VOLUME 26 · NUMBER 21 · JULY 20 2008

JOURNAL OF CLINICAL ONCOLOGY

ORIGINAL REPORT

Lymphedema After Breast Cancer: Incidence, Risk Factors, and Effect on Upper Body Function

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Submitted September 18, 2007; accepted December 6, 2007.

Supported by the National Breast Cancer Foundation (NBCF; funding for the Pulling Through Study) and Johnson and Johnson (contributions to NBCF to fund the fellowship of S.C.H.).

Authors' disclosures of potential conflicts of interest and author contributions are found at the end of this article.

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0732-183X/08/2621-3536/$20.00

DOI: 10.1200/JCO.2007.14.4899

ABSTRACT

Purpose
Secondary lymphedema is associated with adverse physical and psychosocial consequences among women with breast cancer (BC). This article describes the prevalence and incidence of lymphedema between 6 and 18 months after BC treatment; personal, treatment, and behavioral correlates of lymphedema status; and the presence of other upper-body symptoms (UBS) and function (UBF).

Patients and Methods
A population-based sample of Australian women (n = 287) with recently diagnosed, invasive BC were evaluated on five occasions using bioimpedance spectroscopy. Lymphedema was diagnosed when the ratio of impedance values, comparing treated and untreated sides, was three standard deviations more than normative data. UBF was assessed using the validated Disability of the Arm, Shoulder, and Hand questionnaire.

Results
From 6 to 18 months after surgery, 33% (n = 62) of the sample were classified as having lymphedema; of these, 40% had long-term lymphedema. Although older age, more extensive surgery or axillary node dissection, and experiencing one or more treatment-related complication(s) or symptom(s) at baseline were associated with increased odds, lower socioeconomic status, having a partner, greater child care responsibilities, being treated on the dominant side, participation in regular activity, and having good UBF were associated with decreased odds of lymphedema. Not surprisingly, lymphedema leads to reduced UBF; however, BC survivors report high prevalences of other UBS (34% to 62%), irrespective of their lymphedema status.

Conclusion
Lymphedema is a public health issue deserving greater attention. More systematic surveillance for earlier detection and the potential benefits of physical activity to prevent lymphedema and mitigate symptoms warrant further clinical integration and research.

J Clin Oncol 26:3536-3542. © 2008 by American Society of Clinical Oncology

INTRODUCTION

Secondary lymphedema is arguably the most problematic and dreaded complication of breast cancer treatment.[3] Although the incidence is generally accepted at approximately 30%, reported rates vary greatly, ranging between 2% and 83%.[3-5] Lymphedema may present immediately or years after treatment,[6] although the majority of cases occur during the first 18 months.[5-7]

Little is known about lymphedema prevention, and it is regarded as an incurable, progressive, disfiguring, and disabling disorder that is difficult to treat. Our understanding is further complicated by inconsistent relationships reported for a range of potential personal, disease, and treatment-related risk factors.[9] Differences in lymphedema measurement techniques, definitions of what constitutes lymphedema, and timing of lymphedema assessments contribute to inconsistencies in the scientific literature and confusion surrounding clinical practice.

Most findings on incidence and risk factors have been derived from studies that use indirect measures of lymphedema, in particular, circumferences and water displacement. Although not yet globally considered the gold standard, multifrequency bioelectrical impedance, now referred to as bioimpedance spectroscopy (BIS), can directly, accurately, and reliably measure lymphedema.[10] The purpose of this investigation was to determine prevalence and incidence of lymphedema, as defined by use of BIS, from 6 to 18 months after treatment for breast cancer among a population-based sample of women residing in Southeast Queensland, Australia. Secondary objectives were to assess the relationships between a range of personal, treatment, and behavioral characteristics and odds of lymphedema, determine the prevalence of other treatment-related

upper-body symptoms in those with and without lymphedema, and determine the effect of lymphedema on upper-body function.

PATIENTS AND METHODS

Patients

After ethical approval, 511 women diagnosed with unilateral breast cancer within the previous 6 months (diagnosed in 2002), ≤ 75 years of age, and residing within a 100-km radius of Brisbane, Queensland, were randomly selected from the Queensland Cancer Registry to participate in the study. Younger women (< 50 years) were over-sampled to ensure adequate numbers were available for specific age group analyses. Doctor consent was required before contacting eligible participants and was obtained for 82% of the sample (n = 417). Of these, informed consent was obtained for 287 women (69%). This study forms part of a larger investigation, known as the Pulling Through Study, which was designed to track and assess the physical and psychosocial recovery of women after breast cancer treatment. Participation involved a clinical assessment and/or completion of a self-administered questionnaire. Some of the women (26%) agreed to participate in the study on a questionnaire-only basis.

Testing Protocol

Lymphedema status was assessed using BIS at every 3 months between 6 and 18 months after surgery. Baseline lymphedema status was available for 211 women (97% of those who participated in the clinical component of the study), and among these, complete data are available for 158 women (75%).

BIS

The use of BIS as a lymphedema measure has been previously well described.[11,12] Briefly, BIS measurements on each arm were performed using a SEAC SFB3 monitor (SEAC Australia, Impedimed, Brisbane, Australia), and the impedance of the extracellular fluid for each limb was calculated using the manufacturer's software. The ratio of impedance values, comparing the treated and untreated sides, was then calculated. A participant was classified as having lymphedema when the impedance ratio was more than three standard deviations more than normative data, with side of dominance taken into account.[10]

Risk Factor, Treatment-Related Symptoms, and Upper-Body Function

The self-administered questionnaire collected information at the same every 3 months on a range of patient, treatment, and behavioral characteristics. More specifically, patient characteristics included age, income, number and ages of children, body-mass index, place of residence, marital status, side of dominance/handedness, upper-body function (assessed via the Disability of the Arm, Shoulder and Hand Scale [DASH])[13] and quality of life (assessed via the Functional Assessment of Cancer Therapy–Breast instrument).[14] Treatment characteristics included number of lymph nodes removed (abstracted from pathology reports), details of adjuvant treatment (specifically chemotherapy, radiation therapy, or hormone therapy) and type of surgery, number and timing of treatment-related complications, and presence and intensity of upper-body symptoms. Behavioral characteristics included stress and coping with stress, physical activity levels (as assessed by the Behavioral Risk Factor Surveillance System Survey Questionnaire),[15] smoking history, and advice regarding recovery. Only baseline characteristics were used in analyses predicting subsequent incidence of lymphedema.

The DASH[13] collects information about the level of difficulty experienced when performing specific tasks, the extent to which any upper-body problem interferes with normal activities, and severity of specific upper-body symptoms. Final scores range from 0 to 100, where 0 reflects no disability (good function) and 100 reflects extensive disability (poor function). To our knowledge, this is the first use of the DASH questionnaire to assess arm function among women with breast cancer. During the final testing session, the median score in our sample was 7 (95% CI, 5.2 to 10.8) and was used to categorize the sample into those with better or poorer arm function than most, noting that the latter group did not necessarily have poor function.

Statistical Methods

Point prevalence was calculated at each of the five testing phases, whereas cumulative burden describes the proportion of the sample that experienced lymphedema at any stage from 6 to 18 months after surgery. Incidence reflects the proportion of women who developed lymphedema from 9 to 18 months after surgery and excludes those who already had the condition at baseline (6 months after surgery). To ensure that potential risk factor status preceded lymphedema development, bivariate statistics assessed the unadjusted relationships for each baseline (6 month after surgery) patient, treatment, and behavioral characteristic for incident cases only. Characteristics that were theoretically (known from literature), statistically ($P < .10$), or potentially clinically (odds ratio [OR] ≤ 0.67 or ≥ 1.5) important were incorporated into four separate models (categorized as patient characteristics, treatment, treatment-related complications, and behaviors) to examine the independent associations with odds among inter-related characteristics. Those that retained theoretical, statistical, or clinical importance were incorporated into one model to further consider independent relationships. Results are expressed as ORs and 95% CIs, with a two-tailed $P < .05$ taken as evidence of statistical significance and OR ≤ 0.67 or ≥ 1.5 taken as evidence of potential clinically important differences worthy of mention.

Presence of mild to extreme treatment-related upper-body symptoms at baseline, reported by those never having lymphedema, those with lymphedema during 9 to 18 months after surgery, and the entire sample, were calculated and compared. A model to assess potential risk factors for poorer upper-body function incorporated those baseline characteristics included in the final lymphedema model, in addition to having lymphedema at any stage during the 6 to 18 months after surgery (cumulative burden).

Statistical procedures were performed using the packages SPSS version 13 for Windows (SPSS Inc, Chicago, IL) and SUDAAN (Research Triangle Park, NC), and all analysis used weighting procedures to address the oversampling of younger women (weights of 1.0 for those < 50 years and 1.3 for those 50 to 74 years of age).

RESULTS

In comparison with the population of patients with breast cancer in Queensland, our sample had smaller tumors and fewer positive nodes. Age and number of lymph nodes examined were similar between the groups. Demographic and disease characteristics were similar for the women in this study and those in the target sample (Table 1), as well as between those (n = 158) with complete (lymphedema status available at all five testing phases) and those (n = 53) with incomplete data sets (data not shown).

Lymphedema Prevalence, Cumulative Burden, and Incidence

Point prevalence across the study period ranged between 7.5% and 14.7% (Table 2). By 18 months after surgery, more than 30% of the women showed evidence of lymphedema at one or more testing phases. Of these 62 women, 58% had transitory symptoms (ie, for no longer than 3 months) that presented at any time between 6 and 18 months after surgery. Approximately 39% (n = 24) had measurable evidence of the condition for more than 3 months, and of these, the majority (63%) presented with symptoms at the first evaluation (6 months after treatment). Additionally, 63% of the women with long-term lymphedema experienced intermittent periods without symptoms. Incidence of lymphedema between 9 and 18 months after surgery was 23.4% (Table 2).

Table 1. Demographic and Clinical Characteristics of Target Sample and Study Groups:* The Pulling Through Study, Brisbane, Australia

Characteristic	Target Sample† (%)	Study Participants‡ (%)		
		All	Clinical Sample	Questionnaire Only
Total patients	511	287	211	76
Age, years				
Mean	54	55	54	56
Standard deviation	10	10	10	10
Place of residence				
North Brisbane	29.2	28.8	29.8	26.1
South Brisbane	21.4	20.9	21.0	20.7
West Brisbane	18.0	21.8	21.8	21.7
East Brisbane	17.3	18.0	17.1	20.7
Sunshine and Gold Coasts	14.1	10.5	10.3	10.9
Most extensive surgery				
Complete local excision	72.2	72.5	73.9	68.8
Mastectomy	27.8	27.5	26.1	31.2
Largest tumor size, mm				
Median	14	14	14	14
Range	0.3-230	0.50-140	0.50-140	1-75
Lymph node dissection				
Yes	86.3	86.7	87.0	86.0
No. of nodes examined				
Median	12	12	12	13
Range	1-47	1-47	1-47	1-35
No. of positive nodes				
Median	0	0	0	0
Range	0-39	0-39	0-39	0-24
Overall histologic grade				
1	24.3	26.6	25.7	29.0
2	35.7	31.8	31.2	33.3
3	32.2	30.6	31.6	28.0
Unavailable	7.8	11.0	11.5	9.7
Histologic type				
Infiltrating ductal/NOS carcinoma	78.2	72.5	73.8	68.8
Tubular/cribriform carcinoma	3.9	5.2	4.8	6.5
Medullary/mucinous/colloid adenocarcinoma	0.8	0.3	0.4	0.0
Infiltrating lobular	12.4	15.7	15.5	16.1
Other mixed type	4.7	6.4	5.6	8.6

Abbreviation: NOS, not otherwise specified.
*Results presented have been appropriately weighted (< 50 years, 1.0; ≥ 50 years, 1.3) for oversampling of younger women.
†Target sample refers to the age-stratified, random sample obtained from the pool of all women diagnosed with breast cancer in the population-based Queensland Cancer Registry after application of eligibility criteria.
‡Study participants include 211 patients who participated in the clinical examination as well as the questionnaire and 76 patients who completed the questionnaires only.

Risk Factors

Table 3 presents mutual adjustment for all potential risk factors, with adjusted findings, when compared with bivariate associations, being generally stronger. Older age, more extensive surgery (ie, mastectomy), and having a sedentary lifestyle significantly increased odds (three- to six-fold) of lymphedema. Removal of 20 or more lymph nodes, experiencing one or more treatment-related complication or symptom, and being single each increased odds 2.6- to 5.0-fold, but CIs were wide and included 1.0. Conversely, having a lower yearly income significantly decreased odds of lymphedema over the following 12 months five-fold. Being treated on the dominant side, having greater childcare responsibilities, receiving chemotherapy, and having better than average upper-body function were each associated with a halving or greater reduction in lymphedema odds, but results were not statistically significant.

Presence of Other Treatment-Related Upper-Body Symptoms

The study sample reported high prevalences of symptoms at baseline, with the lowest being for poor range of arm movement (34%) and the highest being for numbness (62%; Fig 1). Women who developed lymphedema between 9 and 18 months reported higher prevalences of upper-body symptoms at baseline when compared with women without subsequent lymphedema; the greatest differences between the groups (> 10%) were for pain ($P < .05$), stiffness, weakness, and numbness.

Effect of Having Lymphedema on Upper-Body Function

After adjustment for all characteristics presented in Table 3 (except for baseline upper-body function), having lymphedema between

Table 2. Point Prevalence, Cumulative Burden, and Incidence of Lymphedema Between 6 and 18 Months After Surgery

Parameter	Time of Assessment* (months)				
	6	9	12	15	18
Lymphedema status at each testing phase					
Yes, n	22	20	13	21	27
Total sample, n†	211	183	173	158	184
Point prevalence, %‡	10.7	11.3	8.0	13	14.9
Lymphedema status at any time up to time of assessment					
Ever, n	22	35	44	55	62§
Total sample, n	211	213	192	183	190
Cumulative burden, %‡	10.7	16.9	22.7	31.2	33.6
Lymphedema status between 9 and 18 months after surgery, excluding baseline					
Ever, n					39
Total sample, n					167
Incidence after baseline, %‡					24.2

*Months after surgery.
†Sample sizes varied over time because some women did not participate in all data collection sessions.
‡Results presented have been appropriately weighted (< 50 years, 1.0; ≥ 50 years, 1.3) for oversampling of younger women.
§Because of equipment problems, baseline measures for two women were unavailable. However, there were enough data (quantitative and qualitative) to classify their 9- to 18-month lymphedema status, with one woman having lymphedema at each subsequent phase tested and the other woman being consistently lymphedema free.

6 and 18 months after surgery was associated with having poorer upper-body function by 18 months after surgery (OR = 1.9; 95% CI, 0.8 to 4.6; $P = .15$). This association weakened when baseline upper-body function was also considered but remained clinically important (OR = 1.5; 95% CI, 0.5 to 4.7; $P = .53$).

DISCUSSION

This longitudinal study, using a direct measure of lymphedema, highlights that at any point in time during the first 18 months of recovery from breast cancer, at least one in 10 women is experiencing the condition. Furthermore, by 18 months after surgery, at least 30% of breast cancer survivors have, or have had, lymphedema. Approximately 60% of these women had transitory symptoms, whereby the lymphedema dissipated with or without treatment. However, 40% of patients experienced long-term lymphedema lasting for more than 3 months, with or without intermittent periods of relief. Women with lymphedema were twice as likely to have poorer upper-body function when compared with women who had not developed arm swelling.

Breast cancer continues to be the most common cancer among Australian women, with 11,000 women being diagnosed yearly.[16] Therefore, based on our findings from a representative, population-based sample, in Australia alone, each year more than 3,000 women will experience lymphedema after breast cancer. In the United States, these figures are substantially higher; there are more than 2 million American breast cancer survivors, and as a conservative estimate, more than 200,000 of these women are living with secondary lymphedema.[6] Clearly, lymphedema is a public health issue of concern.

Our data demonstrate that approximately two thirds of those classified with long-term lymphedema developed measurable symptoms by 6 months after surgery. Early diagnosis and treatment of lymphedema is believed to lead to better outcomes.[17] Consequently, the integration of a lymphedema assessment during a routine follow-up visit could lead to significant declines in the emotional, physical, and financial costs of lymphedema to breast cancer survivors as well as to society. However, appropriate timing of this assessment is crucial. If assessed too early, as within 3 months of surgery, normal postoperative swelling could be misconstrued as evidence of lymphedema.[9] For the majority of breast cancer cases, treatment is usually complete within 3 to 6 months after diagnosis. Taking timing of treatment cessation into account, as well as results from this work showing that two thirds of those with lymphedema developed the condition by 6 months, it seems logical to assess lymphedema status toward the end of treatment, but definitely by 6 months after surgery.

We observed that new cases (n = 8) became apparent as late as 18 months after treatment. Regrettably, our surveillance ceased at that time. Other prospective studies with longer follow-up identified new cases arising 3 years after surgery,[5] whereas a retrospective study found new cases as late as 10 years after diagnosis.[18] There is accumulating evidence to suggest that the majority of cases occur by 12 months after diagnosis (70% of our cases and 80% of others[5]). However, longer-term follow-up using a direct measure of lymphedema status warrants further investigation.

It is generally accepted that more extensive treatment, in particular surgery[5,19-21] and lymph node removal,[7,21-23] as well as having adjuvant treatment such as radiation,[18,19,21,22,24] increases risk of lymphedema. Our work also demonstrates that more extensive breast surgery increases odds of lymphedema six-fold (irrespective of extent of axillary dissection) and having more than 20 lymph nodes removed during axillary dissection (irrespective of extent of surgery) increases odds four-fold. The reasons behind the independent association between lymphedema and mastectomy cannot be determined from these data but warrant clinical consideration. In our data, having one to 10 lymph nodes removed or 10 to 19 lymph nodes removed

Table 3. Relationships Between Baseline Patient, Treatment, and Behavioral Characteristics and Incidence of Lymphedema Between 9 and 18 Months After Surgery in a Sample of Women from Brisbane, Australia, With Unilateral Breast Cancer Diagnosed Before Age 75 Years*

Characteristic	Unadjusted Results			Adjusted Results†		
	No. of Patients	OR	95% CI	No. of Patients	OR	95% CI
Age, years						
< 50	58	1.0	Referent	53	1.0	Referent
≥ 50	109	3.1	1.2 to 8.2‡	90	3.3	1.0 to 11.1‡
Income, $ per year						
> 52,000	68	1.0	Referent	64	1.0	Referent
≤ 52,000	107	0.5	0.2 to 1.0‡	87	0.2	0.1 to 0.5‡
Marital status						
Married/de facto	115	1.0	Referent	110	1.0	Referent
Other§	52	1.9	0.8 to 4.23	41	2.6	0.9 to 7.3
Children in care						
None and never	24	1.0	Referent	20	1.0	Referent
Age > 14 years‖	108	0.8	0.3 to 2.2	99	0.6	0.2 to 2.6
Age ≤ 14 years	35	0.2	0.1 to 1.0	32	0.1	< 0.1 to 1.4
Body-mass index						
Healthy or underweight	73	1.0	Referent	66	1.0	Referent
Overweight, obese, or unknown	102	1.0	0.5 to 2.2	85	1.0	0.3 to 2.8
Side of treatment						
Nondominant side	83	1.0	Referent	75	1.0	Referent
Dominant side	84	0.6	0.3 to 1.2	76	0.4	0.2 to 1.1
Most extensive surgery						
Local excision	126	1.0	Referent	115	1.0	Referent
Mastectomy	41	1.5	0.6 to 3.5	36	5.9	1.4 to 22.5‡
Extent of lymph node excision						
None	21	1.0	Referent	20	1.0	Referent
1-19	129	1.4	0.4 to 5.4	116	1.3	0.3 to 5.8
≥ 20	17	3.5	0.7 to 17.6	15	3.9	0.5 to 28.9
Radiation treatment						
No	45	1.0	Referent	42	1.0	Referent
Yes	122	0.7	0.3 to 1.7	109	0.9	0.2 to 4.3
Chemotherapy treatment						
No	95	1.0	Referent	82	1.0	Referent
Yes	72	0.6	0.3 to 1.2	69	0.4	0.2 to 1.2
Baseline complications¶						
0	42	1.0	Referent	39	1.0	Referent
≥ 1	125	1.9	0.7 to 5.2	112	5.0	0.9 to 29.5
Baseline symptoms#						
0	96	1.0	Referent	85	1.0	Referent
≥ 1	71	2.3	1.0 to 5.0‡	66	3.1	0.9 to 10.7
Physical activity levels**						
Sufficient	83	1.0	Referent	76	1.0	Referent
Insufficient	60	1.2	0.5 to 2.9	53	1.4	0.5 to 4.1
Sedentary	24	1.9	0.6 to 5.5	22	6.1	1.3 to 27.6‡
Upper-body function††						
Worse than most	74	1.0	Referent	74	1.0	Referent
Better than most	77	0.6	0.3 to 1.4	77	0.5	0.2 to 1.6

Abbreviation: OR, odds ratio.
*ORs and CIs presented have been appropriately weighted (< 50 years, 1.0; ≥ 50 years, 1.3) for oversampling of younger women.
†ORs and CIs presented for each characteristics have been adjusted for all other characteristics presented.
‡$P \leq .05$.
§"Other" includes single, divorced, or widowed.
‖Children in care are older than 14 years or their ages are unknown.
¶Complications include wound infection, other infection, skin or tissue reaction, seromas, or hematomas.
#Symptoms include stiffness, pain, tingling, weakness, poor range of movement, numbness, and stiffness of the treated side and were of least mild severity.
**Categorized according to Australian national recommendations (ie, ≥ 150 minutes per week represents sufficient activity levels).
††< 7 versus 7+ based on median obtained using the Disability of Arm, Shoulder, and Hand Questionnaire.

showed no statistical or clinical association with lymphedema development (ORs were 0.9 and 1.4, respectively, with CIs overlapping 1.0). In contrast to previous work, we found no association with radiation treatment. The differences in these results may be due to more refined radiation techniques being implemented in more recent years or to the use of BIS to

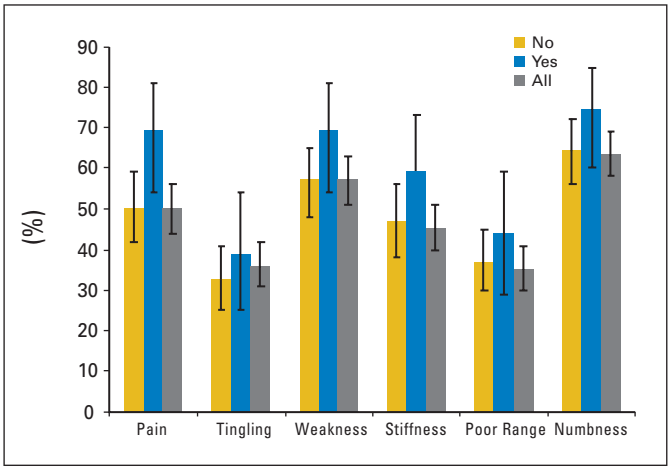

Fig 1. The proportion of women with mild to extreme symptoms present during baseline (6 months after surgery) assessment. Proportions presented have been appropriately weighted (< 50 years, 1.0; ≥ 50 years, 1.3) for oversampling of younger women. Women are grouped according to having never had lymphedema from 6 to18 months after surgery (no, n = 128); had lymphoedema at some point during 9 to 18 months after surgery (yes, n = 39), and all women grouped together, including those lacking objective lymphedema measures (N = 287).

diagnose lymphedema rather than circumferences or self-reported arm swelling. Alternatively, it is plausible that those undertaking radiation are exposed to more advice about shoulder recovery in Australia, and that this advice is associated with lymphedema prevention. This also may explain why having chemotherapy was associated with a protective effect.

The relationship between lymphedema incidence and personal characteristics has been given relatively little attention in previous research. Age is the most studied, with the majority of work reporting no statistical association.[5,7,18,19,24] However, trends in the data suggest increased risk with advancing age in at least three studies.[5,18,24] Our work demonstrated that being 50 years or older was associated with three-fold increased odds of developing lymphedema ($P < .05$). We also found that the odds of developing lymphedema were more than doubled in the absence of having a significant other (that is, being married or being in a de facto relationship), indicating that partner support may play an important role in physical as well as psychosocial recovery after breast cancer. In contrast, we found no association between being overweight or obese and odds of lymphedema, whereas others have reported positive associations.[5,7,22,24-26] The differences in these findings may be explained by variations in lymphedema assessment methods. Previous work used indirect (circumferences, water displacement, and so on) or self-reported methods for identifying cases, which are more prone to measurement error. In particular, fluctuations in weight that are unrelated to lymphedema are more likely to be captured by these techniques. In contrast, BIS, the method used in this study, directly measures extracellular fluid changes. This is an important consideration, because it is well known that weight gain is common after treatment for breast cancer.[27]

Further novel findings relating to personal characteristics identified that having younger children and lower socioeconomic status (as defined by income) were associated with five- to 10-fold reduced odds of lymphedema. These reductions in odds might be related to use of the treated side. Women with young children may find it harder to protect/avoid use of their treated side, and our data indicate that lower incomes were associated with having more manual occupations (blue-collar workers or homemakers). Other independent characteristics found to reduce lymphedema odds that further support this use decreases risk theory include being treated on the dominant side, having better than average upper-body function, and participating in sufficient levels of physical activity at baseline. Other researchers have found either no association[7,19] or increased risk[28] with being treated on the dominant side and lymphedema but have reported similar inverse relationships between activity levels and lymphedema risk.[26,29] Importantly, there is no evidence to suggest that use of the treated side increases risk.

Despite observing associations between treatment-related complications and symptoms at baseline and subsequent development of lymphedema, it is currently not possible to use these as indicators of lymphedema risk in a clinical setting because their prevalence is high even among women who did not develop lymphedema (ranging between 35% for tingling and 62% for numbness). The assessment of symptom intensity did not further aid using symptoms to identify at-risk women.

These findings are derived from longitudinal data, using a population-based, representative sample of women with breast cancer. Estimates of incidence, prevalence, and cumulative burden are likely conservative, given that participants tended to have less extensive disease than the target population. The prospective design and inclusion of only incident cases in logistic regression analyses allowed us to determine characteristics that increase odds of developing lymphedema rather than only identifying factors associated concurrently with presence of the condition. Furthermore, lymphedema was assessed using a direct, objective measure of extracellular fluid, and personal, treatment, and behavioral characteristics were extensively measured. The limited statistical power, as a consequence of the number of lymphedema cases that arose between 9 and 18 months after surgery, represents the primary limitation of the work. Small numbers among exposed and nonexposed lymphedema cases likely produced more extreme OR estimates (ie, overestimates) for positive and inverse associations. Nevertheless, despite relatively wide CIs, statistical significance was attained for a number of characteristics. Additionally, we retained in multivariable analyses those characteristics that met a priori criteria for possible clinical importance for comparison with other studies.

In summary, these data present current estimates of lymphedema prevalence and cumulative burden. In doing so, it is evident that lymphedema after treatment for breast cancer is a disease that is common in our society, warranting greater public awareness. Those at risk, as well as health professionals working with those at risk, should be provided with the education and assistance required for prevention and early detection of lymphedema. A number of the identified risk factors, in particular sufficient physical activity and use of the affected arm, are amenable to interventions and should be investigated for their preventive and therapeutic effects among women after treatment for breast cancer.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The author(s) indicated no potential conflicts of interest.

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Final approval of manuscript: Sandra C. Hayes, Monika Janda, Bruce Cornish, Diana Battistutta, Beth Newman

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Acknowledgment

We thank Sheree Harrison for study implementation, Elizabeth Winkler for statistical analysis, and the women and clinicians who made this research possible.

