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Citation
Holmes, Michelle D., Shona Dalal, Jimmy Volmink, Clement A. Adebamowo, Marina Njelekelka, Wafaie W. Fawzi, Walter C. Willett, and Hans-Olov Adami. 2010. Non-communicable diseases in sub-Saharan Africa: the case for cohort studies. PLoS Medicine 7(5): e1000244.

Published Version
doi:10.1371/journal.pmed.1000244

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Accessibility
Non-Communicable Diseases in Sub-Saharan Africa: The Case for Cohort Studies

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Introduction

We believe there is an urgent need for longitudinal cohorts based in sub-Saharan Africa (SSA). This conclusion is drawn from the fact that non-communicable diseases (NCDs) cause a large and growing disease burden (please see Box 1) [1–6].

In the past, public health in SSA has focused on communicable diseases. The advent of HIV/AIDS reinforced this image of infections as SSA’s major health burden. However, NCDs, including cardiovascular diseases, mental illnesses, trauma, cancer, and diabetes, are now major sources of morbidity and mortality and are projected to overtake infectious diseases by 2030 [7,8]. We argue that SSA lacks adequate resources to respond to this problem.

Prospective cohort studies can be used to study multiple complex diseases and risk factors simultaneously over an individual’s lifetime. Such studies have proved crucial in understanding the etiology, course, and outcome of NCDs in other populations and have informed the design of prevention programs. In addition, cohort studies provide an incomparable resource for the training of public health researchers. Because the payoff from cohort studies continues—and often grows—over time, they are a long-term investment in public health.

In order to highlight the potential impact of cohort studies in SSA, we compared published literature on NCDs from longitudinal studies in high-income countries to publications from Africa. Further, we estimated the costs of establishing cohort studies in SSA and describe the response needed to correct the disparities in research investment between SSA and the world’s more wealthy regions.

What We Have Learned from Prospective Cohorts in the Wealthy Countries

In 2001, Pettiti prepared a list of 55 important findings from epidemiological studies for the Epidemiology Monitor [9]. This list, reproduced and recently revised by Dr. Pettiti (personal communication, D. Pettiti) in Table 1, represents only a partial inventory of epidemiological discoveries and does not refer exclusively to cohorts but all epidemiological designs.

Colditz and Winn recently proposed criteria by which the success of large cohort studies can be judged [10]. The criteria they suggest are: (1) discovery, (2) development, and (3) delivery. Discovery refers to the ability to explain disease etiology and is measured by numbers of publications and the impact factor of the journals in which they are published. Development refers to the provision of a basis for developing prevention and control measures for populations at risk. Development is measured by contribution to the determination of factors causing disease, providing scientific support for prevention, clinical guidelines and randomized trials, and quantification of the preventable burden of disease. Delivery refers to the implementation of findings from the discovery and development phase by clinicians, public health practitioners, policy makers, and the general public. Delivery is measured by health policies, industry applications, and public awareness. Although these criteria were applied to studies of cancer epidemiology, they are more broadly applicable. When applied to the Nurses’ Health Study (NHS), a longitudinal cohort begun in 1976 with 121,700 US female registered nurses, this one study contributed importantly according to the Colditz and Winn’s criteria. Because cohorts are able to focus on multiple outcomes, they can demonstrate the full public health impact of lifestyle factors.

International Disparity in Investment in NCD Research

We attempted to quantify numbers of publications in the following manner. We searched the PubMed on-line database [11] up to November 26, 2009. We included the Medical Subject Headings (MeSH) “cohort studies” in combination with “Africa South of the Sahara” and two NCDs: “stroke” and “diabetes mellitus.” Each condition was inverted and does not refer exclusively to cohorts but all epidemiological designs.

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Enrolled in Long-Term Cohorts

We counted citations retrieved by these having an abstract, and written in English. We estimated the number of people with diabetes and the number at risk for stroke (those with hypertension) in each area from the following sources. Total population was from The WHO’s World Health Statistics 2008 [12]. The prevalence of hypertension in the US was from the National Center for Health Statistics [13]. The prevalence of hypertension in Africa [14–18], Europe [19], China [20], and India [21] was estimated from several sources. The prevalence of diabetes for all countries and regions was from The International Diabetes Federation 2009 Diabetes Atlas [5].

We calculated the number of publications per million people for each condition in each geographic region (Figures 1 and 2). Continental Africa produced a tiny fraction of the publications from cohort studies per affected population compared to the US: 0.6% for stroke and 8% for diabetes.

International Disparity in Adults Enrolled in Long-Term Cohorts

No central database of numbers of adults enrolled in long-term cohorts of NCDs exists. We have relied on our knowledge of the epidemiology field and that of our colleagues to estimate the proportions of populations enrolled. This method is admittedly crude and we have assuredly missed many. For instance, large populations in North America and Europe are monitored through data linkage to the health care system and are regularly used as cohorts. However, we believe that one brief example can provide a conservative estimate of the magnitude of the disparity.

In the US there are 18 cohorts and 2.9 million participants that are part of The Pooling Project [22]. For Africa we included the following cohorts. The Birth to Twenty Cohort studies the health of young adults born in 1990 in Johannesburg-Soweto, South Africa [23]. The Heart of Soweto is a health facility-based South African study that enrolled 4,162 cardiovascular disease cases in 2006. The Women’s Health Study of Accra, Ghana enrolled 1,328 women to study the prevalence of communicable diseases and NCDs [24,25]. The total cohort enrollment from these three sources is 8,763.

Using the populations of the US and Africa from the WHO’s World Health Statistics 2008 [12], we found that compared to the US, Africa had 0.1% as many cohort enrollees. Given that there are certainly more US enrollees than we have counted, and unlikely to be large African cohorts that we have missed, the disparity is likely to be even larger. Recent calls to create even more US cohorts to study gene environment interactions [26,27] would increase this disparity.

INDEPTH is an organization that evaluates population demography in developing countries, including 12 in SSA [28]. Because they assess primarily births, deaths, migration, and not risk factors or longitudinal data, we have not included them in our count of SSA cohorts. Although some have NCD projects, a massive input of resources would be required to convert them to true prospective cohorts.
### Table 1. Epidemiology triumphs.

| Category          | Disease                                                                 | Risk Factor                                                                 | Direction |
|-------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------|
| **Alcohol**       | Esophageal cancer                                                       | Alcohol interaction with smoking                                            | IR        |
| **Viruses**       | Liver cancer                                                            | Hepatitis B virus                                                           | IR        |
|                   | Burkitt's lymphoma                                                      | Epstein Barr virus                                                          | IR        |
|                   | Kaposi's sarcoma                                                        | Herpes simplex virus type 8                                                 | IR        |
|                   | Cervical cancer                                                         | Human papilloma virus                                                       | IR        |
|                   | Nasopharyngeal cancer                                                   | Epstein Barr virus                                                          | IR        |
|                   | Yellow fever                                                            | Transmitted by mosquitoes                                                   | IR        |
|                   | Creutzfeldt-Jacob disease                                               | Prions (interaction with genotype)                                          | IR        |
| **Bacteria**      | Cholera                                                                 | “Something in water” (vibrio cholera)                                       | IR        |
|                   | Peptic ulcer                                                            | Helicobacter pylori                                                         | IR        |
|                   | Puerperal fever                                                         | “Something on doctors' hands” (group B Streptococcus)                       | IR        |
| **Nutrition**     | Pellagra                                                                | “Something in food” (niacin)                                                | P         |
|                   | Neural tube defects                                                     | Folic acid, folate                                                          | P         |
|                   | Oral clefts                                                             | Folic acid, folate                                                          | P         |
| **Occupation**    | Lung cancer                                                             | Asbestos (interaction with smoking)                                         | IR        |
|                   | Bladder cancer                                                          | Aniline dye                                                                 | IR        |
|                   | Mesothelioma                                                            | Asbestos                                                                    | IR        |
|                   | Angiosarcoma                                                            | Vinyl chloride                                                              | IR        |
|                   | Nasal cancer                                                            | Nickel                                                                      | IR        |
|                   | Male infertility                                                        | Dibromochloropropane (DBCP soil fumigant)                                   | IR        |
|                   | Scrotal cancer                                                          | Chimneysweep                                                                | IR        |
| **Environment**   | Cancer                                                                   | Arsenic                                                                     | IR        |
|                   | Chloracne                                                               | Dioxin                                                                      | IR        |
|                   | Polychlorinated biphenyls                                               | Hyperpigmentation at birth                                                  | IR        |
|                   | Chlordecone (Kepone pesticide)                                          | Tremor                                                                      | IR        |
|                   | Methyl mercury exposure from eating fish due to water contamination     | Severe neurologic disease/cerebral palsy                                   | IR        |
|                   | during manufacture of plastics                                          | with intrauterine exposure. Sensory disorders in adults                    | IR        |
|                   | Dental caries                                                           | Fluoride                                                                    | IR        |
| **Drugs & devices**| Myocardial infarction                                                   | Aspirin                                                                     | P         |
|                   | Micrognathia                                                            | Iso-retinone during pregnancy                                               | IR        |
|                   | Pelvic inflammatory disease                                             | Dalkon shield IUD                                                           | IR        |
|                   | Septic abortion                                                         | Dalkon shield IUD                                                           | IR        |
| **Hormones**      | Clear cell adenocarcinoma of the vagina                                 | Diethylstilbestrol                                                          | IR        |
|                   | Venous thromboembolism                                                  | Oral contraceptives                                                         | IR        |
|                   | Venous thromboembolism                                                  | Post menopausal estrogen                                                    | IR        |
|                   | Ovarian cancer                                                          | Oral contraceptives                                                         | P         |
|                   | Endometrial cancer                                                      | Oral contraceptives                                                         | P         |
|                   | Endometrial cancer                                                      | Post menopausal estrogen                                                    | IR        |
|                   | Iron deficiency anemia                                                  | Oral contraceptives                                                         | P         |
|                   | Benign breast disease                                                   | Oral contraceptives                                                         | P         |
|                   | Myocardial infarction                                                   | Oral contraceptives (interaction with smoking)                              | IR        |
|                   | Ischemic stroke                                                         | Oral contraceptives (interaction with hypertension; modified by dose)       | IR        |
| **Genetics**      | Breast cancer                                                           | BRCA1, BRCA2 mutations                                                      | IR        |
|                   | Ovarian cancer                                                          | BRCA2 mutations                                                             | IR        |
|                   | Colon cancer                                                            | APC1 mutations                                                              | IR        |
| **Miscellaneous** | Toxic shock syndrome                                                    | Super absorbent tampons                                                    | IR        |
|                   | Sudden infant death                                                     | Prone sleep position                                                       | IR        |
|                   | Reye's syndrome                                                         | Aspirin (interaction with infection)                                        | IR        |
reasons: to study population-specific disease burden; genetic heterogeneity; unparalleled geographic, social and cultural diversity; practices and secular trends that may be unique risk factors; and to stimulate political will for health promoting change.

Scientific findings from North America and Europe may not be applicable to other regions. Longitudinal studies track changes in risk factors over time and provide health planners with information on disease burden. One example would be hypertension prevalence. This has been considered a problem of more wealthy, sedentary and obese urban but not rural African populations [15]. Yet blood pressure measurements from cross-sectional studies in several rural African locations have found a hypertension prevalence of 11%–25%, similar to that in the cities and in high income countries [15,16]. A cross-sectional study of 1,500 rural villagers over age 15 in three nations (Tanzania, Malawi, and Rwanda) found 23% had hypertension that was independent of obesity (mean body mass index was 21 kg/m²) and associated with diet [31]. Others have confirmed these findings [17,18]. The assessment that hypertension is mainly a problem of cities is therefore wrong. Global dietary changes will affect the trajectory of hypertension prevalence.

Table 1. Cont.

| Category   | Disease                          | Risk Factor                  | Direction |
|------------|----------------------------------|------------------------------|-----------|
| Smoking    | Lung cancer                      | Smoking                      | IR        |
|            | Coronary disease                 | Smoking                      | IR        |
|            | Hemorrhagic stroke               | Smoking                      | IR        |
|            | Ischemic stroke                  | Smoking                      | IR        |
|            | Abdominal aortic aneurysm        | Smoking                      | IR        |
|            | Peripheral vascular disease      | Smoking                      | IR        |
|            | Parkinson’s disease              | Smoking                      | P         |
|            | Ulcerative colitis               | Smoking                      | P         |
|            | Laryngeal cancer                 | Smoking                      | IR        |
|            | Intrauterine growth retardation  | Smoking during pregnancy     | IR        |
|            | Toxemia/preeclampsia             | Smoking during pregnancy     | P         |

From Petitti D. Epidemiology Monitor, July 30, 2001, and revised May 2009, http://www.epimonitor.net/EpiMonday/Triumph62501.htm, used with permission. IR, increased risk; P, protective.

doi:10.1371/journal.pmed.1000244.t001

Figure 1. Ratio of numbers of publications from cohort studies by condition (graph). Ratio of numbers of publications from cohort studies by condition (stroke, diabetes mellitus) per million people with the disease (diabetes) or at risk of the disease (stroke) in Africa, Europe, China, India, and the US.
doi:10.1371/journal.pmed.1000244.g001
in the future, and cohorts will give information on this trajectory that the cross-sectional studies cannot.

Diet is another location-specific cultural practice. Although we know from studies in high income countries that consumption of whole grain based on mostly wheat and rice is associated with lower risk of diabetes [32], this may not be applicable in East Africa where the staple is corn. We need to research local foods that confer protection to formulate interventions.

History is also location specific. With the exception of studies of starved Europeans during World War II [33], studies of the West’s obesity epidemic have all been among populations with a lifetime of more than adequate energy intake. In Africa, under-nutrition remains common [34] yet coexists with the global obesity epidemic [16,35,36]. Evidence from high income countries shows that intrauterine growth retardation predisposes to increased risk of cardiovascular and metabolic diseases [37–41]. The effects of the collision of these two secular trends in Africa (recent under-nutrition and rapid introduction of obesity-enhancing lifestyle factors) cannot be fully anticipated.

The high prevalence of infectious diseases such as HIV in SSA along with NCDs is another location-specific opportunity. Inflammation common to infections is increasingly known to be important for cardiovascular, metabolic, and neoplastic disease [42–44]. SSA presents the opportunity to better understand this pathophysiology.

Adding to the complexity of locale-specific behavior and history is genetic diversity. Humans first evolved in East Africa, and thus African genetic diversity is greater than elsewhere [45]. Studying the interaction between environmental factors and genes elucidates disease mechanisms. If one multiplies the extended range of cultural practices and historical circumstances by the genetic diversity found in Africa, the opportunities for scientific discovery become enormous (S. Dalal, M.D. Holmes, R. Ramesar. Advancing public health genomics in Africa through prospective cohort studies. Journal of Epidemiology and Community Health [In press]).

Even if smoking and intake of salt and refined grains has been shown detrimental in higher income populations, political will for change may be greater among policy makers, clinicians, and the public if shown in their own population.

Although cohort methodology developed in North America and Europe, high income countries may also gain from knowledge derived from African studies. For example, the obesity epidemic in the West is well developed; we have yet to apply our knowledge to interventions having substantial impact [46].

### Estimated Cost of African Cohorts

We propose cohort studies of 50,000 to 100,000 people in three or four countries covering west, east, and southern Africa. The higher number would increase enrollment of Africans to 532 per million, still only 5% compared to the US.

These studies will include the collection and storage of biological specimens, repeated exposure measurements, and ongoing ascertainment of disease among participants. Disease ascertainment poses particular challenges in countries without strong health systems. It will be important to choose strategies that accommodate local circumstances.

We propose to include populations that are urban, rural, and include men, women, and children. We have four overarching goals: (1) to measure disease burden; (2) to study the etiology of NCDs, the distribution of risk factors, and attributable risks; (3) to provide short-term results by nesting randomized intervention trials within the cohorts; and (4) to stimulate academic development and collaboration.
Ideal study sites would be those where African colleagues have some history of cooperation with the population. Sites with established assessments or interventions may offer cost savings. However, such sites are not likely to easily accommodate the additional proposed layers of complexity, including multiple research designs, multinational collaborators, and managing new enrollees with ongoing study participants separately.

Cohort Costs
We estimated costs for establishing cohorts in two ways. The first was by comparison to the mail-based NHS costs for April 1, 2005 to March 31, 2006 in Table S1 (personal communication, S. Hankinson). Personnel costs are lower in Africa than in the US. We used the Source of International Wage Comparisons compiled by the financial firm UBS to calculate wage differences (Table S2) [47]. Using this method, we estimated the cost of an African cohort of 100,000 participants to be $1.2 million per year, or $12/person/year (Table S3).

Costs could be higher without a reliable mail system; thus we estimated African cohort costs a second way. We applied the cost of an African cohort of 100,000 participants to be $1.2 million per year, or $12/person/year (Table S3).

Randomized Controlled Trial Costs
We used information from a randomized controlled trial (RCT) of single versus multiple doses of multivitamins in addition to ART for women with HIV in Tanzania to estimate the cost of a RCT (personal communication, W. Fawzi). The cost was $1 million for 5 years for 3,000 people. However, this included multiple laboratory measurements because participants were ill. Assuming half the cost for an intervention in well people, we estimate RCT costs to be as low as $135/person/year. We applied a range of $135–$270/person/year to our estimates.

The prevalence of hypertension in Africa is similar to the US [15,16]. The Dietary Approaches to Stop Hypertension (DASH) trial significantly lowered blood pressure among 459 hypertensive Americans [48]. An illustrative intervention would be to do an “African DASH” trial substituting culturally appropriate foods to lower blood pressure among 500 Africans lasting 2 years. We propose doing a total of five similar interventions addressing diseases of the epidemiologic transition over 10 years. The costs for 500 people $2,000,000,000, or $675,000 to $1.35 million.

Training Costs
We assumed the costs of educating African scholars using tuition and living expenses at Harvard School of Public Health [49,50]. We propose other concomitant models for training including lecturers in residence at African universities, short courses, and distance learning. We assumed a range of costs depending on the degree program (master’s or doctorate) and whether the student was single or had a family. The cost per student given in Table S4 ranges from $110,000 to $269,000.

Total Cost Scenarios
Table S5 summarizes the assumptions of the range of costs explained in this section. We assumed cohorts would extend at least 10 years; in a recent review successful large cohorts experienced exponential growth after 10 years [10]. We then applied high and low costs for the cohort, interventions, and for training, and combinations thereof in Table 2. The low estimate including interventions and training is $23.7 million for a cohort of 50,000 people in three countries each. The high estimate is $2.36 billion for a cohort of 100,000 people in four countries each.

Comparisons are useful. PEPFAR cost $18.8 billion for 5 years only for HIV/AIDS [51]. The Bill and Melinda Gates Foundation will spend $3.9 billion in 2009 on various causes including global health [52]. Harvard University’s fundraising for fiscal year 2006 was $600 million [53].

The UK Biobank, a cohort of 500,000 people with a baseline assessment only and 8 years of follow-up linked to a national health record, will cost $104 million [54]. The similar Swedish LifeGene cohort of 500,000 people and with baseline assessment and 8 years of follow-up will cost $112 million (personal communication H.-O. Adami). Translated into costs per person per year, the UK Biobank is $26 and LifeGene is $29. The high and low estimates of the African initiative gives a range from $14 to $644/person/year for the added value beyond the European cohorts of repeated exposure measurements, embedded interventions, and academic capacity building. Other scenarios of different size and intensity could be entertained. For instance, a large company that already conducts periodic health examinations of employees might be economically converted to a cohort. Also, funding need not necessarily come from a single source. However, some costs for an African cohort will be higher than a similar cohort in Europe or North America. A generous budget for travel will be needed to allow newly trained personnel to return to the host institution for further

Table 2. African Cohort Initiative named PaCT (Partnership for Cohort Research and Training) – Estimation of range of costs for two scenarios.

|                      | Four Countries (N= 100,000/Country) | Three Countries (N= 50,000/Country) |
|----------------------|------------------------------------|------------------------------------|
|                      | High | Low | High | Low |
| Cohort               | 2,000,000,000 | 48,000,000 | 750,000,000 | 18,000,000 |
| Intervention         | 1,350,000 | 675,000 | 1,350,000 | 675,000 |
| Training             | 9,296,000 | 6,720,000 | 6,972,000 | 5,040,000 |
| Totals               | 2,001,350,000 | 48,675,000 | 751,350,000 | 18,675,000 |
| Cohort+Interventions | 2,001,350,000 | 48,675,000 | 751,350,000 | 18,675,000 |
| Cohort+Training      | 2,009,296,000 | 54,720,000 | 756,972,000 | 23,040,000 |
| Cohort+Interventions+Training | 2,010,646,000 | 55,395,000 | 758,322,000 | 23,715,000 |

doi:10.1371/journal.pmed.1000244.t002
contact and exchange of ideas, but also to enable experienced researchers to visit the sites frequently.

**Sustainability**

Yach defined the following obstacles impeding attention to NCDs in developing countries: policy makers lack evidence of disease burden, beliefs that NCDs affect only the wealthy and elderly, that they arise only from freely acquired risks, and that their control is expensive, ineffective, and a lower priority than infectious diseases [7].

These obstacles will need to be addressed if cohort studies of NCDs are to be sustainable. Health systems will have to be strengthened to absorb the disease burden uncovered by research. Training programs in public health disciplines are also necessary for long-term career development for the next generation of researchers.

We believe that starting large cohort studies in Africa is a 21st century design to overcome the disease burden, but also to strengthen health systems in African countries.

**References**

1. Unwin N, Setel P, Rashid S, Maguini F, Mbanya JC, et al. (2001) Noncommunicable diseases in sub-Saharan Africa: where do they feature in the health research agenda? Bull World Health Organ 79: 947–953.
2. Abegunde DO, Mathers CD, Adam T, Ortony M, Strong K (2007) The burden and costs of chronic diseases in low-income and middle-income countries. Lancet 370: 1929–1938.
3. Mensah GA (2008) Ischaemic heart disease in Africa. Heart 94: 836–843.
4. Connor MD, Walker R, Modi G, Warlow CP (2004) Results of the Women's Health Study of Accra. Int J Gynaecol Obstet 99: 100: 918–925.
5. Mathers CD, Loncar D (2006) Projections of cancer incidence worldwide during the 21st century: the global burden of cancer in the year 2008. Int J Cancer 118: 3003–3013.
6. Parkin DM, Sitas F, Chirenje M, Stein L, Jassal S, et al. (2008) The global burden of cancer in sub-Saharan Africa: a systematic review. International Journal of Cancer 121: 5012–5018.
7. Yach D, Hawkes C, Gould CL, Hofman KJ (2005) The global burden of chronic diseases in low- and middle-income countries. Lancet 370: 1929–1938.
8. Mathers CD, Loncar D (2006) Projections of cancer incidence worldwide during the 21st century: the global burden of cancer in the year 2008. Int J Cancer 118: 3003–3013.
9. Mathers CD, Loncar D (2006) Projections of cancer incidence worldwide during the 21st century: the global burden of cancer in the year 2008. Int J Cancer 118: 3003–3013.
10. Collins FS (2004) The case for a US prospective cohort study of genes and environment. Nature 429: 473–477.
11. Potter JD (2004) Toward the last cohort. Cancer Epidemiol Biomarkers Prev 13: 895–897.
12. INDEPTH Network. Accessed May 13, 2009. http://www.indepth-network.org/.
13. References.
14. Cappuccio FP, Michal FB, Emmett L, Kerry SM, Antwi S, et al. (2004) Prevalence, detection, management, and control of hypertension in Ashanti, West Africa. Hypertension 43: 1017–1022.
15. Adjo J, Sneh L, Leon DA (2007) Hypertension in sub-Saharan Africa: a systematic review. Hypertension 50: 1012–1018.
16. Barnes J, Elze L, Wehnell H, et al. (2008) Hiding in the shadows of the HIV epidemic: obesity and hypertension in a rural population with very high HIV prevalence in South Africa. J Hum Hypertens 22: 236–239.
17. Cappuccio FP, Kerry SM, Adyemo A, Luke A, Amoah AG, et al. (2008) Body size and blood pressure: a population analysis of Africans and the African diaspora. Epidemiology 19: 31–46.
18. Opie LH, Sreedhar V (2005) Hypertension in sub-Saharan African populations. Circulation 112: 3562–3568.
19. Wolf-Maier K, Cooper RS, Banegas JR, Giampoli S, Hense HW, et al. (2003) Hypertension prevalence and blood pressure levels in 6 European countries, Canada, and the United States. JAMA 289: 2363–2369.
20. Gu D, Reynolds K, Wu X, Chen J, Duan X, et al. (2001) Prevalence, awareness, treatment, and control of hypertension in China. Hypertension 40: 920–927.
21. Gupta R (2004) Trends in hypertension epidemiology in India. J Hum Hypertens 18: 321–324.
22. Bossuyt PM, et al. (2008) Prenatal exposure to the tobacco smoke and risk of type 2 diabetes: a prospective cohort study and systematic review. PLoS Med 4: e261. doi:10.1371/journal.pmed.0040261.
23. Vorster HH, Kruger A (2007) Poverty, malnutrition, and health consequences. Lancet 371: 243–260.
24. World Health Organization. Accessed May 14, 2009. http://www.who.int/whosis/whostat/2008/en/index.html. World Health Organization.
25. Health, United States, 2007. Table 70. Accessed May 18, 2009, http://www.cdc.gov/nchs/data/nhsdataset/hus07.pdf#070. National Center for Health Statistics, Centers for Disease Control.
26. Hill AG, Darko R, Sofi F, Adanu RM, Anarfi JK, et al. (2007) Health of urban Ghanaian women as identified by the Women's Health Study of Accra. Int J Gynaecol Obstet 99: 150–156.
27. Dada RB, Kim MP, Darko R, Adanu RM, Sofi F, et al. (2007) Results of the Women's Health Study of Accra: assessment of blood pressure in urban women. Int J Cardiol 117: 115–122.
28. Sacks FM, Svetkey LP, Vollmer WM, McCarter MD, Ordovas JM, et al. (2001) Comparison of the effects of a low-fat and a Mediterranean diet in the防治和控制的潜力。BMJ 311: 171–174.
29. Huxley RR, Smith AW, Law CM (2000) The role of fruit and vegetables in the prevention of coronary heart disease. BMJ 321: 171–174.
30. Bourne LT, Lambert RV, Stoyk (2002) Where does the black population of South Africa stand on the nutrition transition? Public Health Nutr 5: 157–162.
31. Barker DJ (1995) Fetal origins of coronary heart disease. BMJ 311: 171–174.
32. Ortegon M, Strong K (2007) The burden and health consequences. Lancet 371: 243–260. http://www.who.int/whosis/whostat/2008/en/index.html. World Health Organization.
33. Hill AG, Darko R, Sofi F, Adanu RM, Anarfi JK, et al. (2007) Health of urban Ghanaian women as identified by the Women's Health Study of Accra. Int J Gynaecol Obstet 99: 150–156.
34. Dada RB, Kim MP, Darko R, Adanu RM, Sofi F, et al. (2007) Results of the Women's Health Study of Accra: assessment of blood pressure in urban women. Int J Cardiol 117: 115–122.
35. Vorster HH, Kruger A (2007) Poverty, malnutrition, and health consequences. Lancet 371: 243–260. http://www.who.int/whosis/whostat/2008/en/index.html. World Health Organization.
determining systolic blood pressure: a systematic review of the literature. J Hypertens 18: 815–831.

39. Huxley R, Owen CG, Whincup PH, Cook DG, Colman S, et al. (2004) Birth weight and subsequent cholesterol levels: exploration of the “fetal origins” hypothesis. JAMA 292: 2755–2764.

40. Huxley R, Owen CG, Whincup PH, Cook DG, Rich-Edwards J, et al. (2007) Is birth weight a risk factor for ischemic heart disease in later life? Am J Clin Nutr 85: 1244–1250.

41. Newsome CA, Shiell AW, Fall CH, Phillips DI, Shier R, et al. (2003) Is birth weight related to later glucose and insulin metabolism? A systematic review. Diabet Med 20: 339–348.

42. Das UN (2001) Is obesity an inflammatory condition? Nutrition 17: 933–966.

43. Wilson PW (2008) Evidence of systemic inflammation and estimation of coronary artery disease risk: a population perspective. Am J Med 121: 815–820.

44. Schottenfeld D, Beebe-Dimmer J (2006) Chronic inflammation: a common and important factor in the pathogenesis of neoplasia. CA Cancer J Clin 56: 69–83.

45. Stoneking M, Fontius JJ, Clifford SL, Soodyall H, Arcot SS, et al. (1997) Alu insertion polymorphisms and human evolution: evidence for a larger population size in Africa. Genome Res 7: 1061–1071.

46. Hill JO (2006) Understanding and addressing the epidemic of obesity: an energy balance perspective. Endocr Rev 27: 750–761.

47. Prices and earnings: a comparison of purchasing power around the globe (2003) Accessed March 24, 2009 www.ubs.com/1/ShowMedia/ media_overview/media_global/mediareleases?contentId= 341935. Zurich: UBS.

48. Apple LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, et al. (1997) A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group, N Engl J Med 336: 1117–1124.

49. Student Financial Services: Tuition and Fees from July 2008–June 2009. Accessed Jan. 5, 2009 http://www.hsph.harvard.edu/administrative-offices/student-financial-services/tuition-and-fees-from-july-2008-june-2009/index.html. Harvard School of Public Health.

50. Student Financial Services: Student budgeting. Accessed Jan. 5, 2009 http://www.hsph.harvard.edu/administrative-offices/student-financial-services/student-budget/. Harvard School of Public Health.

51. Celebrating life: the U.S. President’s emergency plan for AIDS relief 2009 annual report to Congress highlights. Accessed May 14, 2009 http://www.pepfar.gov/documents/organization/113878.pdf. President’s Emergency Plan for AIDS Relief.

52. Strom S (2009) Gates group plans to give more in 2009 despite losses. The New York Times, New York: The New York Times Company, http://www.nytimes.com/2009/2001/2027/us/2027gates. html?_r = 2001&ref = us.

53. Wrinn J (2006) Harvard fundraising reaches $595M in fiscal year ’06. Harvard University Gazette: Harvard University. http://www.news.harvard.edu/gazette/ 2006/2009/2014/2099-fundraising.html.

54. UK Biobank Limited report and financial statements for the year ended 30 September 2007. Accessed March 25, 2009 http://www.ukbiobank.ac.uk/docs/Annualreport.pdf. Cheshire.