of the uterus and indicators of socio-economic and marital status is present and has to be taken into account in determining the impact of screening on changes in mortality in between these two periods. It is, however, notable that the mortality level in 1970-72 is significantly negatively correlated with screening in 1966 ($r = -0.75$).

In Table VI Pearson correlation coefficients for the percentage decrease in mortality from 1960-62 to 1970-72 and the absolute decrease in mortality for the same time period at the provincial level with screening in 1966 and the census-derived variables are tabulated. The percentage decrease in mortality is positively correlated with screening in 1966, the percentage of dwellings in 1961 with exclusive use of flush toilets, the percentage of dwellings in 1961 with exclusive use of bath and shower, the average income families in 1961, the percentage of women aged 15 or more ever married in 1961, the percentage of women aged 15 or more who attended grade 13 before 1961, the percentage of women of other ethnic origin in 1961, the percentage of women of all other religions in 1961 and 1956-61 female immigrants as a percentage of the female population. It is negatively correlated with the percentage of women of British origin in 1961, the 1962 birth rate per 1,000 population, the percentage of women working in managerial and

TABLE V

CORRELATION OF MORTALITY AT THE PROVINCIAL LEVEL DURING 1960-62 AND 1970-72 WITH CENSUS-DERIVED VARIABLES

Census variable	Pearson Correlation 1960-62 mortality	Pearson Coefficient [1] 1970-72 mortality
1961 population density	0.65	0.60
1961 percentage of dwellings owned	−0.15	0.17
1961 percentage of dwellings in need of major repair	−0.08	0.04
1961 percentage of dwellings with running water	0.24	−0.11
1961 percentage of dwellings with exclusive use of flush toilets	0.16	−0.20
1961 percentage of dwellings with exclusive use of bath or shower	−0.08	−0.43
1961 average income of families	−0.54	−0.80
1961 percentage of women aged 15 or more ever married	−0.75	−0.78
1961 percentage of women aged 15 or more who had attended grade 13	−0.32	−0.63
1961 percentage of women of British origin	0.28	0.49
1961 percentage of women of French origin	0.50	0.32
1961 percentage of women of other ethnic origin	−0.92	−0.95
1961 percentage of Roman Catholic women	0.65	0.54
1961 percentage Jewish women	−0.26	−0.35
1961 percentage of women of all other religions	−0.63	−0.52
1956-61 female immigrants as percentage of female population	−0.45	−0.67
1961 children born per 1,000 women ever married	0.55	0.78
1962 birth-rate per 1,000 population	0.23	0.50
1961 percentage of women working in managerial and technical occupations	0.61	0.77
Change in population density, 1961 to 1971	—	0.28
Change in percentage of dwellings owned, 1961 to 1971	—	0.45
Change in percentage of dwellings with running water, 1961 to 1971	—	0.04
Change in percentage of dwellings with bath or shower, 1961 to 1971	—	0.45
Change in average family income, 1961 to 1971	—	−0.25
Change in percentage of women ever married, 1961 to 1971	—	0.75
Change in birth-rate, 1962 to 1971 (decrease)	—	0.09
Change in number of children born per 1,000 women ever married, 1961 to 1971	—	−0.49

[1] A coefficient of 0.55 or more is statistically significant ($p < 0.05$).

TABLE VI

CORRELATION OF CHANGES IN MORTALITY FROM 1960-62 TO 1970-72 AT THE PROVINCIAL LEVEL WITH SCREENING IN 1966 AND CENSUS-DERIVED VARIABLES

Variable	Pearson correlation coefficients [1]	
	Percentage decrease in mortality	Absolute decrease in mortality
Screening 1966	0.72	0.56
1961 population density	−0.32	−0.03
1961 percentage of dwellings owned	−0.49	−0.69
1961 percentage of dwellings in need of major repair	−0.14	−0.24
1961 percentage of dwellings with running water	0.48	0.72
1961 percentage of dwellings with exclusive use of flush toilets	0.55	0.76
1961 percentage of dwellings with exclusive use of bath or shower	0.71	0.80
1961 average income of families	0.83	0.68
1961 percentage of women aged 15 or more ever married	0.58	0.22
1961 percentage of women aged 15 or more who had attended grade 13	0.81	0.77
1961 percentage of women of British origin	−0.57	−0.54
1961 percentage of women of French origin	−0.02	0.29
1961 percentage of women of other ethnic origin	0.68	0.28
1961 percentage Roman Catholic women	−0.24	0.10
1961 percentage of Jewish women	0.25	0.25
1961 percentage of women of all other religions	0.68	0.28
1956-61 female immigrants as percentage of female population	0.70	0.58
1962 birth-rate per 1,000 population	−0.64	−0.64
1961 percentage of women working in managerial and technical occupations	−0.68	−0.50
Change in population density, 1961 to 1971	0.06	0.32
Change in percentage of dwellings owned, 1961 to 1971	−0.17	0.09
Change in percentage of dwellings with running water, 1961 to 1971	−0.42	−0.69
Change in percentage of dwellings with bath or shower, 1961 to 1971	−0.72	−0.80
Change in average family income, 1961 to 1971	0.50	0.61
Change in percentage of women ever married, 1961 to 1971	−0.57	−0.23
Change in birth-rate, 1962 to 1971 (decrease)	0.21	0.37
Change in number of children born per 1,000 women ever married, 1961 to 1971	0.23	−0.10

[1] A coefficient of 0.55 or more is statistically significant ($p<0.05$).

technical occupations in 1961, the change in the percentage of dwellings with exclusive use of bath or shower from 1961 to 1971 and the change in the percentage of women ever married from 1961 to 1971. The absolute decrease in mortality is positively correlated with screening in 1966, the percentage of dwellings with running water in 1961, the percentage of dwellings with exclusive use of flush toilets in 1961, the percentage of dwellings with exclusive use of bath or shower from 1961 to 1971, and the change in the percentage of women ever married from 1961 to 1971. The absolute decrease in mortality is positively correlated with screening in 1966, the percentage of dwellings with running water in 1961, the percentage of dwellings with exclusive use of flush toilets in 1961, the percentage of dwellings with exclusive use of bath or shower in 1961, the average income of families in 1961, the percentage of women aged 15 or more who attended grade 13 before 1961, 1956-61 female immigrants as a percentage of the female population and the change in average family income from 1961 to 1971. It is negatively correlated with the percentage of dwellings owned in 1961, the 1962 birth-rate per 1,000 population, the change in the percentage of dwellings with running water from 1961 to 1971 and the change in percentage of dwellings with exclusive use of bath or shower from 1961 to 1971.

Table VII presents partial correlation coefficients for screening 1966 with changes in mortality from 1960-62 to 1970-72 at the provincial level after controlling for the census-derived variables. Although a positive correlation of screening in 1966 with both measures of mortality was not abolished by this procedure, of the 26 variables controlled for, the correlation with screening was reduced below conventional levels of significance by nine variables considering the percentage decrease in mortality and by 17 considering the absolute decrease in mortality. The common variables were the percentage of dwellings with exclusive use of bath or shower in 1961, the average income of families in 1961, the

percentage of women aged 15 or more who attended grade 13 before 1961, the percentage of women of other ethnic origin in 1961, the percentage of women of all other religions in 1961, 1956-61 female immigrants as a percentage of the female population, the change in the percentage of dwellings with a bath or shower from 1961 to 1971 and the change in the percentage of women ever married from 1961 to 1971.

Multiple regression analyses (summarized in Table VIII), however, suggested that the effect of screening on the percentage fall in mortality from 1960-62 to 1970-72 was not abolished when the effects of the other variables were taken into consideration. However, the relatively small number of provinces (10) contributing to the dependent variable makes the validity of these analyses doubtful.

TABLE VII

CORRELATION OF SCREENING IN 1966 WITH CHANGES IN MORTALITY FROM 1960-62 TO 1970-72 AT THE PROVINCIAL LEVEL AFTER CONTROLLING FOR CENSUS-DERIVED VARIABLES

Variable controlled for	Partial correlation coefficients [1]	
	Percentage decrease in mortality	Absolute decrease in mortality
1961 population density	0.68	0.60
1961 percentage of dwellings owned	0.81	0.73
1961 percentage of dwellings in need of major repair	0.72	0.56
1961 percentage of dwellings with running water	0.67	0.47
1961 percentage of dwellings with exclusive use of flush toilets	0.67	0.47
1961 percentage of dwellings with exclusive use of bath or shower	0.56	0.24
1961 average income of families	0.46	0.23
1961 percentage of women aged 15 or more ever married	0.53	0.61
1961 percentage of women aged 15 or more who had attended grade 13	0.47	0.16
1961 percentage of women of British origin	0.79	0.57
1961 percentage of women of French origin	0.80	0.80
1961 percentage of women of other ethnic origin	0.46	0.53
1961 percentage of Roman Catholic women	0.76	0.83
1961 percentage of Jewish women	0.71	0.54
1961 percentage of women of all other religions	0.46	0.53
1956-61 female immigrants as percentage of female population	0.51	0.31
1962 birth-rate per 1,000 population	0.61	0.36
1961 percentage of women working in managerial and technical occupations	0.59	0.40
Change in population density, 1961 to 1971	0.73	0.63
Change in percentage of dwellings owned, 1961 to 1971	0.76	0.74
Change in percentage of dwellings with running water, 1961 to 1971	0.68	0.48
Change in percentage of dwellings with bath or shower, 1961 to 1971	0.55	0.21
Change in average family income, 1961 to 1971	0.64	0.40
Change in percentage of women ever married, 1961 to 1971	0.56	0.55
Change in birth-rate, 1962 to 1971 (decrease)	0.83	0.74
Change in number of children born per 1,000 women ever married, 1961 to 1971	0.72	0.69

[1] A coefficient of 0.58 or more is statistically significant ($p < 0.05$).

Changes in mortality at the census division or county level

The percentage fall in mortality from 1960-62 to 1970-72 in the form of weighted averages of the 147 census division or county mortality rates across the five provinces with such data available is presented in Table IX (the complete data on which this Table is based are available from the authors on request). The trend is statistically significant ($p < 0.05$). Pearson correlation coefficients for both mortality levels in 1960-62 and 1970-72 and the two indices of change in mortality over this period for the 147 counties or census divisions are presented in Table X. Considering first the mortality levels, in 1960-62 mortality was negatively correlated with the percentage of dwellings owned in 1961 and the percentage of women of other ethnic origin in 1961. In 1970-72, the mortality level was negatively correlated with screening in 1966, the average income of families in 1961, the percentage of women aged 15 and more who attended grade 13 before 1961 and the percentage of women of other ethnic origin in 1961.

Considering now the indices of change of mortality, percentage change from 1960-62 to 1970-72 was positively correlated with screening in 1966, the average income of families in 1961 and the percentage of women aged 15 or more who attended grade 13 before 1961. Absolute decrease in mortality from 1960-62 to 1970-72 was also positively correlated with

screening in 1966 together with the percentage of women aged 15 or more who attended grade 13 before 1961.

Other analyses were conducted (results not presented here), investigating the effect of screening in 1966 on the measures of change in mortality from 1960-62 to 1970-72 while controlling for other census variables. An association of screening with fall in mortality was still seen when controlling for variables correlated with fall in mortality.

The results of the multiple regression analysis (summarized in Table XI) confirm a significant effect of screening on the dependent variables level of mortality in 1970-72 and percentage change in mortality from 1960-62 to 1970-72 while taking account of the census-derived variables most directly correlated with mortality levels and changes in mortality.

TABLE VIII

SUMMARY OF STEPWISE MULTIPLE REGRESSION ANALYSIS OF SCREENING 1966 AND CENSUS-DERIVED VARIABLES ON THE PERCENTAGE FALL IN MORTALITY, 1960-62 TO 1970-72 AT THE PROVINCIAL LEVEL

Variables in the equation at the final step	B [1]	Standard error of B	F [2]
(A) 1961 Census variables			
Screen,1966	0.14	0.03	16.91
Income, 1961	0.01	0.00	2.19
Percentage Jewish, 1961	−20.11	3.46	33.83
Immigration, 1961	8.23	3.93	4.39
Bath or shower, 1961	−0.16	0.13	1.46
Occupation, 1961	−4.16	1.07	15.07
Percentage Roman Catholic, 1961	0.78	0.21	13.67
Education, 1961	−4.86	1.64	8.77
Constant	75.37		
Overall F value (8,1 df) 59.68			
(B) Change in Census variables 1961-71			
Screen, 1966	0.18	0.03	45.65
Decrease in birth-rate, 1962-1971	−7.04	2.05	11.78
Change percentage ever married	−22.00	3.52	39.17
Change percentage dwellings owned	6.00	1.02	34.94
Change in children born	−0.26	0.04	33.25
Change in population density	6.25	1.22	26.32
Change in running water	4.40	1.15	14.64
Change in income	0.04	0.01	9.89
Constant	−225.96		
Overall F value (8,1 df) 46.94			

[1] Regression coefficient. — [2] No individual F value is statistically significant.

TABLE IX

FALL IN MORTALITY FROM CANCER OF THE UTERUS, 1960-72, RELATED TO SCREENING IN 1966. THREE-YEAR AVERAGE AGE-STANDARDIZED RATES, FEMALES AGED 30-64. COUNTIES AND CENSUS DIVISIONS, PROVINCES OF NOVA SCOTIA, QUEBEC, ONTARIO, MANITOBA AND ALBERTA

Screening in 1966. Rate per 1,000 women aged 20 or more	Percentage fall in mortality, 1960-62 — 1970-72
Less than 24	−27.5
24-49	−23.6
50-99	16.8
100-249	23.8
250 or more	38.7

DISCUSSION

The results presented in this paper not only confirm a positive association of screening in 1966 with changes in mortality from cancer of the uterus from 1960-62 to 1970-72 (Miller, 1975) but also show that this relationship is not abolished when taking account of a number of census-derived variables selected for their relevance to the known features of the epidemiology of cervical cancer (Miller, 1976). The consistency of the association at both the provincial and the county and census division levels, even though British Columbia data could not contribute to the latter analyses, also confirms its validity. It is important to note, however, that screening only accounts for a small proportion of the variance in mortality at the county or census division level and it is therefore necessary to consider carefully the imprecision of the present findings, and whether the effect of screening on mortality could be more satisfactorily accounted for by other variables not taken into account in the analyses. The major factors which could be expected to influence mortality from cancer of the uterus are changes in the population in the incidence of cancer of the cervix or of the uterine corpus, changes in the effect of therapy on mortality from either condition and the introduction and effect of screening programmes for cancer of the cervix.

In the absence of long-term incidence data, mortality data have been assessed in a number of countries and in some not only have falls in death rates been noted, not apparently explicable by screening (Hill, 1975), but also cohort effects that might be expected to exert a disturbing effect when analysing long-term mortality trends (Hill and Adelstein, 1967, Adelstein *et al.*, 1971). These trends have been interpreted as indicating changes in incidence levels, presumably due to to the operation to differing extents of aetiologically relevant factors. Long-term incidence data, where available, especially from cancer registries, have to be regarded with caution, as changing diagnostic practices and the introduction of screening programmes can have

dramatic effects. Nevertheless, data from both the Saskatchewan and Alberta cancer registries suggest that the incidence of cancer of the cervix was falling in these two Canadian provinces before screening programmes were introduced.

Although the census-derived variables used in this analysis are rather poor indicators of relevant epidemiological variables for cancer of the cervix, the association of some of them with mortality levels in 1960-62 appears to confirm that socioeconomic factors account for some of the differences in mortality for cancer of the uterus between Canadian provinces and counties and census divisions within some provinces. This indeed was to be expected in a country the size of Canada with the differing social and ethnic mixing of its population. However, the failure of these factors to abolish the effect of screening suggests that, even had it been possible to include more directly relevant variables in the analysis, a screening effect would still have been noted.

The question still remains, however, whether the effect noted can have been confounded by a fall in the incidence (and consequent mortality) of cancer of the corpus uteri. The age group chosen for this analysis partly eliminates this but, in addition, data from the Saskatchewan cancer registry show that the incidence of cancer of the corpus has been increasing in that province in the relevant age group from 1946 to 1970. An increase in mortality from cancer of the corpus has been noted elsewhere in spite of an apparently effective screening programme for cancer of the cervix (Christopherson *et al.*, 1971). Considering an effect of improvements in treatment in reducing mortality from cancer of the cervix (or corpus) it is apparent that, although many centres have been able to report an overall improvement in end results (Kottmeier, 1973), this has been almost entirely reflected in a change in stage distribution, the fatality within stages having remained stable. This trend has been attributed therefore to improvements n early diagnosis rather than in therapeutic

TABLE X

CORRELATION OF MORTALITY AT THE COUNTY OR CENSUS DIVISION LEVEL WITH SCREENING 1966 AND CENSUS-DERIVED VARIABLES

Variable	Pearson correlation coefficients [1]			
	Mortality		Change 1960-62 to 1970-72	
	1960-62	1970-72	Percentage	Absolute
Screening 1966	—	−0.26	0.17	0.15
1961 population density	0.05	−0.00	0.05	0.04
1961 percentage of dwellings owned	−0.18	−0.04	−0.05	−0.10
1961 percentage of dwellings in need of major repair	0.03	0.01	−0.09	0.02
1961 percentage of dwellings with running water	0.11	0.07	0.11	0.04
1961 percentage of dwellings with exclusive use of flush toilets	0.11	0.03	0.12	0.06
1961 percentage of dwellings with exclusive use of bath or shower	0.12	0.02	0.11	0.08
1961 average income of families	0.03	−0.15	0.15	0.11
1961 percentage of women age 15 or more ever married	−0.07	−0.01	−0.08	−0.05
1961 percentage of women age 15 or more who had attended grade 13	0.08	−0.15	0.21	0.14
1961 percentage of women of British origin	0.00	0.04	−0.04	−0.03
1961 percentage of women of French origin	0.08	0.07	0.03	0.02
1961 percentage of women of other ethnic origin	−0.16	−0.19	−0.01	−0.01
1961 percentage Roman Catholic women	0.11	0.06	0.06	0.05
1961 percentage of Jewish women	−0.00	−0.06	0.06	0.03
1961 percentage of women of all other religions	−0.11	−0.06	−0.06	−0.05
1956 -61 female immigrants as percentage of female population	−0.00	−0.11	0.10	0.06
1962 birth-rate per 1,000 population	−0.04	0.04	−0.06	−0.06
1961 percentage of women working in managerial or technical occupations	0.13	0.13	0.01	0.02
Change in population density, 1961 to 1971	—	−0.01	0.07	0.07
Change in percentage of dwellings owned, 1961 to 1971	—	0.12	0.01	0.04
Change in percentage of dwellings with running water 1961 to 1971	—	−0.11	−0.08	−0.02
Change in percentage of dwellings with bath or shower, 1961 to 1971	—	−0.02	−0.11	−0.08
Change in average family income, 1961 to 1971	—	0.01	0.10	0.10
Change in percentage of women ever married, 1961 to 1971	—	−0.02	0.06	0.04
Change in birth-rate, 1962 to 1971 (decrease)	—	−0.01	−0.03	−0.10

[1] A coefficient of 0.14 or more is statistically significant (p 0.05).

results (Palmer *et al.*, 1973). Further, the overall effect has been relatively minimal, and it seems extremely unlikely, even if this had been incorporated in the present analysis, that it could be responsible for much of the unaccounted variance, or have an effect on abolishing the contribution of screening.

TABLE XI

SUMMARY OF STEPWISE MULTIPLE REGRESSION ANALYSIS OF SCREENING 1966, AND CENSUS-DERIVED VARIABLES ON THE LEVEL OF MORTALITY 1970-72 (A) AND THE PERCENTAGE FALL IN MORTALITY, 1960-62 TO 1970-72 (B) AT THE COUNTY OR CENSUS DIVISION LEVEL

Variables in the equation at the final step	B [1]	Standard error of B	F [2]
(A) Dependent variable: level of mortality 1970-72			
Screen, 1966	−0.02	0.01	6.75
Change percentage dwellings owned	0.30	0.21	2.02
Change percentage ever married	−0.79	0.54	2.14
Change in running water	−0.21	0.13	2.60
Change in bath or shower	0.13	0.08	2.57
Decrease in birth-rate, 1962-1971	−0.22	0.25	0.75
Change in income	0.00	0.00	0.29
Change in population density	0.00	0.01	0.05
Constant	13.74		
Overall F value (8,138 df) 2.01			
(B) Dependent variable: percentage change in mortality, 1960-62 to 1970-72			
Screen, 1966	0.22	0.10	5.15
Education, 1961	9.24	4.40	4.42
Percentage ever married, 1961	−0.60	2.88	0.04
Income, 1961	−0.02	0.02	0.81
Percentage Roman Catholic, 1961	0.20	0.72	0.08
Percentage British, 1961	−0.20	0.58	0.12
Percentage dwellings with flush toilet, 1961	0.19	0.69	0.07
Constant	11.69		
Overall F value (7,139 df) 2.13			
Screen, 1966	0.21	0.09	5.66
Change in running water	−0.60	1.45	0.17
Change percentage ever married	7.43	5.83	1.62
Change in bath or shower	−0.30	0.87	0.12
Decrease in birth-rate, 1962-1971	−1.09	2.70	0.16
Change in population density	0.03	0.07	0.15
Change percentage dwellings owned	0.76	2.28	0.11
Change in income	0.00	0.02	0.04
Constant	5.81		
Overall F value (8,138 df) 1.16			

[1] Regression coefficient. — [2] An individual F of 3.92 or more is statistically significant ($p<0.05$).

Nevertheless, changes in early diagnosis can be anticipated in any screening programme, and therefore it can be debated whether the effect here demonstrated can be attributed to the removal of pre-malignant lesions (carcinoma *in situ* or dysplasia), the removal and " early " treatment of malignant lesions (micro or occult invasive carcinoma) or other factors associated with a screening programme, but not an integral part of it *(e.g.* improvements in general diagnostic awareness for cancer of the cervix). If the effect of screening now demonstrated is due largely to the detection and removal of occult invasive conditions, the long-term effect (the removal of pre-malignant lesions) is yet to be seen, at least in most provinces. This underlines the importance of concentrating attention on women at high risk in the population, especially those not yet screened, and leads to the anticipation of a dramatic further reduction in mortality from cancer of the cervix in the decades to come if programmes are properly directed. Thus, screening could well be responsible for the prevention of an epidemic of invasive disease which might otherwise be anticipated from changes in sexual habits in the last decade.

It is admitted that the indices both of screening and of mortality used in this analysis are less than optimal, but it does not seem likely that their imprecision has resulted in an artefactual effect of screening on mortality; rather the reverse might have been anticipated.

It is thus concluded that a significant effect of intensity of screening on reduction of mortality from cancer of the uterus in Canada in the age-group 30-64 over the period 1960-62 to 1970-72 has been demonstrated, and that this effect is unlikely to be due to other factors, even if all relevant factors could be taken into account.

It is relevant that Cramer (1974), analysing data from the United States, has also demonstrated a relationship between intensity of screening and declining mortality from cervical cancer.

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LA MORTALITÉ PAR CANCER UTÉRIN AU CANADA ET L'INFLUENCE DU DÉPISTAGE DU CANCER CERVICAL

Les taux de mortalité par cancer utérin, standardisés par âge pour le groupe de 30 à 64 ans dans les dix provinces du Canada, ont été évalués en 1950-52, 1960-62 et 1970-72, et les changements observés pendant ces périodes ont été comparés avec le dépistage du cancer cervical et avec les variables dérivées des recensements de 1961 et 1971. Les taux de mortalité aux niveaux du comté et du district du recensement ont aussi été évalués pour les provinces de Nouvelle-Ecosse, Québec, Ontario, Manitoba et Alberta en 1960-62 et 1970-72, et ils ont été comparés avec les variables dérivées du dépistage et du recensement. Il y a peu d'indices d'une contribution du dépistage à la baisse des taux de mortalité constatée dans huit des dix provinces de 1950-52 à 1960-62. On a toutefois obtenu la preuve d'une contribution importante et significative de l'intensité du dépistage (indiquée par le nombre d'examens de cytologie cervicale effectués en 1966 pour 1000 femmes âgées de 20 ans ou plus) à la baisse des taux de mortalité aux niveaux de la province et du comté ou au niveau du district du recensement de 1960-62 à 1970-72, et cet effet subsiste si l'on tient compte des variables dérivées des recensements. Les auteurs en concluent qu'un effet significatif de l'intensité du dépistage sur la réduction de la mortalité par cancer utérin au Canada dans le groupe d'âge 30-64 pendant la période 1960-62 à 1970-72 a ainsi été démontré.

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