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## Productivity Costs Associated with Metastatic Breast Cancer in Younger, Midlife, and Older Women

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### Abstract

**Background:** The objective of this study was to estimate productivity costs due to metastatic breast cancer (mBC) via productive time lost among survivors and potential life-years lost from premature mortality among three age groups: younger (aged 18-44), midlife (aged 45-64) and older women (aged 65 and older).

**Methods:** We estimated the number of work and home productivity days missed due to mBC by age group using 2000-2016 National Health Interview Survey data. Years of potential life lost (YPLL) due to mBC were calculated for each age group using 2015 National Vital Statistics Surveillance System data. We valued both sources of lost productive time using the Current Population Survey and prior studies.

**Results:** The per-woman value of lost productive days (work and home) due to mBC ranged from \$680 for older women to \$5,169 for younger women. The value of lost work and home productivity days associated with mBC nationally was \$67 million for younger women, \$246 million for midlife women and \$66 million for older women in 2015. YPLL was highest among midlife women (403,786 life years), followed by older women (248,522 life years) and younger women (95,943 life years). Midlife women had the highest market value of YPLL (\$4.1 billion), followed by younger women (\$1.6 billion) and older women (\$527 million).

**Conclusions:** Our results demonstrate that mBC generates high economic burden through lost productivity, especially among midlife women.

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**Disclaimer:** The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

## INTRODUCTION

Breast cancer is the second leading cause of cancer death in women in the United States (US).<sup>1</sup> In the US, 6-10% of breast cancers are metastatic at diagnosis and an additional 30% of women diagnosed at earlier stages will eventually progress to metastatic breast cancer (mBC).<sup>2,3</sup> Women with mBC have a more prolonged and costly treatment trajectory due to their need for continued therapy and end of life care. The 5-year relative survival for mBC is only 26.3% compared to 98.8% for localized cancer.<sup>4</sup>

Metastatic breast cancer can lead to substantial economic burden through lost productivity in two ways. First, women with mBC can miss productive days at work and home due to illness, either as a direct result of their mBC or the side effects of treatment.<sup>5-7</sup> Second, premature mortality from mBC creates years of potential life lost (YPLL) for women.<sup>8-10</sup>

Although less than 7% of all distant breast cancers are diagnosed among women younger than age 40, incidence in this age group increased faster than in women above age 40 between 1976 and 2009.<sup>11</sup> The types of breast cancer younger women (ages 18-44) face are typically diagnosed at advanced stages, are aggressive, and result in poor survival.<sup>12-18</sup>

The existing literature on the productivity costs of breast cancer among younger women has not yet focused on mBC. Prior studies suggest that the productivity costs of non-metastatic breast cancer in younger women are substantial.<sup>10,19,20</sup> Because the vast majority of deaths due to breast cancer are effectively due to mBC, the existing literature quantifying the value of YPLL from breast cancer has implicitly focused on mBC but only one prior analysis has reported results for younger women.<sup>10</sup> The one study that did report the value of YPLL from breast cancer among younger women did not report comparable estimates for midlife or older women.<sup>10</sup> Thus, there is currently little evidence reporting productivity costs of mBC across the life-cycle. The objective of this study was to estimate productivity costs due to mBC via productive time lost among women living with the disease and potential life-years from premature mortality among three age groups: younger (aged 18-44), midlife (aged 45-64) and older women (aged 65 and older).

## METHODS

Productivity costs among women living with mBC and the value of years of potential life lost to mBC were estimated separately using different data sources. This section describes both sets of analyses in turn.

### Productivity Costs among Women Living with mBC

**Data**—The primary data source was the National Health Interview Survey (NHIS), a cross-sectional survey of the non-institutionalized population administered by the National Center for Health Statistics. Self-reported responses to the following annual NHIS question were used to identify women with breast cancer: “Have you ever been told by a doctor or other health professional that you had cancer or a malignancy of any kind? [If so,] what kind of cancer was it?” Our sample included women with non-missing responses to questions about having ever been diagnosed with cancer, having ever been diagnosed with breast cancer, and

age at breast cancer diagnosis. However, NHIS does not collect information on stage of diagnosis. Pooled NHIS data from 2000 to 2016 were used to construct samples of women with breast cancer by age group at time of the survey (younger, midlife and older).

The prevalence of mBC was estimated as prevalent breast cancer cases (all stages) from January 1, 2015 multiplied by the proportion with distant metastases in each age group from the Surveillance, Epidemiology, and End Results (SEER).<sup>2</sup> This prevalence estimate is likely conservative because the proportion with distant metastases from SEER does not capture early-stage cancers that progressed to metastatic disease. Following Islami et al.,<sup>9</sup> the value of a work day was estimated from median full-time earnings, adjusted to include fringe benefits, for females by five-year age group using data from the 2016 Current Population Survey (CPS). The CPS is a survey conducted by the US Census Bureau in conjunction with the Bureau of Labor Statistics (BLS) that measures employment characteristics of the US population. The Annual Social and Economic Supplement of the CPS contains data on annual earnings by age, sex, education, and other demographics. The value of a day of home production was from Grosse et al.<sup>21</sup> They proxied the market value of home production using average hourly earnings of “personal care and service occupation workers” from the 2016 CPS. After adjusting this wage for the value of fringe benefits, the average hourly rate for home production for females was \$12.97 per hour.

**Outcomes**—The following question from NHIS was used to measure annual work loss: “During the past 12 months, that is since [12-month reference date], about how many days did you miss work at a job or business because of illness or injury (do not include maternity leave)?” The following question from NHIS was used to measure annual home productivity loss: “During the past 12 months, that is since [12-month reference date], about how many days did illness or injury keep you in bed more than half of the day? (Include days while an overnight patient in a hospital)?”

**Analysis**—All analyses were conducted separately for women in three life stages at the time of the survey: younger (aged 18-44), midlife (aged 45-64) and older (aged 65 and older). Following previous studies, we estimated two-part regression models;<sup>22</sup> the outcome in the first part was an indicator for any days missed and the outcome in the second part was the number of days missed conditional on any days missed. The first part for these analyses included employed women with non-missing responses to the number of work days missed due to illness in NHIS, by age group. The second part included women with non-missing responses to the number of days spent in bed due to illness in NHIS, by age group.

The independent variables of interest were an indicator for a history of breast cancer interacted with a categorical variable for the years since diagnosis (less than two years, two to four years, five to ten years, or 11 or more year). The coefficients on these interaction variables captured the association between breast cancer and productive days lost holding the following characteristics constant: age at the time of survey in years, race/ethnicity (Non-Hispanic, non-white), education (less than high school, high school/GED, some college, bachelor’s degree or higher), household income (less than \$35k, \$35-75k, greater than \$75k), insurance (public, private, uninsured), marital status (married, not married), count of available comorbidities in NHIS (heart disease, stroke, emphysema, asthma, ulcer,

severe migraine, diabetes), ever smoker, region (West, Midwest, South, East), and survey year.

The regressions for home productivity included an additional control variable for employment status. We included observations with complete responses for all covariates (N=266,229). Parts 1 and 2 were multiplied to estimate total expected home/work days lost in the population. We used seemingly unrelated estimation to combine the two parts of the regression models for variance estimates.<sup>23</sup> We used NHIS survey weights and stratum to account for the complex sampling procedure.

We then combined the per-person estimates of work and home days lost associated with breast cancer with the market value of those lost days and scaled by the number of mBC cases in the US. First, we calculated median annual earnings for our three age groups using weighted averages over the five-year age groups from the CPS with weights equal to the number of women in each five-year age group from the US Census. We divided the annual earnings by 250 work days in a year to calculate the average value of a work day lost by age group. For the value of a day of home production, we multiplied the average hourly earnings of female personal care and service workers by eight hours in a work day. Finally, to estimate the national value of lost productivity among survivors, for work and home production separately, we multiplied 1) the number of days missed associated with breast cancer in the first two years after diagnosis from the regression results by 2) the value of a day of production<sup>21</sup> and 3) the number of prevalent mBC cases. NHIS does not have information on stage of breast cancer at diagnosis or whether respondents had mBC. We assumed that mBC cases experienced the same work loss as the average woman across all stages of illness in the first two years after diagnosis. This assumption is likely to lead to conservative estimates for productivity costs associated with mBC among survivors, because the average life expectancy of a woman with mBC is about two years and mBC is associated with higher productivity loss than earlier-stage disease.<sup>24-26</sup>

### Years of Potential Life Lost

**Data**—The primary data source was the CDC’s 2015 National Vital Statistics Surveillance System, which provides data on breast cancer mortality and life expectancy for women.<sup>27</sup> We identified breast cancer as the underlying cause of death using International Classification of Diseases (10<sup>th</sup> edition) code C50. We assumed all deaths with breast cancer as the primary cause were attributed to mBC.

We obtained supplemental data from US Census Bureau’s 2016 CPS’ March Annual Social and Economic Supplement. The annual earnings from this data were based on reported 2015 earnings of employed primary or sole salary and wage workers, which was stratified by age, gender and employment status (i.e., full time and part time). Earnings were adjusted for the value of fringe benefits (e.g., health insurance, sick pay and retirement benefits).<sup>8,28</sup>

**Analysis**—We conducted all analyses separately for women in three life stages at the time of death: younger (aged 18-44), midlife (aged 45-64) and older (aged 65 and older). We calculated YPLL for each breast cancer death as the remaining life expectancy at the age of death. We then summed the YPLL across all breast cancer deaths, by age group, in 2015.

We valued the productivity losses associated with those YPLL using the present value of future lifetime earnings.<sup>9,29,30</sup> We used the same approach as Islami et al.<sup>9</sup> but extended their analysis to report YPLL and the value of lost earnings due to premature mortality for breast cancer by age group. Specifically, the present value calculation accounted for varying life expectancies, probabilities of surviving to the next age and employment rates by age. We used a 3% discount rate and assumed that earnings increased by 1.6% annually.<sup>9</sup>

To analyze uncertainty in earnings, we used Monte Carlo simulation to simulate 1,000 replications of the market value of YPLL for each age group. In each simulation, we drew median annual earnings from a normal distribution with the mean equal to the median and standard deviation equal to the standard error of the median earnings by 5-year age group from the CPS data. We constructed 95% confidence intervals using the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of the simulated distribution.

## RESULTS

### Productivity Costs among Women Living with mBC

We first present findings for productivity among women with breast cancer (all stages) compared to non-breast cancer cases. The number and proportion of breast cancer survivors in NHIS increased with the age group (Table 1). Among women with a history of breast cancer, the distribution of years since diagnosis skewed higher among women aged 65 and older relative to women aged 18-44. Women with a history of breast cancer were more likely to miss any work days (66.5% vs 50.6% among younger women and 54.9% vs 47.9% among midlife women), except among older women, and more likely to miss any home productivity days (60.4% vs 43.1% among younger women, 50.4% vs 41.4% among midlife women and 32.0% vs 30.3% among older women). Among younger and midlife women who do miss work and home productivity days, women with a history of breast cancer missed more days on average than women without a history of breast cancer (27.6 vs 8.0 work days and 25.4 vs 9.5 home productivity days among younger women; 21.6 vs. 11.0 work days and 25.0 vs 18.7 home productivity days among midlife women). Among women with a history of breast cancer, younger women tended to be more likely to have missed any days and, on average, lost more work and home productivity days than older women.

In the adjusted analysis of work and home productivity days lost, younger women within two years of their breast cancer diagnosis lost about seven to eight times the number of days than similar women without a history of breast cancer, although the estimates were unstable (Table 2). The point estimates for lost days remained higher than the non-breast cancer group through five years after diagnosis among younger women. Among women aged 45-64, breast cancer was associated with higher work and home productivity days lost in the first two years after diagnosis, and the effect diminished the further away the women were from diagnosis. Among women aged 65 and older, breast cancer was associated with a small increase in work days lost and home productivity days lost in the first two years after diagnosis.

Using the incremental days lost in the first two years after diagnosis as a lower bound estimate of the days lost associated with mBC, the annual per-woman value of lost days due

to mBC ranged from \$680 for older women to \$5,169 for younger women (Table 3). Based on SEER data, the estimated number of women living with mBC in the US was 12,950 younger women, 55,306 midlife women and 97,424 older women. Together, we estimated the value of lost work and home productivity days associated with mBC nationally to be \$67 million for younger women, \$246 million for midlife women and \$66 million for older women in 2015.

The estimated number of deaths from mBC in 2015 was highest among older women (24,991) and lowest among younger women (2,207; Table 4). However, the YPLL was highest among midlife women (403,786 life years), followed by older women (248,522 life years) and younger women (95,943 life years). Midlife women also had the highest market value of YPLL (\$4.1 billion) across the age groups. The market value of YPLL among younger women was higher than that among older women (\$1.6 billion vs \$527 million) despite younger women experiencing less than one tenth the number of deaths as older women.

## DISCUSSION

A major component of the economic burden of mBC is its effects on women's ability to work. This study estimated the value of lost productive time associated with mBC through two avenues: productive days missed at work and home due to illness and YPLL from premature mortality from mBC. We found that mBC was associated with \$6.6 billion in lost productivity from these two avenues nationally in 2015. Most of those costs (94% = \$6.2b/\$6.6b) were due to premature mortality due to high mortality rates for mBC and relatively short survival time once metastatic. We also found that the per-woman burden of mBC in terms of lost productive time was higher for younger women than for older women.

Our estimates are comparable to previous work. Like Ekwueme et al.,<sup>19</sup> we found the per-woman cost of lost productivity days at work and home were higher for younger women but that total work loss productivity costs were higher for midlife women. While that study focused on all breast cancer survivors aged 18-64, our study focused specifically on mBC and added older women (aged 65 and older) to the analysis. With respect to the value of YPLL associated with breast cancer deaths, several previous studies exist. Bradley et al.<sup>8</sup> found total costs of \$10.9 billion from breast cancer deaths in 2010, which, unlike the current study, included the value of home production of caregivers and housekeepers. Ekwueme et al.<sup>10</sup> focused on breast cancer deaths among women aged 20-49 and reported total costs of \$5.5 billion in 2008. Finally, Islami et al.<sup>9</sup> estimated \$6.2 billion in lost market earnings from premature mortality from breast cancer among all ages in 2015. Because we adopted Islami et al.'s<sup>9</sup> approach and source data, it is not surprising that we report similar total YPLL costs. However, we also report YPLL costs by lifecycle age group—an important departure from prior work, as it allows stakeholders to understand economic burden of mBC by age.

The age comparisons reveal important patterns in the productivity burden of mBC. The per-woman burden of mBC in terms of lost productive time was higher for younger women than for older women because younger women are more likely to be in the labor market and have

longer life expectancy. Younger women had about one tenth the estimated number of prevalent cases of mBC and breast cancer deaths of older women. However, the total market value of lost productive time among younger survivors and YPLL was about three times larger than for older women.

This study has several limitations. First, existing national data sources with information about employment and health for breast cancer survivors do not have information about incident or current cancer stage, which made it difficult to directly attribute lost work time to mBC. We attempted to be conservative in our estimate of lost work time associated with mBC by using the average time lost across all stages in the first two years. There is evidence that mBC is associated with higher productivity loss than earlier-stage disease.<sup>24</sup> Second, our estimates of the value of YPLL considered only workforce earnings and did not include the value of home production, which under-values women not in the labor force. Grosse et al.<sup>21</sup> estimated that the net present value of non-market (i.e., home) production was about 45% of total production for women, implying that, had we included non-market production, our estimates of the YPLL costs of mBC could have been nearly twice as large. Finally, the human capital approach that values time at market rates, even home production at market rates to hire out the work, may not fully capture willingness to pay for healthy time or other health-related quality of life costs.<sup>31-33</sup>

Our results demonstrate the high economic burden mBC generates through lost productivity, especially among midlife women. Midlife is, on average, women's most productive time of life; many women have caregiving responsibilities for children and aging parents and earnings peak during these ages for working women. Given that working women experience some of the greatest economic losses associated with cancer and frequently are sources of economic support for dependents living in the household, this study highlights the potential benefit of supportive resources to help women with mBC guard against potentially severe cancer-related financial losses for themselves and others within their households.<sup>36-38</sup> Further, it provides important data for future studies on the cost-effectiveness of preventive and therapeutic interventions to extend and improve the quality of life of mBC patients. For example, future studies of the value of new interventions for specific breast cancer subtypes that disproportionately affect women of different ages can use our results to model age-specific improvements in productivity.

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**Table 1.**

Descriptive statistics for women in National Health Interview Survey 2000-2016

	Age 18-44		Age 45-64		Age 65+	
	Breast Cancer	No Breast Cancer	Breast Cancer	No Breast Cancer	Breast Cancer	No Breast Cancer
N=	359	123,519	2,515	82,367	4,061	53,408
Years since diagnosis						
<2 years since diagnosis <sup>1</sup>	42.3	-	24.3	-	14.5	-
<2-4 years since diagnosis	26.5	-	21.5	-	14.9	-
5-10 years since diagnosis	18.1	-	25.0	-	20.6	-
11+ years since diagnosis	13.1	-	29.2	-	50.0	-
<b>Dependent Variables</b>						
Any work loss <sup>2</sup>	66.5	50.6*	54.9	47.9*	31.0	28.6
Work loss in days, mean (SD) <sup>3</sup>	27.6 (60.6)	8.0* (21.6)	21.6 (44.8)	11.0* (29.2)	13.9 (31.3)	13.0 (31.5)
Any home productivity loss	60.4	43.1*	50.4	41.4*	32.0	30.3*
Home productivity loss in days, mean (SD) <sup>4</sup>	25.4 (59.5)	9.5* (30.4)	25.0 (56.5)	18.7* (50.5)	22.8 (57.7)	21.5 (56.3)
<b>Demographic characteristics</b>						
Employed	74.4	78.3	64.1	70.5*	14.6	15.9*
Race/Ethnicity						
Non-Hispanic White	59.6	53.7*	73.8	65.3*	82.2	72.8*
Non-White	40.4	46.3	26.2	34.7	17.8	27.2
Education						
Less than high school	14.2	14.7	11.1	14.5*	19.2	26.7*
High school/GED	22.3	23.0	25.9	27.5	32.7	33.3
Some college	34.8	34.2	29.7	30.4	27.0	23.2
Bachelor's degree and above	28.7	28.0	33.4	27.5	21.1	16.8
Annual income (\$s)						
0-34,999	42.3	45.2	34.6	37.7*	58.2	63.3*
35,000-74,999	32.0	33.5	34.5	34.9	29.4	26.8
75,000+	25.6	21.3	30.9	27.4	12.4	9.8
Insurance Status						
Private	62.4	59.8	70.7	67.6*	2.1	3.0*
Public	23.4	24.8	24.2	21.3	97.8	96.4
Uninsured	14.2	15.4	5.2	11.1	0.1	0.6
Married	47.4	43.5	49.9	49.9	31.5	30.3
Smoking Status						
Ever smoker	42.3	31.5*	45.9	42.6*	41.9	37.8*
Never smoker	57.7	68.5	54.1	57.4	58.1	62.2*

	Age 18-44		Age 45-64		Age 65+	
	Breast Cancer	No Breast Cancer	Breast Cancer	No Breast Cancer	Breast Cancer	No Breast Cancer
N=	359	123,519	2,515	82,367	4,061	53,408
Count of comorbidities, mean (SD)	1.03 (1.17)	0.64* (0.88)	1.15 (1.14)	1.09* (1.14)	1.36 (1.05)	1.42* (1.11)
Region						
Northeast	17.5	17.3	19.8	19.1	18.9	19.6*
Midwest	22.8	22.3	22.6	22.2	25.4	23.1
South	35.4	36.9	35.5	36.5	34.5	36.6
West	24.2	23.5	22.2	22.2	21.2	20.6

<sup>1</sup>. % unless stated otherwise

<sup>2</sup>. Conditional on being employed.

<sup>3</sup>. Conditional on being employed and having any lost work days.

<sup>4</sup>. Conditional on having any days lost home productivity days.

\* indicates significant difference between breast cancer and non-cancer groups within age group at the 95% confidence level.

**Table 2.**

Work and home productivity days lost by lifecycle age group and breast cancer status

	<b>Work Days</b>	<b>Home Days</b>
Age 18-44		
No breast cancer	3.9 (0.1)	3.9 (0.1)
0-2 years since DX	32.6 (14.8)	27.8 (15.7)
2-5 years since DX	13.2 (6.1)	7.0 (2.5)
5-10 years since DX	9.7 (5.3)	4.4 (1.6)
10+ years since DX	2.7 (0.9)	4.2 (1.1)
Age 45-64		
No breast cancer	5.0 (0.1)	7.1 (0.1)
0-2 years since DX	30.2 (3.7)	24.2 (2.9)
2-5 years since DX	11.9 (4.0)	12.3 (3.1)
5-10 years since DX	8.5 (2.7)	11.1 (3.5)
10+ years since DX	6.2 (1.1)	12.7 (1.9)
Age 65+		
No breast cancer	3.6 (0.2)	6.9 (0.2)
0-2 years since DX	6.3 (1.9)	12.8 (1.9)
2-5 years since DX	2.5 (1.1)	7.7 (2.0)
5-10 years since DX	2.5 (0.9)	7.9 (1.4)
10+ years since DX	3.0 (0.7)	8.1 (1.2)

DX = diagnosis. Standard errors in parentheses.

**Table 3.**

Productivity costs among survivors of metastatic breast cancer (mBC) by lifecycle age group

	Age (years)		
	18-44	Age 45-64	Age 65+
<b>Work production</b>			
Percent employed	74.4	64.1	14.6
Days lost per woman <sup>1</sup>	28.7	25.2	2.7
Value of day <sup>2</sup>	\$126	\$ 166	\$ 147
Value of lost days per woman <sup>3</sup>	\$ 2,701	\$ 2,680	\$ 58
<b>Home production</b>			
Days lost per woman <sup>1</sup>	23.8	17.1	6.0
Value of day <sup>4</sup>	\$ 104	\$ 104	\$ 104
Value of lost days per woman <sup>3</sup>	\$ 2,469	\$ 1,774	\$ 622
<b>Total</b>			
Value of lost days per woman <sup>5</sup>	\$ 5,169	\$ 4,454	\$ 680
<b>Prevalent mBC cases<sup>6</sup></b>	12,950	55,306	97,242
<b>Value of lost days nationally (millions 2015 \$)<sup>7</sup></b>			
Work	\$ 35	\$ 148	\$ 6
Home production	\$ 32	\$ 98	\$ 61
Total	\$ 67	\$ 246	\$ 66

<sup>1</sup>. Difference between 0-2 years after diagnosis and no breast cancer group in Table 2.

<sup>2</sup>. Median annual wages for full time female workers from Islami et al. (2019)<sup>8</sup> divided by 250 work days per year.

<sup>3</sup>. Days lost per woman multiplied by the value of a day.

<sup>4</sup>. Average hourly earnings of female personal care and service occupation workers, adjusted for fringe benefits, from Grosse et al. (2018)<sup>21</sup> multiplied eight hours per day.

<sup>5</sup>. Sum of value of lost days per woman for work and home production.

<sup>6</sup>. Prevalent breast cancer cases (all stages) multiplied by the proportion with distant metastases.<sup>3,20</sup>

<sup>7</sup>. Prevalent mBC cases multiplied by the value of lost days per woman.

**Table 4.**

Years of potential life lost (YPLL) and market value of YPLL by lifecycle age group

Age Group (years)	Breast Cancer Deaths, 2015	YPLL	Market Value (millions 2015 \$)
18-44	2,207	95,943	1,599 (1,590 - 1,608)
45-54	14,315	403,786	4,086 (4,052 - 4,122)
65+	24,991	248,522	527 (511 - 541)

YPLL = years of potential life lost

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