

**ASSOCIATIONS OF DIET AND DISEASE: A COMPREHENSIVE STUDY OF HEALTH CHARACTERISTICS IN CHINA**

Presenter:

T. Colin Campbell, PhD  
Jacob Gould Schurman Professor  
of Nutritional Biochemistry

Division of Nutritional Sciences  
Cornell University  
Ithaca, NY 14853

Consultation from:

Junshi Chen, MD  
Chinese Academy of Preventive Medicine  
Beijing, PRC China

Banoo Parpia, PhD  
Yanfang Wang, PhD  
Guizhou Hu, MS  
Andrew Flood, MS

Division of Nutritional Sciences  
Cornell University  
Ithaca, NY 14853

Presented at:

Harvard University  
Fairbank Center on East Asian Studies  
Cambridge, MA

"Social Consequences of Chinese Economic Reform"

May 23-24, 1997

## Presentation and objectives.

For my presentation, I was asked, firstly, to examine what nutritional changes in China have occurred as a consequence of the recent market reform and, secondly, what impact these changes might be expected to have on social and economic development. My comments are primarily based on the early results (1) of a nationwide comprehensive survey of dietary, lifestyle and disease mortality characteristics in rural China which was initiated in 1983 and which involved a collaboration between the Chinese Academy of Preventive Medicine, the Chinese Academy of Medical Sciences, Cornell University, Oxford University and, more recently, the Taiwan National Research Council.

However, before presenting these findings and commenting on their implications, I should first pause and ponder the intense personal beliefs which often surrounds our understanding of the subject of nutrition.

## Nutrition knowledge overview

I have found that it is not enough to simply describe nutritional changes, for this leaves to each person's imagination whether these changes are desirable. It is my experience that most people hold fairly strong views on what constitutes good nutrition. Such views are quite personal, often relating more to one's preferences at the table rather than to one's familiarity with, or fidelity to, the scientific evidence.

Views on nutrition are in the same emotive zone as views on sex, politics and religion, all existing at the very core of our being. Such has been the state of nutrition affairs for a very long time, ever since 2500 years ago during the days of the ancient Greek philosophers who offered, in effect, that we are what we eat. So also has this same view held sway in the Orient; in fact, it still may be holding truer to form there than here in the West.

My belief that views on nutrition are too often very personal and without scientific merit is, I admit, a rather cynical, perhaps even arrogant perspective. But please, I beg your indulgence for a moment on this point. I really don't mind what individual people choose to eat for themselves because I value individual choice and individual experience more than whether they abide by my preaching of what I think to be truthful nutrition information. But I do feel a bit of angst, however, when listening to public authorities who develop societal policies on food, agriculture and health and who dispense public funds and administer public programs without having an adequate understanding of the scientific principles of nutrition biology. This troubles me and I make no apologies for my worry.

The predominant world view on what constitutes good nutritional practices has clearly favored that obtained from diets consumed by the rich and powerful. These diets have been and are still perceived to be

those which are generally high in fat, low in fiber, and most importantly, rich in foods of animal origin.

Oftentimes, this diet is considered "Western", a designation reflecting at least historically, its predominance among Western industrialized societies. This view is encased within a profound paradigm which has penetrated virtually every sector of our society and, in so doing, has, in my experience, severely restricted creativity and candor, as much or even more so within science laboratories and medical clinics as anywhere else.

The societies who espouse this way of eating also are the ones which, during the past couple of centuries, scripted the principles and criteria of modern science and produced therefrom the technologies that have underwritten modern medical practice. We call this practice "Western Medicine". And, what's more, these societies mostly are the same ones that unabashedly construct the histories of their own accomplishments, thereby constructing and fixing in place a rigid paradigm of nutrition thinking. And the majority of the historians and scientists from these societies, not surprisingly but perhaps unwittingly, have encouraged views that supported their own personal dietary habits and, lately being within an environment of modern technology and financial largesse, to even create evidence distinctly biased for their own purposes.

I shall illustrate these remarks on the consequences of this paradigm by sharing two examples, the first being a recent exchange among some very important and talented--but nameless people--at the World Bank, the second, a very simple but elegant 1000-word type picture recently taken by a friend of mine in rural China.

On the discussion at the World Bank, the following represents most of the response given by a very important decision maker at the Bank who administers mega millions of dollars to develop a livestock industry in China. He was answering a query from a Bank colleague whether his recent project report on beef cattle development had taken seriously potential problems associated with the consumption of animal-based foods. For background, he was specifically apprised of a recent handout that I had circulated at a Bank seminar that he missed, thus I suspect that he was, to some degree, belatedly replying to my seminar views.

"Thank you for your memo. Briefly, the answer is no, we haven't taken 'the serious problems associated with animal-based foods into account.' I don't think we will do so, either, at least not until China's dietary patterns look a lot more like Western ones, because to do so could easily be taken as a fairly extreme form of paternalism...or worse. Coming from a culture which consumes over 100 kg of meat and 250 kg of milk, plus God knows how many eggs (over 13 kg) per capita per year, where do we get the right to lecture people who eat 3 kg of beef, maybe 25 kg of meat, 3 or 4 kg of milk, 6 or 7 kg of eggs per year?"

"To most people in the world, eating foods they like is part of what is called 'living.' Not doing so is part of what is called 'poverty.' Choosing what to eat is part of what is called 'freedom.' The beauty of prosperity is that it expands the zone of choice, a zone of freedom perhaps even more highly valued in Chinese culture than ours. The Chinese masses, with a bit of money, are also consuming much more tobacco, alcohol, sugar, oils, motorcycles, and other probably unhealthy commodities than ever before. But, frankly, they seem much happier than even 10 years ago. When you read the details of the grisly famine of 1959-61, imposed on them by another group of people who knew what was best for them, perhaps they can be excused a bit of happiness.

I am hereby asking Mr. X to send you a copy of his new *Yellow Cover Study of China: Long-Term Food Security*. It contains several projections of long-term food demand trends, with animal products continuing to grow and declining direct consumption of grains. The subject project is aimed at permitting several hundred thousand desperately poor peasants to profit from this likely inevitable trend, by improved husbandry of beef cattle. I suppose ranchers in USA, Argentina, etc. would rather this not happen, so that they could supply this growing market with weak domestic competition. But our mission is eradication of poverty in China."

And selected excerpts of a reply from his colleague:

"Thank you for sending me a copy of your message...regarding the Beef Cattle Development Project in China. I was pleased to read about the many opportunities for the Bank to assist the Chinese people in projects involving healthful and environmentally-sound agricultural products, such as canola, fruit and fish. Such projects should help alleviate the peasant malnutrition that you described, by providing sufficient types of nutritious foods at the lowest cost in economic as well as environmental terms.

"Specific deficiencies that you mentioned (e.g. in protein and iodine) can be solved through plant-based foods (e.g. soy protein) at a lower cost than through beef, in both economic and environmental terms. In terms of economic efficiency, the production of one pound of beef requires an input of 13-16 pounds of grain. This conversion factor has a parallel in environmental terms, as much greater quantities of scarce resources (e.g. water) will be used in beef production than in plant-food production (e.g. soy) and much more pollution will result.

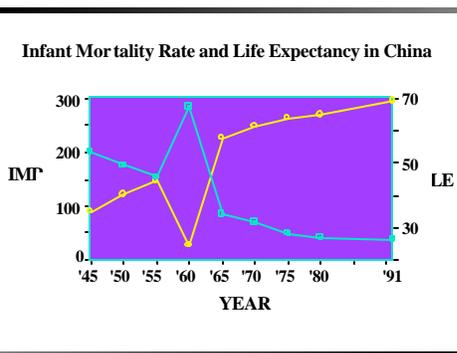
"As you've written, the Chinese people may choose to consume more meat in the same way as they may choose to consume more tobacco. But the World Bank is a developmental institution that has always implemented policies and strategies to steer the people of its client countries away from harmful activities and products like tobacco. It is not difficult to envisage that the Bank, a knowledge-based institution with a developmental mission, may be asked, a few years from now, why it assisted the Chinese people down a path toward dramatically increased disease rates, higher grain prices and greater environmental harm, when the Bank knew better.

"I don't agree with your concern that the World Bank could be accused of paternalism if it raises the issue of the health impact of increased meat

consumption, when a greater degree of paternalism seems to exist in the idea that the Bank should assist China to develop a Western diet. You've written about the search by the Chinese people for happiness, but happiness, as most people know it, is a long-term quality, whereas beef-eating surely falls into the realm of short-term gratification."

It's a good thing that I hold dear the ideas of free speech and free choice!

My second example is a simple picture to show that our paradigm reaches far beyond the office walls of decision makers and, indeed, even seems to lend support to our World Bank decision maker. A Chinese peasant, still bicycling for transportation and perhaps now having a little disposable income, does an obvious thing that virtually every poor man might do, get a side of beef for his family and taste some of the good life of affluence. This idea has penetrated so many for so long, at all levels of human endeavor.



### Trends (1950-1980)

Before presenting the results of our survey work during the 1980s and 1990s in rural China, however, the health trends for the period of about 1950-1980 should be briefly noted. This 1950-1980 period was a time when diet and disease trends occurred under the influence of a centralized command economy, although there is also evidence that geographically localized trends were sometimes found to be responding to local initiative and local incentive.

In spite of a major setback during a severe famine in the late 1950s and early 1960s, China has made remarkable progress during the past half century overcoming what was once considered almost insurmountable and stifling health problems, ranging from substantial successes in reducing infant mortality and increasing life span to the reduction of childhood malnutrition and the prevalence of communicable, infectious diseases. Infant mortality was dramatically decreased by more than 80% and overall life expectancy, mostly a reflection of infant mortality, increased from about 35 years of age just prior to 1950 to 65 years of age in 1980 (Fig 1). Life expectancy is now above 70 years of age even though the infant mortality rate still remains only slightly lower than in 1980, at 38

deaths per 1000 live births. Alan Piazza of the World Bank reported in 1986 (2) that life expectancy at the end of the Second World War was a mere 35 years of age and the proportion of marginally and severely malnourished people was staggering. During the 1950s, I recall the American press consistently reporting that China was a nation unable to feed itself, either then or in the future.

The reduction in the incidence of communicable diseases was particularly impressive. According to Piazza (2), diseases such as smallpox, venereal disease, and cholera were markedly reduced by the mid-1950s, while several widespread parasitic diseases were largely under control by the late 1950s. These improvements were effected through the use of improved vaccines, the extension of the health care system to rural areas, and the more effective use of disease control and treatment methods. The health and anti-epidemic stations that were adopted in the early 1950s to serve the rural areas, eventually grew to 2500 by 1964; these were the stations that later were to serve our survey in 1983.

On nutrition, the first task in the early 1950s was simply to increase food availability (2) (Fig. 2). Energy intake in 1950 was 1742 kcal per capita per day, but by 1980 was 2473 kcal per day, more than enough, given the body size and physical activity of the average Chinese. In the early 1950s, fat intake as a percent of energy intake was 11.3% and, by 1980, still was only 12.6%. These data show that the average diet was mostly plant based, with very little or no added fat or sugar. The average contribution to total energy by animal based foods was 3.6% in 1950 and was still only 5.8% in 1980. As we shall see from our survey results, it wasn't until the introduction of the market economy in the late 1970s and early 1980s that diet composition started to change.

---

**Chinese Food and Nutrient Trends, 1950 - 1980**

Year	Energy (kcal)	Fat (% kcal)	Animal Foods (% total kcal)
1950	1740	11.3	3.1
1955	2230	11.4	3.7
1960	1578	9.8	4.8
1965	2020	11.1	4.2
1970	2190	10.6	4.8
1975	2270	10.8	5.8
1980	2470	12.6	

Piazza, 1986.

---

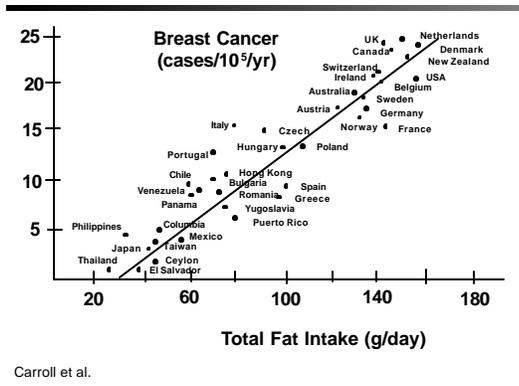
Data on anthropometric measurements showed that male height-for-age between 1953 and 1982 in China increased by 3.2 cm. per decade, which surpasses that of Europe in the twentieth century and is about equal to that of Japan since 1950 (2). Preliminary analysis of the determinants of body height differences among adults in our 1983 data collection suggested that this dramatic improvement in height-for-age from 1953 to 1982 was more due to a decrease in the prevalence of early childhood communicable diseases than to a decreased prevalence of nutritional deficiencies.

Thus, by about 1980, at the dawn of the market reform period, it is now clear that great advances in public health already were achieved in China, an achievement all the more remarkable because of the unusually low expenditure of public funds and because the average Chinese diet during this time was almost entirely (94-96% of energy) plant based. Lest this picture be too rosy, it should also be mentioned that, by 1980, significant minorities of Chinese still remained undernourished, infectious and parasitic diseases were still too common in certain areas, and infant mortality rates could still be further reduced.

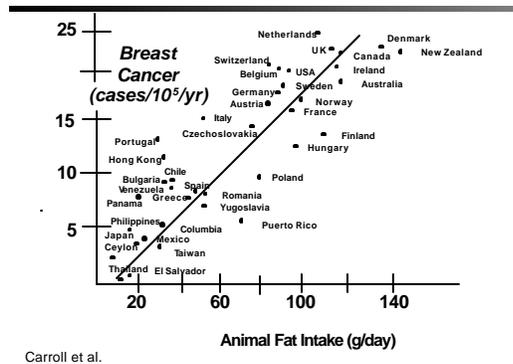
Survey data (1983-present)-basic assumptions

Therefore, I shall spend most of the remainder of my presentation presenting a few summary findings from our comprehensive 1983 survey of dietary, lifestyle, and disease mortality characteristics in rural China, an ongoing collaborative investigation between Cornell University, the Chinese Academy of Preventive Medicine, the Chinese Academy of Medical Sciences, and Oxford University, more lately also including the National Research Council in Taipeh, Taiwan.

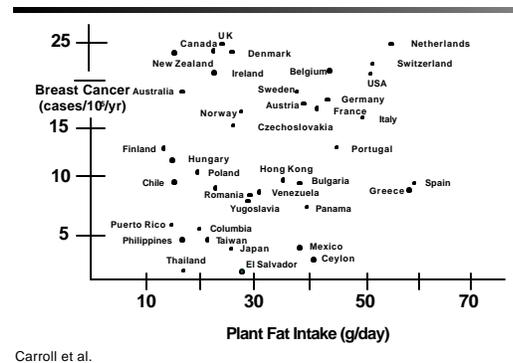
This project was conceived in the early 1980s during the time when the National Academy of Sciences was producing its 1982 landmark report on diet, nutrition and cancer (3). At that time, the principal evidence supporting a link between diet and chronic degenerative diseases came from a comparison of countries whose diet and diseases practices were very different. Certain features of Western type diets were found to be strongly associated with certain diseases found in Western type countries. One such relationship was that for dietary fat and breast cancer: the higher the total dietary fat, the higher the breast cancer incidence (Fig 3).



However, this association seemed to be better explained by factors associated with the consumption of diets rich in animal fat (Fig 4),



more than with diets rich in plant fat (Fig 5).



These data illustrate three important points (Fig 6). First, people who migrate from countries with a high risk of disease to countries with a low risk of disease (or the reverse) gradually acquire the risk of disease of the country to which they move, while keeping their genes essentially the same.

### Effects of Migration on Cancer Risk

**Migrants, without mixing their genes with host population genes, assume cancer risk of country to which they move**

These findings show that, if genes between individuals play a role in the determination of disease--and they undoubtedly do, then diet and lifestyle factors are largely able to control whether these genes produce products which lead to disease.

Second, substantial prevention of disease is possible, not only for breast cancer but also for other chronic degenerative diseases as well. Perhaps even the vast majority of these diseases could be prevented. That is, for each of these diseases, there are countries where disease incidence is very close to nil. Thus, if we could identify the offending risk factors then control them, then these diseases can be prevented without resorting to bizarre and unpredictable interventions such as gene therapy or treatment with highly toxic chemicals.

And third, we need to add a word of caution, substantial caution, on how these data should and should not be interpreted. Using this example, the strong association of dietary fat with breast cancer does not prove that dietary fat, per se, is responsible for these high disease rates. It only means that something characterizing societies consuming high fat diets is associated with disease. Dietary fat might contribute some risk, perhaps more under some circumstances than for others but these data, when standing alone, say little or nothing about how strong this effect might be.

Unfortunately, most researchers since 1982 have focused on dietary fat as the cause of breast cancer and, in my opinion, an enormous amount of wasted funds have been and are being expended. The much publicized association of dietary fat with breast cancer (as well as many other narrowly focused diet-disease associations) is, in my view, far too parsimonious. The dietary and lifestyle causes of disease usually are far more complex, thus suggesting the need to investigate these associations much more comprehensively.

#### Survey hypothesis and study design.

In 1982, when the China Study was being planned, the best guess for an hypothesis to investigate seemed to be dietary and lifestyle factors associated with the consumption of animal fat, as previously explained. The primary and most comprehensive effect of diet upon the development of chronic degenerative diseases could, very simply, be related to the ratio of foods of animal origin to foods of plant origin where animal fat intake is only a surrogate marker for dietary differences. 'Western' type diets, rich in foods of animal origin, characteristically were high in fat, low in dietary fiber, low in an unusually large number of so-called antioxidant nutrients (e.g. vitamins C, E, and beta-carotene) and other constituents of plant material, and high in the type of protein having a high efficiency of utilization--among many other factors.

Thus, an investigation of people experiencing a range of these diseases and consuming diets mostly comprised of a range of foods, especially a range of constituents of plant derived foods was desired. Such an opportunity presented itself in rural China. Chinese scientists had undertaken a study during the 1970s to eventually show in 1980-81 that mortality rates for about a dozen different cancers were vastly different for different parts of the country (Fig 7).

---

**Ranges of Cancer Mortality Rates of China  
Survey Counties (Cases/10<sup>5</sup>/year)**



Cancer site	Males	Females
All Cancers	35-721	35-491
Nasopharynx*	0-75	0-26
Esophagus*	1-435	0-286
Stomach*	6-386	2-141
Liver*	7-248	3-67
Colorectal*	2-67	2-61
Lung*	3-59	0-26
Breast	-	0-20
Cervix	-	4-97
Leukemia*	0-9	0-7

\* Cancers used to select survey counties

---

Across China, diets varied from those rich in plant matter on the one hand to those very rich in plant matter on the other. People tended to consume the same diets from year to year and to reside in the same region most of their lives. Thus, within each reasonably small survey sample area, diet, disease, and residence conditions were reasonably constant. At the same time, across the whole of China, dietary and lifestyle characteristics varied considerably, as illustrated in the highly variable social and economic conditions (Fig 8).

---

**1982 Characteristics of  
65 Survey Counties**



	Minimum	Maximum
Agricultural Employment (%)	42	94
Industrial Employment (%)	1	41
Population Density (persons sq/km)	3	1300
Gross 1982 Income ( ¥/person/year)	134	4706
Junior/Middle School Graduate (%)	7	28
Literacy (%)	32	87

Chen et al., 'Monograph', 1990, 896 pp.

---

An ideal experimental opportunity and cohort were therefore available to investigate the very general but biologically complex hypothesis that diets ever richer in a variety of foods of plant origin are associated with ever decreasing amounts of these diseases. The biological complexity of this relationship may be considered to be due to the combined effect of countless constituents operating through countless biological mechanisms upon countless varieties of degenerative type diseases.

The study was organized to include 65 counties spanning the full range of mortality rates for seven different cancers. Two villages in each county and 50 adults (25 male, 25 female) and their families per village were selected for the survey and the following information was collected.

The field survey itself was organized and carried out under the direction of Dr. Junshi Chen of the Institute of Nutrition and Food

Hygiene of the Chinese Academy of Preventive Medicine in the Fall of 1983 and five kinds of samples and other questionnaire information were collected (Fig 9).

---

<b>Experimental Study Design</b> <b>(1983-84 Survey)</b>	
 <b>County</b> (n=65)	
<b>'Commune' #1</b>	<b>'Commune' #2</b>
50 adults (35-64 yrs.)	50 adults (35-64 yrs.)
3-day dietary intake	3-day dietary intake
Questionnaire	Questionnaire
Blood samples	Blood samples
Urine samples (#1 or #2)	Urine samples (#1 or #2)
Food samples	Food samples

---

Chen et al., 'Monograph', 1990, 896 pp.

The samples of blood, urine and food collected in the survey were analyzed in the laboratory for a variety of nutritional, viral, hormonal and toxic chemical factors between 1984-1988 while the dietary questionnaire information was assembled and entered into computer storage. After 'cleaning' this massive amount of information during 1989-90, a total of 367 items of dietary, lifestyle and disease characteristics (130 villages, 6500 families) were judged to be reliable and were published in a 900 page monograph in 1991 (both in English and Chinese).

Analysis and publication of this information was begun in 1991 and will continue for many years into the future. (As of 1996, only about 2-3% of the total information has been analyzed, interpreted and published.)

## Summary indicators: China vs. US

An overview of dietary characteristics shows that diets in rural China were vastly different from diets in the US (Fig 10).

---

### China Project Data Compare Diets Rich in Plant Foods with Diets Very Rich in Plant Foods, Both Being Much Beyond the Changes Called for in US Dietary Guidelines

	USA(2360 Kcal)	China (2630 Kcal)
Fat, %	36	14
Carbohydrate, %	42	71
Alcohol, %	7	5
Fiber, g/day	11	33
Protein, %	15*	10**
Animal Protein, %	~ 10	~ 1

\* 70% of protein calories are from animal sources  
\*\* 11% of protein calories are from animal sources  
Chen et al., 'Monograph', 1990, 896 pp.



Average intakes of dietary fat and fiber in rural China were, at the time of this survey, markedly different from the US. An especially low intake of foods of animal origin is indicated by the very low intake of animal protein. On average, Americans consume diets containing about 10 times the concentration of animal protein than do rural Chinese. Such a difference obviously indicates major differences in many other dietary and metabolic characteristics as well (Fig 11). For example, blood cholesterol and total fat intake were substantially lower in rural China than in the US.

---

### Fatty Stuff



Indicator	China	USA
Blood cholesterol level (mg/dL)	90-170	170-290
Total fat intake (% en)	6-24	30-46
Body mass index (wt/ht)	20.5	25.8

Chen et al., 'Monograph', 1990, 896 pp.

Energy (calorie) intake, per kilogram of body weight, was about 30% higher in China than the US, yet the prevalence of obesity was much lower in China. This observation is quite remarkable because Chinese energy intake has been standardized for office workers. Thus office worker type people in China consume considerably more energy and are much less inclined toward obesity than 'average' Americans engaged in all manner of work. Undoubtedly, much of increased energy intake in China is attributable to their greater physical activity (most office workers ride bicycles to work) but some of this difference may also be

due to the type of diet being consumed. That is, when a very low fat, high plant food diet is consumed, a significantly higher percentage of the energy being consumed may be 'wasted' or burned off as heat instead of being laid down as body fat.

### Methods of analysis

Our primary aim to date for analyzing and interpreting these data has been directed to an assessment of the more comprehensive and wholistic relationships between causes and effects, a means of assessment traditionally done very poorly by modern, high technology science. We have pursued this aim in two ways. First, disease mortality rates were compared to see if there were any particular tendencies for diseases with common causes to be grouped within similar communities. Then, the dietary and lifestyle factors chiefly associated with these disease groups were identified and associations were assessed.

Second, we hypothesized and investigated associations between specific causes, specific explanatory mechanisms, and specific diseases. Association of these associations of individual factors with individual diseases were then assembled into the whole to see which kind of diet, broadly speaking, was responsible for these associations.

In a sense, the first method initially examines the outside, then peers within, while the second method examines the inside, then looks out. The first describes the whole 'forest' and the main 'trees' which provide the overall appearance. The second examines the trees independently and then attempts to see whether these details match the whole forest description.

### Aggregate group associations

In relation to the first method, two geographically localized groups of disease were found (Fig 12), showing that each disease in either of these two lists is positively associated with diseases in its own list but inversely associated with diseases in the opposite list.

---

#### Consistently Correlated Disease Groups

##### Group A

Pneumonia  
Intestinal obstruction  
Peptic ulcer  
Digestive diseases  
Nephritis  
Pulmonary tuberculosis  
Non-TB infectious diseases  
Parasitic diseases  
Eclampsia  
Rheumatic heart disease  
Metabolic & endocrine disease  
    other than diabetes  
Diseases of pregnancy & birth  
    other than eclampsia

##### Group B

 Colon cancer  
Lung cancer  
Breast cancer  
Leukemia  
Diabetes  
Coronary disease  
Brain cancer 0-14yr  
Stomach cancer  
Liver cancer

Campbell et al., Ecol. Food Nutr 27:133,1992.

---

The first group (A) included diseases characteristic of developing countries while the second group (B) included diseases characteristic of Western countries. Such geographic aggregation of diseases suggests that each disease group tends to have its own set of common dietary and lifestyle causes. Several characteristics measured in the study and possibly representing such common causes were examined. Those which were chiefly associated with Western diseases were total blood cholesterol and urea nitrogen (Fig 13).

---

### Selected Correlations of “Diseases of Nutritional Extravagance”

with:	r
<b>Plasma Cholesterol</b>	<b>0.48***</b>
<b>Plasma Urea</b>	<b>0.41**</b>

\*(urea N correlated with intakes of milk\*\*\*, meat\*\* and eggs\*\*)

\*\* 2p<0.01, \*\*\* 2p<0.001  
Campbell et al., Ecol. Food Nutr 27:133,1992.



Blood urea nitrogen was chiefly associated with intakes of meat, milk and eggs

---

### Correlations of Plasma Cholesterol

with:	
<b>Fat</b>	+ 0.30*
<b>Animal protein</b>	+ 0.24 (2p<0.06)
<b>Meat</b>	+ 0.26*
<b>Neutral detergent fiber</b>	- 0.27*
<b>Cellulose</b>	- 0.37**
<b>Legumes</b>	- 0.35**

\* 2p<0.05, \*\*2p<0.01  
Campbell et al., Cancer Research 50: 6882, 1990.



while blood cholesterol (Fig 14) was directly associated with consumption of dietary fat, meat and animal protein and indirectly with intakes of dietary fiber and legumes.

---

### Dietary Protein Correlations (r) with Plasma Cholesterol (males)

Cholesterol	Animal Protein	Plant Protein
<b>Total</b>	<b>+ 0.39**</b>	<b>- 0.34**</b>
<b>'LDL'</b>	<b>+ 0.40***</b>	<b>- 0.35**</b>
<b>Apo B</b>	<b>+ 0.20</b>	<b>- 0.29*</b>

\* p<0.05, \*\*p<0.01, \*\*\* p<0.001  
 † Female correlations, same direction, less magnitude  
 Zhao et al., J. Nutr. (under review), 1995.



Further analysis showed that both total and LDL cholesterol (the 'bad' kind) were positively associated with animal protein but inversely with plant protein (Fig 15).

I believe these findings are quite remarkable because only small intakes of animal based foods were associated with significant increases in blood cholesterol and other chronic degenerative diseases. (Keep in mind our earlier finding that animal based foods only comprise less than 20% of total protein intake.) Moreover, the higher the intake of foods of plant matter (as indicated by the fiber and legume associations), the lower the level of blood cholesterol.

The most remarkable finding may be the indication that there appears to be no threshold of plant food effect on reducing the prevalence of these diseases (Fig 16).

---

**Consumption of small amounts of 'animal' foods is significantly associated with blood cholesterol, which is significantly associated, in turn, with increased risk for 'Western' diseases**

**For the prevention of 'Western' diseases, there appears to be no threshold associated with increasing the dietary proportions of plant foods (less fat, more fiber, less animal protein, less antioxidants)**



That is, the closer a diet is to an all-plant foods diet, the greater and more comprehensive will be the benefit, at least for many, perhaps most individuals.

The social and economic conditions associated with the development of these two groups of disease are quite well-known (Fig 17).

---

## Diseases Tend to Aggregate Geographically Into:

### Communicable Diseases

### Diseases of Nutritional Extravagance

- Pre-industrialization
- Post-industrialization
- Nutritional deficiencies
- Nutritional extravagances
- Poor countries
- Rich countries



---

Degenerative diseases of Western countries, which may be better characterized as 'diseases of nutritional extravagance', tend to occur in areas where urbanization, industrialization, and wealth converge. That is, as a society begins to acquire additional capital and resources, people rather quickly begin to consume nutritionally richer diets, particularly diets richer in added fat and sugar and foods of animal origin. This phenomenon has characterized the industrialization of countries around the world throughout history. Wealth can easily feed the emergence of Western type diseases if instant dietary and lifestyle gratification is desired.

### Independent associations

The second method used to gain insight into these complex diet and disease relationships is to examine specific associations, then to aggregate the findings to see what 'big picture' might be produced (building the whole forest by examining individual trees). A broad variety of relationships have thus far been investigated, as follows.

Breast cancer increases with increasing dietary fat concentration and higher levels of blood cholesterol (Fig 18).

---

**Breast cancer mortality in China is associated positively with dietary fat intake and plasma cholesterol and inversely with age at menarche**

**It is best predicted by plasma testosterone levels**

Marshall et al., Euro. J. Cancer 28: 1720, 1992.  
Key et al., Brit. J. Cancer 62: 631, 1990  
Wang et al., Brit. Cancer. Res. Treat. 18: 41, 1991



---

This association may also account for the inverse association of breast cancer with age at menarche. Nutritionally rich diets increase the rate of childhood growth thus causing sexual maturation (menarche) to occur

earlier. Many studies have shown that the earlier the age of menarche, the greater the risk of breast cancer later in life. In other words, the fastest rate of childhood growth may not be the healthiest. Breast cancer was also associated with blood testosterone levels (in women) which tend to be elevated with diets higher in fat and foods of animal origin.

Along similar lines (Fig 19), the data from China also showed that body height attained during adulthood is positively associated with increasing intakes of plant protein.

---

#### Protein Consumption and Adult Body Size

**Increased intakes of plant protein are significantly associated with increased adult body size**

**Increased intakes of animal protein are not associated with increased adult body size (statistically insensitive measurement?)**

**Adult body size appears to be more related to prevalence of childhood communicable diseases than to nutritional deprivation**



Zhao et al., under review, 1995

---

This is an exciting observation because it suggests that it is possible to reach our genetic potential for body height simply by consuming adequate intakes of plant-based foods. It is not necessary to consume animal-based foods simply to reach our maximum body height, as most people around the world have assumed. Moreover, choosing to consume adequate amounts of plant-based foods in order to reach our ultimate body size also has the added advantage of minimizing our risk of the degenerative diseases. This finding was briefly mentioned earlier wherein the impressive increases in attained height for adults from 1950 to 1980 were obtained with very little consumption of animal based foods.

The higher are the blood levels of vitamin C and beta-carotene, the lower are the rates of several cancers (Fig 20).

---

**Plasma antioxidant levels  
(especially vitamin C and  
beta-carotene are inversely  
associated with several  
cancers.**

Chen et al., Int. J. Epidemiol. 21:1,1992.  
Wang et al., Brit. J. Cancer, in press, 1993.  
Gao et al., Nutr. Cancer, 13:121,1990.



These antioxidant vitamins are provided almost entirely by plant-based foods.

Dietary fiber may be infinitely complex and its intake can be assessed in many different ways. Associations of multiple fiber constituents with cancers of the large bowel consistently showed lower large bowel cancer when intakes of these fibrous foods were increased (Fig 21).

---

## Colorectal Cancers

**Mortality rates for cancers of the colon and rectum are inversely associated with 14 different fiber/complex carbohydrate intakes, although only one association is  $p < 0.05$**



Chen et al., 'Monograph', 1990, 896 pp.

---

Oftentimes, people mistakenly assume that certain cancers commonly found in the developing countries, such as with liver and stomach cancers, may be caused by the consumption of plant based foods. This is not true. The reason that these cancers are more common in these relatively poor countries is because of the existence of poverty conditions which predispose to these diseases. Thus, there are much higher proportions of people initially susceptible to these diseases. With liver cancer, it is chronic infection to hepatitis B and C viruses, and with stomach cancer, it is the absence of refrigerated food, thus encouraging the use of highly salted and fermented foods. Such foods enhance the development of chronic stomach 'ulcers' associated with a bacterial organism, Helicobacter pylori. Among people who are predisposed, evidence from this study shows that increasing intakes of foods of plant origin actually reduces the likelihood of disease, both for liver cancer and for stomach cancer (Fig 22).

---

**Insufficient intakes of foods of plant origin (and/or excess of animal foods) enhance cancer development among individuals at high risk for stomach and liver cancer**

Campbell et al., Cancer Res. 51: 6882, 1990.  
Kneller et al., Cancer Epi. Biomarkers, Prev . 1: 113, 1992.



Dietary associations with cardiovascular disease, of various kinds, have also been examined from multiple perspectives (Fig 23). Apo lipoprotein B, an index of 'bad' cholesterol, is increased with increasing rates of disease.

---

**Cardiovascular diseases are associated with risk factors usually seen at higher plasma cholesterol levels, especially lower intakes of green vegetables and higher concentrations apo-lipoprotein B, the latter being associated with meat and animal protein, and inversely with legume and plant protein**

Campbell et al., Proc. First Natl. Conf. for Elimination of CHD, 1992.



In turn, this cholesterol level is elevated with increasing intakes of meat and animal protein but is decreased with increasing intakes of legumes, 'light' vegetables, cellulose and plant protein. Again, such data emphasize the health value of plant-based foods.

The dietary and nutritional inferences of these data are many (Fig 24).

---

#### **Nutritional Inferences of China Data**



**Nutrient-biomarker-disease associations span a broad array of diverse relationships**

**Increasing dietary proportions of plant food-based nutrients provide increasing health benefits**

**Number of associations which support the health benefits of diets enriched with plant foods far outweigh associations not supporting (p<0.0000...???)**

**USA Dietary Guidelines, mostly focused on a modest reduction of dietary fat, are not likely to produce significant health benefits**

---

A broad array of specific diet-disease relationships in this study indicate considerable health advantage provided by plant-based diets. The likelihood of there being so many associations pointing toward a plant based diet also appears to be highly statistically significant. Moreover, the fact that there are a plethora of explanatory mechanisms and a virtually unlimited number of possible causes makes this suggestion even more plausible.

These findings are especially important in the context of the American experience. Current dietary recommendations suggest decreasing fat intake to 30% of energy as a national guideline. In contrast, these data from China suggest that this recommendation is unlikely to provide much, if any, benefit.

Summary of survey results

In summary, two general strategies of analysis were used to examine the more wholistic relationships between diet and chronic degenerative disease in this massive data set. The first strategy combined diseases into naturally associated groups, then sought the principal risk factors for these groups. The second strategy examined multiple individual diet-disease associations, then compared their individual relationships to the consumption of plant and animal-based foods. In both cases, the same conclusion emerges. A diet comprised of a variety of good quality plant-based foods is the healthiest. In addition, there are several more specific corollary conclusions to the main finding (Figs. 25-27).

---

COROLLAR Y 1:

**There is no threshold of plant food richness beyond which further health benefits are not achieved**

---

COROLLAR Y 2:

**The closer the foods of plant origin are to their native state (minimal cooking, salting and processing), the greater will be their benefit:risk ratio**

---

---

COROLLAR Y 3:

**The greater the variety of plant foods within a diet, the greater will be the long-term health benefit**

---

These findings represent data collected in a 1983 survey of dietary and lifestyle factors combined with data from a 1973-75 disease mortality survey ('China Study I'). Since then, a second survey (Fig 28) of dietary and lifestyle factors was conducted in 1989-90 and these data are being combined with updated, more expansive disease mortality data for 1986-88. This second data set ('China Study II') is even more

comprehensive than the first and will enable substantially more robust investigations and interpretations.

---

## China Study Survey Components

---

1973-75 Mortality survey : 800 million people, 50+ disease rates

1983-84 Dietary-Lifestyle survey : 130 villages

1986-88 Mortality survey : 100 million people, 100+ disease rates

1989-90 Dietary-Lifestyle-SES survey : 170 villages, 85 counties  
(including mainland China and Taiwan)

Focused surveys : determinants of bone density, determinants of chronic obstructive pulmonary disease, fiber-breast cancer relationships, determinants of vitamin A and iron status, smoking and mortality in 28 urban areas



---

## Implications

These results represent an analysis of a survey undertaken in 1983, just after market reform was being established in rural China. Although this is a one-time sampling, with no trend data (such as for 1950-1980), we can still learn much about the time-dependent disease producing effects of a dietary shift toward a Western type diet, simply by investigating in geographic space what could also be investigated in time. This is what I just presented and the associations are unmistakably impressive. (It should be noted, however, that what is being reported here for China Study I is being strongly supported by early impressions of a second survey of these and further counties in the late 1980's and early 1990's, that is, China Study II.)

Although the biomedical relationships in this study are reasonably clear, the broader societal costs of failing to take seriously this evidence is more difficult to estimate. The main finding from this study, now supported by substantial evidence from other sources, states that future dietary practices ought to minimize consumption of animal based foods. This implies a need for the establishment of appropriate health education programs, while simultaneously minimizing the development of government intervention schemes designed to encourage the production of livestock.

In addition to the biological evidence presented here, it should also be noted that there is supporting evidence from other vantage points as well. First, there are substantial medical treatment costs, although these are very difficult to predict with any degree of certainty. One 'guesstimate' might be drawn from the US experience

**Direct Costs of Treating Diseases Attributable to  
Meat Consumption (in billion \$)<sup>a</sup>**

Disease	Total Costs	Attributable
Hypertension	12.5	2.8 - 8.5
Coronary heart disease	40.4	9.5
Cancer	35.3	16.5
Diabetes	39.0	14.0 - 17.1
Gallbladder disease	3.2	0.2 - 2.4
Obesity related musculoskeletal diseases	13.1	1.9
Food borne diseases	4.7 - 5.5	0.2 - 5.5
<b>Total</b>	<b>148 - 9</b>	<b>29 - 61</b>

<sup>a</sup> Does not include lost productivity costs; Barnard et al, 1995.

Using 1992 dollars, Barnard et al (4) estimated annual direct costs of \$29-61 billion merely to treat diseases attributable to meat consumption, an estimate representing approximately 20-40% of total treatment costs for these diseases (Fig. 29).

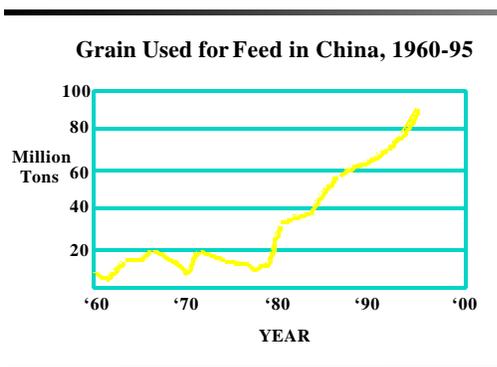
These figures are roughly in accord with estimates by NIH and other US government agencies suggesting that one-third of all cancers could be prevented by dietary means, although others (5) have suggested upwards of 70% of total cancers could be avoided. This estimate of roughly \$30-60 billion might indeed be doubled to \$60-120 billion if one takes into consideration 1) the higher proportion of preventable cancers and other chronic degenerative diseases estimated by some, 2) the contribution to disease prevalence by animal based foods other than meat, and 3) the costs of lost productivity. And further, after adjusting for the population size in China and assuming they choose the Western medical model of disease treatment, this figure could well be in the area of \$300-600 billion per year for China, although I emphasize that this is a very rough approximation.

There are other societal costs for increasing the consumption of animal based foods as well, especially including the adverse effects to the environment and the wasting of natural resources. Quite apart from these additional costs, however, I believe that the relative inability of China to expand its future feed grain production base to accommodate livestock production is one of the more compelling arguments against the increasing use of animal based foods.

The economy of China has been expanding at an unprecedented pace, growing 57% over the four years of 1992-1995 ((6), cited by Brown), thus making it the fastest growing economy in the world during the 1990s. Individual income has increased by more than one-half during this period, thus permitting them to consume 'higher' on the food chain, that is, consuming diets richer in animal based foods. Much of this increase is comprised of chicken and pork, partly because of the limited availability of land for the grazing of ruminant animals and partly because of the greater efficiency of conversion of feed grains to meat. Beef cattle fed in the feedlot require large amounts of grain and

produce one kilogram of beef for every 7 kilograms of grain consumed; one kilogram pork production requires 4 kilograms of grain and one kilogram of beef production requires 2.2 kilograms of grain (7). China, at 37 million tons of pork in 1995, accounts for about one-half of the consumption of the world's consumption, growing at a phenomenal rate of 60% in just 5 years (7). Even though beef consumption lags far behind pork and chicken consumption, it still quadrupled from 1990 to 1995 to an annual consumption level of 4.4 million tons.

These dramatic changes in the consumption of animal based foods in China are ominously reflected in the rapid rise in the use of grain to feed these animals (Fig. 30).



With feed grain production being rather static during the period of 1960 to the late 1970s, use of feed grain has sharply and steadily increased from about 1980 to the present--with no abatement of this increase in sight. The upward inflection around the late 1970s and early 1980s also coincides with the advent of the introduction of the market economy.

Although there seems to be no evidence that this dramatic increase in grain consumption by livestock and poultry is slowing down in China, clearly this must soon be the case. Quite apart from the environmental consequences and economic limitations of producing livestock, grain yield per hectare could soon be reaching its limit, with many observers believing that there is little opportunity for China to meet future grain shortfall by importing grain from elsewhere in the world.

China, although substantially increasing yield per hectare by 4-fold since 1950, is now reaching the yield limit already seen in the US (Figs. 31-32).

---

**United States: Change in Grain Yield Per Hectare  
by Decade, 1950-90**

Year	Annual Yield Per Hectare <sup>1</sup> (tons)	Increase by Decade (percent)	Average Annual Gain by Decade (percent)
<b>1950</b>	<b>1.65</b>		
<b>1960</b>	<b>2.40</b>	<b>+ 45</b>	<b>+ 3.8</b>
<b>1970</b>	<b>3.43</b>	<b>+ 43</b>	<b>+ 3.6</b>
<b>1980</b>	<b>4.13</b>	<b>+ 20</b>	<b>+1.9</b>
<b>1990</b>	<b>4.56</b>	<b>+ 10</b>	<b>+1.0</b>

<sup>1</sup>Each year shown here is actually a three-year average that is used to minimize the effect of weather fluctuations.

---



---

**China: Change in Grain Yield Per Hectare  
Selected Years, 1950-94**

Year	Annual Yield Per Hectare <sup>1</sup> (tons)	Increase by Period (percent)	Average Annual Gain by Period (percent)
<b>1950</b>	<b>1.04</b>		
<b>1977</b>	<b>2.11</b>	<b>+ 103</b>	<b>+ 2.7</b>
<b>1984</b>	<b>3.41</b>	<b>+ 62</b>	<b>+ 7.1</b>
<b>1995</b>	<b>4.06</b>	<b>+ 16</b>	<b>+1.6</b>

---

The U.S. increased its efficiency of production from 1.65 tons per hectare in 1950 to 4.56 tons in 1990, largely through the use of fertilizers and plant breeding and pest control programs. However, the relative increase per decade has steadily declined each of the last 4 decades to the point where further increases in yield efficiency during the 1990s is not expected to be significant. In other words, the maximum yield potential appears to have been reached because of various climatic and technological resource limitations. China, although lagging behind the U.S. in reaching this limit, also is now (in 1990) at 4.06 tons per hectare. Unless one assumes that much higher yields are achieved with labor intensive methods of production, then China will soon be reaching its limit as well.

The major 'take home' lesson from this research seems to be this. Why, given the overwhelming data showing the health hazards of consuming animal based products, would a country then plan to enlarge or to stress the use of its precious land and water resources with little likelihood of increasing productivity, only to produce the most expensive food thus to produce the most expensive diseases? This hardly seems happiness, as claimed by some.

## References

1. Chen, J., Campbell, T. C., Li, J. , and Peto, R. Diet, life-style and mortality in China. A study of the characteristics of 65 Chinese counties, pp. 894. Oxford, UK; Ithaca, NY; Beijing, PRC:Oxford University Press; Cornell University Press; People's Medical Publishing House, 1990.
2. Piazza, A. Food consumption and nutritional status in the People's Republic of China., pp. 256. London:Westview Press, 1986.
3. Committee on Diet Nutrition and Cancer. Diet, nutrition and cancer, pp. 478. Washington, D.C.:National Academy Press, 1982.
4. Barnard, N. D., Nicholson, A. , and Howard, J. L. The medical costs attributable to meat consumption. Prev. Med., 24:xxxxx, 1995.
5. Doll, R. , and Peto, R. The causes of cancer: Quantitative estimates of avoidable risks of cancer in the Unites States today. JNCI, 66:1191-1308, 1981.
6. International Monetary Fund International Monetary Fund, Washington, DC. World Economic Outlook, October 1995.
7. Brown, L. R. Tough Choices, Facing the Challenge of Food Scarcity, pp. 160. Washington, D.C.:W. W. Norton & Company, 1996.