Environmentalist (2012) 32:353–359
DOI 10.1007/s10669-011-9344-7

Sustainability in medicine: a case for the prevention of chronic non-communicable diseases

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Published online: 5 August 2011

Abstract Chronic non-communicable diseases have increased worldwide, threatening not only the health of individuals but also social stability. Global studies have identified behavioral, environmental, and stress-related factors that account for a substantial amount of variance in these diseases. Identification of these relatively easy modifiable lifestyle factors holds great potential for the development of global prevention strategies in order to improve health and thereby promote economic, ecologic, and social sustainability worldwide.

Keywords Chronic non-communicable diseases · Global health · Lifestyle · Prevention · Sustainability

Chronic non-communicable diseases, which include cardiovascular diseases as the leading cause of death (coronary heart disease [CHD], hypertension, heart failure, and stroke), followed by diabetes, several cancers, chronic respiratory conditions, and depressive disorders, have reached epidemic proportions, contributing significantly to the burden of disease worldwide (Lopez et al. 2006). It has been estimated that of all deaths in low- and middle-income countries in 2005, 33% were due to cardiovascular diseases and diabetes, 12% to cancers, and 8% to respiratory diseases (Abegunde et al. 2007). In the United States, these conditions together accounted for more than 60% of all deaths in 2007 (Xu et al. 2010). Additionally, since 1980, a dramatic increase in obesity, a major risk factor of chronic diseases, has been observed in all regions of the world (Finucane et al. 2011).

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1 Chronic non-communicable diseases and public health

Chronic non-communicable diseases clearly have become a great challenge to public health globally, producing considerable costs not only for the individual but also to society in terms of reduced economic productivity and increased burden on health care systems (Daar et al. 2007). A recent report on the future of cardiovascular disease in the United States estimates that by 2030, 40.5% of the U.S. population will have some form of cardiovascular disease. Associated medical costs are projected to triple between 2010 and 2030 (from $273 billion to $818 billion). Additionally, for the same time period, costs associated with lost productivity are estimated to increase from $171 billion to $276 billion (Heidenreich et al. 2011).

Clearly, the mere increase in the number of persons suffering from chronic diseases presents a major threat to public health. Another contributing factor is related to the increase in costs of common medical procedures. In the U.S., for example, the mean hospital charge for a coronary artery bypass graft (CABG) in 2002 was $57,140 and rose to $117,094 in 2008. The average charge for a percutaneous coronary intervention (PCI), the most commonly performed coronary revascularization procedure, shows a similar increase, from $27,622 in 2000 to $56,258 for each of the 700,425 procedures performed in 2008 (National Healthcare Cost and Utilization Project 2011).

With advances in medical technology and the development of new procedures, costs are expected to rise further. For example, the recent surge in the number of left

ventricular device (LVAD) implantations in patients with advanced heart failure (Kirklin et al. 2011) has prompted attempts to assess the societal value of this procedure. An analysis comparing costs of LVAD implantations to heart transplants (limited by donor shortage) in the U.S. not only indicates higher costs associated with this new technology (Digiorgi et al. 2005) but also raises questions about the safety of these devices for recipients, especially for women (Dhruva and Redberg 2010).

As many of these procedures are becoming standard medical care, their effectiveness is rarely questioned. Exceptions are the concerns expressed by a few health professionals regarding the uncritical use of coronary revascularization procedures, especially the aforementioned commonly employed PCI. For example, Katritis's and Ioannidis's meta-analysis of studies comparing PCI to non-invasive conservative therapy concluded that in patients with chronic stable coronary artery disease (CAD), PCI does not offer any benefit in terms of death, myocardial infarction, or the need for subsequent revascularization compared with conservative medical therapy (Katritsis and Ioannidis 2005). Similarly, a comparison of non-invasive medical therapy (i.e., intensive pharmacologic therapy plus American Heart Association-recommended lifestyle changes) to PCI plus medical therapy demonstrated there was no significant difference in benefit with respect to mortality or cardiac-related events in patients with stable CAD over a five-year period (Boden et al. 2007).

It appears that the adoption of a medical procedure into standard medical care (covered by the patient's health insurance) may contribute to its uncritical use. In a study examining factors influencing physicians' use of standard medical procedures, Lin et al. (2007) found that the widespread use of PCI in patients with stable CAD (despite evidence of little benefit in outcomes over medical therapy) may be due to psychological factors (e.g., belief that performing PCI would benefit the patient; fear of lawsuits). Thus, it is not surprising that a recent review of the use of coronary revascularization procedures in the United States concludes that some patients may be getting more treatment than they want or need (Lucas et al. 2008). Helping physicians to more fully incorporate clinical evidence into medical decision making could benefit patient outcomes and optimal use of new technologies (Lin et al. 2007).

In sum, the vast financial incentives for performing costly medical procedures, together with the industries' comparatively generous research funding and special marketing relationships with physicians (see Blumenthal 2004), may have far-reaching consequences not only in terms of the patient's safety but also in terms of the burden to society, raising serious concerns about the sustainability of current medical practice.

2 A case for prevention

While the increase in chronic diseases and their costly and sometimes questionable treatments presents a major challenge to societies worldwide, it is rather fortunate that most chronic diseases can be prevented. Several large epidemiological studies examining risk factors for heart disease, stroke, and cancer in many countries have identified modifiable behavioral, environmental, and psychosocial factors that account for a large amount of variance in the major chronic diseases. The largest global study on risk of myocardial infarction (MI) to date is the INTERHEART study (Yusuf et al. 2004). This study compared over 15,152 cases with 14,820 sex- and age-matched controls in 52 countries on all continents. Findings from this study confirmed the importance of results from many prospective population studies conducted in the U.S. and Europe in regard to the importance of smoking, physical inactivity, diabetes, abnormal lipids, hypertension, and abdominal obesity as risk factors for MI.

In addition, the INTERHEART study also points to the global significance of other lifestyle factors, such as regular consumption of fruits and vegetables, and a "psychosocial stress index" consisting of depression, stress at work or at home, financial stress, major life events, and low locus of control. Interestingly, this index, adjusted for age and region, accounted for 25.3% of the population attributable risk (PAR) for acute MI in men and 40% in women. All risk factors together accounted for over 90% of the PAR (i.e., the reduction in incidence that would be observed if the population was unexposed to these factors). The authors conclude that "nine easily measured and potentially modifiable risk factors account for an overwhelmingly large proportion of the risk of an initial acute MI. The effect of these risk factors is consistent in men and women, across different geographic regions, and by ethnic group, making the study applicable worldwide" (Yusuf et al. 2004, p 945). They further state that "lifestyle modification is of substantial importance" (Yusuf et al. 2004, p 951; see Iqbal et al. 2008 for more details on dietary habits in INTERHEART; see Crowe et al. 2011 for recent results from the EPIC-Heart Study).

In regard to stroke, similar modifiable risk factors have been identified in the INTERSTROKE study, a case–control study in 22 countries between 2007 and 2010 (O'Donnell et al. 2010). Significant risk factors for both ischemic and intracerebral hemorrhagic stroke were smoking, obesity, unhealthy diet, physical inactivity, diabetes, excessive alcohol consumption, abnormal lipids, psychosocial stress, and depression. Together, these factors were associated with 90% of the risk of stroke (O'Donnell et al. 2010).

With respect to cancer, a worldwide study of behavioral and environmental risk factors for several of the major cancers concluded that of the seven million deaths from cancer worldwide in 2001, an estimated 35% (41% for men and 27% for women) were attributable to modifiable behavioral and environmental factors (Danaei et al. 2005). Among the main risk factors were smoking, excessive alcohol use, low fruit and vegetable intake, obesity, physical inactivity, unsafe sex, and urban air pollution. The observed sex difference was largely due to men's greater smoking and alcohol use. The authors of this report conclude that the emphasis on curing advanced cancer has contributed to preventing progress in the war on cancer. Also, the fact that access to cancer screening and treatments is limited in poorer countries (as well as in rich countries lacking universal health care, such as the USA) has prompted the authors to conclude "These limitations further reinforce the importance of our results for policies and programmes that modify behavioral and environmental factors to reduce the burden of cancer" (Danaei et al. 2005, p 1791).

Considering that Danaei et al. 2005 did not assess many other well-known risk factors, such as exposure to occupational risk factors and environmental carcinogens (e.g., Brody et al. 2011; Rudel et al. 2011; Soto and Sonnenschein 2010), the percentage of cancer deaths attributable to modifiable risk factors would probably be much larger. Clearly, regulations to limit exposure to environmental toxins as well as the adoption of a healthy lifestyle could have a tremendous impact on the burden of chronic non-communicable diseases in the world. The following two sections will review the evidence for health benefits of adopting a healthy lifestyle in order to (1) avoid the disease (primary prevention) and (2) prevent the disease from progressing or recurring (secondary and tertiary prevention; also see Weidner and Kendel 2010).

2.1 Primary prevention

Following a healthy lifestyle (e.g., a combination of a prudent diet, regular exercise, maintaining healthy body weight, and not smoking) has been associated with significant health benefits in several large population studies in the U.S. and Europe (e.g., Knoops et al. 2004; Chiuve et al. 2006; Kurth et al. 2006; King et al. 2007). However, the low number of individuals practicing a healthy lifestyle is of concern. Data from a community study of 15,708 middle-aged adults found that only 8.5% practiced healthy lifestyles (King et al. 2007). During a four-year follow-up of participants in this study, an additional 8.4% adopted a healthy lifestyle (i.e., diets high in fruits and vegetables, regular exercise, maintaining a healthy body weight, and not smoking) and experienced a rather prompt benefit: mortality and cardiovascular disease risk were significantly reduced (40 and 35%, respectively) compared to participants with less healthy lifestyles (King et al. 2007).

While this study points to the benefits of adopting a healthy lifestyle, it also illustrates the problems associated with recommending behavior change in primary prevention: very few people are willing to change their lifestyle in order to reduce their chances of developing a chronic disease in the future. Thus, it is not surprising that efforts to reduce risk factors in the general population have been disappointing. In their review of 39 education-based lifestyle interventions, Ebrahim and colleagues conclude that "different approaches to behavior change are needed…the availability of healthier foods and better access to recreational and sporting facilities may have greater impact on dietary and exercise patterns….than health professional advice" (Ebrahim et al. 2006, p. 2).

In regard to smoking policies, restricting smoking appears to hold much promise. In the U.S. where smoking in public places is prohibited, smoking rates have declined (Moskowitz et al. 2000; Meyers et al. 2009; Hopkins et al. 2010). With recently implemented similar restrictions in Europe, a reduction in smoking may be seen there as well. While the U.S. has a longer history of regulating smoking, it lags behind most European countries in regard to restricting advertising of unhealthy foods, especially to children (Nestle 2006). Thus, actions at the policy level, such as menu-labeling laws (Pomeranz and Brownell 2008), restrictions on health claims on food packages, marketing, and advertising (Nestle 2006), and banishing smoking from public places, may lead to better health outcomes in the population than intervening at the level of the individual (also see Weidner and Kendel 2010).

2.2 Secondary and tertiary prevention

Attempts to change lifestyle behaviors in secondary and tertiary prevention trials have been somewhat more successful than efforts to change these behaviors in disease-free persons (Weidner and Kendel 2010). With respect to physical activity and smoking, the two behaviors generally targeted in cardiac rehabilitation and exercise interventions appear to show some benefit. A systematic review of the effectiveness of exercise programs on mortality and morbidity based on 8,440 CHD patients estimates a 27% reduction in all-cause mortality (Jolliffe et al. 2001; also see meta-analysis by Taylor et al. 2004).

Considering the adverse health effects of smoking on all chronic diseases (especially on lung cancer and respiratory illnesses), it is disheartening that smoking cessation remains difficult to achieve. Even among patients waitlisted for a heart transplant, 4% admitted that they were still smoking (Spaderna et al. 2009). A review of 16 smoking cessation

trials reports modest success, leaving much room for improvement (Barth et al. 2008; Lai et al. 2010; also see Fiore et al. 2008). Similarly, interventions focusing on dietary fat reduction have not yielded encouraging results (Hooper et al. 2001; Yancy et al. 2003). It is conceivable that changes in health policies restricting smoking and regulating food advertising may also benefit secondary and primary prevention.

While excessive dietary cholesterol and saturated fat intake plays an important role in all major chronic diseases, the health-protective effects of adhering to a healthy diet have only been investigated recently. For example, the INTERHEART study investigated three distinct dietary patterns: Western (high in fried foods, salty snacks, eggs and meat), oriental (high intake of tofu and soy), and prudent (high in fruit and vegetables). While there was some evidence for an adverse relationship of the Western diet with MI, it was the prudent diet high in fruit and vegetables that showed an inverse association to MI worldwide, with a PAR of 30% (Iqbal et al. 2008). The protective role of this dietary pattern has also been observed for diabetes (Villegas et al. 2004) and several cancers (Danaei et al. 2005).

Encouraging a healthy eating pattern (together with exercise) has been found to be particularly effective in reducing the risk for developing diabetes in patients at high risk for this disease. In one randomized controlled trial with a follow-up of >3 years, the risk of diabetes was reduced by 58% in the intervention group. The reduction in the incidence of diabetes was directly associated with changes in lifestyle (Tuomilehto et al. 2001). Similar encouraging results have been reported by the Diabetes Prevention Program Research Group (2005).Thus, interventions aiming to increase the intake of protective dietary factors may present a promising venue to reduce risk for chronic disease (also see Connor et al. 2004; Dewell et al. 2008).

While psychosocial stress is among the major modifiable factors linked to cardiovascular diseases worldwide (Yusuf et al. 2004; O'Donnell et al. 2010) and increases the risk for diabetes (Knol et al. 2006), few clinical trials have targeted this factor. A meta-analysis of randomized controlled studies evaluating the effects of psychological treatments in cardiac patients found a reduction in two-year mortality of 27% (Linden et al. 2007). Interestingly, beneficial outcomes were especially pronounced when accompanied by perceptions of reduced stress and with treatments initiated at least 2 months after the event, yielding a reduction in mortality of 72% (Linden et al. 2007). Clearly, attempts to modify this risk factor are promising.

Considering the multitude of modifiable risk factors that have been identified, it would make sense to target as many risk factors as possible in order to prevent the progression and recurrence of chronic diseases. For example, the reductions in risk for diabetes observed in the aforementioned intervention studies emphasizing both diet and exercise were particularly striking. Programmatic research targeting these two behaviors as well as psychosocial stress (reducing social isolation, perceived stress, depression, and hostility) has been shown to improve cardiovascular health in both women and men with CHD and in persons with elevated coronary risk factors, who had already quit smoking at study entry (for review, see Weidner and Kendel 2010). For example, in one multisite study targeting diet, exercise, and psychosocial stress in patients with CHD, reductions in angina symptoms were similar to those reported in studies of coronary artery bypass graft or percutaneous coronary intervention (Frattaroli et al. 2008). In this program of research, improvement in coronary risk factors was also noted across socioeconomic levels (Govil et al. 2009), in patients with diabetes (Pischke et al. 2006), and in patients at risk for heart failure (Pischke et al. 2007, 2010). There is also some indication that targeting multiple lifestyle behaviors may benefit patients with early stage prostate cancer (Ornish et al. 2005, 2008a, 2008b). Of particular interest are the findings from one pilot study, which suggest that improvements in multiple lifestyle behaviors, such as consuming a vegan diet, engaging in moderate physical activity, and practicing stress management may modulate gene expression in the prostate (Ornish et al. 2008b). Thus, the way we treat our genes may be as important to our health as the genes themselves. Clearly, integrating genetic information into epidemiologic studies of chronic non-communicable diseases holds promise for our understanding of disease development and for the design of individualized interventions in the long run (Willett 2002). However, compared to the more immediate benefits of public health interventions targeting lifestyle and psychological stress and implementing health policies, these relatively complex and costly genetic studies may have little influence on the current global epidemic of chronic non-communicable diseases.

In summary, a relatively small investment in psychological stress reduction, exercise and healthy eating may lead to significant reductions in morbidity and mortality, especially among those with cardiovascular disease and/or diabetes. The benefits of policies regulating smoking and food advertising aimed at primary prevention of chronic non-communicable disease may also extend to secondary and tertiary prevention.

3 Conclusions

The continued increase in chronic and non-communicable diseases worldwide poses a considerable challenge to poor and rich countries alike, threatening the sustainability of

even the most advanced health care systems. Global studies of chronic disease, such as the INTERHEART study, illustrate the advent of a global economy characterized by a stressful lifestyle; physical inactivity; the consumption of a Western diet high in animal fat, salt, and refined carbohydrates; and decreased consumption of a whole-foods plant-based diet. In China, for example, the consumption of animal products increased by nearly 40% in less than 10 years, and fast food sales have doubled between 1999 and 2005 (Hu 2008). This "Coca-colonization," referring to the ubiquitous presence of Coca-Cola, Pepsi, and McDonald's (Hu 2008), has not only been accompanied by a worldwide "tsunami of cardiovascular disease" (Anand and Yusuf 2011) and an epidemic of obesity (Finucane et al. 2011) but also by serious threats to ecological sustainability. For example, the Western diet is high in animal products and in refined carbohydrates, but low in whole grains, fruits, and vegetables. Such a diet requires the conversion of forested land to cropland and increases global warming due to methane emissions from ruminants. Furthermore, meeting the demands of a sedentary lifestyle requires new roads and increases car sales, thus contributing to carbon-based pollution worldwide.

The identification of global risk factors common to many of the major chronic non-communicable diseases suggests that a common set of recommendations can be made to prevent most of these conditions on a worldwide basis. The adoption of a healthy lifestyle (no smoking, healthy diet, physical activity, and reduced psychological stress) would substantially reduce the incidence of many major chronic diseases, thus reducing the burden on the individual as well as on the health care system. Prevention and treatment of chronic diseases, however, require strong and sustainable health care systems. Clearly, continued implementation of standard medical treatment procedures has raised serious questions about how societies (even the richer ones) can continue on this path (Heidenreich et al. 2011). The key to a solution appears to be found in prevention, both at the individual level (for those already afflicted with chronic disease or at high risk for the disease) and at the societal level (policy changes to prevent chronic disease in the population). Population-based strategies incorporating policy changes in order to reduce salt intake and to control tobacco use appear to hold some promise in terms of both health effects and financial costs (Asaria et al. 2007).

Unfortunately, the role of stress-related factors in chronic diseases is still overlooked by global health initiatives, such as the Global Disease Action Group (Beaglehole et al. 2007). The global importance of stress-related factors in cardiovascular disease has been confirmed by both the INTERHEART study (Yusuf et al. 2004) and the INTERSTROKE study (O'Donnell et al. 2010). In the INTERHEART study, for example, psychosocial stress was responsible for 32.5% of the population attributable risk for MI, only a slightly lower PAR than that observed for smoking (35.7%). Psychosocial factors related to stress have also been implicated in the cardiovascular disease epidemic observed in many Central and Eastern European countries after the dramatic political upheaval in 1989 (Weidner and Cain 2003; Weidner et al. 2002). Recognizing the contribution of these risk factors to global chronic disease—together with other modifiable health behaviors and environmental factors—has great potential to enhance our ability to improve health and thereby promote economic, ecologic, and social sustainability worldwide.

Acknowledgments Preparation of this article was supported by grants from the Alexander-von-Humboldt Foundation, the German Academic Exchange Service, and the German Research Foundation (MA 155/75-1). I thank Edward Carpenter and Joanne Skirving for their helpful comments and assistance in the preparation of manuscript (JS).

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