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Estimating Productivity Loss from Breast and Non–Small-Cell Lung Cancer among Working-Age Patients and Unpaid Caregivers: A Survey Study Using the Multiplier Method

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Abstract

Background. Traditional approaches to capturing health-related productivity loss (e.g., the human capital method) focus only on the foregone wages of affected patients, overlooking the losses caregivers can incur. This study estimated the burden of productivity loss among breast cancer (BC) and non–small-cell lung cancer (NSCLC) patients and individuals caring for such patients using an augmented multiplier method. **Design.** A cross-sectional survey of BC and NSCLC patients and caregivers measured loss associated with time absent from work (absenteeism) and reduced effectiveness (presenteeism). Respondents reported pre- and postcancer diagnosis income, hours worked, and time to complete tasks. Exploratory multivariable analyses examined correlations between respondents' clinical/demographic characteristics—including industry of employment—and postdiagnosis productivity. **Results.** Of 204 patients (104 BC, 100 NSCLC) and 200 caregivers (100 BC, 100 NSCLC) who completed the survey, 319 participants (162 BC, 157 NSCLC) working ≥40 wk/y prediagnosis were included in the analysis. More than one-third of the NSCLC (33%) and BC (43%) patients left the workforce postdiagnosis, whereas only 15% of caregivers did. The traditional estimate for the burden of productivity loss was 66% lower on average than the augmented estimate (NSCLC patients: 60%, BC patients: 69%, NSCLC caregivers: 59%, and BC caregivers: 73%). **Conclusions.** Although patients typically experience greater absenteeism, productivity loss incurred by caregivers is also substantial. Failure to account for such impacts can result in substantial underestimation of productivity gains novel cancer treatments may confer by enabling patients and caregivers to remain in the workforce longer. Our results underscore the importance of holistic approaches to understanding this impact on both patients and their caregivers and accounting for such considerations when making decisions about treatment and treatment value.

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Highlights

- Cancer can have a profound impact on productivity. This study demonstrates how the disease affects not only patients but also the informal or unpaid individuals who care for patients.
- An augmented approach to calculating health-related productivity loss suggests that productivity impacts are much larger than previously understood.
- A more comprehensive understanding of the economic burden of cancer for both patients and their caregivers suggests the need for more support in the workplace for these individuals and a holistic approach to accounting for these impacts in treatment decision making.

Keywords
breast cancer, human capital method, lung cancer, multiplier method, productivity loss

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Introduction

The economic burden of productivity loss is increasingly examined in cost-of-illness studies. The Second Panel on Cost-Effectiveness in Health and Medicine recommended that cost-effectiveness analyses include a societal perspective, which includes productivity effects, as a reference case.[1,2] Value assessments that exclude productivity benefits often undervalue interventions, which may influence coverage decisions.[3]

The most common approach to estimate productivity loss is the traditional human capital method, which uses the cost of the employee to value lost productivity due to illness. This is grounded in economic theory, which suggests that the marginal product of the worker will at least equal the full marginal cost of employing that worker.[4] When implemented as intended, application of the human capital method requires the measurement of the full marginal cost of the worker to the firm, which consists of an individual's money income or wage, plus the value of fringe benefits and employer-paid payroll taxes. Because wages are often readily available in survey data and fringe benefits are not, in practice, researchers often consider only lost work hours and the individual's money wages to estimate productivity loss. This approach to valuing lost time, however, would likely undervalue the burden of productivity loss[5,6] and thereby fail to fully capture the value of output lost due to illness or the value of additional output from treatment.

In addition to omitting the value of fringe benefits (and employer-paid payroll taxes), the typical implementation of the human capital method also fails to account for potential spillover loss in the productivity of coworkers.[7] Prior studies have shown that the value of total lost productivity often exceeds the worker's individual productivity loss. In team production settings, in particular, the absence of a worker will typically impose greater costs in lost output than the value of the worker's compensation because other team members are also less productive during the absence (i.e., the effect multiplies). To illustrate how the omitted effect on team members leads to underestimation, imagine a simplified example of 2 individuals producing a widget. Both individuals are required to make the widget, and each individual is

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compensated the amount w per hour. Together they make 1 widget per hour, which is sold for a price of $2w$. (In our example, we set the product price equal to the total amount paid to factors of production in order to be consistent with economic equilibrium.) If 1 worker misses an hour due to illness, the traditional human capital measure would value the lost productivity at w. However, the coworker is also unproductive during this time because both individuals are required to produce the widget. Thus, the actual societal productivity loss would be $2w$, the price (or marginal value to society) of the widget that is not produced.

The "multiplier method" has been designed to overcome this limitation of the traditional method. It measures not only the lost productivity of the ill individual but also the lost productivity of colleagues and the wider organization due to the worker's absenteeism or presenteeism.[8–10] Absenteeism refers to time missing from work, or the extensive margin of a unit of labor. Presenteeism refers to the intensive margin of a unit of labor, or the worker's reduced productivity while present at work. For example, an individual with cancer may suffer from fatigue or nausea from medications or psychological consequences of illness that reduce their ability to be as effective on the job as they were prior to their illness.

Another avenue in which a single diagnosis can have a spillover effect is through an unpaid or informal caregiver who chose to devote their time and effort to provide care. In 2017, about 41 million informal or unpaid caregivers in the United States provided an estimated 34 billion hours of care, corresponding to $470 billion of economic value, to adults with limitations in daily activities.[11] Caregivers of individuals with cancer—approximately 7% of adult caregivers[11,12]—are often the most vulnerable to emotional strain and distress, which may affect their productivity and thus should be considered in the productivity estimates.[13–17]

Although the diagnostic and treatment landscape in oncology has dramatically improved, cancer-related morbidity remains, creating a major cost to patients and to society. Two high-incidence cancers, breast cancer (BC) and non–small-cell lung cancer (NSCLC), have been found to result in high health care expenditures and lost productivity.[18–20] With these challenges in mind, we conducted a study of working-age BC and NSCLC patients and caregivers of BC and NSCLC patients, aiming to quantify the burden of productivity loss among this population and the extent to which the value of productivity loss is underestimated using the traditional human capital method when omitting the effects of team production and fringe benefits (including employer-paid payroll taxes).

Throughout this article, "traditional method" refers to typical applications of the human capital method whereby productivity loss is calculated by taking a worker's monetary income or wage to value a unit of work time and then multiplied by the amount of time lost due to illness. Our "augmented method" includes separate corrections for team production and for fringe benefits (we include employer-paid payroll taxes within the term "fringe benefits"). We show separate calculations for patients and their unpaid caregivers and present differences in percentage terms.

Methods

Overview of Study Design

To quantify the burden of productivity loss among BC and NSCLC patients and unpaid caregivers of such patients, this study used two web-based cross-sectional, prospective surveys. The Advarra Institutional Review Board, an independent organization accredited by the Office for Human Research Protections and the Association for the Accreditation of Human Research Protection Programs in the United States, reviewed study procedures and granted human subjects approval.

Study Population

The surveys were fielded to a convenience sample of 1) individuals aged 18–64 years with a self-reported diagnosis of BC or NSCLC, currently receiving cancer treatment, and employed at the time of their diagnosis and 2) individuals aged 18–64 years who had reported providing unpaid or informal care to a patient diagnosed with BC or NSCLC and employed at the time of the patient's diagnosis or the onset of caregiving. For this study, we specifically targeted the working age population because we sought to understand the effects of a cancer diagnosis on workplace productivity. Selected panel members were invited to participate in the survey through Schlesinger Group's online research panel (https://www.schlesingergroup.com/en/). Patients were invited for participation in the study irrespective of their cancer subtype, biomarker status, or stage at diagnosis. Paid caregivers were excluded from participation. Interested participants were directed to a website to complete eligibility screening that included questions about the respondent's history of cancer (patient) or history of caring for a patient with cancer (caregiver). Both patients and caregivers

Table 1 Input Variables for Burden of Productivity Loss Calculations[a]

Variable	Survey Question	Response Options
Lost productive time (absenteeism)	PRIOR TO YOUR CANCER DIAGNOSIS, on average, how many hours did you work for pay during a typical 7-day period?	Free text
	PRIOR TO YOUR CANCER DIAGNOSIS, how many weeks (out of 52 total) of a year were you on the job? For example, if you take 4 weeks off a year, regardless of whether it is paid or unpaid leave, your answer should be 48 weeks.	
	PRIOR TO YOUR CANCER DIAGNOSIS, approximately how many hours a week did you spend on: housework, shopping, odd jobs and chores, doing things for or with your own children, voluntary activities.	
	POST DIAGNOSIS: During the past 7 days, how many hours did you work for pay?	
	POST DIAGNOSIS: During the last year, how many weeks (out of 52 total) of a year were you on the job? For example, if you take 4 weeks off a year, regardless of whether it is paid or unpaid leave, your answer should be 48 weeks.	
	POST DIAGNOSIS: During the past 7 days, how many hours of paid work did you miss, (e.g., called in sick) as a result of your cancer diagnosis and/or treatment?	
Lost productive time (presenteeism)	POST DIAGNOSIS: Think about all the work you have completed during the past 7 days. Would you complete the same amount of work in less time if you were NOT experiencing any cancer-related health problems (i.e., any physical, mental, or emotional problems or symptoms)?	Yes/No/Not applicable
	POST DIAGNOSIS: Think about all the paid work you have completed in the past 7 days.	Free text
	a. How many hours did it take you to complete that work?	
	b. How many hours would it have taken you to complete that work before your current health problems?	
Wage	What was your income from work in the 12 months PRIOR TO YOUR CANCER DIAGNOSIS?	$14,999 or less
	POST DIAGNOSIS: What is your current annual income?	$15,000 to $24,999
		$25,000 to $34,999
		$35,000 to $49,999
		$50,000 to $74,999
		$75,000 to $99,999
		$100,000 to $149,999
		$150,000 or more

[a]In the caregiver survey "PRIOR to the time of your cancer diagnosis" was replaced with "PRIOR to assuming a role as a caregiver."

were required to be proficient in the English language, as the surveys were administered in English.

Survey Development

Two separate, but complementary, surveys were developed, each tailored to the specific respondent population. To calculate the burden of productivity loss, the survey instruments included questions designed to collect work income information as well as information on productive time lost due to a cancer diagnosis or due to providing care to a patient with cancer, respectively (Table 1). To measure absenteeism, respondents were asked about the number of 1) hours worked during a typical 7-d period and 2) weeks worked during a 52-wk period before and after the cancer diagnosis or assuming caregiving duties, respectively. To measure presenteeism, the respondents were prompted to think about an average 7-day period, and the work completed during that time. Subsequently, the respondents were asked about the number of hours it took to complete the work and the number of hours it would have taken to complete the work, had the respondent been healthy or did not need to provide care.

To calculate the teamwork multiplier, we queried respondents about their work environment and included questions designed to collect information on the percentage of time worked in teams, the typical size of teams, impact of absenteeism/presenteeism on team outcome,

Table 2 Workplace Characteristics to Calculate Teamwork Multiplier[a]

Variable	Survey Question	Response Options
Teamwork	Think about your job PRIOR to the time of your cancer diagnosis. How often did you work within a team? Please select ONE answer that BEST describes your situation.	None of the time About 25% of the time About 50% of the time About 75% of the time All the time
Team size	Think about your job PRIOR to the time of your cancer diagnosis. How many coworkers were typically in your team (excluding you)?	Free text
Impact on team outcome	Think about your job PRIOR to the time of your cancer diagnosis. What was the impact of your absence on how well the team functioned? Please select ONE answer that BEST describes your situation.	Functioned as usual Affected a little bit—about 25% of the time Affected somewhat—about 50% of the time Affected quite a lot—about 75% of the time Cannot function—affected all the time
Substitutability (yes/no, who)	Think about your job PRIOR to the time of your cancer diagnosis. Was your work taken over when you were absent (due to illness)? Think about your job PRIOR to the time of your cancer diagnosis. Who took over your work when you were absent (due to illness)?	Taken over by others Partly taken over; partly postponed Postponed entirely Coworkers or supervisors Temporary workers/additional staff hired from outside agencies to do my work No one
Efficiency of substitute by coworker or supervisor	Think about your job PRIOR to the time of your cancer diagnosis. If you were absent, could any of your coworkers or supervisors complete your work? Please select ONE answer that BEST describes your situation.	There are coworkers who could complete my work in the same amount of time as me There are coworkers who could complete my work 75% of the time There are coworkers who could complete my work 50% of the time There are coworkers who could complete my work 25% of the time There are no coworkers who could complete my work
Efficiency of substitute by temp worker	Think about your job PRIOR to the time of your cancer diagnosis. Could any temporary workers hired from external agencies complete your work? Please select ONE answer that BEST describes your situation.	There are temporary workers who could complete my work in the same amount of time as me There are temporary workers who could complete my work 75% of the time There are temporary workers who could complete my work 50% of the time There are temporary workers who could complete my work 25% of the time There are no temporary workers who could complete my work

[a]In the caregiver survey, "PRIOR to the time of your cancer diagnosis" was replaced with "PRIOR to assuming a role as a caregiver."

and the type of substitution available in the case of absenteeism/presenteeism (Table 2).

All surveys included an eligibility screener, a module assessing lost productive time, a module assessing wage and workplace characteristics, questions on employment at the time of diagnosis or onset of caregiving, and a module on clinical characteristics of the patient and sociodemographic characteristics of the respondent. We hypothesized that the clinical characteristics of the patient respondent or patient cared for might affect the

lost productive time of the patient themselves, as well as the lost productive time of the caregiver. Thus, we collected self-reported clinical data including information on cancer type and stage of disease, treatments received, mutation status, and presence of comorbidities. We also collected self-reported sociodemographic characteristics, including information on respondent race, ethnicity, and gender, as well as other variables such as marital status and education level, to investigate if these classification variables could have an effect on wages and workplace impacts.

Survey modules were developed based on published questionnaires.[8,10,13–15] To ensure that the survey instruments were appropriate for the target sample populations, a medical oncologist and health economist reviewed the content of the developed surveys and adapted questions that were pertinent for addressing the objectives of the current study.

Survey Administration

The study was performed in two phases: a pilot testing phase, conducted in May 2019, and a primary data collection phase, conducted from September to October 2019. Eight individuals were recruited to pilot test the surveys and assess respondent comprehension of the background content and survey questions. Modifications to the revised surveys based on pilot feedback were editorial in nature, with the exception of two material changes. First, in the original version, participants were asked to calculate and report hours worked per week. Participants who worked hourly (variable shifts) as opposed to salaried employees found this difficult to calculate on a consistent basis. This question was modified to ask about average hours worked per day. Second, participants found the question asking about weeks of paid work per year (out of 52) to be confusing. We revised this question by providing more detail (e.g., stating "on the job") and providing an example (i.e., "If you take 4 weeks off a year, regardless of whether it is paid or unpaid leave, your answer should be 48 weeks"). Results from the pilot testing and consultation with clinical experts informed revisions to the final versions of the 2 surveys, both of which were hosted on a web-based survey platform.

After the pilot studies and revisions were completed, recruitment for both the patient and caregiver surveys began. We arrived at a target sample size of $N = 400$ participants with 200 individuals per survey sample, a sample comparable to similar studies.[10,21,22]

The survey vendor contacted potential participants from proprietary panels of cancer patients and caregivers. Patients with BC or NSCLC were identified from the survey vendor's cancer patient panel, and individuals in the survey vendor's larger participant panel who did not report a previous or current diagnosis of BC or NSCLC and who met study eligibility criteria were recruited for the caregiver sample. These participants were not the caregivers of participants enrolled in the patient sample. Study participants received an e-mail with a link to the online survey website. After providing informed consent, participants were directed to a set of instructions and then asked a series of questions to assess their eligibility. Those who failed to provide informed consent or who did not meet the eligibility criteria were excluded. To ensure a balanced sample, we set sample quotas by cancer type, time since diagnosis, and stage of disease; however, we did not establish quotas by other sociodemographic characteristics including gender, race, or ethnicity. Once sample quotas were filled, the survey was closed to further respondents possessing a particular characteristic of interest.

Before administration of each module, the respondents were provided instructions about the type of questions they would be asked. For example, in the workplace characteristics module, respondents were provided the following background: "In this section, think about your job PRIOR to the time of your cancer diagnosis. We will ask about some characteristics of your workplace at that time. For each of the following questions, please indicate the response that best describes your situation. If you are unsure about how to respond to a question, please give the best answer you can."

All respondents who successfully completed the survey, including the pilot test participants, were compensated for their time and effort.

Data Analysis

This study aimed to estimate the value of productivity loss associated with a cancer diagnosis using the traditional human capital method and to compare that with the estimated value of productivity loss when also considering team production and the value of fringe benefits. To include team production and fringe benefits into productivity loss calculations, teamwork multipliers and fringe benefits multipliers were estimated for the eligible cancer patient and caregiver samples. These multipliers were then used to adjust the traditional estimate of productivity loss to find a more accurate measure of the burden of cancer-related productivity loss.

In addition, we explored possible links between the teamwork multipliers and socioeconomic characteristics.

We examined which industries tend to have higher teamwork multipliers and therefore a burden of productivity loss from a cancer diagnosis. Using an ordinary least squares regression analysis, we also explored who is more likely to have a larger impact on team productivity based on demographic and socioeconomic characteristics.

Teamwork Multiplier

To estimate the teamwork multiplier, we followed a framework presented in prior studies.[8–10] The additive algorithm described below was used to derive a teamwork multiplier for the individual:

$$\textit{teamwork multiplier} = 1 + (\textit{subsitution factor} * \textit{team effect})$$

A teamwork multiplier of 1 indicates that the total productivity loss corresponding to a worker's lost productive time is derived solely from the individual's personal productivity loss. That is, either 1) the worker's tasks can be completed by others with equal efficiency or 2) there are no complementarities between the productivity of the individual and other team members. A teamwork multiplier larger than 1 indicates that in addition to individual productivity loss, there is an effect on the overall team's production. There are complementarities in the team, and the individual's tasks (and inability to find substitutes for the individual) prevent these tasks from being fully completed when the individual is ill.

The team effect variable, which measures the impact of absenteeism or presenteeism on team productivity, was calculated as the product of percentage of time worked in teams, typical team size (excluding the respondent), and the impact on team function:

$$\begin{aligned}\textit{team effect} &= \%\ \textit{of time worked in teams}\\ &* \textit{typical team size (excluding the respondent)}\\ &* \textit{team function without worker}\end{aligned}$$

The substitution factor is 1 if no one can substitute for the worker. If the job could be filled and entirely performed by a coworker or a temporary worker, the substitution factor is 0. If the work can be only partially completed by a replacement worker, the substitution factor is assigned a number between 0 and 1, depending on efficiency of the coworker or temporary worker. In essence, the substitution factor can be defined as

$$\textit{substitution factor} = \begin{cases} 0, & \textit{perfect substitute exists} \\ (0,1), & \textit{imperfect substitute exists} \\ 1, & \textit{no substitute exists} \end{cases}$$

Please note that the team effect excludes the respondent but is included in the teamwork multiplier calculation. Take, for example, an individual who works 100% of the time with 4 other individuals. The 4 coworkers would represent the team size (excluding the respondent) and be included under the team effect. The teamwork multiplier would then be 5, essentially incorporating the individual respondent and the rest of the team.

Fringe Benefits Multiplier

To account for fringe benefits, we needed to measure the average proportion of an employee's cost that is not directly paid to the employee, that is, the rate of payroll tax and nonpecuniary benefits. Since the proportion of total compensation that is not paid directly to the employee is usually not readily known by the employee, we turn to data from employers. We used employer cost data reported by the Bureau of Labor Statistics, which regularly collects and releases data on the average cost to employers including wages/salaries and benefits per employee hour worked. The information is collected through the National Compensation Survey,[23] which tracks approximately 35,000 occupations from nearly 8,000 establishments. We matched the respondent's reported industry of employment to data from the National Compensation Survey to obtain the average proportion of the fringe benefits for a worker in a given industry.

We calculated the fringe benefits multiplier by using the average proportion of the total cost of an employee that is allocated to fringe benefits (defined as B_f) and find the multiplier by computing $\frac{1}{1-B_f}$. For example, a fringe benefit multiplier of 1.25 indicates that an employer incurs an additional 25% of cost on top of wages in terms of benefits and payroll tax.

Value of Productivity Loss

The augmented value of productivity loss was calculated based on components of the traditional method and the estimated multipliers. These components include 1) lost productive time (either due to absenteeism or presenteeism), 2) baseline (precancer diagnosis or precaregiving) income, 3) teamwork multiplier (to adjust for productivity loss of team members), and 4) fringe benefits multiplier (to adjust for employer cost beyond wages paid to workers such as health insurance, pension benefits, and payroll taxes). The adjusted productivity loss was determined by calculating the product of measured wages

Table 3 Framework for Burden of Productivity Loss

Approach	Burden of Productivity Loss
Traditional human capital method	*lost productive time∗wage*
Augmented multiplier method	*lost productive time∗wage∗teamwork multiplier∗fringe benefits multiplier*

and lost productive time and multipliers, as applicable (Table 3).

Results

Study Population

A total of 2,744 responded to the study invitation (1,541 patients, 1,203 caregivers), with 1,320 individuals immediately excluded for not meeting study inclusion criteria or not providing informed consent. Of these, 865 patients were allocated to the patient group and 204 completed the survey. In the caregiver sample, 559 caregivers were allocated to the caregiver group and 200 completed the survey. Participation was closed to further enrollment upon meeting the quota of 200 respondents per respondent type. Of these, 10 individuals across both samples were excluded from the analysis for inadequately answering questions about their workplace substitutability. This occurred for individuals who responded "don't know" for how substitutable they were or if they made contradictory statements.

An additional 60 participants were excluded because they reported less than 40 weeks of working time in the year prior to diagnosis. The 40-wk minimum per work-year requirement was set to allow us to study individuals who worked on a consistent basis. The Bureau of Labor Statistics has reported that between 2010 and 2019, the median number of weeks of unemployment was 12.6 weeks.[24] Given our threshold of working a minimum of 40 of 52 wk, we are likely capturing individuals who are consistently working or those who may have been a consistent worker but became unemployed during this time period.

In addition, a very small number (n = 15, 3.7% of participants) were excluded because of a large increase in hours worked per week (from <10 prediagnosis to 30 or more postdiagnosis). A total of 319 participants (82 BC, 76 NSCLC patients; 80 BC, 81 NSCLC caregivers) were included in the final analysis (Figure 1).

The mean age was 45 years for NSCLC patients and 48 years for BC patients; corresponding figures among caregivers were 41 years and 40 years, respectively. A higher proportion of males constituted the NSCLC patient sample. With respect to educational attainment, more than half of patients and caregivers had achieved a bachelor's degree or higher (59% patients and 61% caregivers). Table 4 details the summary statistics for respondent characteristics.

Impact on Absenteeism and Presenteeism

The proportion of patients who left the workforce was much higher than that for caregivers: 32% of NSCLC and 41% of BC patients left the workforce after diagnosis, whereas only 15% of both NSCLC and BC caregivers left the workforce after the onset of caregiving (Table 5).

Given that the proportion of patients who left the workforce was higher, it is unsurprising that patients incurred more absenteeism than caregivers. After diagnosis, on average, NSCLC patients worked only 51% of the hours they worked prior to diagnosis, whereas a similar value for BC patients was 41%. NSCLC and BC caregivers worked 61% and 68%, respectively, of the hours relative to prediagnosis (Table 5).

Of those who remained in the workforce, presenteeism was found to have a similar effect on all the subgroups. Patients with BC reported themselves to be only 88% as productive compared with prediagnosis, while NSCLC patients were only 79% as productive as they were prior to diagnosis. Similarly, NSCLC and BC caregivers were 89% and 79%, respectively, as productive as they were prediagnosis (Table 5). (Since presenteeism can be calculated only for individuals who could provide their level of efficiency in the workplace after diagnosis, presenteeism in Table 5 is calculated only for those who remained in the workforce.)

Comparison of the Augmented Method with the Traditional Method

The evidence indicates a substantial loss in total productivity because of losses to team production. Failure to account for fringe benefits also leads to underestimates of productivity loss. The average teamwork multiplier was 1.85, and the average fringe benefit multiplier was 1.26. When combined, these two effects result in a multiplier of 2.33. The combined multipliers for NSCLC and

Table 4 Patient and Caregiver Demographics and Health-Related Characteristics

	NSCLC Patients $n = 100$	BC Patients $n = 104$	NSCLC Caregivers $n = 100$	BC Caregivers $n = 100$
Age, y (mean)	44.92 (11.60)	48.11 (9.94)	40.97 (10.94)	40.1 (9.40)
Age (youngest)	25	27	22	19
Age (eldest)	64	63	64	60
% Male	60	0	51	43
% Female	40	100	49	57
Race				
American Indian or Alaska Native	3	1	0	1
Asian	3	2	4	3
Black or African American	8	8	14	22
Native Hawaiian/Pacific Islander	0	1	0	0
Caucasian	84	89	79	70
Two or more	1	1	1	1
Other	1	2	2	3
Ethnicity				
Hispanic or Latino	19	1	19	20
Not Hispanic or Latino	81	96	81	80
Marital status				
Currently married	65	56	52	62
Not married but living with a partner	9	7	10	14
Widowed	1	3	3	1
Divorced	5	23	8	6
Separated	4	3	1	1
Never married	6	12	26	16
Level of education attained				
Less than high school	2	0	0	1
Some high school, no degree	1	0	2	2
High school graduate or GED	12	9	18	9
Some college, no degree	12	21	10	13
Associate's degree (e.g., AA, AS, etc.)	11	15	13	11
Bachelor's degree (e.g., BA, BS, etc.)	39	37	36	46
Some graduate courses, no degree	5	4	4	2
Graduate degree or higher	18	18	17	16
Health insurance status				
Commercial health insurance	75	70		
Medicare (fee-for-service)	17	8		
Medigap	4	1		
Medicare Advantage	10	2		
Medicaid	9	20		
Military health care	7	2		
Single service plan	3	2		
Other insurance, please specify	2	3		
No coverage of any type	2	3		
Don't know	2	0		
Household income				
$14,999 or less	2	5	5	0
$15,000 to $24,999	6	13	7	12
$25,000 to $34,999	12	17	11	11
$35,000 to $49,999	9	18	1	19
$50,000 to $74,999	17	25	16	24
$75,000 to $99,999	23	11	20	25
$100,000 to $149,999	19	11	15	13
$150,000 or more	12	4	15	6
Industry of employment[a]				
Agriculture, forestry, fishing, and hunting	4	0	0	0
Mining, quarrying, and oil and gas extraction	1	0	0	0

(continued)

Table 4 (continued)

	NSCLC Patients $n = 100$	BC Patients $n = 104$	NSCLC Caregivers $n = 100$	BC Caregivers $n = 100$
Utilities	5	0	6	1
Construction	18	9	11	12
Manufacturing	10	7	11	10
Wholesale trade	0	1	0	0
Retail trade	7	5	8	13
Transportation and warehousing	1	1	4	1
Information	5	1	9	4
Finance and insurance	10	7	4	8
Real estate and rental and leasing	2	4	1	2
Professional, scientific, and technical services	9	12	9	10
Management of companies and enterprises	3	1	3	2
Administrative and support	1	1	3	0
Educational services	5	19	3	3
Health care and social assistance	6	14	8	13
Arts, entertainment, and recreation	2	1	1	5
Accommodation and food services	1	1	3	0
Other services (except public administration)	2	2	2	3
Public administration	0	0	0	2
Other	8	18	14	11
Patient's stage of cancer at diagnosis				
Stage 1	14	22	14	22
Stage 2	30	33	30	33
Stage 3	31	27	31	27
Stage 4	25	22	25	22
Time since cancer patient's diagnosis				
Less than 3 mo ago	5	1	5	1
3–6 mo ago	10	5	10	5
6–12 mo ago	21	7	21	7
1–3 y ago	52	38	52	38
3–5 y ago	9	21	9	21
5–10 y ago	3	32	3	32

NSCLC, non–small-cell lung cancer; BC, breast cancer.
[a]Industry categories are consistent with Bureau of Labor Statistics classifications.

BC patients were 2.06 and 2.36, respectively. As for caregivers, the combined multipliers were 2.29 and 2.62 for NSCLC and BC, respectively.

For the patient and caregiver population, using the traditional method, the average burden of productivity loss associated with a cancer diagnosis across both cancer types was calculated to be $40,088. After incorporating the teamwork and fringe benefits multipliers, the average burden of productivity loss was estimated to be $116,623. Thus, the overall productivity loss was underestimated by 66% when omitting fringe benefits and team production (Table 6).

For NSCLC patients, the traditional method underestimated the burden of productivity loss by 60% ($125,974 estimated with the fringe benefits and teamwork multipliers, as opposed to $50,328 estimated with the traditional method). For BC patients, the burden of productivity loss was underestimated by 69% ($120,404 using the multiplier method compared with $37,445 with the traditional method). Among the caregivers, the traditional method underestimated the burden of productivity loss by 59% for NSCLC caregivers and by 73% for the BC caregivers relative to the augmented method (Table 6; Figure 2).

Heterogeneity across Industries

We explored variation in the multipliers across different industries. Figures 3 and 4 show absenteeism quotients (i.e., the ratio of productive work time postdiagnosis to prediagnosis) and teamwork multipliers by major industries: construction (19 patients, 20 caregivers), finance/insurance (14 patients, 9 caregivers), education (15 patients, 5 caregivers), health care (17 patients, 15

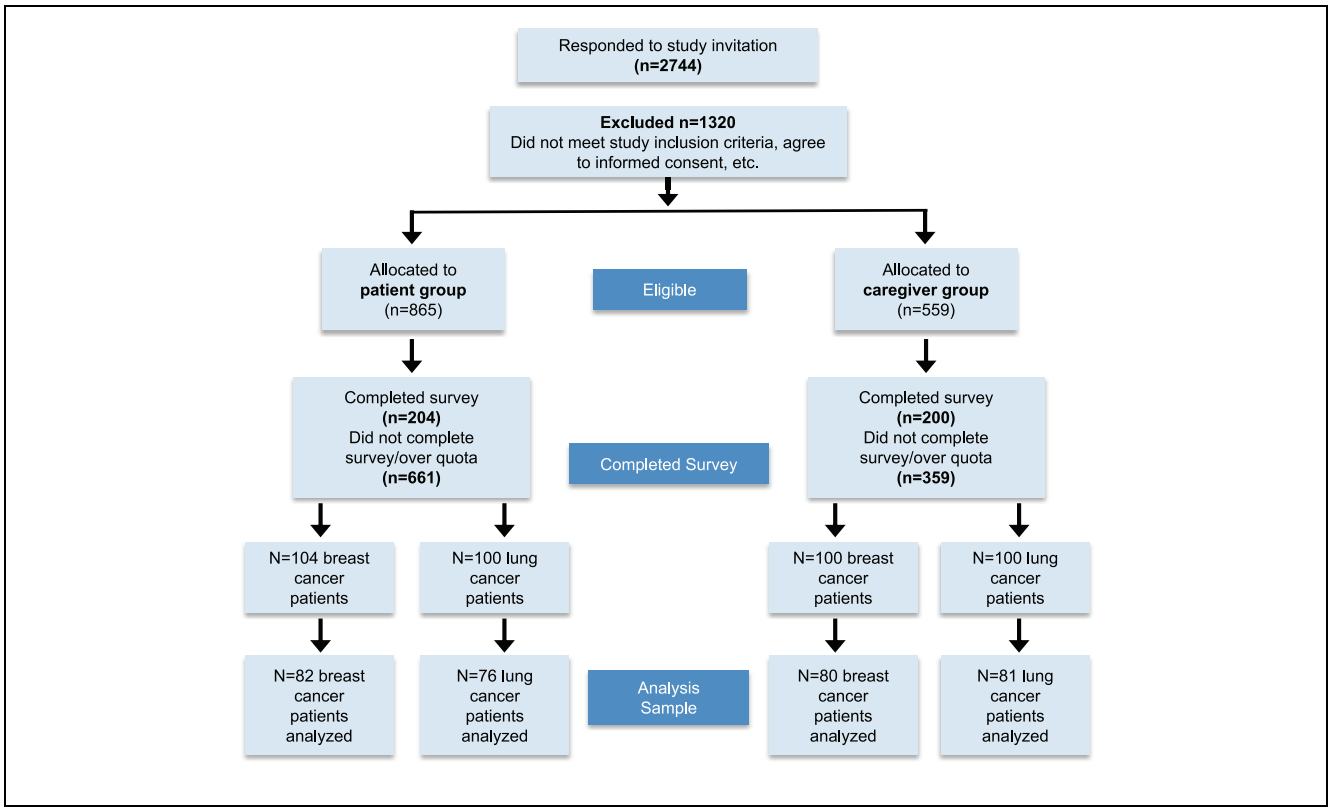

Figure 1 Consort Flow Diagram Stratified by Sample.

caregivers), manufacturing (14 patients, 15 caregivers), retail (11 patients, 17 caregivers), and professional/scientific/technical services (19 patients, 18 caregivers). We found that the average teamwork multiplier was 1.89 across all participants; however, the teamwork multiplier was consistently above average in the professional/scientific/technical services, ranging from 2.03 to 3.13 between different subgroups. Among respondents employed in the health care industry, absenteeism for patients was similar to that seen in other sectors; however, for caregivers, absenteeism was relatively low—only 9% to 11% decrease in working hours was observed (Figure 3). For the 5 caregivers employed in the education sector, the loss from absenteeism was found to be very high, with 89% and 99.9% reduction in hours worked.

Worker Characteristics Associated with Team Production

We also explored which demographic characteristics were correlated with the teamwork multipliers. Figure 4 and Table 7 detail the results from the regression analysis of the teamwork multiplier on various demographic characteristics. The duration of employment in the current job was a significant predictor of the teamwork multiplier for patients, whereas income was also strongly correlated with the teamwork multiplier for both the patient and caregiver groups.

For the educational attainment variables, we combined responses into degree levels. We combined "less than high school" and "some high school but no degree" into our reference category, high school degree and some college (no degree) into the high school degree category, bachelor degree and some post-college (no degree) into the bachelor degree category, and associate's degree and graduate degree remain in their own categories. Although none of the educational attainment categories were found to have a significant impact on the teamwork multiplier, it should be noted that income, age, and current job tenure were highly correlated with educational attainment, and thus, the lack of statistical significance on the educational attainment categories may be because they are highly collinear with other covariates. Alternatively, the statistical significance of the income coefficients despite the inclusion of educational attainment variables in the regression may imply that within

Table 5 Mean Absenteeism/Presenteeism/Multipliers[a]

	NSCLC Patients	BC Patients	NSCLC Caregivers	BC Caregivers	All
Teamwork multiplier	1.62	1.84	1.82	2.08	1.85
n	76	82	81	80	319
SD	1.18	2.48	2.47	2.28	2.18
Absenteeism	0.51	0.41	0.61	0.68	0.55
n	76	82	81	80	319
SD	0.65	0.43	0.41	0.84	0.61
Presenteeism	0.79	0.88	0.89	0.79	0.80
n	52	48	69	68	237
SD	0.21	0.16	0.21	0.21	0.20
Fringe benefits multiplier	1.27	1.26	1.26	1.26	1.26
n	76	82	81	80	319
SD	0.05	0.05	0.06	0.04	0.06
Left workforce after diagnosis, % (*n*)	32 (24)	41 (34)	15 (12)	15 (12)	26 (82)

NSCLC, non–small-cell lung cancer; BC, breast cancer.
[a]Absenteeism was calculated for the entire respondent samples for both patients and caregivers. Presenteeism was calculated for those who remained in the workforce, as denoted by the sample *n* presented in parentheses.

Table 6 Productivity Loss Results[a]

	NSCLC Patients	BC Patients	NSCLC Caregivers	BC Caregivers	All
Traditional method calculation, mean (SD)	$50,328 ($54,646)	$37,445 ($39,919)	$39,751 ($43,771)	$33,410 ($66,396)	$40,088 ($52,206)
Augmented method calculation, mean (SD)	$125,975 ($200,761)	$120,404 ($339,029)	$97,062 ($164,115)	$123,669 ($363,321)	$116,623 ($280,154)
Mean % total underestimated when fringe benefits and teamwork are not included	60	69	59	73	66

NSCLC, non–small-cell lung cancer; BC, breast cancer.
[a]The "traditional method" refers to calculating productivity loss using only the worker's wage and lost effective work time, which does not include fringe benefits nor teamwork effects.

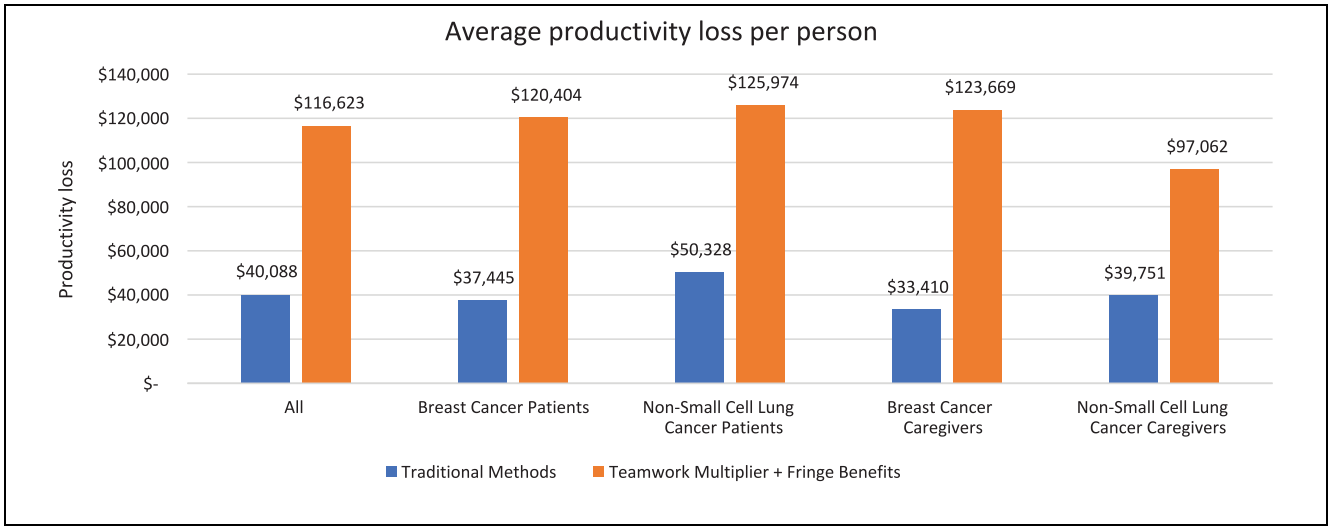

Figure 2 Productivity Loss.

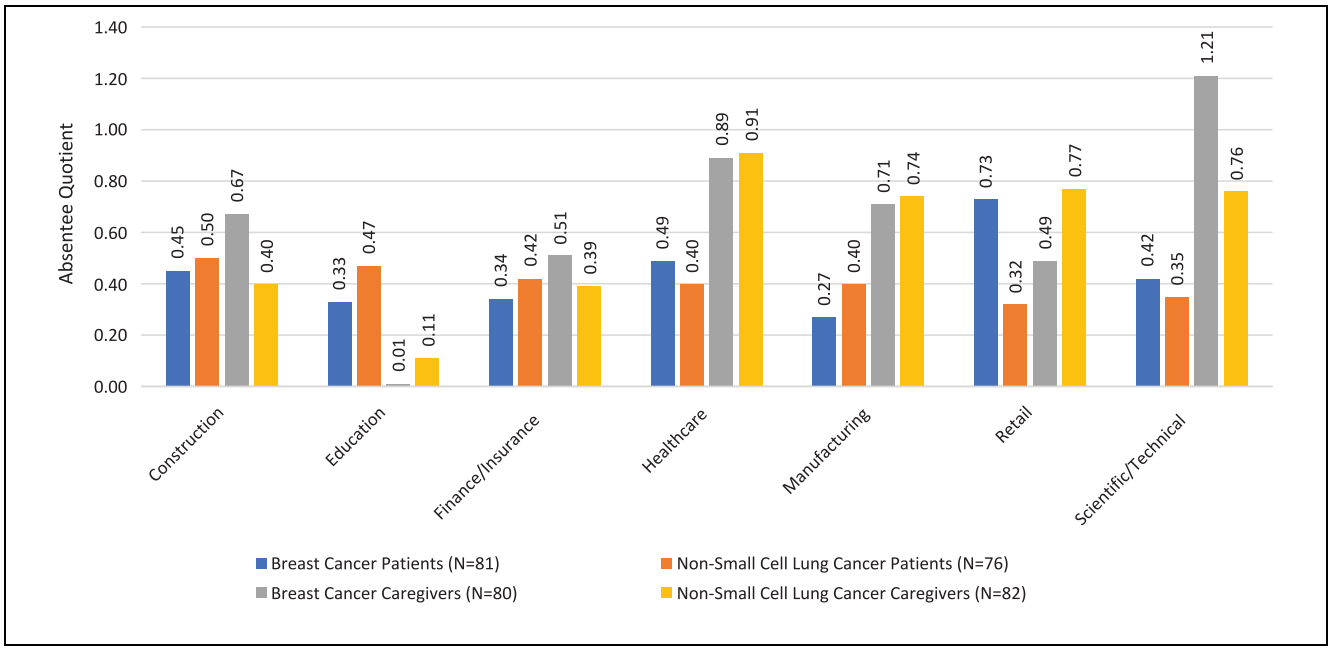

Figure 3 Absenteeism Quotient.

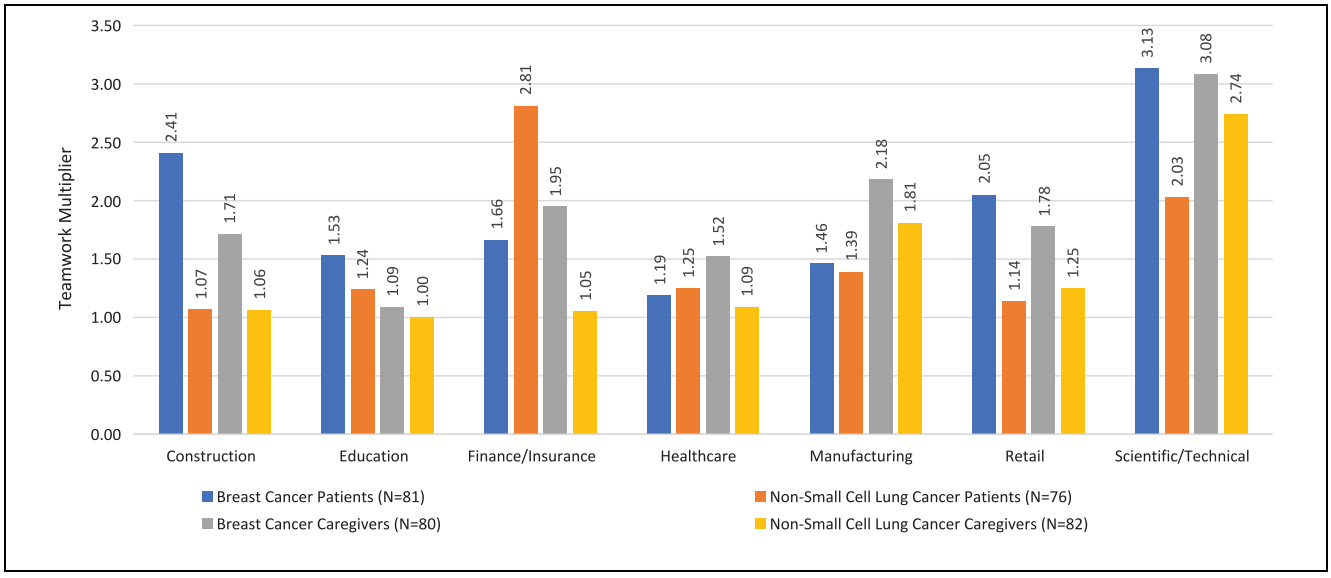

Figure 4 Teamwork Multiplier by Industry Group.

Table 7 Demographic Correlation on Teamwork Multipliers[a]

Demographic Variable	Teamwork Multiplier (All)	Teamwork Multiplier (Patients)	Teamwork Multiplier (Caregivers)
Female	0.580** (0.291)	0.690* (0.378)	0.439 (0.412)
Age	−0.0144 (0.00953)	−0.0115 (0.0137)	−0.0166 (0.0172)
Length of employment	0.0345* (0.0178)	0.0498* (0.0296)	0.0191 (0.0220)
Income (per $10,000)	0.0858*** (0.0298)	0.0844** (0.0389)	0.0872* (0.0475)
High school degree	−2.042 (2.070)	0.0593 (0.265)	−2.944 (2.981)
Associate's degree	−2.480 (2.086)	−0.416 (0.368)	−3.386 (3.023)
Bachelor's degree	−2.144 (2.095)	0.304 (0.245)	−3.401 (3.025)
Graduate degree	−2.309 (2.154)	−0.272 (0.454)	−3.156 (3.143)

[a]Standard errors are given in parentheses.
*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.

categories of workers with similar education, the higher-income workers were more involved in team production.

Sensitivity Analysis: Inclusion of Part-Time Workers

Although we had excluded from the primary analysis respondents who worked less than 40 wk prior to their diagnosis and those who had large increases in work reported following diagnosis (approximately 14% of the study sample), we conducted additional sensitivity analyses on the full study sample to identify any potential differences in outcomes. We find using the human capital method, productivity loss is $37,367 ($46,631 for NSCLC patients, $35,864 for NSCLC caregivers, $35,485 for BC patients, and $31,905 for BC caregivers). Using our augmented method, productivity loss is $103,609 ($128,695 for NSCLC patients, $64,675 for NSCLC caregivers, $109,070 for BC patients, and $113,018 for BC caregivers). This finding suggests that the human capital method underestimates productivity loss by 63.94% (63.77% for NSCLC patients, 44.55% for NSCLC caregivers, 67.47% for BC patients, and 71.77% for BC caregivers), which is similar to the findings from the primary analysis.

Discussion

The Second Panel on Cost-Effectiveness in Health and Medicine has recommended the use of a reference case based on a societal perspective, with productivity costs included in the calculations.[25] The Panel has further recommended the use of the human capital approach for estimating productivity costs.[4] This approach is preferred over others such as the friction cost approach, a method that understates societal costs by implicitly assuming replacement workers have no value in alternative endeavors.[4] That is to say, the method assumes a replacement worker is hired from a pool of workers who are not currently providing any production in the economy nor value their leisure time. While the frictional cost method is useful for an employer's calculation of productivity loss when hiring from a pool of unemployed workers, it may not provide an accurate representation of productivity loss from a societal perspective. In our study alone, 70.2% of respondents stated that their work is taken over by a coworker rather than a replacement worker from a pool of unemployed workers. In addition, when work is taken over by someone other than a coworker, there is a cost to society because the replacement worker would either have been working somewhere else in the economy, or, if not working, the value they place on their leisure time should still be counted as part of societal cost.

Our analysis augments the traditional human capital approach by estimating multipliers that correct for two important omissions that often occur in practice in traditional analyses: 1) failure to account for team production, thereby ignoring the impact of a given worker's absenteeism and presenteeism on the productivity of coworkers, and 2) failure to capture the full costs of the worker to the employer by omitting the value of fringe benefits and employer-paid payroll taxes. We also estimated the burden of productivity loss for caregivers, in addition to productivity loss incurred by BC and NSCLC patients, thereby providing a more comprehensive estimate of productivity loss corresponding to these illnesses.

We acknowledge that the human capital method has been deployed differently across studies, with results dependent on how productivity is calculated within a given study. For example, some studies have included death of a worker, and thus future wages, as productivity loss, which would place the present value calculation of productivity loss greater than $200,000.[26–28] In this study, we estimated productivity loss in a manner similar to the approach used by Yin et al.[5] in their study of BC progression and

workplace productivity. They calculated lost wages at two time periods, estimating productivity loss between $24,166 and $30,666, similar to our calculation of $37,445.[5]

We found that traditional methods underestimate productivity loss by 60% for NSCLC patients and 69% for BC patients in comparison with our preferred approach of accounting for teamwork and fringe benefits. Thus, more than half of productivity loss is unaccounted for in cost-effectiveness calculations that use estimates generated using the traditional method.

Our teamwork multiplier calculations were developed based on previous studies that have estimated the teamwork multiplier by surveying managers, rather than our approach of surveying employees themselves, about the effect of absenteeism or presenteeism on their organization's productivity.[8,29,30] These studies report a range of wage multipliers, from 1.05 to 2.49, depending on the estimation model specification used in the study. Our study estimated a mean team multiplier of 1.85, which is within the range of multiplier estimates from previously published work. Very few studies have looked at how a specific illness affects teamwork productivity. We are aware of only one other such study, which investigates the impact on the patient's productivity of rheumatoid arthritis.[10] To our knowledge, this article is the first to use the teamwork multiplier method to estimate productivity loss from cancer, which can shed light on how a cancer diagnosis affects total productivity.

The impact of an informal caregiver's absenteeism or presenteeism on overall productivity is often not well accounted for. The traditional method underestimates the burden of productivity loss by 59% for NSCLC caregivers and 73% for BC caregivers compared with the augmented method, which accounts for team production and fringe benefits. Overall, we found that across all workers—patients and caregivers—the traditional method underestimates the burden of productivity loss by 66%. Burden of productivity loss calculations typically include only individual patients and not their informal caregivers. Our augmented method found an average patient productivity loss of $119,266. Because a single diagnosis often affects more than 1 individual (the patient and informal caregiver[s]), the additional average caregiver cost of $111,728 almost doubles the burden of lost productivity estimate.

Limitations

The limitations of this study revolve around the small sample size (overall $N = 319$) and potential for recall bias. With respect to recall bias, we conducted an analysis of variance test to test for differences in means across the 6 response categories in the "time since first diagnosed" or "onset of caregiving." We found no difference in the mean estimates of team size, substitutability, and other workplace measures across these groups. This suggests that even in the presence of possible recall bias at the time of survey completion, the bias does not appear to be different for those diagnosed, or caring for a patient, more recently than those who had experienced cancer or caregiving for a longer time period. The number of participants was powered to generate estimates among the patients or caregivers and by cancer type. Exploratory analysis was also performed for possible correlations between absenteeism and individual sociodemographic characteristics, but the analysis did not yield any statistically significant correlations between the characteristics and absenteeism. Furthermore, our study was not powered for additional subpopulation analysis, thus limiting our ability to comment on the effects on absenteeism and teamwork multipliers of characteristics and classification variables such as industry of employment, specific demographic grouping, or particular cancer mutation for the respective patient/caregiver/cancer type subgroups. Respondents were asked to report average hours worked prior to and after the cancer diagnosis, thus raising the potential for recall bias in the data noted in previous studies examining the effect of cancer treatment on the work productivity of patients and caregivers.[31] Respondents were also asked to report to what extent their assigned responsibilities at work could be assumed by others. This leaves open the possibility for subjective assessments around the ability of others to assume a respondent's responsibilities in the workplace. With respect to the patient respondents, we note that the average age of participants in our study was lower than the age of typical breast or lung cancer patients in the United States. This is because we specifically sought to include working-age patients between the ages of 18 and 64 years to understand productivity burden for the respondent as well as the impact on the workplace. Thus, our findings do not extrapolate to the overall breast and lung cancer patient population. Lastly, participation in the study was based on accurately passing the eligibility screening questions. Thus, we were unable to verify the cancer diagnosis of the respondent (patient) or the individual for whom the respondent provided care (caregiver) through electronic medical records or health care administrative data.

Implications for Policy, Clinical Practice, and Future Research

Disease and ongoing treatment may have a profound impact on productivity. To accurately measure the value

of treatments, it is imperative for health economic evaluations to consider the effect of disease and treatments on productivity, thus considering societal and employer perspectives, in addition to the payer or health care system perspective. Better estimation of productivity effects would lead to more accurate estimates of the value of treatments. Value assessments that exclude productivity benefits often undervalue interventions, which may influence coverage decisions.[1] Over time, appropriate analyses that include productivity effects would favor the development of treatments that allow patients and caregivers to remain in the workforce at higher rates, either by curing or suppressing the underlying illness or because of easier administration of therapy or reduced adverse events. Although the burden of caregiving is well recognized, this study highlights the substantial productivity losses caregivers can incur and underscores the importance of employer investments in comprehensive caregiver assistance program.[32–34]

Conclusion

Current methods for calculating productivity loss may severely underestimate the true value of lost productivity due to illness, and analyses often omit the impact on productivity of unpaid caregivers. This study demonstrates that traditional analyses may substantially understate the productivity gains from novel cancer treatments by failing to account for caregiver burden, the cost of fringe benefits, and the broader impacts of team production in the workplace.

Authors' Note

A portion of this work has been presented at the following conferences, as detailed in the following citations:

1. Chiu K, MacEwan J, Bognar K, et al. Estimating productivity losses for cancer patients and caregivers of cancer patients. Online abstract presented at the American Society for Clinical Oncology (ASCO) Annual Meeting; May 29–31, 2020.
2. Chiu K, MacEwan J, Bognar K, et al. The impact of a cancer diagnosis on worker productivity: results from a survey of cancer patients and caregivers of cancer patients. Poster Presentation at AMCP NEXUS Virtual; October 2020.
3. May SG, Chiu K, MacEwan J, et al. The impact of cancer diagnosis on worker productivity: results from a survey of cancer patients and caregivers. Featured poster presentation at the American Society for Clinical Oncology (ASCO) Quality Care Symposium; October 2020.

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Supplemental Material

Supplementary material for this article is available on the *MDM Policy & Practice* website at https://journals.sagepub.com/home/mpp.

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