Prof. H.A. de S. Gunasekera was Professor of Economics and Head of the Dept of Economics & Political Science of the then University of Ceylon. He succeeded Prof. Das Gupta to become the second occupant of the Chair (and the first Sri Lankan) in the Department in 1961.

He also served as the Dean of the Faculty of Arts at Peradeniya (1963-1969) and later on as Secretary, Ministry of Planning (1970-1977) under Prime Minister Sirimavo Bandaranaike. He was a much respected academic and public servant. A large number of his students have made outstanding contributions to both academic and public life in Sri Lanka and overseas.

Prof. Tilak Abeysinghe has served in the Department of Economics, National University of Singapore (NUS) since 1988. His research interests lie across a range of theoretical and empirical applied econometrics topics which include the Singapore economy, housing affordability, social epidemiology and quantitative health research.

He has published in highly reputed international journals in the field. At NUS, he also serves as the Director of the Singapore Centre for Applied and Policy Economics (SCAPE) and as a Senior Fellow at the Asia Competitiveness Institute. Prof. Abeysinghe holds a B.A. in Economics from the University of Peradeniya, M.Sc. in Statistics from the University of Colombo, M.A. in Economics from Thammasat University, Thailand and a Ph.D. in Economics/Econometrics from the University of Manitoba, Canada.

PROFESSOR H.A. DE S. GUNASEKERA MEMORIAL ORATION

2015

21St September 2015

at

4.00 pm

Senate Room
University of Peradeniya

Department of Economics and Statistics
and the
Prof. H.A. de S. Gunasekera Memorial Trust Fund

PROFESSOR H.A. DE S. GUNASEKERA MEMORIAL ORATION 2015

Program

4.00-4.05	**Opening Ceremony**
4.05-4.10	**Welcome and Introductory Remarks** Head, Department of Economics and Statistics
4.10-4.15	**Vice Chancellor's Address** Vice Chancellor, University of Peradeniya
4.15-4.20	**Introducing the Speaker** Dean, Faculty of Arts
4.20-5.20	**Oration** Prof. Tilak Abeysinghe Department of Economics, National University of Singapore
5.20-5.30	**Vote of Thanks** Secretary, Professor H.A. de S. Gunasekera Memorial Trust Fund
5.30-6.30	**Refreshments** Committee Room, Senate Building

Stress and Cancer: A Link through the Chinese Cultural Revolution

H.A. de S. Gunasekera Memorial Oration

Sep 21, 2015.

University of Peradeniya

By Tilak Abeysinghe

Department of Economics

National University of Singapore

Abstract

It is now well recognized that preventive health care requires going beyond the immediate causes of diseases and understanding their fundamental socioeconomic determinants. Cancer is one of these diseases that has emerged as the top killer, both physically and economically, surpassing heart disease, in many high-income countries. Does stress contribute to these increasing trends in cancer incidence and deaths? This is a question that does not have an easy answer. Opinion surveys tend to over-estimate or under-estimate the role of stress in causing cancer. Although it is not possible to conduct human experiments similar to those on animals, stressful events like the Chinese Cultural Revolution are a natural choice to study this link. Increase in cancer incidence among the cohorts born in the 1950s in two of China's largest cities, Shanghai and Tianjin, show a robust link between the Cultural Revolution and cancer incidence; young adults who faced the Cultural Revolution have become more susceptible to cancer as they aged. The results show that the plight of the so called lost generation of China has gone beyond the already documented socio-economic circumstances to other manifestations such as cancers.

Vice-Chancellor, Dean-Faculty of Arts, family members of late Professor H.A. de S. Gunasekara, the academic community gathered here and friends. It was with great humility that I accepted the invitation to this annual oration in memory of an iconic intellectual in Sri Lanka, Professor H.A. de S. Gunasekera. Although I was not a direct student of Prof. H.A. de S. Gunasekera, I always felt that many of us in my batch were his students because we often talked about him and read his writings. This reflects the legacy he left behind.

For this oration I was debating with myself whether to make a presentation on Singapore's development experience or my research on stress and cancer. In 2010, while I was on a short term visiting appointment at Peradeniya University, I delivered a lecture on Singapore and subsequently I wrote a couple of articles on the subject to Sri Lankan newspapers. Therefore, I decided to talk about stress and cancer, a topic very close to our hearts. The main reason for choosing this topic is to highlight an important role that social scientists can play in the multi-disciplinary field of public health.

The appended article is a joint research study, I carried out with my co-researcher Ms Jiaying Gu who is now attached to the Department of Economics at University of Toronto. A slightly different version of the paper is available at http://brainimmune.com/category/stress-immune-link. In this presentation I will focus not only on my research but also on research by other social scientists on the subject.

Introduction

Cancer is emerging as the top killer in many developed countries. Although cancer is not yet the top killer in some high income countries, in terms of economic cost the American Cancer Society has ranked cancer as the top economic killer (John and Ross, 2010). Estimates by the World Health Organization (WHO) shows that in 2008 the risk of getting cancer before age 75 for US men and women respectively was 33.5% and 26.7%. These figures in India were 10.2% and 10.8% respectively (Cancer Incidence in Five Continents, Vol. IX, WHO, online). In fact, there is a close linear relationship between per capita income of a country and the risk of getting cancer before age 75 (Figure 1). As countries move up the income ladder the cancer risk also tends to increase. Cancer appeared to be rare in antiquity (David & Zimmerman, 2010). The rapid increase in cancer incidence in modern societies is largely attributed to increasing exposure to carcinogens and behavioral factors such as improper diet, smoking and a lack of physical activity (Colditz, 2002). In Japan, however, the cancer incidence rates have trended upward despite falling trends in cigarette smoking and heart disease rates (Cancer Statistics in Japan, online). Does stress contribute to these increasing trends in cancer incidence and deaths? This is a question that does not have an easy answer because of the difficulties involved in assessing the link. Nevertheless, examining the link between stressful events and cancer may shed light on this important health issue.

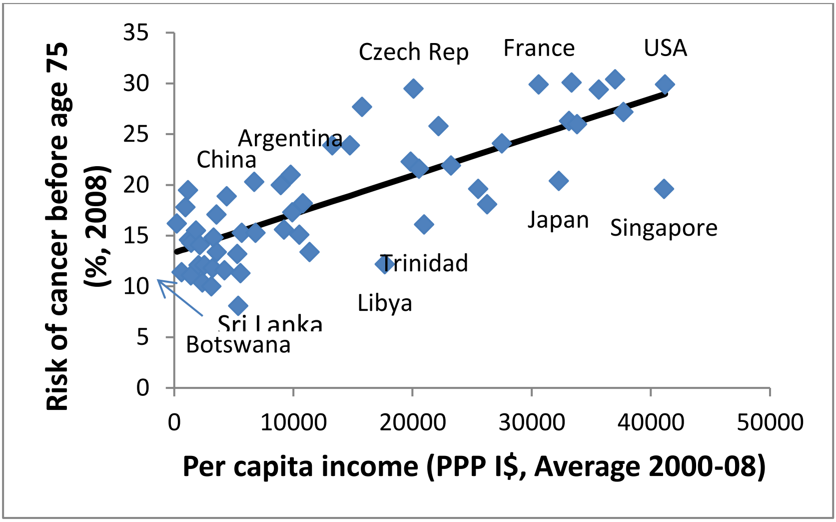


Figure1. Linear relation between per capita income and risk of getting cancer before age 75 (Corr. = 0.78). Per capita income in international dollar is from Penn World Table 7.0, series rgdpch (Heston, 2011) and cancer risk is from WHO. Systematically sampled 55 countries from a list of 190 ranked by per capita income (excludes oil rich outliners).

It is now well recognized that many present-day chronic diseases and health problems have socio-economic origins (WHO, 2010). The basic thrust here is to go beyond immediate causes of diseases and examine the fundamental socio-economic causes in order to formulate preventive-care measures. The conceptual framework that the World Health Organization has presented circumscribes how circumstances of daily life interacting with socio-economic structures in place work through material, social, psychological, behavioral and biological factors to produce different health outcomes in different societies and different layers of the same society (WHO, 2010, Ch. 4, Kaplan, 2012). Wilskinson and Pickett (2010; http://www.equalitytrust.org.uk) present an extensive analysis of the link between income inequality and health and other social malaise. A collection of articles published in Social Science & Medicine (2012, Vol. 74, Issue 5) reviews a sizable literature on how economic crises affect health outcomes through increased unemployment, reduced income and wealth and altered educational opportunities, health care provisions and housing conditions (Bartley, 2012; Berkman, 2012; Braveman, 2012; Burstrom, 2012; Kaplan, 2012; Suhrcke and Stuckler, 2012).

An important mechanism through which socio-economic conditions affect health outcomes is psychological wellbeing (WHO, 2010). Some research demonstrates that the socio-economic climate experienced as a child may become an important determinant of adult mental health (see Quesnel-Vallée and Taylor, 2012; Gelkopf, 2012 and references therein). Psychological distress is likely to affect health adversely both indirectly through lifestyle changes and directly through the effects on stress hormones (Kelly et al. 2011, Kristenson 2012). However, data constraints have been a major deterrent to assessing the impact of psychological distress on health.

Research on the link between psychological factors and cancer also remains limited. Existing scientific research has not established a definitive link between the two (Dalton et al. 2002, Garssen, 2004). Nevertheless, recent randomized control experiments on fruit flies (Wu et al., 2010) seem to provide new evidence on a direct link between stress and cancer. How these results extend to humans remains to be seen. Scientific experiments on humans similar to those on animals are not possible. As a result the assessment of the link between stress and cancer is mostly confined to opinions of cancer patients as to whether they were under prolonged stress before the onset of their cancers. Such opinion surveys unfortunately may overemphasize or underemphasize the role of stress and produce tenuous conclusions (Catherine et al., 2010).

Although it is difficult to conduct scientific experiments on humans similar to those on animals, human history is replete with "experiments" that have caused enormous stress on some human populations. Had there been data available from such historical events they would provide a rich source of information to examine the impact of stressful events on cancer incidence.

The objective of our exercise is to focus on one such "human experiment" – the Cultural Revolution in China – and examine how it relates to cancer incidence. It is well documented that the Cultural Revolution that began in October 1966 with the objective of further propagating the socialist ideology and transforming the bourgeoisie lasted more than a decade and took violent forms, caused enormous social, political and economic upheaval subjecting large segments of the population to unbearable mental and physical stress (Thurston, 1984, 1985). We were motivated to this exercise by a Singapore cancer specialist who talked about a link between stress and cancer and drew attention to an increase in cancer incidence during the

Chinese Cultural Revolution (Ang, 2008). In an intriguing account of traumatic experiences of some Chinese who have lived through the Cultural Revolution, Thurston (1985) also draws attention to the link between stress and cancer. After searching through the literature we came across one study that examined the impact of another major stressful event, the Nazi Holocaust, on cancer (Keinan-Boker et al., 2009). The conclusion of this exercise was that the Israeli Jews who were potentially exposed to the Holocaust experienced higher incidence of all cancers later in their lives.

In our analysis we wanted to focus on a cohort analysis to assess how the Cultural Revolution affected different cohorts of populations across China. City populations are of particular interest because of the “send down policies” that made urban people work in rural areas. However, the paucity of data has been a challenge for the study; complete data records pertaining to our study are hardly available over the Cultural Revolution period. Although we have used data from Shanghai and Tianjin, we were able to carry out a sufficiently detailed analysis only on Shanghai. Section 2 describes the data and sources in detail. In the process of analyzing the data we introduce some refinements to the techniques of age-period-cohort analysis and show how to obtain changes in cohort effects through a differenced model and then obtain the level cohort effects in an index format. In Section 3 we present the estimated cohort effects both in changes and levels. This provides a sharper focus on the hypothesis of interest. Both descriptive and regression analyses show a clear link between the Cultural Revolution and increased incidence of cancers. Results also bring out two unexpected outcomes – firstly, it was largely the so-called “lost generation” of China that has succumbed to cancers triggered off by the Cultural Revolution and, secondly, the Cultural Revolution seems to have created a ripple effect by making the children of this generation also susceptible to cancers. Section 4 provides concluding remarks.

Methodology

Since city populations suffered the most during the Cultural Revolution a good data set from some major cities of China that cover the Cultural Revolution period and beyond would be ideal for our analysis. The data set has to include not only the records of cancer incidence but also a set of control variables that helps us isolate the impact of the Cultural Revolution on cancer. After a considerable search we were able to compile a reasonably complete data set only for Shanghai. We have some limited data for Tianjin. For a comparison with a non-Chinese Asian city population we use Osaka data as well.

Our focus is to isolate the impact of the Cultural Revolution on the increase in cancer incidence in different birth cohorts as they pass through the Cultural Revolution during their working ages. The methodology used is an adaptation of the age-period-cohort (APC) analysis, also referred to as cohort analysis. In a proper longitudinal study the same individual is tracked over years whereas in cohort analysis, when data are recorded by age and year, the same birth cohort can be tracked over the years. (A more technical paper can be obtained upon request.)

Results

A graphical plot of the Shanghai overall cancer incidence rate (per 100,000) by year shows a spike in 1978 and then again in 1989. From such a data plot alone it is difficult to ascertain the impact of the Cultural Revolution on cancer incidence. Table 1 provides a clearer picture where the rate of change of cancer incidence from one birth cohort to the next at the same age group is presented. Although the Tianjin data set is not complete, the cancer pattern in the two cities is very similar. Both cities show three sets of positive numbers (from left to right in the table), at the beginning, in the middle and at the end. In the table we have presented the diagonal averages with corresponding birth cohorts in parentheses and highlighted the middle set. Positive numbers at the end of the table is not surprising because cancer is, in general, an old-age disease. But what is interesting to note is that there has been a substantial drop in cancer incidence in the age group 55-69 since the early 1990s and old-age cancer incidence has shifted to above age 70. The positive numbers at the beginning are unexpected and we will discuss this later. The positive numbers in the middle of the table show that the birth cohorts indicated by years 1948, 1953, 1958 experienced on average 58%, 63% and 28% increase in cancers in Shanghai and 38%, 57%, and 16% increase in Tianjin respectively. These people were young adults during the Cultural Revolution. The most affected appears to be those who were born in early 1950s, those who were in their late teens when the Cultural Revolution began in 1966. Since the numbers in the table do not control for the effect of population and other variables we will discuss the results after the regression analysis.

Table 1. Growth rate (%) of cancer incidence at the same age in Shanghai and Tianjin

Year \ Age	0	5	10	15	20	25	30	35	40	45	50	55	60	65
Shanghai														
1978-82	32.2	-25.2	-50.3	-33.5	**27.0**	**64.1**	**59.5**	-19.6	-38.1	-13.3	-5.9	3.1	12.1	14.3
1983-87	97.4	10.9	-22.4	-41.6	-16.7	**36.9**	**59.8**	**58.1**	-6.6	-28.2	3.5	9.1	15.4	20.5
1988-92	-11.3	94.6	13.6	1.4	-43.5	-30.9	**43.6**	**86.1**	**70.0**	2.9	-26.3	5.5	13.4	21.8
1993-97	-45.9	-19.3	48.5	-11.5	-14.9	-49.4	-47.2	**1.6**	**37.4**	**37.1**	-20.1	-42.1	-11.9	-1.4
1998-02	-41.0	-57.4	9.0	79.8	3.8	-4.7	-41.8	-33.8	**28.1**	**65.7**	**66.1**	-4.0	-31.1	3.5
Diag Ave	-41.0	-51.6	-7.2	80.1	9.8	-13.2	-45.3	-32.4	**27.5**	**62.6**	**58.2**	-9.5	-33.2	-2.5
				(1983)	(1978)				**(1958)**	**(1953)**	**(1948)**			
Tianjin														
1983-87	29.4	-3.3	-22.3	-6.9	-3.5	**3.5**	**45.8**	**39.3**	11.3	0.2	5.0	15.6	29.9	16.6
1988-92	-21.2	23.0	23.5	-36.8	-35.1	-18.2	**32.6**	**71.7**	**42.6**	1.8	-8.5	15.7	32.7	39.0
1993-97	-36.9	16.8	61.9	52.8	7.4	-32.9	-21.6	**12.4**	**54.0**	**33.0**	-3.6	-17.3	11.0	32.1
Diag Ave	-36.9	-2.2	38.1	24.3	-17.3	-25.0	-14.4	**16.1**	**57.2**	**38.3**	3.2	-8.5	10.6	26.8
			(1983)	(1978)				**(1958)**	**(1953)**	**(1948)**				

Note: Diagonals represent birth years. Diagonal averages are from left to right. In parentheses are the reference years of birth cohorts for the diagonal averages. Tianjin data are not available for the full sample period.

Table 2. Regression Results. Dependent variable: Growth Rate of Cancer Incidence

	Shanghai				Osaka (for comparison)			
	Male		Female		Male		Female	
	Coeff est	std error	Coeff est	std error	Coeff est	std error	Coeff est	std error
Constant	13.519	4.467	5.434	6.558	7.588	5.145	1.070	3.736
Population growth	0.242	0.147	0.441	0.194	0.481	0.309	0.816	0.270
Energy/Income growth	0.142	0.074	0.004	0.090	1.217	0.222	0.810	0.150
Age*Energy growth	-0.032	0.015	-0.018	0.022	-0.053	0.012	-0.044	0.007
Agesq*Energy growth	0.0004	0.000	0.0003	0.000	0.0004	0.000	0.0004	0.000
Birth Cohorts								
C1883	-	-	-	-	20.616	-	-6.367	-
C1889	-	-	-	-	34.009	12.597	13.268	7.646
C1893	22.816	-	10.598	-	34.516	12.745	14.022	7.694
C1898	34.671	7.741	17.299	11.962	36.164	10.470	19.870	9.279
C1903	23.195	6.565	8.593	9.527	23.061	7.540	12.241	7.589
C1908	17.081	5.642	1.903	8.353	17.053	4.658	9.195	5.871
C1913	14.246	8.331	17.180	13.375	10.317	2.725	7.748	4.030
C1918	10.738	6.402	10.221	8.486	1.026	2.938	1.222	1.943
C1923	7.593	5.509	7.038	7.339	14.855	5.083	8.596	3.547
C1928	1.819	4.057	0.433	5.881	23.524	8.507	4.363	4.390
C1933	-5.273	3.555	-0.155	5.189	8.006	5.458	4.815	3.704
C1938	-34.815	7.007	-21.507	8.625	-7.063	4.617	-0.639	3.082
C1943	-12.052	4.978	-0.595	6.309	1.350	4.825	3.566	2.984
C1948	**36.763**	6.161	**30.175**	8.789	-4.678	5.416	10.212	3.385
C1953	**40.049**	6.278	**31.399**	8.656	-22.036	11.812	-9.389	9.530
C1958	**23.060**	5.064	**14.896**	7.124	-27.327	11.512	-10.615	9.570
C1963	-32.880	8.229	-22.433	11.147	-13.367	6.111	7.387	6.281
C1968	-46.809	9.984	-42.420	12.380	-3.615	4.492	-8.027	4.182
C1973	-12.498	7.509	-13.314	11.366	-17.598	6.089	-0.120	6.641
C1978	-0.098	5.600	-5.087	9.278	-25.732	12.106	-14.962	10.123
C1983	41.844	8.766	41.930	14.397	-30.996	12.970	-4.784	9.259
C1988	-5.854	10.462	-11.398	9.986	-24.316	12.220	-22.062	10.846
C1993	-63.335	25.300	-44.826	17.102	-21.065	7.555	-21.606	6.646
C1998	-60.263	7.238	-29.930	11.398	-26.702	4.947	-17.935	3.484
		p-value		p-value		p-value		p-value
No of observations	90		90		126		126	
Mean of dependent var	5.66		6.11		12.242		10.248	
R-squared	0.94		0.89		0.85		0.87	

Note: RESET=regression equation specification error test. Standard errors are heteroscedasticity and autocorrelation consistent. C1883 for Osaka and C1893 for Shanghai are minus the sum of the other cohort coefficients. Cohort coefficients show the difference over the previous cohort. Highlighted are the statistically significant positive effects that pertain to the Cultural Revolution.

Table 2 presents the regression results with some diagnostics for Shanghai and Osaka for the growth of total cancer incidence by sex. In Table 2 under Shanghai, statistically significant positive cohort coefficients relevant to our hypothesis are highlighted. Figure 2 plots the cohort coefficients to provide a better visual effect. These, as discussed before, are the changes in cohort effects. Shanghai cohort effects show two distinct humps for both males and females. The estimates pertaining to these humps are statistically significant and not sensitive to different specifications of the regression model. Figure 3 plots the level of cohort effects (in index format) to highlight the relative position and trends of the curves for males and females. A similar plot of Osaka cohort effects do not show a hump corresponding to that of Shanghai.

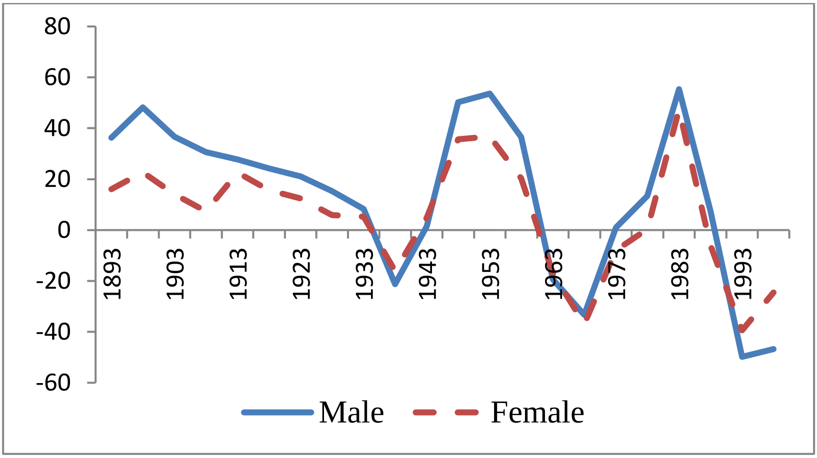


Figure 2. Shanghai cancer incidence: Change in cohort effects by birth cohort.

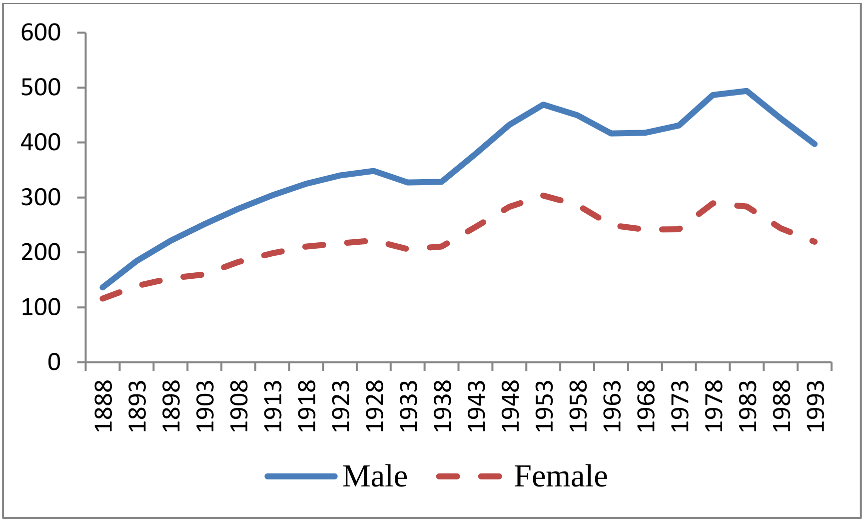


Figure 3. Shanghai cancer incidence: Level (index) of cohort effects by birth cohort.

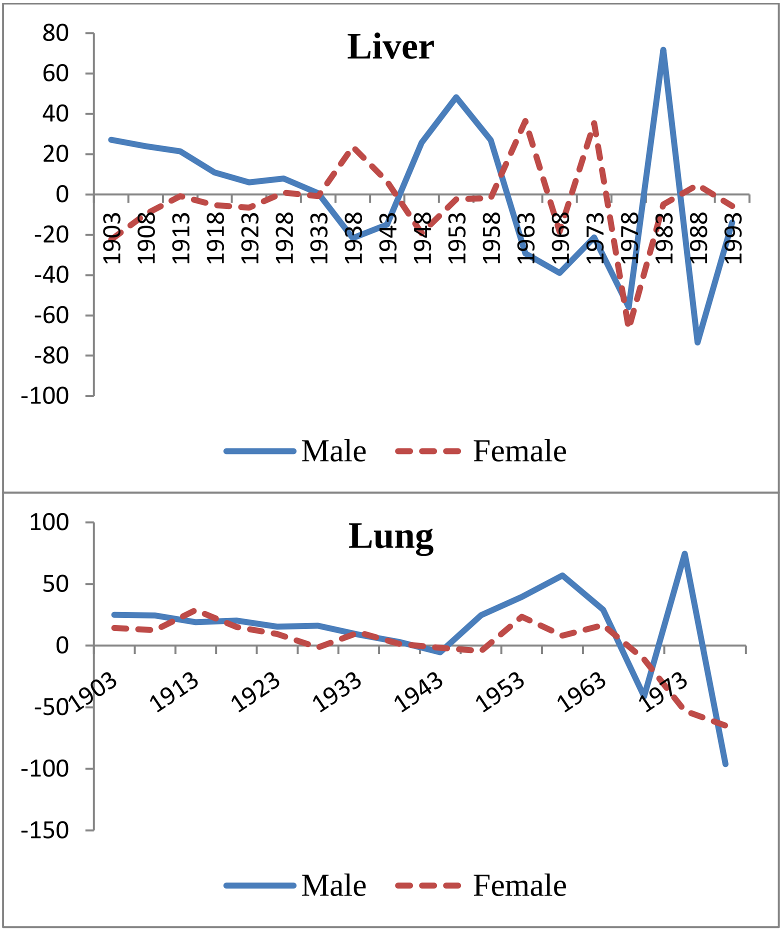
The first hump in Figure 2 pertains to cohorts born between 1944 and 1958. These cohorts were in their young working ages during the Cultural Revolution. Having controlled for age, population, income and pollution effects and also observing the absence of a corresponding hump in Osaka we have to attribute these sharp increases in cancer incidence to the Cultural Revolution. As we observed in Table 1, these cohorts experienced higher incidence of cancer in the late 1970s when they were still young (below 35) and also as they aged. Both Tables 1 and 2 show that the most badly affected cohorts appear to be those born in the 1950s; most of them must have been in their late teens at the peak (around 1970) of the Cultural Revolution.

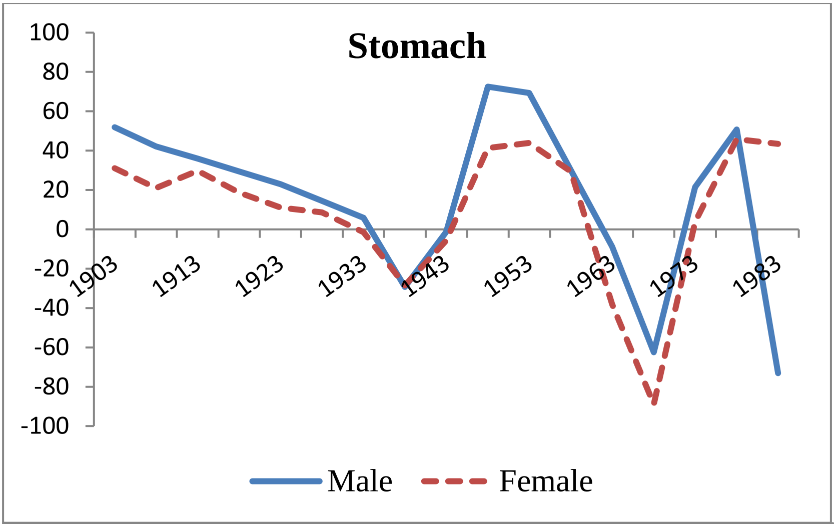
What is further interesting to note in Figures 2 and 3 is the second hump that peaks for the cohort born over 1983-1987. The data show that this peak is due to a sharp increase in leukemia cases in the youngest age group 0-4. The positive numbers in Table 1 at young ages correspond to this jump. This appears to be a ripple effect of the Cultural Revolution itself; parental exposure to stresses of the Cultural Revolution and the incidence of leukemia in babies is likely. Whether such an association is mediated through behavioral factors like maternal alcohol consumption and smoking needs to be studied (MacArthur et al. 2008).

Cancer by Type

As stated in the introduction, a depressive socio-economic environment may cause psychological distress which may result in poor health either through changes in behavioral factors or through the effects on stress hormones or both. The difficult question is how to separate these effects from the jump in cancer incidence that resulted from the Cultural Revolution. The link between some behavioral factors such as smoking, physical inactivity, excess weight and improper diet and cancer is well established (Colditz et al. 2002). In the absence of good data on these behavioral factors we cannot isolate the direct stress effect by controlling for other factors. However, we can shed some light on this issue by applying the cohort analysis to Shanghai data by type of cancer. We limit our analysis only to some illustrative cancer types because of data limitations. The estimated cohort effects for these cancer types are presented in Figure 4 (Tables are not presented for brevity).

Figure 4 shows that the first hump observed in Figure 2 is present in each case though with some variation between males and females. In Figure 4, notable differences in the hump shape between males and females occur in liver cancer and to some extent in lung cancer. Since these cancers are more prevalent among men it is possible that the interaction between stress and men seeking to more alcohol, smoking and other intoxicants such as opium may have caused higher incidence of cancers among men. It should be noted, however, that, strict rules under the new Communist Government brought opium abuse that plagued China for centuries under control since the early 1950s (Lin et al., 2008). Data also show that cigarette smoking grew only moderately over the Cultural Revolution period, 1-1.3 cigarettes per person per day. Cigarette smoking increased substantially only after 1977 and peaked around 1990, about 4 cigarettes per person per day, before declining mildly in later years (US Department of Agriculture, 2004). Among women, tobacco use was substantially lower; about 4% of women smoked in the 1990s as compared with 67% of men (Yang et al. 1999, Peto et al. 2009). Furthermore, studies on rural counties of China show that more plant based diet has kept chronic diseases like cancer and heart diseases low in rural China at the time of the Cultural Revolution (Chen et al., 1990). Therefore, city populations that were deployed in rural areas were less likely to have faced higher incidence of cancer as a result of improper diet. These observations and the presence of more pronounced hump shapes for women in the case of stomach and rectum & anus cancers, which are also more prevalent among men, precludes us from attributing the entire hump to changes in behavioral factors mentioned above.




Stomach
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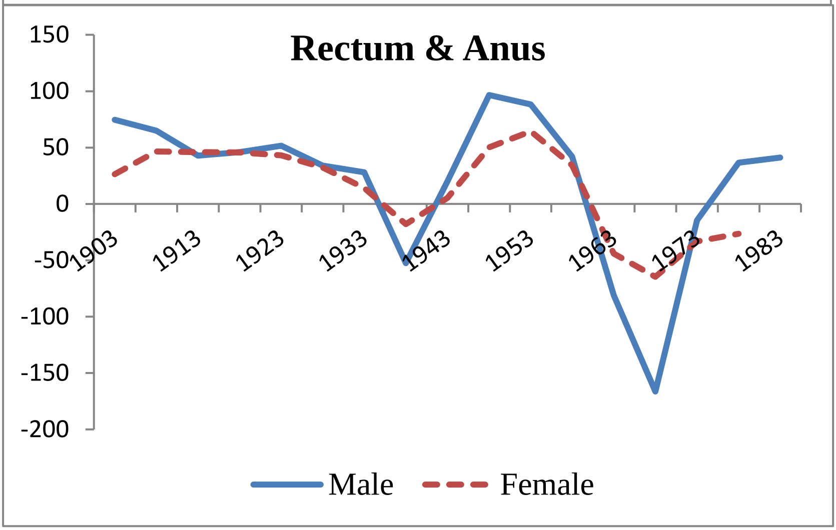
Rectum & Anus
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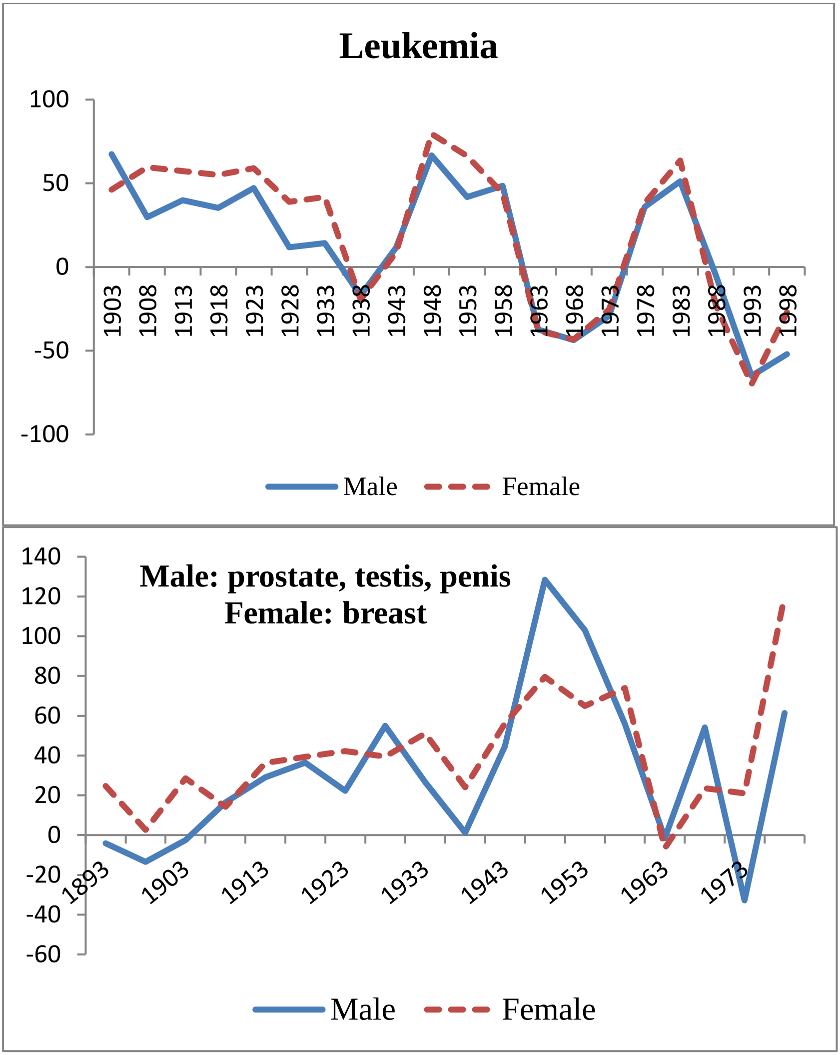

Figure 4. Shanghai: Changes in cohort effects by cancer type and birth cohort.

The picture becomes even clearer in charts for leukemia, prostate, testis, penis and breast cancer. Since leukemia incidence had been somewhat higher in women very similar humps for leukemia cannot be attributed purely to the changes in behavioral factors. Similarly the jumps in prostate, testis and penis cancer in the case of males and breast cancer in the case of females cannot be attributed purely to changes in behavioral factors. Therefore, we cannot rule out the possibility that there was a direct link between stress and cancer incidence resulting from the Cultural Revolution.

The lost generation of China

Our results bring out an unexpected link, a link to the so called “lost generation” of China, those born in the 1950s (more specifically 1947-57 according to Hung and Chiu (2003), 1947-61 according to Meng & Gregory (2002) and Han et al. (2011) or 1947-69 according to Zhang et al. (2007)). The detrimental effect of the Cultural Revolution on these cohorts through deprived educational opportunities and reduced earnings is well documented (Deng & Treiman, 1997; Zhou & Hou, 1999; Meng & Gregory, 2002). The hard labor in the country side imposed on city populations through the so called “send down policy” not only altered the life course of these cohorts for the worse (Zhou & Hou, 1999), a lack of education and skills also made them victims of the subsequent transition of the country to the capitalist system (Hung & Chiu, 2003). However, some have contested the thesis of low returns to education of the Cultural

Revolution cohorts (Zhang et al., 2007). Jun and co-authors have argued that the affected cohorts tried to overcome their disadvantage by re-schooling and investing in skill improvements subsequently (Han et al., 2011).

In contrast to these well-researched socioeconomic outcomes, research on health outcomes of the Cultural Revolution is hard to come by. In this context, our results, though specific to cancer, show that the plight of the lost generation has gone beyond socio-economic circumstances to other manifestations like cancers. Exposure to traumatic events and physical and psychological stresses of the Cultural Revolution must have affected the young adults more for them to become victims of cancer. As Thurston (1985) observes: "Those who were middle-aged at the start of the Cultural Revolution had already experienced, at a minimum, the Japanese invasion, the civil war, the anti-rightist campaign, and the natural disasters of the "three bad years" from 1959-61." As for young people, Thurston observes that there were both direct victims and indirect victims; the latter refers to those who began as active supporters of the Cultural Revolution but subsequently becoming its victims.

Conclusion

Whether stress is going to cause cancer in an individual depends on how the individual copes with stress. We can observe three types of responses by individuals to stress: 1. Some resort to external stimuli like alcoholic drinks and smoking, 2. Some simply suffer mentally and 3. Some manage stress by cultivating mental strength. Therefore, data at an individual level show large variations and make it difficult to measure the link between mental stress and cancer, an aspect scientists are more interested in. However, data from stressful events like the Cultural Revolution that lasted over a prolonged period are likely to show both the direct and indirect link between stress and cancer.

Our analysis of Shanghai (and Tianjin) cancer data shows a very clear robust link between the Cultural Revolution and increase in cancer incidence. After controlling for population effect, age effect, period effect, and age-pollution interaction effect the regression estimates show a statistically significant sharp jump in cohort coefficients pertaining to those who were exposed to the Cultural Revolution during their young working ages. Rather unexpectedly these birth cohorts also belong to the so called "lost generation" of China, an outcome of the Cultural Revolution. Some of the increase in cancers in this generation may be attributed to changes in behavioral factors such as increased alcohol consumption and smoking. However, the similarity in the jump in the incidence of different types of cancers between men and women indicate a possible direct link between stress and cancer. As the effects of the Cultural Revolution withered away, growth of cancer incidence (adjusted for other effects) in subsequent cohorts also came down.

Based on death and disability related lost life years, John & Ross (2010) ranked cancer as the top economic killer globally. Their estimates indicate that this indirect cost of cancer consumes 1.5% of world gross domestic product that is nearly 19 percent higher than heart disease. Estimates in Ping et al. (2010) indicate that cancer has become the top economic killer in China as well. Their estimates show that indirect cost of cancer was twice the direct cost in 2003. Although the authors do not discuss in detail, it is likely that the indirect cost estimates do not include lost productivity of family care givers. Since direct cost from health care expenditures on cancer patients can easily be estimated, a rough ratio of direct to indirect cost will provides us useful information on total economic cost of cancer. Total economic cost of cancer is likely to be much higher than estimated. Therefore, the importance of cancer prevention, both from individual and national perspectives, need not be over emphasized. However, the role of stress, especially considering the long latency of cancers, may require more emphasis than it does receive in cancer prevention programs.

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