• ORIGINAL STUDIES •

Productivity Loss in Puerto Rico's Labor Market due to Cancer Mortality

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Background: In Puerto Rico (PR), cancer is the second leading cause of death and the disease that causes most premature deaths, representing about 15% of them. Thus, premature death due to cancer decreases the productivity capacity in PR.

Objective: This study aimed to estimate the labor-market productivity loss in PR during 2004 as a result of premature mortality due to overall cancer and cause-specific cancers.

Methods: A model based in the incidence-based approach and in the human capital approach was developed to estimate the labor-market productivity loss. Economic data were obtained from the Public Use Microdata Sample (PUMS) of the PR Community Survey (PRCS). Mortality data were obtained from the Vital Statistics of the PR Department of Health.

Results: The productivity costs of all cancer deaths were estimated to be approximately $64 million (in constant value). The cancer deaths that contributed the most to productivity loss were lung and bronchus, colorectal, breast, and liver and intrahepatic bile duct.

Conclusions: Although these results must be interpreted with caution, this study contributes to show a broader picture that includes the economic dimension of cancer in our society. These estimates imply that productivity cost due to cancer mortality have a great burden in PR. The leading cancer sites that generate most productivity losses are highly preventable or can be diagnosed early or are related to tobacco consumption. This study should be considered within the framework of future cost analyses for the development of health and cancer control policies. [*P R Health Sci J 2010;3:241-249*]

Key words: Cancer mortality, Productivity loss, Human capital approach, Burden of cancer

Cancer is a leading cause of death worldwide, accounting for 7.4 million deaths (around 13% of all deaths) in 2004 (1). In Puerto Rico (PR), cancer is the second leading cause of death and the disease that causes most premature deaths, representing about 15% of them (2). Besides being a clinical problem, disease and death comprehend other social issues, including economic aspects that cause a significant burden to society. Therefore, premature death due to cancer represents an impairment of labor, a valuable economic resource, that prevents a person from contributing productively to society in the future, decreasing its productivity capacity.

Economic theory provides different methods to assess the economic impact of a health condition, as is cancer. The Cost of Illness (COI), developed by Rice (3-6), is the most widely accepted conceptual framework for cost estimates. COI estimates involve three components: direct costs, morbidity costs and mortality costs. Within this framework, several studies

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with different approaches have been conducted to determine the economic burden of different diseases (7-17). These studies have concluded that the component with the greatest impact lies in the productivity cost, even more than the costs for medical treatment of patients. For example, the National Institutes of Health(18) estimated the cost of illness for different causes of death in United States (US) for 2007. This study estimated the overall cost of cancer at $219.2 billion, of which, $89 billion correspond to direct costs of health expenditure, $18.2 billion in morbidity costs and $112.0 billion in mortality costs (representing more than 52% of total costs). Others studies of the economic burden of cancer in California (14-15) have concluded that the premature mortality cost of breast cancer is 80% of the total costs of the disease. Also, mortality costs of gynecological cancers like ovarian and cervical cancer represent more than 65% of total cost of these cancers. This pattern has also been observed in the state of Texas and in Sweden, Canada, and Spain (10-11, 17, 19-20). Other studies (20-25) have focused on estimating the productivity cost due to cancer mortality. Although these studies show some discrepancies in their methodology, data sources, and the inclusion of indirect costs components, such variations are not necessarily a weakness. Different arenas of application require different approaches and schemes (e.g., economic burden estimates vs. cost-effectiveness analysis) (4-5, 26).

From a societal perspective, estimates of the value of labor productivity loss due to premature mortality are important in determining the economic burden of disease. Previous studies in PR have used the COI approach to estimate the cost of AIDS, schizophrenia and traffic accidents (7, 27-28). For example, cumulative total cost of AIDS in PR from period of 1982-1989 was estimated to be $ 525.2 million (27). Despite the importance of evaluating the economic impact of cancer in PR, there are no previous studies that have used the COI approach to investigate this issue. In fact, this economic component has been overlooked in cancer investigations in PR. Although the value of a person's life transcends its economic value as a productive unit, cost studies present another dimension of a health problem, providing valuable information for society and for policymakers to decide how to allocate scarce resources more optimally (27). Consequently, the aim of this study is to estimate the labor-market productivity loss in PR, as a result of premature mortality, due to overall cancer and by cause-specific cancers in 2004.

Methods

Model

COI studies may consider different timeframes for cost estimation. Two recognized models for establishing a time frame have been used in COI studies: the prevalence-based model and the incidence-based model (5, 29-30). The prevalence-based model quantifies economic costs to society incurred during a period of time (usually a year) as a result of the prevalence of disease. The prevalence approach is functional for measuring the effectiveness of cost control and how well health care expenditure targets are met. This approach measures the value of resources lost during a specified period, irrespective of the time of disease onset. The incidence-based model estimates the lifetime costs of an illness, based on all cases with onset of disease in a given base year. The approach adopted depends on the purpose of the analysis (5, 29). Our study estimated the labor productivity loss due to cancer using an incidence-based approach (the lifetime loss of productivity of those who died of cancer in 2004) instead of a prevalence-based approach (the loss of productivity in 2004 of those who died of cancer in 2004 or in previous years and who otherwise would have been alive in 2004) (22). We selected this model because the incidence approach is better suited for decision making about treatment or research strategies as it more realistically reflects the impact of reduced incidence or improved outcomes in the context of future costs (5).

We also based our study on the human capital approach, that is founded on the assertion that social welfare is reduced by disease, disability, and premature death (4, 6, 31-32). The 'human capital approach' focuses in measuring and valuating production that is lost due to morbidity and mortality in a period. This period is equal to the numbers of years of potential economic contribution of a person to society (27, 31, 33). A person would have continued to be productive for a number of years if he or she had not died prematurely from cancer (13-15). This approach does not measure the value of a life, but instead, it measures only the value of labor, using earnings or imputed earnings as a proxy measure (21). Economists at the Centers for Disease Control and Prevention (CDC) use the human capital approach to value the morbidity and mortality outcomes in cost-benefits analysis (31, 34).

In various studies, productivity is calculated as the present value of the sum of earnings and the imputed value of household production over the lifetime, adjusted for survival, discounting and expected growth (10, 12-17). In the present study, we estimated the value of lost earnings that would have been accrued through the labor market and did not include the non-paid care giving and housekeeping activities like other studies have done. Without reducing importance of all the above items, we focused on those components for which we have enough valid data to report reliable estimates. This will lead us to consider only productivity in the labor market. Our model also considered the earning and employment changes over the life cycle, by summing the expected earnings in each year of forgone life over a given life expectancy, accounting for changes in the probability of employment and earning that occur from age group to age group, for each sex (21). The component of earning consisted of money paid directly to individuals in the form of wage, salary income, and self-employment earnings (34-35).

Following a similar nomenclature of another report (10), we used the following formula (Formula 1) to estimate the present

value of lifetime earnings (PVLE), that potentially was lost due to premature mortality from cancer.

Formula 1

$$PVLE = \sum_{n=a}^{65} \left(Y_{ns} W_{ns} P_{as}^{n} \right) \frac{(1+g)^{na}}{(1+i+\alpha)^{na}}$$

Where

a = midyear age for the given cohort of persons
s = sex
n = age
Y_{ns} = annual average earnings for all persons of a given sex with earnings in an age group where the midpoint age is n
W_{ns} = average employment ratio of a given sex in the age group where the midpoint age is n
P^{n}_{as} = the approximate probability that an individual of age a and sex s survives to age n
g = annual rate of growth of labor productivity
i = discount rate
α = inflation rate

The potential productivity years of life lost (PPYLL) were estimated according to the total premature cancer deaths and by cause-specific cancer. The first component of the formula is the sum of the estimated value of earning for persons in the labor force ($Y_{ns} W_{ns} P_{nas}$) that takes into account the annual average earning, labor employment ratio and the probability of survival for each age group and sex. That estimate was adjusted for changes in labor productivity (g) and discounted (i) to convert the lifetime earning into a present value. Changes in labor productivity adjustment (g) serve to consider the fact that changes in productivity, which is a function of the availability of capital and technology, lead to real earnings growth (e.g., through new technological developments). The discounted rate adjustment is used to express the value of the future costs in present value. Finally, to express the productivity loss in constant prices we deflated average earnings using the average of the last five years of deflator of Gross Product of PR (36). This procedure is necessary to adjust for the effect of inflation (α). Inflation is an increase in the general level of prices of goods and services in an economy over a period usually as measured by the Consumer Price Index (CPI). Nevertheless, in PR the use and the validity of this indicator as a measure of inflation has been questioned (37). Therefore, we decided to use the deflator of the Gross Product of PR. Gross Product deflator is a measure of the price of all the goods and services included in the Gross National Product (GNP).

Assumptions

Important assumptions and parameters were used for this model. First, we assumed that no earnings are earned between the ages of 0 to 15, as the legal age to be hired for employment in PR is 16 years. Also, the age of legal retirement in PR, 65 years of age, was considered as the age limit to stay in the labor market. Nevertheless, even though 92% of people 65 years of age and older opt for retirement, the remaining 8% represent less than 0.5% of the workforce in the labor market in PR (38). Additionally, earning capacity included both wage earnings and employer provided fringe benefits (35). To include total earnings, we imputed the recommended 22.4% of earning compensation attributed to fringe benefits (20-21). These benefits include vacation pay, health insurance, and retirement benefits.

We used the annual rate of productivity growth at 1.8%, as estimated in PR in a previous study (7). In the basic model, we applied a discount rate of 3% to employment earning to reflect the present value of future productivity. This rate is the most commonly used in this type of study. In fact, CDC currently recommends that a 3% social discount rate should be used in analyses that require adjusting future costs and benefits of public health interventions, programs, and policies (31, 39). The discount rate is a financial measure that is used to determine the present value of future payments. The lower the discount rate, the higher the present value of future income. A discount rate of 0% indicates no distinction between present and future costs and benefits. Sensitivity analysis is recommended anytime there is uncertainty (30, 39). Following previously published studies (10, 14, 21-22, 40), we compared with the base scenario how the results changed when we applied different discount rates. In the sensitivity analysis, the discounted rate varied from 0% to 10%.

Data Sources

Mortality data were obtained for the most recent year of data publication (2004) provided by the PR Department of Health, through the Auxiliary Secretariat for Planning and Division Analysis (41). Cancer deaths were defined as all deaths of persons aged 0-65 years, for which the primary cause of death was cancer. SEER cause of death recode was used to classify the cancer deaths by means of the SEER*Stat 6.5.2 software (42). To calculate the life expectancy tables for PR for the year 2004, we used mortality data from Vital Statistics and population estimated data from the PR Planning Board. Life expectancy was calculated by sex; these estimations were calculated with the use of EpiDat 3.1 software (43). As in other studies, in the absence of sufficient data for further modeling, persons dying of cancer were assumed to otherwise have comparable life expectancies of general population (23, 43). Also, the employment ratio and the average earning by sex for the year 2005 were estimated using the Public Use Microdata Sample (PUMS) of Census Bureau's PR Community Survey (PRCS) (35). This survey collects information about population and housing characteristics for the nation, states, cities, counties, metropolitan areas, and communities on a continuous basis. The collection for the PRCS began in January 2005, with an annual sample size of approximately 36,000 addresses. For that reason we decided to use the 2005 file, instead of that for 2004.

Results

Employment and earnings estimated, by sex and age groups, for the population of PR are presented in Table 1. In all age

groups, earnings and employment ratios were higher for males than for females. For both sexes, employment ratios and earnings were smallest in the youngest age groups. These earnings and employment ratios increased substantially in later ages and dropped again before the usual age of retirement at 65 years of age.

Table 1. Estimated Employment and Earning Data in Puerto Rico in 2005

Sex and Age Group	Average Earnings ($)	Fringe Benefits ($)	Total Earning ($)	Employment Ratio
Male				
16-19	3,905	875	4,780	0.14
20-24	9,300	2,083	11,383	0.52
25-29	16,852	3,775	20,627	0.69
30-34	23,920	5,358	29,278	0.76
35-39	25,471	5,706	31,176	0.73
40-44	27,709	6,207	33,916	0.70
45-49	27,428	6,144	33,572	0.63
50-54	29,657	6,643	36,301	0.60
55-59	27,057	6,061	33,118	0.49
60-64	24,711	5,535	30,246	0.32
Female				
16-19	3,680	824	4,504	0.08
20-24	8,685	1,945	10,630	0.36
25-29	15,453	3,462	18,915	0.52
30-34	20,333	4,555	24,887	0.57
35-39	20,863	4,673	25,537	0.56
40-44	22,274	4,989	27,263	0.51
45-49	25,109	5,624	30,734	0.48
50-54	24,018	5,380	29,398	0.40
55-59	22,244	4,983	27,227	0.26
60-64	18,335	4,107	22,442	0.15

Source of data: U.S. Census Bureau, 2005 Puerto Rico Community Survey PUMS

The number of pre-retirement deaths from all causes of death and attributed to cancer, the PPYLL and the estimates of the PVLE for the year 2004 are shown in Table 2. In total, 8,953 persons died before the age of 65 in PR in 2004, of which 1,515 persons died due to cancer. Premature cancer deaths represent nearly 31% of the total cancer deaths. These cancer deaths accounted for loss of 17,475 PPYLL due to premature cancer mortality. Breast cancer had the largest relative contribution in terms of premature death and PPYLL, followed by colorectal cancer and lung and bronchus. The estimated PVLE from all malignant cancer in 2004 was approximately $64.2 million (in constant value), assuming a discount rate of 3%. This corresponds to 13.8% of total productivity cost in the labor market ($464 million) in PR (Table 2). Lung cancer premature deaths accounted for 11.8% ($7.6 million) of the total PVLE. The other most costly cancers were colorectal cancer ($7.5 million) and breast cancer ($6.6 million), which accounted for 11.7% and 10.3%, respectively, of the total PVLE loss. These three types of cancer represented more than a third (33.6%) of the total PVLE costs. By contrast, prostate cancer (the type of cancer that causes more deaths in males) accounted for only 2.6% of the total cost. When we analyzed the losses related to hematopoietic cancers and myeloma, and consider them as a total, these losses nearly reached the total costs of breast cancer.

More than 30% of the labor productivity loss was caused by the types of cancer directly related to tobacco use (lung and bronchus, oral cavity and pharynx, esophagus, pancreas, stomach and larynx). As well, the most costly cancers per death were testis cancer ($71,347.93), followed by kidney and renal pelvis cancer ($69,110.16), mesothelioma ($67,438.08), myeloma ($50,929.26) and oral cavity and pharynx ($59,194.52). Although there were few cancer deaths from these types of cancer, as compared to other cancer types, the largest proportion of deaths occurred in younger age groups.

Figure 1 shows the PVLE, by sex, for the major cancer types. The productivity loss due to all types of cancer combined was two times higher for men than for women ($21.6 vs. 42.7 million). Moreover, colorectal cancer, the second type of cancer that causes more PVLE for both men and women, in fact produces more than twice the PVLE in men as compared to women. We also found that the types of cancer that cause more PVLE differ by sex (Figure 1). For males, the most expensive cancers in terms of lost productivity are lung and bronchus ($6.2 million), colorectal ($5.3 million), liver and intrahepatic bile duct ($4.7 million) and oral cavity and pharynx ($3.4 million). For females, breast cancer is the most costly cancer ($6.4 million); almost three times more expensive than the second one (colorectal cancer, $2.2 million). The next most costly cancers for women were lung and bronchus ($1.4 million), followed by ovarian ($1.2 million) and non-Hodgkin lymphoma ($1.0 million).

Given that the estimated PVLE is sensitive to the discount rate chosen, we conducted a sensitivity analysis (using discount rates varying from 0% to 10%), in order to provide a range of possible lifetime productivity losses. Figure 2 illustrates the results of this analysis that produced productivity losses for premature mortality ranging from $28.9 million (using a discount rate of 10%) to $101.9 million (using a discount rate of 0%).

Discussion

This study describes, for the first time, the economic impact of cancer in PR. Specifically, it describes the extent of the potential losses due to premature cancer death for the Island's economy. The total productivity losses in the labor market due to cancer in PR in 2004 were approximately $64 million (at a 3% discount rate and in constant value). These estimates represent nearly 14% of the total productivity loss in the labor market ($464 million) for 2004 in PR. Therefore, although cancer is a disease that usually occurs late in the life cycle, the losses of productivity caused by premature cancer death are a great burden in PR. This could be explained, in part, by a change in

the cancer incidence pattern among persons aged <65 years. For the period 1987-2004, cancer incidence trends showed a significant increase (APC= 2.7%, p<0.05) in people <65 years of age, while, trends in people aged 65 years of age and older remained stable (APC = -0.1%, p>0.05) (44). Although overall cancer mortality trends have decreased in average 1.0% annually from 1987-2004 (similar in persons aged <65 and >=65 years), cancer remains the leading cause of premature death in PR, representing nearly 17% of total deaths in 2004 (45).

Although it is important to notice that cost studies generated with different methods are not directly comparable, we can recognize that the cancer sites that generate most productivity loss in PR (lung and bronchus, colorectal, and breast cancer) also represent the greater productivity cost in the US, representing 27.4%, 9.0% and 7.6%, respectively (21). These types of cancer are either highly preventable or can be diagnosed early (46-47). Furthermore, it is evident that a large proportion of the productivity loss causing cancers are those related to tobacco use. This risk factor is associated with increased risk for at least 15 cancer types including lung and bronchus, oral cavity and pharynx, and esophagus (46-47). In PR, it has been estimated that the attributable risk of oral cavity and pharynx due to alcohol and tobacco use is around 76% (95% CI: 65-87%) for men and 52% (95% CI:28-75%) for women (48). Also, the prevalence of cigarette use among adults in 2004 was 12.6%, although it showed a decrease over the last decade from 14.5% in 1996 to 11.7% in 2008 (49). Thus, even though the prevalence of current cigarette smoking is not as high as in the US (20.9%) (50), we should continue to promote public policies focused on reducing the use of tobacco in PR, if we expect to decrease the productivity loss in a significant way.

Table 2. Present Value of Lifetime Earnings by site- specific cancer among people less than 65 years old in Puerto Rico, 2004

Cancer Site	Deaths	PPYLL	PVLE ($)	Percentage of total cancer cost	PVLE / Death ($)
All Causes of Death	8,953	161,410	463,703,434	-	51,793
All Malignant Cancer	1,515	17,474	64,178,973	100.00%	42,362
Lung and Bronchus	178	1,515	7,562,024	11.78%	42,483
Colon and Rectum	180	1,840	7,511,262	11.70%	41,729
Breast	209	2,572	6,630,413	10.33%	31,724
Liver and Intrahepatic Bile Duct	121	1,094	5,460,698	8.51%	45,129
Leukemia	70	1,465	3,651,523	5.69%	52,164
Non-Hodgkin Lymphoma	76	1,121	3,642,117	5.67%	47,922
Oral Cavity and Pharynx	61	612	3,610,865	5.63%	59,194
Stomach	69	727	3,106,856	4.84%	45,026
Kidney and Renal Pelvis	27	434	1,865,974	2.91%	69,110
Esophagus	37	287	1,801,173	2.81%	48,680
Pancreas	47	372	1,701,248	2.65%	36,196
Prostate	41	262	1,678,758	2.62%	40,945
Myeloma	31	232	1,578,807	2.46%	50,929
Brain and Other Nervous System	31	480	1,529,117	2.38%	49,326
Larynx	22	200	1,247,411	1.94%	56,700
Ovary	42	545	1,226,229	1.91%	29,195
Soft Tissue including Heart	17	375	897,124	1.40%	52,772
Cervix Uteri	26	385	870,616	1.36%	33,485
Corpus and Uterus, NOS	30	355	857,071	1.34%	28,569
Urinary Bladder	16	130	579,330	0.90%	36,208
Bones and Joints	11	152	379,815	0.59%	34,528
Testis	4	110	285,391	0.44%	71,347
Melanoma of the Skin	5	57	226,176	0.35%	45,235
Vulva	4	50	139,405	0.22%	34,851
Mesothelioma	2	30	134,876	0.21%	67,438
Penis	2	15	103,044	0.16%	51,522
Vagina	2	20	58,181	0.09%	29,090
Thyroid	2	15	57,204	0.09%	28,602
All other sites	152	2016	5,786,252	9.02%	38,067

PPYLL = Potentially productive years of life lost PVLE =Present Value of Lost Earning

Significant costs differences were also observed by sex. The types of cancer linked to tobacco consumption had a higher cost for men as compared to women. These findings are consistent with the differences in the prevalence of tobacco use in men and women in PR. In 2004, the prevalence of current smoking in males was 17.4%, compared with 8.4% in females (49). In addition, PVLE for liver and intrahepatic bile duct cancer was higher in males compared with females. These results may be associated with a higher prevalence of alcohol consumption, hepatitis B (HBV), hepatitis C (HCV), all of them risk factors for hepatic cirrhosis, a well-known pre-malignant condition for developing liver cancer, and more common among males. In 2004, the prevalence of men having more than two drinks per day was 4.6% compared with 2.0% in females (49). Also, the prevalence for HCV in men was 4-fold as compared to women (4.0% vs. 1.0%) among the PR population (51). Moreover, the prevalence of HBV was twice as frequent in males, (4.3%) as compared to females (2.5%) (51).

We also observed that oral cavity and pharynx cancer had a very high cost per death, although this is not a typical cancer among persons aged <65 years. The median age at diagnosis is 64 years and the median age for death is 68 years (52), this type of cancer also affects adversely more males in the working age. This is of particular relevance as oral cancer is still among the top leading cancer types in men in PR (52). It is important to note that the median age of death from oral cavity and pharynx cancer is less than the median age at diagnosis for lung and bronchus cancer (70 years) (53). Given that oral cavity and pharynx

cancer share an important risk factor with lung cancer, tobacco use, we can hypothesize that deaths due to the former in some way deplete the pool of people susceptible to developing and dying from lung cancer (tobacco users) years later. If we could control for oral and pharynx cancer death, smokers would still be at risk of developing and dying from lung cancer.

Another important finding from our study is that although mortality from stomach and from esophagus cancers have decreased since the 1950's in PR (54-55), both remain highly costly diseases, partly because of the poor survival typical of these types of cancer. Meanwhile, leukemia, myeloma, non-Hodgkin lymphoma, and brain and central nervous system tumors have a substantial burden in both sexes. This impact

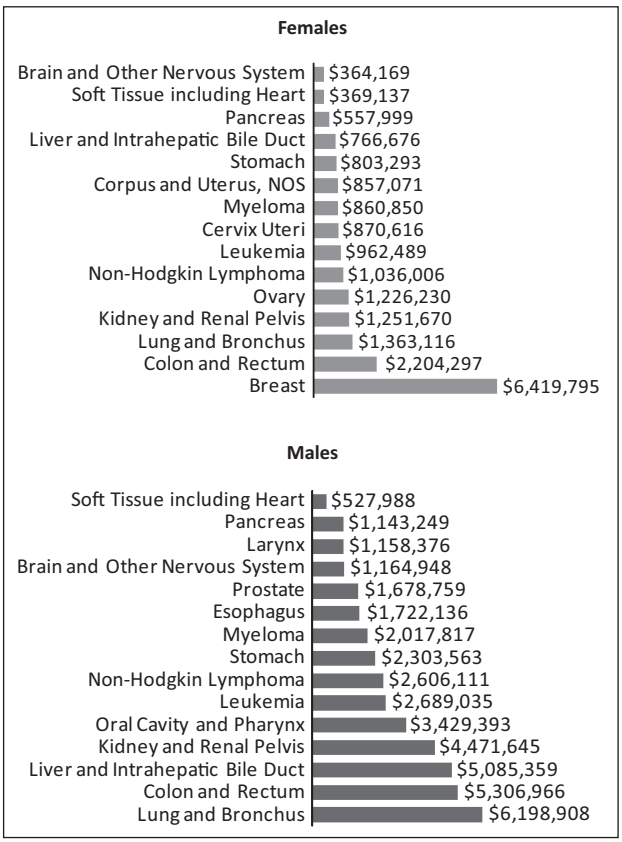

Figure 1. Top 15 Cancer Sites of Present Value of Lifetime Earnings Loss due to Premature Mortality by Sex in Puerto Rico, 2004

could be attributed to the greater mortality of many of these types of cancer in children, producing a higher PVLE. Although childhood cancer accounts for about 1% of all cancers in PR, leukemia, brain tumors and lymphoma account for the vast majority of childhood cancer related deaths.

It is important to note that breast cancer, the most common cancer among females in PR, is more costly than prostate cancer, the most common cancer among men. This study demonstrated that although men have higher wages, employment, and mortality from cancer than women, breast cancer ranks as the third type of cancer causing more loss of productivity in PR. These results are due, in part, to the higher proportion of younger females dying of breast cancer, while prostate cancer affects primarily older men. While the median age at diagnosis for breast cancer is 59 years, and the median age at death is 63 years, for prostate cancer the median age at diagnosis is 10 years later (69 years at diagnosis) and the median age at death is 82, well beyond retirement age (56-57). Although we observed that Puerto Rican females younger than 65 years of age showed a significant reduction in breast cancer mortality rates (58), potentially due to the progress made in reducing breast cancer mortality, it remains a deadly disease among working age females and a costly one for the Puerto Rican society.

Implications for health policy

In economic terms, cancer affects the most important productive resource, the human capital. While the productivity loss due to cancer death represents a very high cost for society, someone may be tempted to consider as a benefit the payment of pensions that will never be paid due to premature deaths. This notion, however, does not consider that public health interventions do not have as final objective the saving of monetary expenses or the budgetary control (25). The primary target of any intervention in public health must be the prolongation of survival and improvement of the quality of life of cancer survivors. The considerations in which premature mortality have a saving component could jeopardize the achievement of this objective (25).

Interventions in cancer must be implemented through a comprehensive public policy that includes attention, not only to the medical aspect, but also to social and economic issues, including scientific research and development. According to the PR Comprehensive Cancer Control Plan 2008-2012 (59) it is necessary to have a comprehensive approach to reach the goal of cancer control and prevention in PR. In order to achieve these objectives, it is necessary to create accurate and reliable estimates of cancer-related cost and others empirical studies to improve how to allocate limited economic resources for cancer control. These types of studies represent an important analytic tool for the design and implementation of public health policy.

Investments in programs that decrease lung, colorectal, breast, and liver cancer mortality are likely to generate the major decline in productivity loss in PR. As a fundamental part to maximize the social well-being, it is necessary to place emphasis in cancer prevention. The leading cancer sites that generate most productivity losses are highly preventable or can be diagnosed early. One of the most important objectives for cancer control programs, from an economic perspective of cost in terms of labor productivity, is the investment in programs that reduce the types of cancer directly related to the use of tobacco in our society.

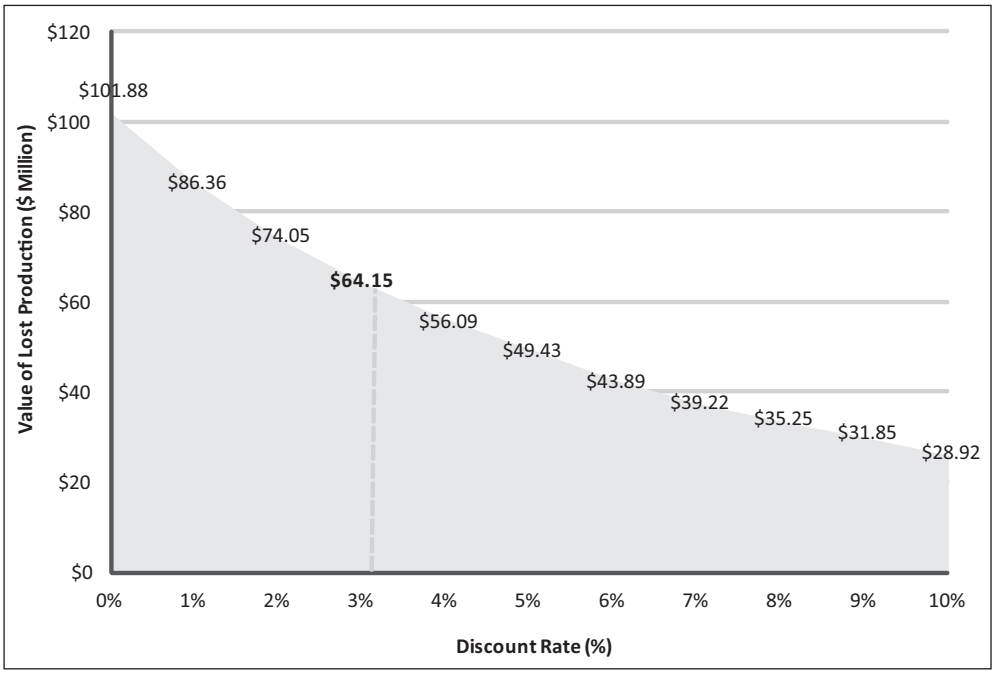

Figure 2. Sensitivity Analysis: Value of Lost Production due to Premature Mortality varying Discount Rates, Puerto Rico, 2004

Limitations and Recommendations

Various limitations of this study should be acknowledged. This kind of study can demonstrate which type of cancer may require increased allocation of prevention or treatment resources, but is limited in determining how resources are to be allocated, as it does not measure benefits. In addition, studies can vary by perspective, sources of data, inclusion of indirect costs, and the period of costs, which can limit the comparability of findings with the present study (19). In addition, the estimates do not include the value of care giving, household work, and earning from informal economy, contributions that could be more important for females given their traditional roles in our society. Also, it is important to point out that productivity loss due to premature mortality is only one component of a framework for estimating the economic cost of cancer in PR. The estimations presented in this study do not represent the total of productivity loss in PR's labor-market due to cancer. In addition, an important aspect that was not considered in this study was the labor productivity loss associated to disability. Although this study focused in mortality, disability represents a significant problem that has great impact in the labor market. The improvements in early detection and advances in treatment of cancer have increased the survival rate for all cancers in general, raising the prevalence of people diagnosed with cancer (60). People diagnosed with cancer have a high probability of suffering a loss of productive capacity, consequently, affecting the productivity in the labor market. One in six cancer survivor workers in the US report they were unable to work and an additional 7% indicated that they were limited in the amount and type of work they could perform (61-62). Therefore, future studies in PR should focus on obtaining reliable data to estimate the total productivity cost, including costs caused by disability, as the exclusion of disability from these estimates can result in an underestimation of the total productivity loss due to cancer.

Furthermore, if direct costs (medical expenses resulting from cancer) were added to the COI estimates, the economic impact of cancer will be substantially higher. According to a study performed in PR, 20.4% of the Gross National Product (GNP) in PR corresponds to health expenditures (63). This is twice as much as in Europe and 25% more than in the US. Therefore, the direct cost of cancer can be extremely costly and represents a great burden for PR (59, 63). These limitations suggest that the estimates of productive cost of cancer in PR could be even greater than those estimated in the current analysis. But, as mentioned earlier, we considered only productivity loss in the labor market because we focused our analysis on those components for which we had valid data to report reliable estimates. The impact of premature mortality due to cancer in the economy of PR evidenced in this study confirms the need for funding to increase research capacity in this area. It is essential to estimate the other components of COI in order to provide more accurate information of the burden of cancer. Consequently, informed decisions can be taken to allocate resources more efficiently for cancer control.

Conclusion

Our study shows a broader picture that includes the economic dimension of cancer as a health problem in our society. The leading cancer sites that generate most productivity losses are highly preventable or can be diagnosed early. We have identified that the mayor labor productivity loss was caused by the types of cancer directly related to tobacco use. Our results also show that despite the widespread availability of breast and colorectal cancer screening and the efforts to reduce the use of tobacco and other risk factors for developing cancer, it is evident that a substantial health and economic impact associated with these types of cancer remains. Future research including those that consider the other

components of COI should be developed and considered within the framework for health and cancer control policies.

Resumen

Trasfondo: En Puerto Rico (PR) el cáncer es la segunda causa de muerte y es la enfermedad que más muertes prematuras ocasiona, representando cerca del 15% de éstas. Es importante estimar los costos de cáncer para asignar eficientemente los recursos limitados con el fin de reducir la carga del cáncer en PR. Objetivo: Estimar la pérdida de productividad laboral asociada a la mortalidad por cáncer en general y por tipos específicos en PR para el año 2004. Métodos: Para estimar la pérdida de productividad en el mercado laboral se desarrolló un modelo basado en el "enfoque de la incidencia" y en el "enfoque de capital humano". Los datos económicos fueron obtenidos de los Microdatos para el Uso Público (PUMS) de la Encuesta sobre la Comunidad de PR (PRCS). Resultados: La pérdida de productividad laboral de todas las muertes por cáncer se estimó en aproximadamente $64 millones (en valor constante). Las muertes que más contribuyeron a la pérdida de la productividad fueron atribuidas a cáncer de: pulmón y bronquios, colorrectal, mama, e hígado y conducto biliar intrahepático. Conclusiones: Aunque estos resultados deben ser interpretados con cautela, contribuyen a mostrar un panorama más amplio que incluye la dimensión económica del cáncer en nuestra sociedad. Estas estimaciones implican que el costo de la productividad debido a la mortalidad por cáncer tiene un gran impacto en PR. Los tipos de cáncer que generan la mayor pérdida de productividad son altamente prevenibles, se pueden diagnosticar temprano, ó están asociados a consumo de tabaco. Este tipo de estudio se debe considerar dentro del marco del análisis de costos para el desarrollo de políticas de control de la salud y del cáncer.

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