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Using "Population Attributable Fraction" to Understand: To What Extent Can Breast Cancer Incidence Be Attributed to Higher Socioeconomic Status?

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Introduction

With few exceptions, higher socioeconomic status (SES) has been found to be associated with higher breast cancer risk in both developed and lesser developed countries using a variety of measures of SES, including income, education level, and occupation type (Faggiano et al., 1997). This article examines the extent to which breast cancer incidence can be attributed to higher socioeconomic status in the United States (U.S.). An oft-recited but frequently misunderstood statistic used for estimating the extent to which disease incidence can be attributed to a risk factor is the "population attributable fraction." Therefore, this article first examines the concept of population attributable fraction.

Understanding Population Attributable Fraction

Population attributable fraction is a statistic used to estimate the proportion of cases that can be attributed to one or more specified risk factors. More precisely, population attributable fraction is the "proportional reduction in average disease risk over a specified time interval that would be achieved by eliminating the exposure(s) of interest from the population while distributions of other risk factors in the population remained unchanged. This also can be interpreted as the proportion of disease cases over a specified time that would be prevented following elimination of the exposures, assuming the exposures are causal" (Rockhill et al., 1998). As illustrated by the formula below in the shaded box, the population attributable fraction (*PAF*) depends on the prevalence (P_e) of the risk factor and the relative risk of the risk factor (*RR*).

Figure 1 illustrates the calculation and interpretation of a population attributable fraction for an imaginary breast cancer (BC) risk factor: handling two or more frogs during adolescence. In this example, 30% of the female population handled two or more frogs during adolescence. For use in this formula, however, the prevalence should be expressed as a proportion (i.e., 0.30). The relative risk (*RR*) estimate for this risk factor is 1.6. That is, women who handled two or more frogs during adolescence are 1.6 times more likely to develop breast cancer than women who never touched a frog during adolescence. In other words, women who handled two or more frogs during adolescence are 60% more likely to develop breast cancer than those who never touched a frog during adolescence. After plugging in $P_e = 0.30$ and $RR = 1.6$ into the formula, the calculated population attributable fraction is 0.15. This can be interpreted correctly as, 15% of

$$PAF = \frac{p_e(RR-1)}{p_e(RR-1)+1}$$

PAF = the proportion of cases that would be prevented if the risk factor were eliminated.

P_e = the estimated proportion of the population that is exposed to the risk factor of interest (i.e., prevalence expressed as a proportion).

RR = the relative risk estimate for the risk factor of interest ($RR \geq 1$) which represents the magnitude of the association between the risk factor and the disease. *RR* may be a risk ratio, a rate ratio, or an approximation of one of these two ratios, such as an odds ratio.

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breast cancer cases could be avoided if frog handling in adolescence were eliminated assuming that handling two or more frogs during adolescence is causally related to increased breast cancer risk and that the distribution of all other risk factors remains unchanged.

Figure 2 shows how the population attributable fraction increases for increasing values of *RR* while the prevalence (P_e) is held constant at 0.30. Given $P_e = 0.30$ and $RR = 1.6$, one can look up the population attributable fraction using this graph. The frog icon is situated at the place on the plotted line that corresponds to $RR = 1.6$; this corresponds to a population attributable fraction of 0.15 (or 15% if expressed as a percentage). Again, this can be interpreted correctly as, 15% of breast cancer cases could be avoided if frog handling in adolescence were eliminated assuming that handling two or more frogs during adolescence is causally related to increased breast cancer risk and that the distribution of all other risk factors remains unchanged.

Figure 3 illustrates how the population attributable fraction increases as the prevalence of the exposure (P_e) increases. Each black line plotted on this graph corresponds to prevalences from 0 to 1.0, inclusive. The black lines plotted between the bottom and top black plotted lines correspond to prevalences of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9, respectively. For example, where the red and pink lines intersect in Figure 3 corresponds to $P_e = 0.30$, $RR = 1.6$, and a $PAF = 0.15$, the same situation illustrated in Figure 2. Back to the frog handling example: if the prevalence of frog handling were reduced to 0.10 (or 10% if expressed as a percentage) and the relative risk remained equal to 1.6, corresponding to where the red and gray lines intersect in Figure 3, the population attributable fraction would be reduced to 0.06 (or 6% if expressed as a percentage). If the prevalence of frog handling were greater in the population, then a greater number of cases could be prevented if frog handling were eliminated. For example, if all women in the population handled two or more frogs during adolescence (P_e =1 or 100% exposure) and the *RR* remained equal to 1.6, corresponding to where the red and black lines intersect in Figure 3, then the population attributable fraction would be 0.38 (or 38% if expressed as a percentage).

For rare exposures, the population attributable fraction will be small even when the exposure is strongly related to the disease. As is illustrated in Figure 4, regardless of the magnitude of the relative risk (*RR*), if the prevalence is equal to zero, then the population attributable fraction will be zero. With a very high relative risk (*RR*) of 10 and a low prevalence (P_e) of 0.10 (or 10% if expressed as a percentage), the population attributable fraction will be only 0.47 (or 47% if expressed as a percentage). Even with a high prevalence of 1.0 (or 100% if expressed as a percentage), an exposure with a relative risk (*RR*) of 10 still will not account for 100% of cases.

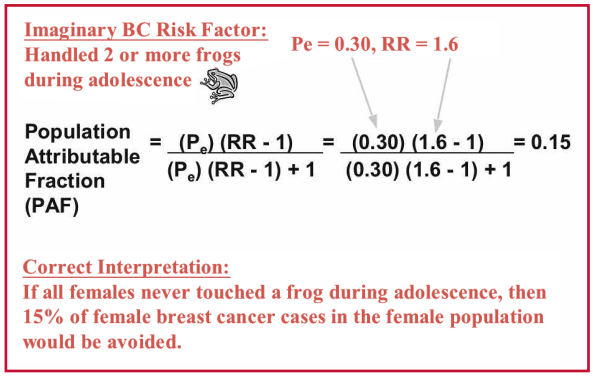

Figure 1. Example Calculation of Population Attributable Fraction (*PAF*). For this example, consider an imaginary breast cancer (BC) risk factor, handled two or more frogs during adolescence. If 0.30 (or 30% if expressed as a percentage) women in the population of interest were exposed to this risk factor and the relative risk associated with this risk factor were 1.6, then the *PAF* would be 0.15 (or 15% if expressed as a percentage).

Warnings About Population Attributable Fractions

WARNING #1 - Population attributable fraction is easily misinterpreted. Often the population attributable fraction is incorrectly thought to represent the proportion of cases having any risk factors. A population attributable fraction equal to 15% does not mean that only 15% of women have any known breast cancer risk factors nor does it mean that 85% of cases do not have any risk factors. The correct interpretation of a population attributable fraction equal to 15% is that 15% of breast cancer cases would be avoided if the risk factor is causally related to breast cancer and is eliminated.

WARNING #2 – Population attributable fractions calculated for individual breast cancer risk factors

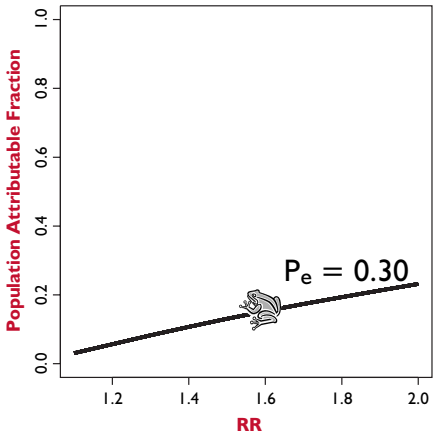

Figure 2. Population Attributable Fraction (*PAF*) is a Function of Relative Risk and Exposure Prevalence. The greater the relative risk (*RR*), the greater the *PAF* for any given exposure prevalence (P_e). In this figure, the prevalence (P_e) is set to 0.30 (or 30% if expressed as a percentage), and the relative risk (*RR*) ranges from 1.0 to 2.0.

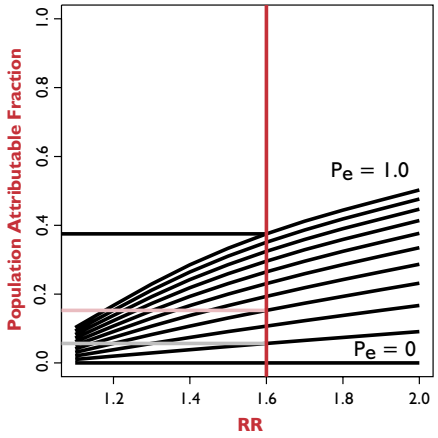

Figure 3. Population Attributable Fraction (*PAF*) is a Function of Relative Risk and Exposure Prevalence. As both the relative risk (*RR*) and exposure prevalence (P_e) increase, so does the *PAF*. Each line on the graph corresponds to a different exposure prevalence (P_e). The line plotted closest to the horizontal axis corresponds to an exposure prevalence of 0 (or 0% if expressed as a percentage). The line plotted furthest away from the horizontal axis corresponds to an exposure prevalence of 1.0 (or 100% if expressed as a percentage). The relative risk (*RR*) ranges from 1.0 to 2.0.

will not sum to 1.0. Because many risk factors are correlated, population attributable fraction estimates calculated for single risk factors should not be summed.

WARNING #3 - Note that the selection of exposure cutpoints used for defining "exposed" is somewhat arbitrary and can have a major impact on the population attributable fraction. For example, if the imaginary risk factor were defined as "handled 100 or more frogs during adolescence," the proportion of the population meeting this new definition would be much smaller, thus reducing the population attributable fraction. The population attributable fraction is influenced by the cutpoint used in defining the risk factor exposure because this cutpoint can affect the prevalence (P_e). A change in cutpoint (i.e., exposure definition) also may affect the relative risk (*RR*). Thus, it is important to pay attention to the exposure definition when considering the meaning of a particular population attributable fraction estimate.

WARNING #4 - Actual reduction in disease burden after removal of the risk factor assumes that the risk factor is causally related to the disease.

Back to Known Breast Cancer Risk Factors...

Consider the typical relative risks associated with the established breast cancer risk factors given in Table 1.

PAF for Risk Factor with Strongest Association with Breast Cancer

The established breast cancer risk factor with the strongest association with breast cancer listed in Table 1 is family history of breast cancer in one or more first-degree relatives (*RR* = 2.6). While prevalence of family history of breast cancer will vary from population-to-population, let's consider a prevalence estimate taken from the Women's Contraceptive and Reproductive Experiences (CARE) Study (McDonald et al., 2004). The CARE Study was a large population-based case-control study of 4,575 cases and 4,682 controls between the ages of 35 and 64 years who were sampled from five metropolitan sites in the U.S. The prevalence estimate of family history among controls may be used to estimate the source population prevalence. In the CARE Study, 9.7% of controls had a family history of breast cancer in one or more first-degree relatives (in a mother, sister, or daughter, specifically). Assuming that the CARE Study population is fairly representative of the U.S. urban population, the population

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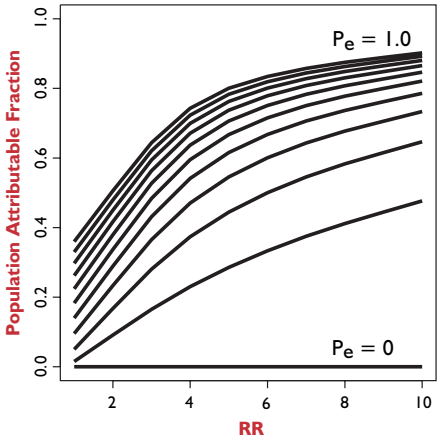

Figure 4. Population Attributable Fraction (*PAF*) is a Function of Relative Risk and Exposure Prevalence. As both the relative risk (*RR*) and exposure prevalence (P_e) increase, so does the *PAF*. Like Figure 3, each line on the graph corresponds to a different exposure prevalence (P_e). The line plotted closest to the horizontal axis corresponds to an exposure prevalence of 0 (or 0% if expressed as a percentage). The line plotted furthest away from the horizontal axis corresponds to an exposure prevalence of 1.0 (or 100% if expressed as a percentage). The relative risk (*RR*) ranges from 1 to 10.

TABLE 1. Relative risk (*RR*) estimates for some established breast cancer risk factors.

Risk Factor	*RR*	Source
Age at menarche <12 years	1.2	Gail et al., 1989
Age at 1st birth/nulliparous ≥30 years	1.9	Gail et al., 1989; NCI, 2003
Family history of breast cancer in ≥1 1st degree relatives	2.6	Gail et al., 1989
Postmenopausal body mass index >27	1.3	Colditz et al., 2000
More than one alcoholic drink per day	1.4	Colditz et al., 2000

attributable fraction for family history of breast cancer in this population is 0.134. In other words, if family history of breast cancer were eliminated in the U.S. urban population, then approximately 13.4% of new breast cancer cases could be avoided in this population.

PAFs for Other Breast Cancer Risk Factors

The relative risks associated with known breast cancer risk factors other than family history typically range from 1.1 to 2.0. Given this moderate relative risk range, the proportion of breast cancer cases attributed to any one of the other established breast cancer risk factors will not exceed 50% as illustrated in Figure 3. That is, for the extreme example where the prevalence is 100% (or 1.0 if expressed as a proportion) and *RR* = 2.0, the population attributable fraction will equal 0.50 (or 50%). Table 2 presents prevalences for some of the established breast cancer risk factors estimated from relatively large samples from various populations. While prevalences for breast cancer risk factors vary from population to population, the prevalences in Table 2 provide a basis for illustrating what population attributable fractions might be expected for some of the established breast cancer risk factors. Using the relative risk estimates in Table 1 and the prevalence estimates in Table 2, example population attributable fractions for some breast cancer risk factors were calculated and are given in Table 3.

TABLE 2. Prevalences for some established breast cancer risk factors from various populations.

Risk Factor	Prevalence	Source
Age at menarche <12 years	0.15	Gail et al., 1989
Age at 1st birth/nulliparous ≥30 years	0.31	Erdmann et al., 2003
Family history of breast cancer in ≥1 1st degree relatives	0.097	McDonald et al., 2004
Postmenopausal body mass index ≥30	0.37	NCHS, 2005
More than one alcoholic drink per day	0.07	NCHS, 2005

TABLE 3. *PAF* estimates based on RRs in Table 1 and prevalences in Table 2.

Risk Factor	*PAF*	*PAF* x 100
Age at menarche <12 years	0.029	2.9%
Age at 1st birth/nulliparous ≥30 years	0.218	21.8%
Family history of breast cancer in ≥1 1st degree relatives	0.134	13.4%
Postmenopausal body mass index >27	0.099	9.9%
More than one alcoholic drink per day	0.027	2.7%

Proportion of Breast Cancer Cases "Attributed" to Higher SES

Using the first National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up Study, Madigan et al. estimated the proportion of breast cancer cases attributed to higher SES in the U.S. female population (Madigan et al., 1995). With higher SES exposure defined as "income in the upper two thirds of the U.S. population," the *PAF* estimated for the U.S. female population was 18.9%. If higher SES were eliminated, the 18.9% of breast cancer cases could be avoided in the U.S. female population, assuming that higher SES is causally related to increased breast cancer risk and that the distribution of all other risk factors remains unchanged. Of course, higher SES is not a direct cause of breast cancer. While the association between SES and breast cancer risk is strikingly consistent, it provides neither a basis for a breast cancer prevention target nor a biologic clue. Instead, higher SES acts as a proxy for a combination of breast cancer risk factors that do have a biologically plausible association with breast cancer risk. In some studies, the association between SES and breast cancer risk appeared to be explained by variation in the distributions of biologically plausible breast cancer risk factors (e.g., later age at first birth, earlier age at menarche, and hormone therapy use) (Heck and Pamuk, 1997; Braaten et al., 2005). That is, women in higher socioeconomic groups tend to have a higher prevalence of exposure to known breast cancer risk factors that are plausibly biologically linked to breast cancer than women in lower socioeconomic groups. So, although it is possible to calculate a population attributable fraction for higher SES, of greater interest and utility are population attributable fractions for breast cancer risk factors for which SES is a proxy and which have a biologic basis. An article by Dr. Suzanne Snedeker in this issue of *The Ribbon* further discusses the relationship betwen SES, breast cancer risk, and survivorship.

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BCERF Collaborates with the Roswell Park Cancer Institute in Buffalo for its Spring 2006 Regional Cancer and Environment Forum

BCERF worked with faculty and staff at the Roswell Park Cancer Institute (RPCI) to bring its Regional Cancer and Environment Forum to the Buffalo area on June 2, 2006.

We had complementary topic goals for this Forum: we wanted to bring information we had presented in the eastern part of the state in October 2005 to those in the western region and to integrate some of the current work of our colleagues doing breast cancer epidemiology at RPCI. We also wanted a panel of local researchers and activists that would reflect the scope of related scholarship and activism taking place in the region. Over 70 participants took part in the day.

Occupational cancers in women and mammary carcinogens

The morning's presentations were updated versions of the talks that Dr. Suzanne Snedeker of BCERF, and Nellie Brown, Director of Workplace Health and Safety Programs for the Cornell School of Industrial and Labor Relations, delivered at the previous Forum, held in Albany last fall. Overviews of these presentations, "Women, the Workplace, and Cancer Risk," and "Mammary Carcinogens: Scenarios for Exposures" can be read in the Volume 10, Number 4 issue of *The Ribbon,* or at **http://envirocancer.cornell.edu/Newsletter/minutes/Oct05.cfm**.

Genetic/environment interaction and breast cancer risk

Dr. Christine Ambrosone, of RPCI and the University at Buffalo, gave the afternoon's scientific presentation entitled, "The Study of Genetics to Clarify Relationships between Breast Cancer and the Environment." Dr. Ambrosone opened by providing an overview of known and suspected breast cancer risk factors, and the epidemiologic rationale behind inquiry into breast cancer and the environment. The theme of her talk was that in studying environmental risk factors for breast cancer, it is becoming increasingly clear that common genetic variants in the population may modify the effects of a given exposure on risk outcome. One example that Dr. Ambrosone provided was PCBs (polychlorinated biphenyls) and breast cancer risk. She cited four studies indicating that the risk of postmenopausal breast cancer risk with a high PCB body burden and a particular genotype *(CYP1A1)* was significantly elevated. This genotype is carried by 10-15% of the Caucasian population. She also overviewed data on breast cancer risk and cigarette smoking, where there is some evidence the genotype *NAT2* may increase susceptibility (studies have been inconsistent). In addition to introducing the group to these concepts of "biochemical individuality" in the population, and how that bears on breast cancer epidemiology, Dr. Ambrosone also touched on issues of life stage and breast cancer risk, including gene/environment interaction and puberty onset. She outlined the many exposures of interest, with regard to potential hormonally-active agents.

Emerging science on breast cancer and the environment: Where do we go from here?

At this Forum, we were fortunate to feature a diverse panel, with rich academic, activist and personal experiences to share with the group. Special thanks to Greg Beehler at RPCI for helping to organize the panel. Panel participants were:

- **Dr. Kirsten Moysich,** epidemiologist, of RPCI and the Department of Social and Preventive Medicine at the State University of New York at Buffalo;
- **Nellie Brown**, Director of Workplace Health and Safety Programs for the Cornell School of Industrial and Labor Relations, in Buffalo;
- **Dr. Erin Robinson,** Assistant Professor of Sociology at Canisius College in Buffalo;
- **Joan Morrissey,** Outreach Specialist for the U.S. Army Corp of Engineers' Buffalo Districts' Special Projects Branch;
- **Marcia Heaney,** President of the Breast Cancer Network of Western New York;
- **Marilyn Deans**, President of the Sisters Network, Buffalo Chapter, an affiliate of Sisters Network, Inc., a national African-American breast cancer survivorship organization.

All panel participants introduced themselves and described to the group either their research or whom they represented, and their immediate comments on the day and its topics. A unique feature of this panel was that we

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Searching for Answers: "Unpacking" How Socioeconomic Status Affects Breast Cancer Survivorship and Risk

by Suzanne M. Snedeker, Ph.D., BCERF Associate Director of Translational Research

In my ten years with BCERF, I have written about chemicals and cancer risks in a variety of formats, from detailed critical evaluations of the literature for scientists, to fact sheets and work shops for consumers, professionals, and cancer advocates, to *Research Commentaries* published in *The Ribbon*. Occasionally, I find myself between the proverbial rock and a hard place because of the gaps (or rather crevasses) in scientific approaches that have not allowed us to go forward to fully determine what factors do or do not contribute to breast cancer risk. How can we better define how and to what extent environmental factors contribute to rising rates of breast cancer here in the United States, and in countries like the People's Republic of China and Japan, where rates have skyrocketed in the last 30 years? Unlike my usual pattern of critiquing one or several research studies, I ask your indulgence in using a different approach in this commentary. I would like to "unpack" several issues, specifically, how does socioeconomic status (SES) affect breast cancer survivorship and breast cancer rates? And, what do we know (and what do we need to know) about how SES (including "buying power" or lack thereof) affects choices related to risk, from what we eat, to how we behave, to where we live, to exposures to specific chemicals of concern?

What is SES?

The definition of Socioeconomic Status (SES) in "A Dictionary of Epidemiology" (Last, 2001) is:

> *Descriptive term for a person's position in society, which may be expressed on an ORDINAL SCALE using such criteria as income, education level attained, occupation, value of dwelling place, etc.*

It is known that we have a paradox in breast cancer related to SES. Breast cancer mortality rates (dying of breast cancer) tend to be higher in those lowest on the income scale, yet breast cancer incidence (developing breast cancer) tends to be higher with a greater income. What are the factors that may explain these trends, which are seen worldwide, and how is SES a "proxy" factor for many other factors that affect breast cancer survivorship and risk?

SES and Surviving Breast Cancer

Switzerland has one of the highest life expectancies and average incomes in the world, with an extensive network of accessible medical treatment facilities. Yet, a study conducted by Bouchardy and colleagues (Bouchardy et al., 2006), found that social disparities affected the rates of dying from breast cancer in their study based in Geneva, Switzerland. Patients that had the lowest economic class had a 2.4-fold higher risk of dying from breast cancer compared to women of the highest economic class. Why is this so? The authors found that despite access to health care, women with a lower income tend to be screened less frequently, and when screened had a more advanced stage of breast cancer. After a diagnosis of breast cancer, women with a lower income tended to have less use of breast conserving surgery, hormone therapy, and chemotherapy. Yet, when all of these treatments were controlled for, the women with the lowest SES still had a 1.8-fold higher risk of dying of breast cancer compared to Swiss women of higher incomes. It is still not completely understood as to why, despite dramatic increases in life expectancy and improvements in living conditions, social disparities still contribute to a poorer outcome, and a higher death rate from breast cancer in women with low SES. Social inequality, the authors conclude, may be an independent factor affecting breast cancer survivorship.

Alternatively, could there be unidentified factors that contribute to a poorer outcome that are related to the environment of women with less economic buying power? Few studies have evaluated *how* economic status might affect the development of the disease because of, for example, differences in working conditions, exposure to pollution, dietary choices, or use of household chemicals and personal care products. The time may have come to stop speculating and to start thinking outside the usual box to determine how we can test hypotheses of how income affects the total environment and ultimate disease outcome. While there is increased awareness of how economic justice issues affect chemical exposures, we have only started to explore how economic factors affect breast cancer risk in socially disadvantaged populations.

Disparities have been noted in breast cancer death rates between white women compared to women of African American ethnicity in the United States: African American women have poorer survivorship *even after* controlling for SES (Newman et al., 2006). Why there are differences in survivorship remains a matter of speculation. Earlier studies suggested differences in screening

frequency with subsequent diagnosis of a more advanced, frequently metastatic stage of the disease in African American women compared to white women (Heck and Wagener, 1997). However, other studies have shown when delivery of care is tightly controlled in a randomized trial (controlled for stage of disease, work-up, and delivery of care), the survivorship was still poorer in African American women compared to white American women (Albain et al. 2003 [ref. no. 25], as cited by Newman et al., 2006). While current hypotheses suggest possible genetic differences in the underlying morbidity risks in women of different ethnicities, as well as differences in when women bear their children, could there be other explanations? Could causal factors be different because of different diets (protective and non-protective elements) or exposures to different types and quantities of environmental chemicals encountered on the job, or in the local neighborhood, or different patterns of use of personal care products? We have no definitive answers, but these are questions and avenues that need in-depth exploration.

What we lack for breast cancer epidemiology is an index of how exposures to specific chemicals of concern differ (or not) according to income, including the extent of exposure to known mammary carcinogens and endocrine disrupting chemicals.

High Rates of Breast Cancer in the United States: Individual versus Community Effects

Within an urban community, researchers have found higher risk of advanced stage of breast cancer in women living in areas with lower levels of education and income regardless of ethnicity. Merkin and colleagues evaluated risk of advanced staged diagnosis of breast cancer in women living in New York City. After adjusting for age and year of diagnosis, low SES increased the chances of an advanced staged breast cancer diagnosis 50% in black women and 75% in white women (Merkin et al., 2002).

A very interesting study was conducted by Robert and colleagues from the University of Wisconsin and the Fred Hutchinson Center in Seattle, Washington (Robert et al., 2004). They asked the questions: are women at higher risk for breast cancer if they as individuals have a higher SES, or if they live in a community that has a higher SES overall, or if they live in an urban community? This case control study included 14,667 women residing in Wisconsin. These researchers looked at individual risk factors, including age, mammography use, family history, parity, age at first birth, alcohol intake, body mass index, hormone replacement use, oral contraceptive use, and menopausal status. After all of these individual risk factors were controlled for, they found that women living in communities with the highest SES had about a 20% higher risk of having breast cancer compared to women living in communities with the lowest SES. Risk of having breast cancer was also higher (about 17% higher) for women living in urban compared to rural communities. These authors stated that future research studies needed to determine why living in communities with higher SES or in urban communities results in a higher risk of breast cancer.

In California, there are wide geographical variations in breast cancer rates. A study on how SES (based on occupation, income, and education) and urbanization affected regional rates of invasive breast cancer was conducted by Reynolds and colleagues (Reynolds et al., 2005). The study was based on cases identified in the California Breast Cancer Registry between 1988-1997. In this study, researchers found that regional variations in ductal breast cancer rates were largely attributed to variations in SES and urbanization. However, for lobular breast cancer, in the San Francisco Bay area breast cancer risk was still moderately elevated even after controlling for age, race, urban/rural location, and SES. This is one of the few studies that considered the type of breast cancer and relationship to SES and urbanization.

How does income relate to chemical exposures? A review of environmental health studies suggests that lower SES is associated with higher exposures to certain environmental chemicals, including a higher likelihood of living closer to hazardous waste sites (such as hazardous waste facilities in Detroit, and the uranium mines near native American reservations in the western United States); indoor air pollutants (use of tobacco products; fuel exhaust; unvented gas heaters); and poorer water quality (Evans and Kantrowitz, 2002). However, these are generalizations, and do not fully take into consideration a basic toxicology principle; effects are determined by the hazard of *that particular chemical*, and the *extent and timing of exposure*. What we lack for breast cancer epidemiology is an index of how exposures to specific chemicals of concern differ (or not) according to income, including the extent of exposure to known mammary carcinogens and endocrine disrupting chemicals. Does income level affect, for example: what is chosen for cleaning products; the carpets and furniture in homes treated with endocrine disrupting chemicals; the use of building materials that may out-gas chemicals of concern; storage of paper (including books) that may off-gas known carcinogens such as formaldehyde; the presence of closed ventilation systems in higher income dwellings compared to open windows in lower income households; or prescription rates and use of over the counter as well as prescribed medications?

Researchers are starting to evaluate how use of personal care products and medications affects environmental exposures (Hauser et al., 2004; Liebig et al., 2006; Ruckart

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et al., 2004; Rudel et al., 2003; Schettler, 2006; Spaeth, 2000). Many of our regulations on air pollutants have emphasized limiting releases into air and water, but have not yet addressed the problem of identifying and controlling exposures encountered in homes. Polycyclic hydrocarbons and certain volatile organic chemicals (VOCs) have been identified as chemicals of health concern detected in indoor air (Spaeth, 2000; Guo et al., 2004). Researchers are starting to call attention to the need for interdisciplinary collaborations that study pollutants in relationship to specific socioeconomic indicators and health outcomes (Bell et al., 2005).

Some researchers have suggested a more rigorous reexamination of indoor air regulations and prevention measures (Spaeth, 2000). Some of the VOCs identified in indoor air include: 1,1-dichoroethene, chloroform, methylene chloride, trichlorethene, benzene, tetrachloroethane and styrene. The Silent Spring Institute has published the results of pilot studies on levels of environmental chemicals in the air and dust samples in households on Cape Cod (Rudel and Brody, 2001; Rudel et al., 2003). There are few human studies, and none of adequate size or quality, that have investigated exposures and breast cancer risk with residential exposures to these chemicals. There is suggestive evidence from occupational studies conducted in China and Sweden that exposure to benzene in occupational settings is associated with a higher breast cancer risk (Hansen, 1999; Petralia et al., 1998; Pollán and Gustavsson, 1999; Snedeker, 2006). Most studies on chemicals and cancer incidence have been conducted in occupational settings (Boffetta, 2004; Snedeker, 2006). It now may be time to turn our attention to the impact of residential exposures to chemicals as affected by income levels as well as cultural and community influences.

Dramatic Rising Rates of Breast Cancer in Urban China

In many ways, urban areas of the People's Republic of China are "living laboratories" allowing scientists to study how rapid urbanization and westernization affects many chronic diseases, from heart disease to many types of cancer. Breast cancer rates (incidence) have risen dramatically in urban areas of China during the last 30 years. Hong Kong has the highest breast cancer incidence rate in Asia. Studies examining trends in breast cancer rates from 1973-1999 showed rates increasing at the rate of 3.6% per year in Hong Kong, China (Leung et al., 2002) (age standardized rate). China has 20% of the world's population of women, so changes in breast cancer rates may have a major effect on global rates of breast cancer. The authors of this paper suggested that the move toward higher rates may be due to following a more western lifestyle. Breast cancer rates in Hong Kong women were 2 to 3 fold higher in women born in the 1960s compared to women born at the turn of the last century (1900). Breast cancer rates started to rise dramatically in women who were born after 1935. Because Hong Kong did not have an organized mammographic screening program until the mid-1990s, it is unlikely that the rise in breast cancer rates can be attributed solely to more widely available screening services, and rates have not been dramatically higher since the time when screening has been more common. The authors hypothesize that there may be a "set of exposures that exerts its primary effect early in life" (Leung et al., 2002, pg. 987).

Other factors that may have affected breast cancer risk include lower parity, not having children at all, rising rates of obesity, and a more sedentary lifestyle. While the age of menarche in China has decreased from an average of 12.60 years in 1981 to 12.07 in 2001, the extent to which this explains the rising rates reported in this paper is not clear. Breastfeeding rates have also changed in China, with it being common practice in 1900, while very low levels were recorded in the 1980s, and rates starting to rise again by the late 1990s.

Most of the cancer registries in China are located in large urban areas, and little information is available to assess national trends, including if similar rises in breast

Ways to investigate social status and environmental hazards

There have been models published on ways to investigate how social status affects exposure to environmental hazards. Cutter and colleagues developed a "Social Vulnerability" index to environmental hazards in the United States (Cutter et al., 2003). This model has three components; conditions that make people or places more vulnerable to an "extreme" natural event (e.g. a disaster, chemical leak, etc.); assumption that vulnerability is a social condition; and that societal status may influence the ability to resist or bounce back from exposures to environmental hazards. In this model, the potential for an exposure to be hazardous (capacity to cause harm) is not only affected by the properties of the chemical, but also by geography (affects how physically close you are to the hazard), and social fabric (includes experience, perception of risk, and the actual built environment). So, there are both biological and social elements of vulnerability in this model. However, such models have not yet been used to specifically study how breast cancer risk is affected by the interaction between social status and exposure to environmental risk factors.

cancer rates are occurring in rural areas as western lifestyles are adopted. More recent estimates of breast cancer risk indicate that between 2000 and 2005 existing cancer registries in China showed a 27.5% increase in the risk of female breast cancer (Yang et al., 2005). But again, these rates are largely reflective of large urban areas. Studies have started to address the causes of the rising rates of breast cancer in urban areas of China. A recent study (Leung et al., 2005) suggested that about 45% of the risk of developing breast cancer in China can be attributed to increased longevity during the last 25 years, and 55% to a "secular rise" in breast cancer rates ("secular" defined as changes due to westerinization and accompanying socioeconomic changes). While again, lowered fertility, younger age at menarche, older age at childbirth, obesity and inactivity have been suggested as risk factors that may contribute to rising rates of breast cancer in a westernized urban China, there were no studies located that had investigated exactly how westernization has affected specific dietary patterns, and whether there have been changes in personal habits, and use of products that may include chemical carcinogens or endocrine disrupting chemicals.

Changes in breast cancer rates with lifestyle changes are not only happening in Asia; a recent review of migration studies published in the *Journal of the National Cancer Institute* suggested that Polish immigrants to the United States have increased rates of breast cancer that may be due to dietary changes, specifically a decrease in cabbage consumption (Nelson, 2006). Cabbage is a cruciferous vegetable that contains glucosinolates that can form anti-carcinogens (isothiocyanates) in the body. Consumption of glucosinolate containing foods, and its affect on cancer risk, and gene-environmental interactions, is being studied in Shanghai, China (Fowke et al., 2003).

Unpacking the SES puzzle: Challenges and Future Directions

How can a plethora of factors rooted in social status and economics be adequately studied for how they individually, and collectively, affect breast cancer risk and survivorship? We may need to move toward the use of computer models that could take into account the large number of complex factors that may affect breast cancer risk, to determine how both a western lifestyle and elements of SES impact on breast cancer risk in different ethnic populations in different parts of the world. The modeling to look at the social and biological interface may need to use the developing field of bioinformatics. It is clear that our practice of looking at single factors or types of factors needs to evolve. Study objectives are frequently determined by the expertise of the investigators, resulting in studies that may primarily look at either dietary or chemical factors while controlling for established breast cancer risk factors. Resources frequently limit the scope of epidemiological studies. Funding to support characterizing the extent of chemical exposures in non-occupational settings is relatively recent, and this is still an emerging area of research.

Future efforts may need to focus on developing new paradigms and new methods to evaluate how society, cultural values and economics all impinge on choices and conditions that affect cancer risk, as well as how social justice and lower economic status affect risk because of adverse locations and lack of resources, including lack of access to health care. The time may have come for economists, epidemiologists, and cancer biologists to think outside the usual box to more fully understand how socioeconomic status may affect the risk of breast cancer and other chronic diseases.

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News from the Web

1 Slide Shows

Two new slide shows and detailed scripts are available. One takes a guided look at the Centers for Disease Control and Prevention's (CDC) Third National Report on Human Exposure to Environmental Chemicals (2005). The other explains how The Sister Study uses biomonitoring approaches and techniques. On the web at http://envirocancer.cornell.edu/presentations/presentations.cfm.

2 FAQ

The Frequently Asked Questions (FAQ) section has been revitalized with new questions and updated answers to old questions. On the web at http://envirocancer.cornell.edu/learning/faq/qa.cfm.

3 Investigation Update

BCERF provides links to the newly released follow-up report on the Coram/Mt. Sinai/Port Jefferson Station Breast Cancer Investigation. On the web at http://envirocancer.cornell.edu/map/NYresources.cfm.

http://envirocancer.cornell.edu is BCERF's home on the web

Stay in Touch with the eUpdate! Subscribers to the BCERF eUpdate receive periodic emails detailing additions to the site and current BCERF news. If you'd like to subscribe to the eUpdate, send an email to Ellen Hartman: eh79@cornell.edu.

Searching for Answers: "Unpacking" How Socioeconomic Status Affects Breast Cancer Survivorship and Risk *continued from page 9*

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Cancer Support and Information: A Collaborative Effort in Tompkins County

Bob Riter, Associate Director for Educational Services, Ithaca Breast Cancer Alliance, http://www.ibca.net
Coordinator, Cancer Support and Information Program, Cayuga Medical Center

I was diagnosed with breast cancer ten years ago. If I had to have cancer, I was thankful that it was *breast* cancer because so many support services were available. I could call the Ithaca Breast Cancer Alliance (IBCA) and connect with others facing the same disease. I could go on-line and find a gazillion breast cancer sites. I could go to a library or bookstore and find dozens of books written by survivors and experts. I could join with hundreds of other breast cancer survivors and participate in IBCA's annual Walkathon and run in the Komen Race for the Cure. (I even won a medal as the fastest male breast cancer survivor in a Komen race. OK, OK. I was the *only* male breast cancer survivor in the race. But I still won a medal!)

In general, people with other cancers don't have this array of support. To begin to address this discrepancy in Tompkins County, New York, the Ithaca Breast Cancer Alliance, Cayuga Medical Center, and Hospicare & Palliative Care Services have joined forces to offer a "Cancer Support and Information Program" that's available to men and women with any type of cancer as well as to their families and friends. Funding was provided by a grant from the New York State Department of Health.

As coordinator of the program, I visit with patients in Cayuga Medical Center's Department of Radiation Medicine and spend time in the offices of local oncologists to connect with patients receiving chemotherapy. I also spend one evening a month providing assistance to patients at the Ithaca Free Clinic.

Much of the assistance I provide is very practical and focused on Tompkins County: Is financial assistance available? Where can I buy a wig? How can I get to my chemotherapy appointment?

Other people are looking for information about cancer in general and their cancer in particular. I can provide brochures from a variety of sources, recommend useful internet links, and suggest local and national organizations that might be helpful. Some of the most appreciative clients are those who are not fluent in English and for whom I've been able to find cancer information written in their native language.

My most important service is assisting men and women without a great deal of social support. I help them navigate the health care system, advocate on their behalf with insurance companies, help arrange rides to treatment, and generally check in on them from time to time.

Many of the people I see are happy to make a connection with someone who's been there as a cancer patient. Making connections is a fundamental part of being human. When you've been diagnosed with cancer or other life-threatening illness, those connections become even more important. That's why we're here.

Our program in Tompkins County is new and evolving. We'd love to share our experiences with communities planning such a program and learn from the more established programs throughout the state and elsewhere. Please contact Bob Riter at bob@ibca.net or at 607-277-0960.

BCERF Collaborates with the Roswell Park Cancer Institute in Buffalo for its Spring 2006 Regional Cancer and Environment Forum
continued from page 5

had two risk communication practitioners, Dr. Robinson and Ms. Morrissey, both of whom have experience working with affected communities on critical environmental health topics, such as, in Dr. Robinson's case, Love Canal. We also had three panelists who themselves had experienced or were currently experiencing breast cancer, and who shared important information on how breast (and other) cancer organizations were maturing in western New York. All panelist enthusiastically shared ideas on how they would bring back information and new contacts from the day, and help push breast cancer and environment research and education forward.

Next Forum:

Thursday, September 28, 2006 • 10:00am – 3:00pm
Planting Fields Arboretum State Park
Oyster Bay, New York
We hope all readers received publicity on this Fall Forum.

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Using "Population Attributable Fraction" to Understand: To What Extent Can Breast Cancer Incidence Be Attributed to Higher Socioeconomic Status? *continued from page 4*

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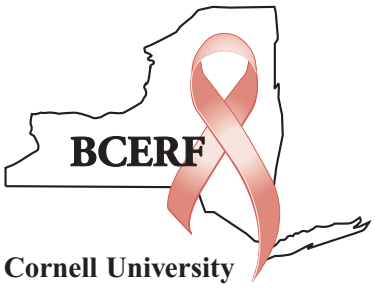

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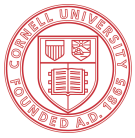

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