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Economics of Cancer Prevention and Health Promotion in Public Health Programs for Underserved Populations

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Abstract

Providing health services to the public under any government-sponsored program, such as the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), involves an opportunity cost. Public funds devoted to a particular intervention are no longer available to fund other activities. Maximizing the benefit from limited resources requires decision makers to identify the most efficient strategies to provide effective services (e.g., cancer screening) to maximize population health. Such decisions may benefit from collection and analysis of valid, accurate and reliable economic cost and effectiveness data related to program activities. The results may help decision makers identify and select best practices to improve program operations and performance. In this paper, we provide a brief description of the economic evaluation methods used in estimating the costs and benefits of public health programs, and discuss the application of these methods to the NBCCEDP.

Introduction

Economic analysis is the study of decisions in order to maximize value in an environment of resource constraints. Because public funds for health services are finite, decision makers must allocate available resources among various activities to promote health and prevent diseases. Economic analysis provides a systematic appraisal of the costs and benefits of alternate public health spending choices. The results of this analysis can guide decisions regarding the most effective and efficient use of public health resources.¹

Economic analyses of publicly funded cancer prevention programs are vital for three reasons. First, cancer is a costly disease. The cost of cancer care in the United States was \$124.5 billion dollars in 2010 and is projected to increase by nearly 40% by the year 2020.² Second, effective cancer prevention offers high value. Routine screening for early detection of colorectal, breast, and cervical cancers are among the 25 most cost-effective preventive services recommended by the United States Preventive Services Task Force.³ Third,

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underserved populations experience disparities in receipt of these high-value cancer prevention services⁴ and are more likely to have adverse cancer outcomes.⁵

Public health programs can improve access to cancer prevention services for these underserved populations, thereby reducing cancer morbidity and mortality in a cost-efficient manner. Further, to the extent that underserved populations may be at greater risk of poor cancer outcomes than the general population, public health programs targeted to underserved populations may be even more effective than among the general population. Hence, economic evaluation of public health programs for cancer prevention, especially focused on the underserved, is essential to provide evidence of their value to decision makers to ensure their scalability and replicability.

Economic analysis methods commonly used in research related to public health programs are cost-of-illness studies, program cost analysis, cost-effectiveness analysis, cost-utility analysis, cost-benefit analysis, and budget impact analysis.⁶ We provide a brief description of key concepts in economic analyses, describe each of the economic analysis methods and present examples of their application to evaluating public health cancer prevention programs for the underserved, with a focus on the Centers for Disease Control and Prevention's (CDC) National Breast and Cervical Cancer Early Detection Program (NBCCEDP). Details of the NBCCEDP is provided in Wong et al paper in this supplement. Briefly, the program provides breast and cervical cancer screening to low-income, underserved women.

Key Concepts in Economic Analyses

Key concepts important to all types of economic analyses include the perspective of the analysis and categories of costs attributable to the disease. The perspective of the analysis is the viewpoint from which the analyses are conducted. Typical perspectives include the patient and family; employer; health insurers or payer, including federal and state programs such as Medicare and Medicaid; or society overall. Three categories of costs attributable to disease are usually identified as follows: (1) direct costs resulting from the use of resources for medical and non-medical care; (2) indirect costs, also known as productivity losses, associated with morbidity and premature mortality from cancer; and (3) psychosocial (intangible) costs, such as pain and suffering.⁷ Examples of these cost categories and their measurements are listed in Table 1.

Direct costs are typically measured by health insurance payments and patient out-of-pocket spending. Indirect costs, or losses caused by illness or premature death, are typically measured as time lost from work, or loss of usual activities, and valued in one of three ways: the human capital (HC), friction cost (FC) or willingness-to-pay (WTP) approach.⁷ In the HC approach, gender- and age-specific average wages are combined with time lost from work to calculate the value of the lost time, which is based on the patient's estimated earnings in the labor market. In contrast, the FC approach calculates lost hours only as those not worked until another employee takes over the patient's work.⁸ The WTP approach estimates the amount an average individual would be willing to pay for an additional year of life.⁹ All three approaches yield different estimates of the value of productivity losses.⁹ Estimating productivity costs by using any of these three approaches is challenging for

underserved populations, because these populations have lower wages and subsequently, lower time costs and lower willingness-to-pay than those of the general population.¹⁰

Overview of economic analysis methods

Table 2 presents an overview of economic evaluation methods used in public health and their advantages and limitations. The choice of method is largely dependent on the purpose of the analysis, the audience requesting the analysis, and the availability of data. These methods are briefly described next.

Cost-of-illness (COI) studies

COI studies estimate the economic burden (to the payer, patient, or society) attributable to a disease. COI studies draw attention to a specific disease or condition. For cancer, COI studies vary in the categories of costs that they include (Table 1). Many studies have focused on direct medical costs of cancer care from a payer's perspective.^{11,12} Some studies examine only the out-of-pocket costs paid by patients. These out-of-pocket costs may be restricted to direct medical costs¹³ or may also include direct non-medical costs¹⁴ depending on the data used in the study. Underserved populations may face unique economic burdens across some of these cost categories (out-of-pocket costs, direct non-medical costs of transportation or caregivers). Hence, some studies have estimated these cost categories specifically among underserved populations. Table 3 presents examples of all economic evaluation methods described in this paper and their application to cancer prevention and control among underserved populations.

Program cost analysis

Program cost analysis refers to a systematic collection of the cost of a program¹⁵ and can be performed as a stand-alone analysis or as an essential step in the complete economic evaluation of a health program. When performed as a stand-alone analysis, the results of program cost analyses are presented either as average cost or incremental cost of program per individual served.¹⁶ Program cost analyses are helpful in making a case for starting or expanding a health care program.¹⁷ Program costs include both fixed and variable costs. Fixed costs are costs that do not change with the number of people served, and include costs for facilities and capital equipment (e.g. rent and depreciation or amortization), and overhead expenses for shared resources such as administrative personnel.¹⁵ Variable costs increase with the number of individuals served and usually include clinical personnel time and materials.

Finkelstein and colleagues¹⁸ recommend that economic evaluations of public health programs should include more than only the direct dollar outlays associated with implementation of the program. To evaluate the true societal cost of a program, the opportunity cost (the cost to society of giving up on alternate, competing programs) of participation in the program and program resources such as donated volunteer hours or donated facilities and equipment also should be included.¹⁸ Gorsky presents methods for estimating program costs using a seven-step resource-cost or ingredients-based approach

that includes three types of resource costs—variable costs, fixed costs and participant costs.
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Cost-effectiveness analysis (CEA)

CEA incorporates both the costs and consequences of competing health interventions to determine the intervention that offers the highest value. The cost-effectiveness of an intervention is computed by using an incremental cost-effectiveness ratio (ICER) that compares the cost and outcomes of an intervention with either the standard of care or the next least expensive alternate intervention in case of multiple competing interventions. The ICER is compared with some selected threshold value based on literature and/or accepted norms. For instance, the ICER for a program that addresses cancer screening among underserved women would be compared to a threshold computed based on ICERs from evaluation of other similar programs that provide disease prevention services to underserved populations. If the ICER is below this selected threshold, the intervention is considered to be cost-effective.²⁰ CEA is the most common method of economic analysis in the health care literature because the outcome is measured in short-term, natural units such as patients screened or cancers detected, which are easier to measure and easier to interpret as compared to long-term health benefits.^{21,22}

CEA is useful when comparing alternative interventions within a health care program that address the same health outcome, or when comparing alternate health programs that deliver similar services, such as cancer screening. All direct medical, direct non-medical, and indirect costs can be included in CEA study depending on the perspective of the analysis. Examples of application of CEA to public health programs for the underserved populations are presented in Table 3.

Cost-utility analysis (CUA)

CUA is a special case of CEA wherein the health outcome is a broader measure of health that incorporates both survival and quality of life. The quality-adjusted life year (QALY) is the most common outcome measure in CUA in developed countries. QALYs are computed as a product of the life-years gained and a utility weight. Utility weight is a value assigned to a particular health state based on the desirability of living in the state, typically from the highest desirability of living in “perfect” health (weighted 1) to the lowest desirability of death (weighted 0).^{23,24} When the effect of an intervention is measured by using QALYs, the analysis is called CUA because the health outcome has been adjusted for quality of life by using utility weights.²⁵ QALYs serve as the common outcome measure that enables comparison of ICERs across programs that address diverse public health outcomes. Using QALYs ensures that programs that may not improve longevity but improve quality of life are not undervalued.²⁶ QALYs are generated using utility weights derived from the general population and there are no standardized methods to measure utility weights for underserved populations served by public health prevention programs.²⁷

Cost-benefit analysis (CBA)

In CBA, a monetary value is assigned to health outcomes such that costs and effects of all programs are measured in dollars. In the place of ICERs computed in CEA and CUA, results

of CBA are reported as net monetary benefit, which is derived by subtracting total costs from total benefits. A net monetary benefit greater than zero implies that the program is cost-effective. CBA is typically performed by using the societal perspective to capture all costs and benefits irrespective of who accrues them. This makes CBA useful when comparing programs across various sectors such as health, education, and housing. Although CEA and CUA answer questions about technical efficiency of a health program (i.e., Given that a goal has been decided, what is the least costly way of achieving it?), CBA answers questions about allocative efficiency (i.e., How much of society's limited resources should be allocated to achieving this goal as compared to other societal goals?).²⁸

CBA differs from an evaluation of whether a program is cost minimizing. Cost minimization analysis compares only the costs of programs that have equivalent outcomes. Zarnke and colleagues found that nearly 53% of studies labeled as CBA are cost minimization analyses and do not appraise health outcomes.²⁹ Monetary value of health benefits may be derived by using the WTP, HC or FC approach as described earlier. Nearly 70% of the true CBAs examined by Zarnke et al. (1997) used the HC approach to value health states.²⁹ CBA of healthcare interventions is rare in the United States because assigning a monetary value to health and life is controversial. When the focus of the intervention is underserved populations, these populations differ from the general public in terms of work productivity or willingness to pay, the measures used for computing monetary value of health benefits in a CBA.⁶ CBA is more popular in European nations³⁰ and in other US governmental agencies such as the Environmental Protection Agency and the Congressional Budget Office.³¹

Budget impact analysis (BIA)

A BIA is an economic assessment that estimates the financial consequences of implementing a health program or whether the intervention is affordable. BIA is an analysis of all the expenditures and savings associated with the implementation of a health care program accrued to the payer, usually a government entity, in the short-term, including diagnostic and treatment costs for cancers detected in the screening program.³² BIA usually does not take into consideration the costs incurred by the patients and the non-monetary consequences of the program implementation, including health benefits. Although BIA considers the number of people benefitting from a program, it does not consider the sociodemographic characteristics of the population being served. Reducing health disparities caused by sociodemographic factors is an important strategy of Public Health 3.0.³³ Thus, programs that accrue benefits to the underserved and reduce inequity should be evaluated using a broader lens of equity and ethics and not budget impact alone.

Applying economic analysis to the National Breast and Cervical Cancer Early Detection Program (NBCCEDP)

The CDC's NBCCEDP is a national program providing breast and cervical cancer screening to low-income, uninsured, and under-insured women in the United States.³⁴ Currently, the NBCCEDP funds 70 state, tribal, and territorial health agencies. There is a substantial body of literature applying economic analysis to evaluate the activities of the NBCCEDP. Some of

these studies are highlighted in Table 3. Several COI analyses related to the NBCCEDP have been published. Ekwueme and colleagues estimated the personal direct non-medical and indirect costs, including travel, parking, child care and opportunity costs, incurred by women receiving mammography screening as part of the NBCCEDP.³⁵ Women who are diagnosed with breast or cervical cancer under the NBCCEDP are eligible for Medicaid coverage for cancer treatment under the Breast and Cervical Cancer Prevention and Treatment Act of 2000 in nearly all states.³⁶ Thus, cancer treatment in Medicaid is a component of the NBCCEDP. Subramanian and colleagues performed COI analyses of cervical and breast cancers among Medicaid insured patients.^{12,37}

Several studies have used a web-based cost assessment tool (CAT) to conduct program cost analyses. Ekwueme and colleagues estimated the program costs per woman screened and per cancer detected under the NBCCEDP for both breast and cervical cancer along with cost per program component.¹⁶ Trogon and colleagues demonstrated economies of scale in the provision of screening and diagnostic services under the NBCCEDP.³⁸ Finally, several studies have estimated the impact of NBCCEDP on health outcomes. Hoerger and colleagues estimated the life years saved by breast cancer screening under the NBCCEDP,³⁹ whereas Ekwueme and colleagues estimated the life years and the QALYs saved by cervical cancer screening.⁴⁰

The articles in this supplement build on this previous work and present several new economic analyses of the NBCCEDP. The papers include updated program cost analyses with more years of data and extended to tribes and territories. In addition, the articles explore how program characteristics, such as delivery structure, affect program costs. There are two new BIAs. The first investigates the association between funding levels and the number of women served over time. The second uses a computer model to optimize allocations across programs to maximize the number of women served. Finally, new CEAs investigate the changes in lifetime breast and cervical cancer incidence and QALYs if the NBCCEDP increased its reach.

Conclusion

Economic evaluation of public health programs for underserved populations, such as the CDC's NBCCEDP, can help identify effective and efficient use of public health resources. A systematic, transparent economic analysis can help to demonstrate value and guide decisions to implement effective public health programs that may improve efficiency and equity in allocating resources to all sub-groups of the population. Therefore, the lessons learned from the economic analysis of the NBCCEDP can be applied to other public health programs that may provide health promotion and disease prevention services to underserved populations, including the National Comprehensive Cancer Control Program, also funded by the CDC.

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Table 1—

Medical Care Cost Categories

Cost Component		Examples	Measurement
Direct Costs	Medical	Cost of hospitalizations, physician visits and cancer therapy	Health insurance payments, patient out-of-pocket health care spending
	Non-Medical	Cost of transportation to and from medical care and housekeeping services	Patient spending
Indirect Costs	Morbidity	Cost of time lost from work/lost productivity, time spent seeking medical care, caregiver time or changes in caregiver productivity	Days lost from work from employer or patient perspective combined with value of time
	Mortality	Cost of productivity lost due to premature death	Years of life lost combined with value of time
Intangible/Psychosocial Costs		Cost of pain, suffering, grief	Usually measured as reduction in quality of life

Table 2—

Methods Used in Economic Analyses

Method	Measure of costs and benefits	Features	Perspective	Cost categories			
				Direct medical	Direct non-medical	Indirect	Intangible
Cost-of-illness analysis	Total cost for incident or prevalent cases; no measure of benefits	Results straightforward, but not directly actionable. Lack of standardization regarding the categories of costs to be included limits comparability.	Societal	X All payers, including patient	X	X	X
			Payer	X Specific payer			
			Employer	X Specific employer		X	
			Patient	Out-of-pocket	X	X	X
Program cost analysis	Total cost per patient served, costs include fixed and variable resources; no measure of benefits	Results straightforward, but not directly actionable. Lack of standardization regarding program costs to be included limits comparability.	Payer	X Specific payer			
Cost-effectiveness analysis	Incremental cost-effectiveness ratio; health benefits in natural units gained	Outcomes straightforward, but no comparability between programs affecting different outcomes.	Societal	X All payers, including patient	X	X	X
			Payer	X Specific payer			
Cost-utility analysis	Incremental cost-effectiveness ratio; benefits measured in quality adjusted life years (QALYs) gained	Results comparable across healthcare programs. No standard definitions on utility measures, especially for underserved populations	Societal	X All payers, including patient	X	X	Intangible costs included in the utility measure
			Payer	X Specific payer			
Cost-benefit analysis	Net benefit: health benefits valued in dollars	Results comparable across healthcare programs. Assigning monetary values to health outcomes is controversial	Societal	X All payers, including patient	X	X	X
			Payer	X Specific payer			
Budget impact analysis	Short-term incremental cost	Provides actionable findings on affordability. Biased against programs with long term benefits and high short term costs	Payer	X Specific payer			

Table 3—
Examples of Economic Analyses Applied to Cancer Prevention and Control among Underserved Populations

Author, Year	Study Setting	Perspective	Cost Categories Included	Effectiveness Measure	Key Findings
Cost-of-illness analysis					
Pisu, 2010	Survey data were collected from 46 <i>nonwhite</i> and 216 white breast cancer survivors participating in a breast cancer education trial	Patient/ Family	Direct medical and non-medical	.	Out of pocket (OOP) costs averaged \$316 per month since diagnosis. Direct medical costs were \$281, and direct non-medical were \$66. There were no significant differences in total OOP costs or direct medical and non-medical OOP costs between nonwhite and white Breast Cancer Survivors (BCS). However, among BCS with incomes lower than \$40,000, nonwhite BCS spent a significantly higher proportion of their income on total OOP and direct medical OOP costs compared to their white counterparts, reflecting higher economic burden among nonwhite BCS.
Subramaniam, 2011 [#]	Claims data were collected for 848 <i>Medicaid enrollees</i> from 2002 to 2004 under the age of 65 diagnosed with breast cancer and 1696 non-cancer controls	Payer-Medicaid	Direct medical	.	Compared to non-cancer controls, breast cancer survivors had higher direct medical cost at 6, 12 and 24 months after cancer diagnosis. The incremental costs at 6 months after diagnosis are \$14,341, \$24,002, and \$34,469 for those with local, regional, and distant breast cancers, respectively; and these costs increased to \$22,343, \$41,005, and \$117,033 at 24 months.
Program cost analysis					
Ekwueme, 2014 [#]	Program cost data were collected from 63 of the 66 regional centers for the NBCCEDP serving <i>low-income uninsured women</i> during the 2006/2007 fiscal year	Payer-Center for Disease Control and Prevention (CDC)	Direct medical costs including in-kind donations	.	Total cost of all NBCCEDP services was \$296 (per woman served). The estimated cost of screening and diagnostic services for breast cancer was \$110 with an office visit and \$88 without, the weighted mean cost of a diagnostic procedure was \$401, and the weighted mean cost per breast cancer detected was \$35,480. For cervical cancer, the corresponding cost estimates were \$61, \$21, \$415, and \$18,995, respectively.
Tangka, 2013	Program cost data were collected from 5 federally funded demonstration programs for <i>underserved populations</i> from 2006 to 2009	Payer-CDC	Direct medical costs	.	The average cost per fecal occult blood test was \$49 in Nebraska and \$148 in Greater Seattle. The average costs per colonoscopy test were \$1600, \$654, \$842, \$1030 and \$874 in Baltimore, St. Louis, Nebraska, Suffolk County, N.Y, and Greater Seattle, respectively.
Cost-effectiveness analysis					
Lairson, 2014	Cost and screening outcomes data were collected from 613 <i>low-income women of Mexican descent</i> enrolled in the <i>Ayudando a las Mujeres con Información, Guía, y Amor para su Salud (AMIGAS)</i> trial during 2008–2011 to compare four education strategies	Payer-CDC and Participant	Direct cost for planning, training staff, recruiting eligible women to receive the intervention, and delivering the intervention; indirect cost of participant time	Number of women receiving Papanicolaou (Pap) screening	Per person cost of full, flipchart-only, and video-only interventions were \$223, \$219, and \$216, respectively, from the payer plus participant perspective. The ICER computed was \$980 (95% CI: \$650, \$1,974) comparing controls to the video-only intervention; \$71 (95% CI: \$4.10, \$6.60) comparing the video-only to flipchart only arm; and \$4 (95% CI: \$1.80, \$1.60) comparing the flipchart-only to the full intervention arm.

Author, Year	Study Setting	Perspective	Cost Categories Included	Effectiveness Measure	Key Findings
Lich, 2017	Individual-based modeling was used to simulate and compare intervention costs and results under four evidence-based and stakeholder-informed intervention scenarios to increase colorectal cancer screening among <i>underserved populations</i> in North Carolina for a 10-year intervention window, from January 1, 2014, through December 31, 2023	Payer-State of North Carolina	Direct cost for intervention reflecting the expected resources needed for implementation of each intervention scenario above and beyond what would be covered under usual care	Life years participant is up to date with screening guidelines over the entire study period	Mailed reminder, combined mailed reminder and mass media, combined mail reminder and mass media and voucher and lastly combination of all four interventions were all cost-effective whereas mass media alone, voucher alone and expansion of endoscopy facilities alone were not cost-effective. Combined mailed reminder and mass media was the most cost-effective (ICER: 20\$ per additional life year up to date) at a willingness to pay threshold of \$20. Mailed reminders reduced the screening disparity for Medicaid enrollees; mass media intervention reduced the gap between white and black populations and the voucher for uninsured reduced the gap between privately insured and uninsured residents. Expansion of endoscopy facilities did not increase overall screening or reduce the gap between counties with the highest and lowest screening rates.
Cost-utility analysis					
Goldie, 1999	A state-transition Markov model was used to estimate the costs and effects of six alternative strategies for cervical cancer screening among <i>HIV-infected women</i>	Societal	Direct medical costs and indirect costs of travel, waiting time, and time spent for direct care.	Quality adjusted life years saved	Annual Pap screening had an incremental cost effectiveness ratio (ICER) of \$12,800 per QALY saved. Annual Pap after two negative smears obtained 6 months apart had an ICER of \$14800 per QALY saved. Semiannual Pap had an ICER of \$27,600 per QALY saved, whereas semiannual colposcopy had an ICER of \$375,000 per QALY saved.
Melnikow, 2013	Individual-based modeling was used to simulate and compare costs and outcomes of eight alternate screening strategies among <i>underserved enrollees</i> of the Every Woman Counts (EWC) program in California for a 15-year intervention window for screening outcomes.	Payer-State Public Health departments and the CDC	Direct medical costs	Life years saved	Biennial film mammography for women aged 50 to 64 years was projected to reduce breast cancer mortality by nearly 7.8%, at \$18,999 per additional life-year. Annual film mammography added to mean life expectancy at \$106,428 incremental cost per additional life-year, and annual digital mammography incremental cost per additional life-year was \$180,333.
Cost-benefit analysis					
Budget impact analysis					
Kim, 2017	A state transition Markov model using process maps and a cost/outcome database from a comprehensive, community-based CRC prevention program from 2012 through 2014 in El Paso, Texas, for <i>uninsured Hispanic people</i> aged 50 to 75 years	Payer	Direct cost of the intervention including medical costs	.	The incremental 3-year cost was \$1.74 million compared with the status quo. The program cost per person was \$261 compared with \$86 for the status quo. Budget impact was highest in the first year and decreased in years two and three.

#Note: Examples of studies applying economic evaluation methods to the National Breast and Cervical Cancer Early Detection Program (NBCCEDP)