HHS Public Access

Author manuscript

Can J Cardiol. Author manuscript; available in PMC 2016 September 01.

Published in final edited form as:

Can J Cardiol. 2015 September ; 31(9): 1081–1093. doi:10.1016/j.cjca.2015.06.035.

A global perspective on cardiovascular disease in vulnerable populations

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Abstract

Cardiovascular disease (CVD) is a major contributor to the growing public health epidemic in chronic diseases. Much of the disease and disability burden from CVDs are in people under the age of 70 years in low- and middle-income countries (LMICs), formerly "the developing world". The risk of CVD is heavily influenced by environmental conditions and lifestyle variables. In this article we review the scope of the CVD problem in LMICs, including economic factors, risk factors, at-risk groups, and explanatory frameworks that hypothesize the multi-factorial drivers. Finally we discuss current and potential interventions to reduce the burden of CVD in vulnerable populations including research needed to evaluate and implement promising solutions for those most at risk.

INTRODUCTION

Cardiovascular disease (CVD) is a major contributor to the growing public health epidemic in chronic diseases or non-communicable diseases (NCDs). Much of the disease and disability burden from NCDs are in people under the age of 70 years in low- and middle-income countries (LMICs), formerly "the developing world". This has major implications for the prevention, detection, treatment and follow-up of NCDs including CVD.

Terminology

According to the World Health Organization (WHO), CVD includes coronary heart disease, stroke, peripheral arterial disease, rheumatic and congenital heart disease and deep vein thrombosis. The two main contributors to CVD morbidity and mortality are stroke and coronary heart disease.[1] We will therefore limit our discussion primarily to these two conditions.

"Chronic disease" is a broad category that includes NCDs (primarily CVD, diabetes, chronic lung disease, chronic kidney disease and diabetes) and some chronic infections (e.g. HIV/AIDS, tuberculosis). Although the term NCD is used to distinguish them from infectious or communicable diseases, some chronic diseases have an infectious component. Others refer to chronic diseases as "lifestyle-related" to emphasize the importance of individual behaviours in their development, prevention and treatment. However the risk of developing these diseases is heavily influenced by environmental conditions that shape individual choices. In addition, lifestyle variables are also important for many communicable diseases.

Given the intense discussion by international agencies such as the United Nations (UN) on how to address NCDs, and CVD, as a major contributor to NCDs, we will use the term "NCD" throughout this paper unless we are drawing attention to a point related specifically to CVD.[2] In this article we review the scope of the NCD problem including economic factors, modifiable and non-modifiable risk factors, at-risk groups, and explanatory frameworks that hypothesize the multi-factorial drivers of the problem. Finally we discuss current and potential interventions to reduce the burden of NCDs in vulnerable populations including research needed to evaluate and implement promising solutions for those most at risk.

THE PROBLEM: NON-COMMUNICABLE DISEASES AND CVD

Significance of NCDs

NCDs have been called "the dominant public health challenge of the 21st century"[3] and a "public health emergency in slow motion".[4] They are responsible for nearly two-thirds of all global deaths[3] This figure has been steadily increasing over time from 57.2% of global deaths in 1990 to 63% in 2008. This figure is expected to rise by another 15% by 2020, reaching five times the number of deaths from communicable diseases by 2030.[5,6] CVD is the leading NCD, accounting for nearly half of the world's NCD-related deaths.[7,8] The majority of these deaths are due to coronary heart disease and stroke, with peripheral arterial or vascular disease and other conditions playing lesser roles.

Clearly any discussion of CVD beyond an examination of programs to prevent or treat specific diseases should be couched within an understanding of the larger NCD epidemic. Much work has been done to bring this crisis to the attention of governments, health departments, policy- and decision-makers, and funders at the global and regional levels. Therefore this paper will draw on literature on both causes and remedies for the NCD crisis with specific attention paid to CVD among vulnerable populations.

Risk Factors for NCDs and CVD

There is overwhelming consensus that NCDs, including CVD, are largely associated with four so-called conventional or lifestyle risk factors: poor diet, physical inactivity, tobacco use and excessive alcohol use. There is incontrovertible evidence that these factors are associated with hypertension, elevated blood sugar and cholesterol levels, type 2 diabetes mellitus (T2DM) and other risk factors that are precursors of CVD.[2, 9–14] There are other unmodifiable risk factors such as age, male sex, and family history of early onset coronary heart disease (CHD) which may be important when designing NCD programs.

WHO IS AT GREATEST RISK?

When considering ways to address the NCD/CVD crisis it is important to consider which groups and individuals are at greatest risk and therefore should be the focus of risk-reduction and treatment programs.

Women

NCDs are the biggest threat to women's health globally, linked to 65% of female deaths worldwide.[15] CVD is the leading cause of death in women globally, responsible for 33.2% of female deaths in 2008, ahead of infectious and parasitic diseases (13.9%) and cancers (13.0%).[16,17] Among women, coronary heart disease deaths outnumber strokes in high and low income countries and NCD's are a significant cause of female death in LMICs during childbearing years and cause considerable suffering and disability among older women.[18] It is also important to note that low SES, strongly linked to the risk of NCDs, has a stronger impact on women than on men.[19]

The Poor

Once known as a disease of the rich, research has shown that disadvantaged groups are at greater risk for CVD. The inverse relationship between socioeconomic status (SES) – a combined sociological and economic measure of one's work experience and relative economic and social position based on income, education and occupation[18] -- and CVD incidence and mortality has been shown across several populations.[19–23] Rates of smoking, heavy drinking, obesity and diabetes are more prevalent among the poor[24–30] not only due to increased exposure but also the relative lack of opportunity for physical activity, healthier foods and preventive services or care.[12, 30–32] For this reason it is not accurate to state that lifestyle choices individuals make are responsible for increasing or decreasing their risk for an NCD because they are often made in response to social determinants of health.[33]

Recent studies show a bi-directional relationship between CVD and poverty. The poor in high- and middle-income countries and in urban centres of low-income countries are more likely to spend proportionately greater amounts of their income on tobacco products and cheaper processed foods that are high in calories and salt, increasing their risk for disease.[32–33] They also must spend proportionately more to pay for the long-term clinical care for NCDs.[33] At national and regional levels the growing burden of NCDs has been implicated as a major barrier to socioeconomic development.[34]

People in Low- and Middle-Income Countries (LMICs)

Many recent documents on global health categorize countries into levels based on their gross national income (GNI) per capita based on USD in 2010 (low income: ≤ $1,005, middle income: $1,006–$12,275; high income: ≥ $12,276).[35,36] The term "upper middle-income country" is now beginning to appear in economic and health literature, referring to one of four categories in the updated classification system[37] (low income: ≤ $1,035; lower middle income: $1,036 – $4,085; upper middle income: $4,086 – $12,615; high income: ≥ $12,616). These distinctions are widely used when comparing the economic and health status of countries even though they fail to capture nations' development status, social conditions, physical environments or disease patterns that can vary widely both within and between GNI categories.

Another large group at higher risk for CVD are people living in LMICs. All NCD's and including CVD are increasing at much faster rate in LMICs than in high-income countries (HICs),[38] with 78% of all NCD-related deaths and 75% of all CVD-related deaths occurring in LMICs as of 2005.[38–42] Meanwhile infectious diseases and maternal/ neonatal deaths are still prevalent, producing the so-called double burden of diseases in LMICs.[42]

According to the WHO Global Burden of Disease study, since 1990 age-standardized death rates for CVD have fallen in many HICs and MICs but population growth and ageing resulted in overall increase in the total number of cardiovascular deaths, particularly from coronary heart disease and stroke (including hemorrhagic stroke).[43] Coronary heart disease (CHD) and CVD were the #1 and #2 causes of death in 2000 in the world, respectively. Although the proportion of deaths attributed to these conditions were higher in HICs, the predicted rate of increasing burden by 2020 is much higher in LMICs than HICs for both CHD (+57.1% vs. +6.6%) and CVD (+36.3% vs. −7.3%)[44,45] This pattern is clearly linked to rates of exposure to CVD risk factors. Recent estimates using pooled analyses of data from population-based surveys[46–49] to derive estimates of CVD risk factor levels for several countries found that although the prevalence of obesity and diabetes had increased in all countries studied, the prevalence of hypertension, high blood cholesterol and tobacco use was increasing in LMICs while decreasing in HICs, putting people in those areas at greater risk.

NCDs are strongly associated with poverty and the level of development in a region or country.[50] People in LMICs have the greatest vulnerability, least resilience and capacity to cope with NCDs. Competing health priorities such as communicable diseases and maternal/ child health issues often exhaust nations' meager health resources. Much of the care and prevention of NCDs requires out-of-pocket costs, which can often drain the financial

resources of households living below the local poverty line and reduce their ability to recover financially due to lost labor productivity.[51]

Although much of the literature on global NCD/CVD patterns compare HICs with LMICs, there are times when it would be better to distinguish between LICs and MICs as well. For instance, 2004 figures show that CVD accounts for 17.5 million disability-adjusted life years (1 Disability Adjusted Life Year = 1 lost year of health life) in HICs, 57.3 million in LICs and 76.2 million in MICs.[52] Furthermore, terms such as HIC and LMIC mask the reality that there are subsets or pockets of people in a country or region with different levels and risk for NCDs. For example, in countries undergoing rapid social and economic development there may be an increase in CVD among early adopters of a more affluent and 'modern' lifestyle[49,53].

The Poor in LMICs

CVD risk patterns are in transition within countries and expected to rise most quickly in LMICs. Major social change due to globalization and a shared economy have resulted in rapid urbanization. The percent of the world living in urban areas increased from 36.6% in 1970 to 44.8% in 1994, and expected to reach 61.1% by 2025[7,8,9,11,12]. Often these new urbanites are the poor seeking a better life. Lifestyle changes that accompany this shift put people at increased risk for NCDs due to greater consumption of energy-rich foods, reduced physical activity due to little access to space and facilities that support an active lifestyle, more obesity, dyslipidemia, T2DM and hypertension.[54] Although the urban poor in LMIC's have higher rates of NCD's and CVD in particular, rural areas are also transforming to mirror some patterns seen in urban areas due to mechanization of agriculture, increased use of motorized vehicles, the global influence of TV and social media that promote increased consumption of processed foods (the modern lifestyle) and both urban and rural dwelling poor living in LMIC's have restricted access to a continuous supply of medications due to availability (typically in rural areas) and cost.[44,49,55]

Indigenous/Aboriginal People

Indigenous people in North America, Central and South America as well as Australia, New Zealand and other Pacific Islanders are particularly vulnerable to NCDs and CVD[56]. In Canada, the term 'Aboriginal' refers to the indigenous inhabitants including First Nations, Métis (people with a First Nations mother and French or English/Scottish father) and Inuit.[57] The largest proportion of Aboriginal people self-identify as First Nations, followed by Métis then Inuit (60.8%, 32.3% and 4.2%, respectively).[58] Many studies on Aboriginal peoples' health make global comparisons between them and non-Aboriginals living in the same geographic area. The lack of more group-specific data means we cannot take into account important differences in disease burden and risk factors that affect particular groups of Aboriginal people due to geographic, cultural, historical and genetic differences.[59–61]

Although Canada has a high standard of living and promises universal access to high-quality care, vulnerable subpopulations such as Aboriginal people carry a disproportionate burden of disease and exposure to risk factors. For instance, an Aboriginal baby is about three times more likely than a non-Aboriginal one in Canada to die within the first year of life.[62]

Research shows that although infectious disease mortality rates have dropped among Indigenous people in North America, they still have a much lower life expectancy than non-Indigenous people. This is partly due to the very high and increasing rates of NCDs and in particular CVD. [63–66] For instance, 20 years ago heart disease was five times more prevalent among Aboriginal than non-Aboriginal Canadians.[64–66] More recent data on First Nations members of the Six Nations Reserve in southern Ontario found a 17% prevalence of CVD versus 7% for non-Aboriginal Canadians[65–67] and much higher rates of traditional risk factors and non-traditional risk factors.

Two major risks for CVD in Aboriginal groups are high rates of smoking and T2DM. Cigarette smoking is strongly associated with CVD and cancer, the two leading causes of death among North American Aboriginal groups.[63,66] Rates of current smoking are higher than in any of the 75 sites in the 43 countries included in the 2002 Global Youth Tobacco Survey.[66]

T2DM is reaching epidemic proportions among indigenous people in the Americas [67–71] Research consistently shows the link between lifestyle changes (including lack of physical activity and a non-traditional or Western diet high in carbohydrates, fat, salt and sugar) and obesity, glucose intolerance, and ultimately T2DM.[72,73] Obesity and physical inactivity however are much more prevalent among Aboriginal Canadians living off-reserve (often in urban areas) than on reserve, particularly among children and youth, which has implications for CVD risk later in life.[72]

The studies presented highlight and consistently reinforce the notion that major lifestyle changes due to “Westernization” in LMICs plus colonization go a long way to explaining the higher risk of disease among North American Aboriginal people (cf “Epidemiological Transition” section below). The loss of which is traditional ways of living have negative impacts on large numbers of people’s income, education and living conditions as in many LMICs. There are also Aboriginal-specific determinants – colonization, dispossession of land, loss of language, culture and traditional practices – that contribute to their poorer health status which, in turn, influence the proximal (modifiable) risk factors for NCDs including CVD (diet, physical activity and nontraditional tobacco use). We discuss the implications of these determinants of health for cost-effective and acceptable NCD/CVD control programs later in this paper (see Section Best Buys and NCD Prevention).

Other Ethnic Minorities

some ethnic groups are at particularly high risk of CVD, such as urban and migrant Asian Indians who have an elevated risk of T2DM. Possible reasons are stress from psychological adversity, living in crowded homes, financial strain, low neighborhood social cohesion and lack of control over work and social environment, as well as racial harassment.[73]

The Imprisoned

NCD rates are particularly high among those in vulnerable situations such as in prison or detention. Most of the 9.8 million incarcerated people worldwide are from the poorest most marginalized sectors of society and their level of risk is compounded by the poor living conditions they face while imprisoned.[74–75]

Explanatory Frameworks to better understand NCD's and CVD

The Demographic Transition

This model links global shifts from high to low fertility and morbidity rates to stages of economic development or industrialization. Early in a nation's transition a decline in mortality is followed by reduced fertility. The first stage of mortality decline is due to fewer air- and water-borne infectious and contagious diseases that result from effective public health measures and improved nutrition. HICs have reached their maximum potential for such change and further reductions will be from declining rates of chronic and degenerative diseases. In other parts of the world, the expected declines in mortality rates have been slowed or interrupted by major infections such as HIV/AIDS in sub-Saharan Africa and stagnating or declining life expectancy rates in Eastern Europe and the former Soviet Union. A dramatic increase in age of the population is the inevitable final stage of the global demographic transition due to low fertility plus long life.[76]

The Epidemiological Transition Model

An early and seminal paper on this model linked changes in disease patterns with economic growth noted that in "less developed" countries infectious disease, nutritional deficiencies, perinatal and maternal deaths are the main causes of morbidity in children and women but the pattern shifts to increasing numbers of accident- and violence-related deaths and disability.[77] However the paper did not mention NCDs and could not have foreseen newer epidemics of infectious diseases (eg HIV/AIDS, drug-resistant TB) which have reversed the trend in declining infectious diseases.[42, 46–49] A later test of this model used pooled data from population-based surveys to derive estimates of CVD risk factors globally. Researchers found hypertension, high blood cholesterol and tobacco use were decreasing in HICs but increasing in LMICs[49–53].

Yusuf and colleagues[54] confirmed these patterns in their five-stage model linking stages of development and CVD patterns. With increasing industrialization and socioeconomic development, countries experience a shift away from nutritional deficiencies, infectious disease and maternal/infant health problems as the major causes of morbidity and mortality (Stage 1). In a later stage, they are of less importance compared to growing numbers of people with chronic coronary artery diseases in middle age. An even later stage of development is characterized by heart failure in the elderly, common in many HICs. A fifth stage exists in areas where social upheaval and/or war have caused a breakdown in social and health systems, resulting in a resurgence of earlier health problems plus increased CVD deaths.

As noted earlier many LICs and some MICs also experience a double burden of disease, with high rates of morbidity and mortality attributable to NCDs and to infections, nutritional deficiencies, and maternal and peri-natal causes.[42] However, even in the poorest countries the pattern that is emerging is one of more deaths caused by NCDs than from other causes.[78–79]

The Epidemiological Transition Model has also been used to explain pockets of "underdevelopment" and increased rates of NCDs in HICs, such as among Indigenous

people. Rapid 'Westernization' and adoption of major lifestyle changes put these vulnerable groups at higher risk for many NCDs, CVD and overall poor health status.[80–82]

The Social Determinants of Health Model

This approach is widely used to explain inequalities in health outcomes across nations or sub-populations.[83–84] The premise is that risk factors and pathways to poor health are unequally distributed across socioeconomic groups, with the disadvantaged faring much worse overall.[85]

We know that traditional (behavioural) risk factors leading to NCDs are influenced by one's social status which, in turn shapes material and psychosocial factors.[83–84] Research into these determinants often focuses on such social determinants of health as social gradient or SES, unemployment, stress, social support, conditions in early life, addiction, food, work, transport and social exclusion.[86–89]

In addition, some work has shown that the same level of exposure may have different effects on various groups depending on factors in their socioeconomic environment, life course or ability to detect risk factors and their consequences early, including lower education and literacy levels, low income, poor housing and living conditions, insecure employment, social exclusion and poor access to health care services.[83–89]

Economics of NCDs

According to a recent World Economic Forum, NCDs are the second greatest risk to global economic growth,[85] reflecting their large economic burden – approximately US$ 6.3 trillion as of 2010, a figure that is expected to rise to US$ 13 trillion by 2030. For every 10% rise in NCD-linked mortality, economic growth is reduced by 0.5% [185–86] for a projected loss in economic output of US$ 56.7 trillion over the next 20 years. Nearly half of this (46%) will take place in LMICs. In large part the burden is staggering because half of those who die from NCDs are in their productive years so lost productivity is great, particularly in LMICs where many sufferers of CVD are younger than in HICs. In addition, the high out-of-pocket costs for care and services related to NCDs/CVD are catastrophic for the poor.[3]

There are also major economic implications for countries' ability to eradicate poverty, seek economic growth and meet internationally recognized goals such as the Millennium Development Goals (MDGs) in face of a heavy NCD burden, such as in LICs and in particular sub-Saharan Africa.[86–87]

Life Course Approach

Although CVD usually manifests in middle age it is the exposure over time that is responsible for disease progression. For example, changes in blood vessels can start in early childhood,[90] pointing to the value of examining the risks for NCDs/CVD using a life course approach.

Data suggest that living in a low-SES household in childhood has a strong negative impact on adult CVD and associated risk factors because of the increased chances of poor

nutritional status and higher prevalence of infections.[87] In adulthood T2DM, a major CVD risk factor, is clearly associated with low SES and poverty. More recently other risk factors – smoking, hypertension, dyslipidemia, obesity and inflammatory markers are also more prevalent in the poor. Low SES is also associated with reduced access to medical care, social and family support, a sense of control over one's life and health, all of which increase the risk of CVD,[86,90]

Approaches to Prevention

The goal for NCD prevention is to increase the number of healthy years by reducing time spent disabled or ill. ***Primordial prevention*** aims to stop the development of risk factors before they happen by addressing distal or upstream causal factors or the social determinants of health. Effective means are policy changes that modify factors such that making pro-health choices become the norm. Examples of such policy include legislation that reduces salt, *trans* fats and sugar in food, creates smoke-free environments and cigarette excise taxes[91].

Primary prevention focuses on reducing the impact of risk factors by targeting high-risk individuals or those already diagnosed with the targeted disease to prevent clinical outcomes. Some programs combine these two functions, such as tobacco cessation programs for pregnant women (primary prevention for the mother, primordial prevention for the fetus).

Individual versus Population Approaches to Address NCDs

There is considerable debate about whether to target populations or high-risk/diagnosed individuals in resource-poor settings. Programs that target individuals have shown the effectiveness of both lifestyle interventions and proven pharmacological interventions to reduce risk. These programs are also more cost-effective than population-wide efforts, possibly because high-risk individuals may be more motivated to change behaviours than society overall and it is easier to promote change in individuals than in large groups[92]. There are also clinical trials showing good outcomes by modifying the classic or traditional risk factors such as cholesterol and blood pressure in high-risk groups,[93–94] although there are limited benefits for the community overall.[95–96]

On the other hand, costs associated with identifying and treating high-risk individuals can be prohibitive in low-resource areas. Individual approaches also ignore the prevention paradox (Rose Hypothesis) that a larger number of cases of a specific disease will develop in people exposed to a low level of risk because the number of high-risk individuals in a population is small.[91] Others argue that such approaches leave large residual risk, produce a small population impact at high cost, medicalize previously healthy people and do not address the root causes of the problem.[93–96]

Evidence suggests that population-wide approaches are effective because a small risk reduction in a large number of people will prevent the development of many more cases than treating a small number of high-risk individuals.[8,11,12,14,16] Programs that address NCDs at

a systemic level are particularly effective if they work to shift the entire population distribution towards lower levels of exposure.

Equity and NCD Programs

There is growing evidence that shows an additional benefit to population-based NCD approaches is their ability to promote health equity. As described earlier, inequalities in the social determinants of health more heavily affect disadvantaged groups, with low-income families more heavily represented among people who smoke and eat unhealthy diets. Because they have the greatest risk burden, they are likely to gain the most from programs reducing inequities.[97–98] For example, increasing the price of cigarettes can reduce tobacco use across society and that will benefit groups with the highest smoking rates.[98–99]

Studies also show that individual-level programs actually widen inequality gaps in risk factors[100–101]. First, they mobilize individual material and/or psychological resources and so favour those with more of them, as shown by the social gradient of people who most often use smoking cessation programs or follow dietary advice given on an individual basis.[97–101] Second, as stated in the “Inverse care Law” the availability of good medical care is less available to those in greatest need so people in very poor health have the smallest net health gains from interventions, further contributing to cumulative inequality in a population. Third, individual-based programs are not designed to work directly on population exposure to risk factors or address resulting inequalities in risk-factor profiles that appear later [100–102].

Combined Approaches

To recap, the biggest problem with individual approaches to combatting NCDs is that the majority of disease occurs in people with low or average levels of risk so targeting high-risk individuals will not root out the problem. However population-based approaches are more expensive and may take longer to produce results because they are focused on entrenched societal factors. A relatively new approach is to both change policies and laws to reduce a nation’s exposure to risk factors while also providing appropriate and affordable care and follow-up for high-risk or diagnosed individuals. Results from such programs are promising[101–102] even though their effectiveness has yet to be fully evaluated nationally or internationally.

Best Buys and NCD Prevention

In association with the 2011 UN High-Level Meeting on Non-communicable Diseases the WHO identified a set of evidence-based, cost-effective and scalable interventions feasible and appropriate for implementing in LMICs and other resource-constrained settings.[2,15] “Highly cost effective” is a term used to designate interventions that can generate an extra year of healthy life by averting one disability-adjusted life year at a cost below the average annual income or gross domestic product per person.[2,6,12,14,15,16,41,43] The Best Buys most relevant to CVD prevention address both the key underlying risk factors (tobacco and harmful alcohol use, physical inactivity, unhealthy diet) and intermediate risks for CVD (elevated blood pressure, blood sugar and cholesterol). Best Buys in CVD prevention are highlighted in Table 1.

Population-level Best Buys

The interventions for reducing tobacco, based on the WHO Framework Convention on Tobacco Control (FCTC) are the most cost-effective and produce the greatest return on investment.[2] Key components are legislation to increase taxes, create smoke-free environments, provide health information and warnings to the public, and ban advertising, promotion and sponsorship of tobacco products. [2,15] These steps would avert over 5 million deaths in the 23 large LMICs alone for the 2006–2015 period at a cost of less than US$ 0.40 per capita per year in LMICs. [2,15] To ensure that a program to reduce smoking is feasible and scalable, the two most cost-effective elements (increasing excise tax increases and creating smoke-free environments) could be implemented first in a stepwise fashion.

The cost of implementing these Best Buy strategies is low, for example only US $ 0.30 per capita in the two largest LMICs, India and China[2,12,14,42].

Individual-level Best Buys

Data show it is difficult to carry out programs to identify and treat asymptomatic conditions associated with CVD (hypertension, T2DM). For example, a study in Tanzania found that less than one-third of the people identified with hypertension through home screening attended a health center for care and follow up; fewer than 3% of them were on antihypertensive treatment 12 months later. [103]

A very cost-effective and feasible option is to treat people at high risk or with diagnosed CVD with a combination fixed-dose generic cardiovascular drugs (a cardiovascular ***polypill)*** plus counseling on lifestyle behaviors[104.] Reducing the number of medications patients take can improve adherence, lower cost, simplify treatment schedules and supports task-sharing from physicians to nurses and other non-physician health providers and reducing a country's cost of human health resources, and, is more cost-effective than conventional single risk factor interventions[104.] Economic estimates suggest that to have an impact would require treating 5–10% of all adults aged 35–64 years old, which would cost US$ 1–2 per capita per year, for a total of US$ 12 billion per year in all LMICs. [22,93,94]

Synergy

The most effective interventions combine population- and individual-level strategies. Structural changes such as legislation to reduce *trans* fats and salt in food or urban planning to create safe green spaces for physical activity will make it much easier for people to make healthy choices because they eliminate the need for individuals' understanding or cooperation to produce life-affirming changes. Research on the cost-benefits of scaling up more complete Best Buy intervention packages in LMICs by the World Economic Forum [14] draws on earlier work on the economic impact of NCDs and the cost of scaling up programs in the 42 LMICs with populations in excess of 20 million people and where 90% of the NCD burden in developing regions of the world occur. [14,85] NCDs will cost LMICs over US $ 7 trillion in the 2011–2025 period, (approximately US$ 500 billion/year) versus US$ 2 billion/year to mount population-based programs to address the four main causes of NCDs (< US$ 0.40/person).

An Example of the Future for Best Buy NCD Initiatives

A recent report by the Pan American Health Organization (PAHO) and WHO describe initiatives in its 35 member countries that are consistent with the WHO 2008–2013 Action Plan for the Global Strategy for the Prevention and Control of NCDs Comprehensive Global Monitoring Framework's indicators and targets for preventing and controlling NCDs. [105] This regional approach to tackling NCDs has updated previously existing strategies by adhering to core principles including integrating NCDs and their risk factors into development and economic agendas of its member countries and the region; emphasizing health promotion, education and prevention as well as early detection, recognizing the social determinants of health, including equity, education, gender, migrant status and ethnicity (particularly regarding indigenous populations) in addition to economic, cultural and environmental factors; using a life course approach in NCD policies and programs; reorienting health systems to integrate NCD prevention and control into primary health care through training and capacity-building. The overall goal of the PAHO NCD Strategy is to reduce NCD morbidity, disability and premature mortality in the Americas, including at least a 25% reduction in premature mortality from the four main NCDs by 2025.

To reduce inequities in health outcomes and reduce CVD, health care providers in Canada – both in primary care and among the specialties that care for Canadians with CVD need to advocate for combined approaches to CVD risk reduction among their patients and within the health system at large. More importantly, health care providers must advocate for comprehensive national programs to tackle 'upstream' problems such as poverty. For reductions in NCDs and CVD to occur downstream, health providers must use a 'bifocal' lens that addresses individual level risk factors at the level of the patient and advocating for upstream programs to reduce poverty. Moreover, despite the principals of 'universality' in access to health care, Canada does not have a national or 'universal' drug access program. A recent study has shown that such a program is affordable[106] and Canadian health professionals can play a role in advocating for improved drug access.

The role of task-sharing to detect and manage CVD risk factors in low-income countries

The NCD epidemic in LMICs is occurring in the context of three very intractable problems: the ongoing health transitions we described earlier, poor infrastructure of national healthcare systems in LMICs, and probably most importantly, the critical shortage of healthcare workers. For example, although sub-Saharan Africa has 11% of the world's population and bears over 24% of the global disease burden, it harbors only 3% of the global health workforce[107]. The global deficit of doctors, nurses, and midwives projected for 2035 is 12.9 million; and approximately 74% of this deficit is projected to occur in Africa and South East Asian countries[108]. Thus, the ability of these countries to identify and manage complications of these risk factors is greatly hampered by the acute shortage of healthcare workers. Using a life course approach in NCD policies to reduce CVD in the next decade will require significant capacity building and health workforce strengthening in primary health care. Task sharing among members of the health work force is one way to meet this critical demand for health care providers to mitigate the growing burden of NCD's. The WHO

defines task sharing as the "process of delegation whereby tasks are moved, where appropriate, to less specialized health workers. By reorganizing the workforce in this way, task sharing can make more efficient use of the human resources currently available." Task sharing involves delegation, continuous supervision and ongoing training while allowing for efficient use of human resources. Task-sharing describes a situation where a task normally performed by a physician is transferred to a health professional with a different or lower level of education and training, or to a person specifically trained to perform a limited task only, without having formal health education.[109]

A recent systematic review evaluated the evidence for task sharing among LMICs for management of non-communicable diseases and found that task-sharing from physicians to NPHWs, if accompanied by health system re-structuring is a potentially effective and affordable strategy for improving access to healthcare for NCDs. The authors highlighted that since the majority of study designs reviewed were of inadequate quality, future research methods should include robust evaluations of such strategies[110] Another systematic review evaluated randomized controlled trials for task sharing interventions for CVD risk reduction in LMICs and found that there is a dearth of evidence on the implementation of task-sharing strategies to reduce the burden of CVD in LMICs. Effective task-sharing interventions targeted at reducing the global CVD epidemic in LMICs are urgently needed.[110]

The potential of results-based financing to prevent, detect and manage NCD's and CVD in low- and middle-income countries

Over the last decade, there has been a growing interest in identifying alternative approaches to financing the prevention, detection and management of NCDs[111]. As evidence of the financial and economic impacts of NCDs builds, LMICs are searching for innovative strategies to enhance the performance and efficiency of their health systems. Results-based financing has gained significant momentum globally as a means of improving performance and aligning incentives for health workers with public health goals.[112] Results-based financing (RBF) for health is defined as, "a cash payment or non-monetary transfer made to a national or sub-national government, manager, provider, payer or consumer of health services after predefined results have been attained and verified" [113]

RBF includes a wide range of approaches. Three common RBF mechanisms show the most promise for improving NCD management: facility-based performance-based financing (PBF); 2), community-based PBF for community health workers, and 3) demand-side financing, such as conditional cash transfers to patients. In facility PBF, providers are (at least partially) funded on the basis of their performance, while conditional cash transfers (CCT), provide incentives directly to beneficiaries and seek to motivate them to perform or change specific behaviors.

Numerous LMICs countries have reported positive results for RBF programs. A review of PBF experiences in Burundi, DRC, Tanzania and Zambia found considerable increases in staff and health service productivity and improvements in a majority of targeted indicators.[114, 115] A recent systematic review concluded that overall, RBF has made substantial differences in terms of utilization and coverage of incentivized health

services.[116] For demand-side interventions, Progressa/Oportunidades in Mexico provided incentives to households by transferring payments to women for engaging in certain behaviors related to child health, nutrition and education. Results showed improvement in child health indicators, among others.[117] Although the majority of RBF programs have been applied to maternal and child health (MCH), evidence from existing RBF programs suggests that RBF can be applied to broader health programs, including those for NCDs.[118] In Belize, an PBF program targeted an indicator that measured improved quality of care for chronic illness and found an increase in use of primary care and the diagnosis and treatment of diabetes and hypertensions, the country's top two causes of mortality.[118–119]

While the evidence for PBF remains limited, it is encouraging. Demonstrated success from a number of PBF programs and lessons taken from others, suggest that facility and community-level PBF could be successful applied to the clinical management of NCDs and CVD. The success of CCT programs in changing health behaviors has important implications for NCDs, and could potentially by used to reduce known risk factors, including diet and exercise.[119] The introduction of RBF for NCDs and CVD has incredible potential. Programs targeting NCDs and CVD could benefit from the improvements in service delivery, provider motivation and health system performance that have resulted from RBF programs targeted at maternal and child health and health system strengthening in more than 30 LMICs.

Integrating the use of mobile health to prevent, detect and manage NCD's and CVD risk factors in high, middle and low-income countries

Mobile health (mhealth) refers to the use of mobile telecommunication and mobile technologies (mobile phones, tablets) for healthcare delivery.[120] Moreover, it has been predicted that by the year 2017 there will be "more mobile phones than people" on the planet, and currently three-quarters of the world's population have access to a mobile phone. The World Health Organization (WHO) has announced that mhealth has the potential to transform the face of health service delivery across the globe.[121] As the number of mobile phones is expected to continue to rise globally, especially in LMIC's, mobile phones and related technology and applications are expected to become critical tools for improving access to health care, especially for the poor in LMIC's. [122] Mhealth has been shown to improve disease management and facilitate communication between a patient and their health care provider to assist in disease management. Many studies have focused on high-income country health systems but there is an emerging literature on programs in low-income countries utilizing SMS (short message service/text messaging) as a tool to improve management of communicable disease (HIV, malaria) as well as chronic diseases.[123–124] A recent systematic review highlighted that the majority of RCT's using SMS to manage NCD's had positive outcomes in all dimensions.[125]

Linking Research with Action

To address gaps in our understanding of NCDs, research agendas for use in LMICs and among other vulnerable populations, need to emerge with evidence behind effective strategies. However in some areas the population-level burden of NCDs is unknown because

estimates from global burden-of-disease studies are derived from a patchwork of existing, sometimes low-quality data. In other settings we know the population burden of NCDs but not their causes. Health services research is well developed in high-income countries but still in development in most LMICs. We also need implementation research in these settings in order to help shift evidence into practice. Robust and pragmatic approaches to complex community-based interventions for chronic diseases, knowledge translation and engagement of policy makers through implementation science research which are currently underway, [126–128] should, and can transform access to proven interventions that can prevent, reduce and control the impact of NCDs as a whole. Furthermore, the impact of health services research is huge, particularly in the emerging areas of mhealth as well as mobile technology for noninvasive imaging to aid diagnosis, and, integrated patient electronic healthcare records. Many of these developments, have in fact, been pioneered in LMICs and evaluated with robust methods, and have potential to produce global benefits through frugal innovation (previously known as reverse innovation).

Conclusion

NCD's and in particular, CVD, represent a significant burden on vulnerable populations in Canada and around the globe. Those living in poverty and especially those in low-income countries are significantly more impacted by CVD. Decades of research has helped us to better understand the mechanisms driving CVD and NCDs and the interplay of risks over the life course and through globalization and urbanization of populations around the world. There are feasible and evidence-based efforts that are known and when implemented effectively for both individuals and populations, can significantly reduce CVD in vulnerable populations. These have been summarized in Table 2. Further research into better methods for implementation of complex health system interventions is needed, especially among vulnerable populations, and to find pragmatic and innovative solutions to reduce CVD risk by bringing research to action.

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BRIEF SUMMARY

Cardiovascular disease (CVD) is a major contributor to the growing public health epidemic in chronic diseases. This article reviews the scope of the CVD problem in LMICs, including economic factors, risk factors, at-risk groups, and explanatory frameworks that hypothesize the multi-factorial drivers and discusses current and potential interventions to reduce the burden of CVD in vulnerable populations including research needed to evaluate and implement promising solutions for those most at risk.

Table 1

"Best Buy" Interventions Relevant to CVD

Risk factor / disease	Interventions
Tobacco use	• Tax increases • Smoke-free indoor workplaces and public places • Health information and warnings • Bans on tobacco advertising, promotion and sponsorship
Harmful alcohol use	• Tax increases • Restricted access to retailed alcohol • Bans on alcohol advertising
Unhealthy diet and physical inactivity	• Reduced salt intake in food • Replacement of trans fat with polyunsaturated fat • Public awareness through mass media on diet and physical activity
Cardiovascular disease (CVD) and diabetes	• Counseling and multi-drug therapy for people with a high risk of developing heart attacks and strokes (including those with established CVD) • Treatment of heart attacks with aspirin

Source: World Health Organization and World Economic Forum. From burden to "best buys": reducing the economic impact of non-communicable diseases in low- and middle-income countries. Geneva: WHO and World Economic Forum; 2011. (15)

Table 2

Recommendations to improve CVD health in vulnerable populations

General Principles	
• Think regionally and globally (Share information, data and success stories; insist on integrating NCDs, including CVD, and their risk factors into larger development and economic agendas/programs; promote cross-sectoral (all-of-society) approaches combining the experience and efforts of multiple government sectors/bodies, civil society, academia, the private sector and international organizations • Develop programs that combine population- and individual-level approaches to address the proximate causes of CVD (i.e. smoking, unhealthy alcohol use, diet high in salt, sugar and trans-fats, inadequate physical activity) plus the distal causes or social determinants of health (e.g., issues related to equity, education, gender, migrant status, ethnicity, economic, cultural and environmental factors) • Use a life course approach that targets children, youth and future generations (pregnant women) while focusing on vulnerable groups (e.g., the poor, ethnic minorities, migrants, women, etc.) • Improve health systems by: a) integrating NCD/CVD prevention and control into primary health care (through training as well as capacity-building), b) strengthening the health sector workforce through training, education and task shifting (more use of non-physician providers), c) integrating the use of m-health to prevent, detect and manage NCDs/CVD risk factors • Link research and action by: a) applying evidence-based solutions based on data from surveillance and local/regional research that, b) disaggregating data by such factors as geographic region, level of development (HICs, MICs, LICs), SES, gender and ethnicity	

Addressing Proximal Causes of CVD: Smoking	
Individual approaches	• Provide culturally relevant affordable or free tobacco cessation programs (including diagnosis, pharmacological treatment & counseling) targeted to specific groups (e.g., pregnant women)
Population-wide approaches	• Legislation: a) taxes (with proceeds spent on NCD/CVD programs); b) ban smoking in indoor spaces & on public transport; c) ban on advertising & sponsorship, deceptive ads & incentives for products; d) combat illicit trade in tobacco products; e) prohibit distribution/sale of tobacco products in public, especially to minors • Information/education/communication (IEC) campaign: a) visible health warnings in print & pictures; b) access to public awareness programs on health risks
Combined approaches	• Develop & disseminate locally relevant evidence-based clinical guidelines for healthcare practitioners & program providers → develop, offer & evaluate smoking cessation programs • Create viable alternatives for tobacco growers/sellers → provide education & other supports for former growers/sellers
Gender-linked risk	• Gender-linked risks (e.g., more males than females smoke; smoking rates risking much faster for females; some gender-specific tasks put females at increased risk of second-hand smoke) so develop gender-specific programs
Ethnicity-linked risk	• Tobacco use very high among Aboriginal people in some countries (e.g., Canada, the US), particularly among minors so develop culturally-relevant and age-appropriate programs

Addressing Proximal Causes of CVD: Excessive Alcohol Use	
Individual approaches	• Provide culturally relevant, affordable or free programs for people with alcohol dependence/ addiction (including diagnosis, pharmacological treatment & counseling)
Population-wide approaches	• Legislation: a) taxes (with proceeds spent on NCD/CVD programs); b) ban on advertising & sponsorship, deceptive ads & incentives for products; c) combat illicit trade in alcoholic products; e) prohibit distribution/sale of tobacco products in public, especially to minors • Information/education/communication (IEC) campaigns on health risks targeted to specific groups (e.g., men, women especially when pregnant, minors, the poor, ethnic minorities) • Improve labeling (visible health warnings in print & pictures on packages)

Addressing Proximal Causes of CVD: Excessive Alcohol Use	
Combined approaches	• Develop & disseminate locally relevant evidence-based clinical guidelines for healthcare practitioners & program providers → develop, offer & evaluate alcohol cessation programs • Create programs targeting specific groups (e.g., women, minors, ethnic minorities, the poor)
Gender-linked risk	• Females at greater risk of undetected alcohol dependency/addiction due to smaller size & sex-specific hormones (so smaller amount of alcohol needed to produce negative effects in females), false perception that excessive alcohol use is a male problem so can be undetected in women, additional risk to unborn child if woman drinks during pregnancy so develop programs for females

Addressing Proximate Causes of CVD: Poor Diet, Suboptimal Levels of Physical Activity	
Individual approaches	• Programs providing education/counseling & financial support for improved diet for specific groups (e.g., minors, pregnant women)
Population-wide approaches	• Legislation: a) require reduced levels of salt, trans-fats and sugar to safer levels in packaged or prepared foods; b) require improved labeling, in text & pictures, to promote healthy food & beverage choices (e.g., colour-code the amount of salt, sugar & fats in beverages & food products: green = acceptable level, yellow = moderately high, red = very high); c) ban on unhealthy foods & beverages sold in schools & workplaces; d) ban on advertising foods & beverages with high levels of salt, sugar & fats; e) taxes on beverages & foods with high levels of salt, sugar &/or fats; f) where possible, subsidize healthier food & beverage options where products or ingredients are sold • Information/education/communication (IEC) campaigns on health risks targeted to specific groups (e.g., minors, the poor) • Create safe green spaces for increased physical activity • Promote sports programs for girls through schools, religious institutions, etc.
Combined approaches	• Provide community-based programs to increase public awareness of healthier life choices + pro-exercise groups for harder-to-reach subgroups (e.g., escorted walks for women & girls)
Gender-linked risk	• In many societies females have less control over finances and physical movement so should develop programs specifically for females that include healthy diets and increased activity in culturally acceptable ways
SES-linked risk	• The poor have less disposable income available for transportation to or shopping in areas providing more expensive, higher quality foods so should develop food security and quality programs that meet their needs