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The changing landscape of
non-communicable diseases and
associated risk factors

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The Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat organized an Expert Group Meeting on "Priorities for Improved Survival: ICPD beyond 2014" at the United Nations Headquarters in New York on 21 and 22 October 2013. The meeting was convened to inform substantive preparations for the forty-seventh session of the Commission on Population and Development in April 2014. In light of the twentieth anniversary of the 1994 International Conference on Population and Development (ICPD), the Commission's theme for 2014 is an "Assessment of the status of implementation of the Programme of Action of the International Conference on Population and Development".

The meeting brought together experts from different scientific disciplines and regions of the world to address key questions about the progress in improving survival at different stages of life since the ICPD, as well as the challenges and opportunities for future mortality reduction. A selection of the papers prepared by experts participating in the meeting is being issued under the Expert Paper Series published on the website of the Population Division (www.unpopulation.org).

This paper discusses the evidence for a changing risk environment for non-communicable diseases (NCDs), with attention to the situation in both developed and developing countries. By reviewing key data on the issue published in recent years, this paper highlights research and policy priorities to address NCDs, especially cardiovascular and metabolic diseases, and their leading risk factors including tobacco use, unhealthy diet, physical inactivity and the harmful use of alcohol.

The Expert Paper series aims at providing access to government officials, the research community, non-governmental organizations, international organizations and the general public to overviews by experts on key demographic issues. The papers included in the series will mainly be those presented at Expert Group Meetings organized by the Population Division on the different areas of its competence, including fertility, mortality, migration, urbanization and population distribution, population estimates and projections, population and development, and population policy.

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A. INTRODUCTION

The burden of non-communicable diseases (NCDs) is becoming a major concern for policymakers. Yet there are numerous questions about what is actually changing about NCD risk, particularly in low- and middle-income countries, what evidence helps direct appropriate action on NCD risk factors, and what key aspects of the NCD risk environment present significant concerns for the agenda agreed upon by Governments at the 1994 International Conference on Population and Development (ICPD) in Cairo.

This paper discusses the evidence for a changing risk environment for NCDs, with attention to the situation in both developed and developing countries. It highlights research and policy priorities to address NCDs and their leading risk factors, including in low-resource settings, by reviewing key data on the issue published in recent years, identifying critical deviations between prior hypotheses and current data, and suggesting what conclusions might be made at this point to define an agenda for ICPD beyond 2014. To narrow the scope of discussion, the paper focuses particularly on cardiovascular and metabolic diseases, given that these are the subjects of the author's expertise, and given that these conditions constitute the majority of NCDs worldwide in terms of both prevalence and mortality (Lozano et al., 2013). This is not meant to diminish the importance of mental health, other chronic NCDs such as chronic obstructive pulmonary disease, or mixed infectious and chronic diseases such as human papilloma virus infection leading to cervical cancer. However, it is well known that the major causes of premature death from NCDs at the current time, and into the foreseeable future, are cardiovascular and metabolic in nature, hence this dilemma defines the focus of the current paper.

B. IS THE RISK ENVIRONMENT FOR NCDs TRULY CHANGING?

1. *Evidence for trends in NCD risk*

While NCDs have garnered increasing attention in international policy documents and public health literature, manifesting in a recent United Nations high-level meeting catalysing the desire for political action to address the high burden of chronic diseases (Beaglehole et al., 2011), a reasonable question is whether the prevalence of risk factors for NCDs is truly changing or merely a consequence of surveillance bias as the previously hidden burden of these diseases are now increasingly reported.

Unfortunately, most conventional risk factor surveys and NCD prevalence reports suffer from numerous deficiencies or biases. Perhaps the most valiant effort to overcome the limitations of data availability is the Global Burden of Disease Study (GBD), from which most recent reports about NCD burden have been derived. Despite extensive efforts to amass as much data as possible on actual morbidity and mortality from NCDs, in many cases very limited sub-national surveillance reports are available to project onto whole nations or even neighbouring countries that lack adequate vital registration systems (Murray et al., 2012b). Subnational records can suffer from bias that cannot easily be corrected, as a result of relying on surveillance systems that over-sample higher-income urban groups (Vellakkal et al., 2013). The imputation procedures used to project individual surveys onto whole countries, while highly complex, cannot typically answer questions about within-country heterogeneity in risk across income classes, or true prevalence changes over time in many circumstances (Murray et al., 2012c). Even when official vital registration systems were supplemented by verbal autopsies (trained interviewers undertaking demographic surveillance exercises), only 10 per cent of such data were nationally representative (Lozano et al., 2013). There is a general sense from the GBD that NCD prevalence is high and NCDs are a leading risk factor for death in many countries, that disability associated with NCDs is also very high, and that a striking burden of global NCDs is burdening low- and middle-income countries (Wang, H. et al., 2012). The answers to many of the other key questions cannot be as easily determined: which populations within countries are truly experiencing the greatest risk changes (especially across the socioeconomic gradient, or between urban and rural zones), at what pace these changes are taking place

(as the best estimates are available for the years 1990 and 2010, and the pace of change is unlikely to be linear), and why such changes are taking place. Other major NCD data sources, such as the World Health Organization's Global InfoBase (World Health Organization, 2012), also rely on the GBD and related estimates, and contain limited surveillance data for which it is also difficult to evaluate trends over time. More extensive population-representative household surveys such as the WHO Study on Global Aging and Adult Health (SAGE) and related surveys oversampling older adults (particularly in India and China) are in their early stages or first few waves of publicly available reporting (Kowal et al., 2012). Many international tobacco surveys (Global Youth and Adult Tobacco Surveys) also provide relatively recent estimates of NCD risk, but contain limited longitudinal data to date from most countries because they remain in their early years of data collection (Palipudi et al., 2013).

In the setting of so many data limitations, an alternative approach to address the question of changing NCD risk is to look from the perspective of the risk factors themselves—the so-called social life of things perspective (Appadurai, 1988). A few key risk factors are classically described in the medical literature as risky commodities—unhealthy foods (those high in fats, sodium and sugars), tobacco and alcohol. The institutions most likely to keep track of these risky commodities are, of course, their producers and sellers. Hence, one can look at the NCD risk environment in some detail by obtaining data from the producers of processed foods and tobacco.

2. *Trends in processed food and beverage consumption*

Collecting and validating data on individuals' self-reports of food and beverage consumption is notoriously difficult. Studies have unsurprisingly observed that self-reported consumption is often vastly underestimated, given social acceptability biases and self-perceptions that individuals consume far less than they do (Archer et al., 2013). Hence, one approach that has been suggested in the literature is to use sales data to track consumption of key products of interest (Stuckler et al., 2012).

Figure I displays annual data obtained from global suppliers of processed foods and soft drinks, organized using consistent surveillance systems (direct sales) in consistent units (per capita consumption) across 15 years, including 38 low- and middle-income countries and 48 high-income countries (Euromonitor International 2013). The dominant trend in these data is a dramatic rise in per capita sales of packaged foods and soft drinks in low- and middle-income countries. Indeed, the major projected sales growth for global processed food and soft drink manufacturers is in low- and middle-income countries, as there is essentially already a high steady-state rate of sales in high-income countries for these commodities (figure I). The leading sellers of these commodities in the low- and middle-income country cohort are large, primarily United States-based multinational corporations (e.g., Nestle, Kraft, PepsiCo and Unilever) (Stuckler et al., 2012). In prior statistical regressions, it was found that the rate of growth in sales of these products was significantly associated with high foreign direct investment and free-trade agreements with the United States (Stuckler et al., 2012).

Do these changes in consumption meaningfully affect NCD rates? That is, are these changes clinically relevant in a medical sense? In a series of regression studies, it was observed that increases in consumption of processed food and soft drinks do in fact statistically explain large increases in obesity and type 2 diabetes that have been observed in low- and middle-income countries over the past several decades, even after statistically controlling for ageing populations, economic growth, urbanization, changes in other types of food calories, and changes in physical activity (i.e., increasingly sedentary lifestyles) (Basu, Yoffe, et al., 2013; Basu, McKee, et al., 2013; Basu et al., 2012). Indeed, changes in soft drink consumption in particular were statistically related in a dose dependent manner to changes in type 2 diabetes rates, even independent of obesity rates, likely due to biochemical mechanisms that lead high sugar consumption to drive metabolic dysfunction even in the absence of high body mass index (Lustig, Schmidt, and Brindis, 2012). As a result of these and related findings, the use of body mass index as an

Figure I. Trends in consumption of processed foods and soft drinks worldwide, 1997-2010
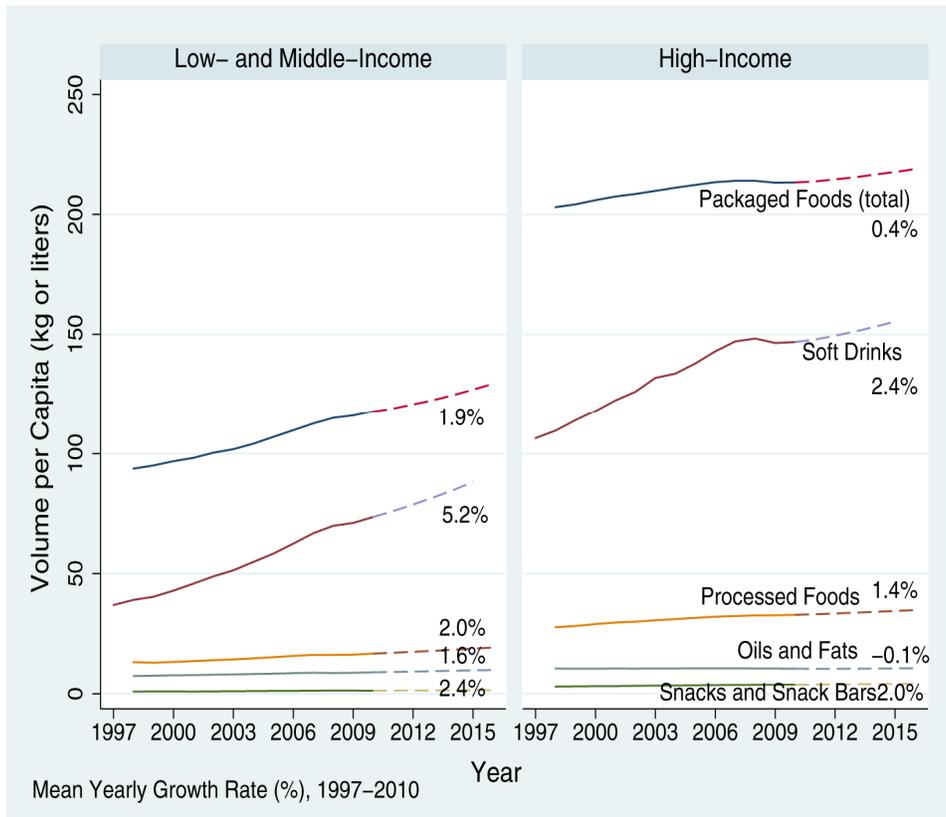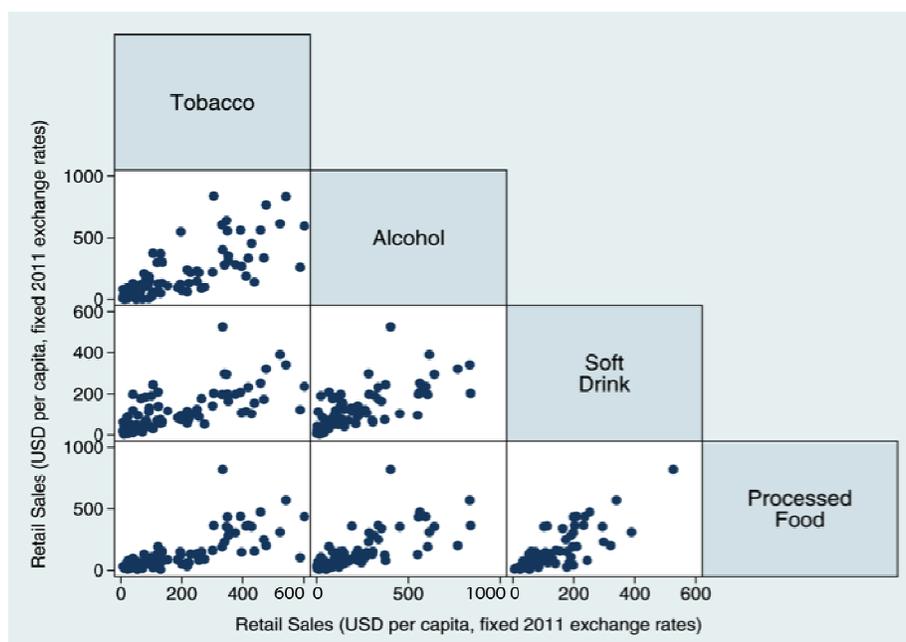

Source: Euromonitor International, 2013.

isolated indicator of metabolic disease risk is increasingly falling out of favour, as other metrics are becoming increasing popular for understanding how food consumption affects the risk of type 2 diabetes; these include, for example, the "glycemic load" of food, an index of how much different types of calories alter the concentration of sugar in the bloodstream, which is associated with insulin resistance and type 2 diabetes (Barclay et al., 2008). Increasing availability of sugars in local markets has been related to increases in type 2 diabetes rates, and decreased availability of sugars to reduced type 2 diabetes rates, even after changes in other control variables, secular trends, and time-invariant differences among countries (i.e., fixed effects) were taken into account (Basu, Yoffe, et al., 2013).

Are these changes simply an inevitable result of economic growth? While high processed food and soft drink consumption is correlated with high tobacco and alcohol consumption (figure II), it does not appear that this trend in increasing consumption is an inevitable consequence of economic growth; as shown in figure III, significant deviations, or natural experiments, have occurred, in which countries with rising or high levels of gross domestic product and otherwise similar populations experience very different rates of consumption in processed foods and soft drinks, and experienced very different trajectories in alcohol and tobacco use as well (Stuckler et al., 2012), suggesting that key policy choices or population events may dramatically alter the trajectory of consumption of leading NCD risk factors. We return to this issue below, in discussing what policy opportunities may explain why some populations have significantly reduced NCD risk factors and disease outcomes.

Figure II. Correlations among sales of commodities associated with heightened risk of NCDs, 2011

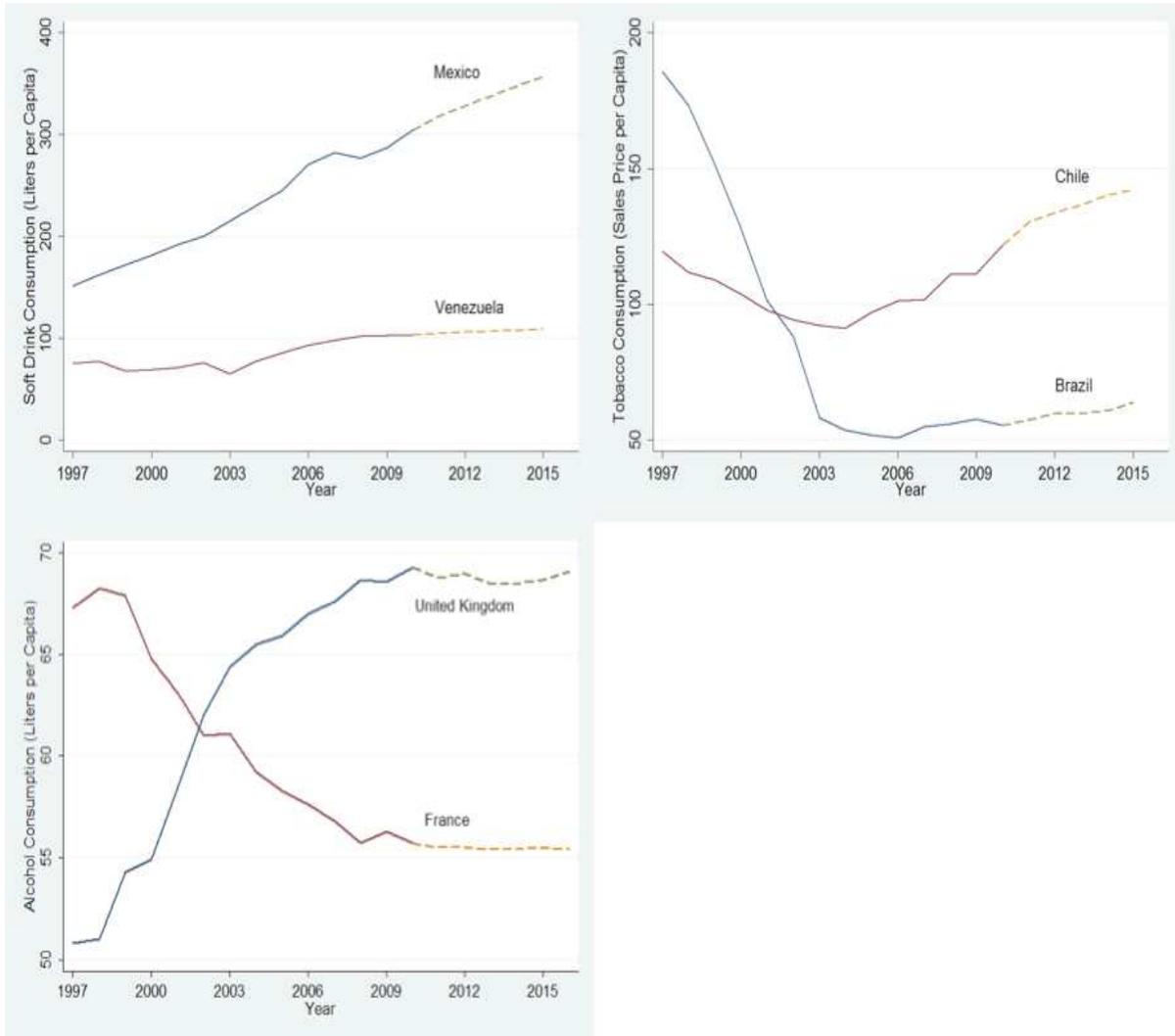*Source*: Euromonitor International, 2013.

3. *Persistence of tobacco use as a risk factor*

While processed foods and soft drinks are a subject of increasing concern among NCD epidemiologists, a leading classical risk factor for both pulmonary (and other) cancers, chronic obstructive pulmonary disease (i.e., emphysema and chronic bronchitis), and cardiovascular disease has been tobacco. There is reason to dwell on tobacco as a risk factor in part because projections of how to best avert the rising burden of cardiovascular disease (the leading cause of death) in rapidly-developing countries is to control tobacco, as compared to other major medical or public health interventions (figure IV displays the comparative effectiveness of tobacco versus other measures for populations in India, for example) (Basu, Glantz et al., 2013).

Unlike public health regulations affecting the other risky commodities, tobacco control benefits dramatically from the first international public health treaty, the Framework Convention on Tobacco Control (FCTC), a legally binding document signed by 174 countries in 2003, which sets minimum country-level standards that govern the production, sale, distribution, advertisement, and taxation of tobacco (Shibuya et al., 2003).

As with the processed food and soft drink data, much of the best longitudinal, consistently collected data on tobacco use are from tobacco companies themselves, particularly regarding sales to adults (Euromonitor International, 2013). Cigarette purchases among adults have markedly diverged among countries in similar income brackets over the past decade. Using industry data from 1997 to 2010, it's clear that a few countries have markedly reduced the proportion of adults who smoke cigarettes, having lowered smoking prevalence by 10 per cent or more: Norway (from 33 per cent of adults smoking in 1997 to 19 per cent smoking in 2010), South Korea (from 35 per cent to 21 per cent during that period), Slovenia (from 36 per cent to 24 per cent), Japan (from 36 per cent to 25 per cent) and Denmark (from 32 per cent to 22 per cent). These data reveal that even prior to the FCTC, tobacco use lowered in many

**Figure III. Estimated and projected trends in consumption of soft drinks,
tobacco and alcohol in selected countries, 1997-2015**

Figure IV. Projected myocardial infarction deaths averted from 2013-2024 by tobacco control policies as compared to medications when incorporating the impact of healthcare access and medication adherence in India, using a mathematical model.
UM = urban men; RM = rural men; UW = urban women; RW = rural women
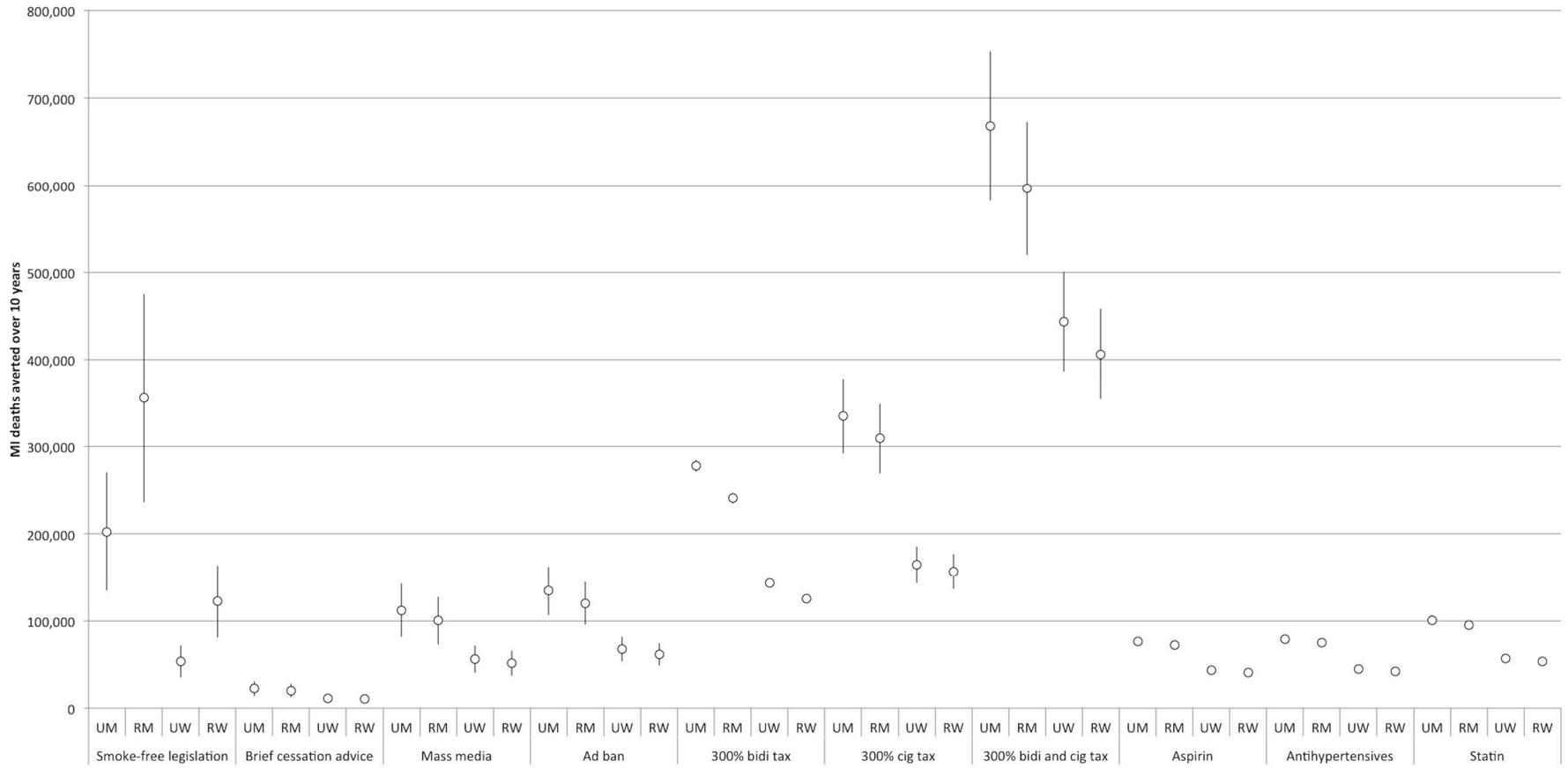
Source: From Basu, Glantz et al., 2013.

high-income countries (figure V). The latest tobacco control reports from these countries indicate that they implemented tax policies to reduce tobacco consumption (most instituted a combination of a specific tax—like a tax per quantity of cigarettes sold—and ad valorem taxes taking a percentage of the sales price). The countries also confiscated equipment and supplies related to illicit tobacco trading, banned smoking in a number of public places, and enforced various package labelling requirements. Denmark and Slovenia additionally implemented a comprehensive ban on all tobacco advertising, promotion and sponsorship (World Health Organization, 2013).

Figure V. Countries with substantial smoking prevalence rate declines among adults, 1997-2010
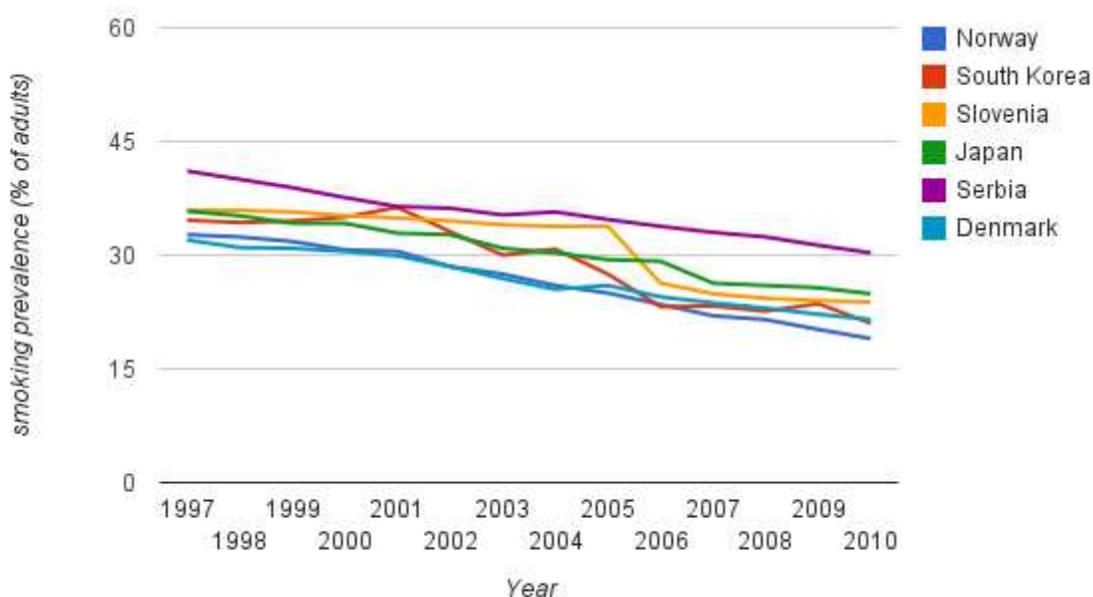
Source: World Health Organization, 2013.

The tobacco industry has arrived at its own projections for where tobacco smoking prevalence is likely to rise and fall in the future. The available projections span five years, and predict the largest declines in adult smoking prevalence in the Ukraine (from 29 per cent smoking prevalence in 2010 to 24 per cent in 2015), Cameroon (from 13 per cent to 9 per cent during that time period), Serbia (30 per cent to 27 per cent), Norway (19 per cent to 15 per cent) and New Zealand (21 per cent to 18 per cent) (Euromonitor International 2013). Of 80 countries for which data are available, 63 are anticipated to experience declines in smoking prevalence and three are expected to have no significant change in prevalence over the next five years. The few countries who are projected by the industry to have a significant rise in future smoking prevalence over the next half decade are in Africa and the Middle East: Morocco (increasing prevalence from 20 per cent in 2010 to 29 per cent in 2015), Kenya (20 per cent to 23 per cent), Tunisia (36 per cent to 38 per cent), Iran (19 per cent to 21 per cent) and Saudi Arabia (30 per cent to 31 per cent). Kenya has implemented FCTC provisions since 2004 and kept up to date with all of its reporting, while the other countries anticipated to face a rise in prevalence have failed to report on their progress in ratifying the treaty's provisions (World Health Organization, 2013).

The overall adult prevalence statistics from these countries, however, disguise a striking demographic feature hidden beneath the averaged data. That is, there is a marked difference within countries between how much adult men smoke and how much adult women do. In several countries, male smoking rates are at least twice the rates among women. In Russia, for example, 62 per cent of adult men smoked in 2010, while about 29 per cent of women did. Similarly, 61 per cent of Tunisian men, 48 per cent of Chinese men and 24 per cent of Indian men smoked, while the rates of smoking among women in those countries was 11 per cent, 3 per cent and 4 per cent, respectively. There are a few locations where prevalence rates of smoking among women are strikingly high, but still not as high as among men (33 per cent of Bosnian women, for example, smoke, as compared to 46 per cent of Bosnian men).

Because prevalence statistics simply reflect the proportion of a country's population that smokes, the statistics make it hard to visualize actual NCD risks, since cigarette smoke exhibits a dose-response effect on negative outcomes like heart and lung disease, such that an individual with a longer and heavier smoking history will have a greater likelihood of experiencing tobacco-related disease than someone with a brief or light smoking history, and since prevalence data fail to capture secondhand smoke effects. The only other consistently-collected industry data do not solve this problem; this reflects the number of actual cigarette sticks sold, which can give some sense of the burden of cigarettes on a population, capturing some aspects of the population size of smokers across countries and the dosage of cigarette exposure affecting different countries or regions.

The number of cigarettes sold by region and by country (figure VI) reveals the true impact of Chinese tobacco use on the overall global tobacco epidemic. While other countries have a greater absolute smoking prevalence, China's moderately high prevalence (26 per cent of adults smoking in 2010) translates into an effectively very large market of consumers given the country's massive population size. Of greater concern is that while the absolute smoking prevalence in the country has remained essentially flat for the last decade (and is projected to remain flat for the next five years according to the industry's own projections) the number of sticks sold in China has increased dramatically and continues to rise on an exponential upward trajectory that is about five times faster than the population curve, suggesting heavier smoking over time. Overall, 2.3 billion cigarettes were sold in China last year, which is projected to rise to 2.8 billion by 2015. When China is removed from the figures (figure VI), it becomes apparent that cigarette sales have declined in North America, Western Europe and Latin America, plateaued in Eastern Europe to some extent, and risen in the Middle East and Africa. Among the top cigarette consuming nations, the United States and Japan have markedly lowered their consumption over the past decade or so, while Russia and Indonesia have increased their cigarette consumption, also beyond their population growth curves, as with China.

4. *Trends in heavy alcohol use*

The most recent estimates of alcohol-related deaths suggest that about 2.5 million deaths each year are directly attributable to alcohol, with the highest percentage of alcohol-related deaths among people between 15 and 29 years old (alcohol is responsible for nearly 1 out of 10 deaths in this age group worldwide) (Shield et al., 2013). This makes alcohol the world's third largest risk factor for disease; it is the leading risk factor in the Western Pacific and the Americas and the second largest in Europe. Looking at disaggregated alcohol-related death data, it appears that harmful drinking mostly leads to unintentional injuries and cardiovascular diseases, followed by cirrhosis of the liver and various cancers; an increasing number of analyses also find a significant burden of sexually transmitted diseases attributable to alcohol intoxication, including HIV/AIDS infections, and a number of infections attributable to alcohol's immuno-modulating properties, which predispose alcoholics to diseases like tuberculosis (however, this may be confounded by housing insecurity among chronic alcoholics, as living in cramped quarters is an independent risk factor for TB infection) (World Health Organization, 2011).

Figure VI. Cigarettes sold by region, 1997-2010 actual, 2010-2015 projected by industry
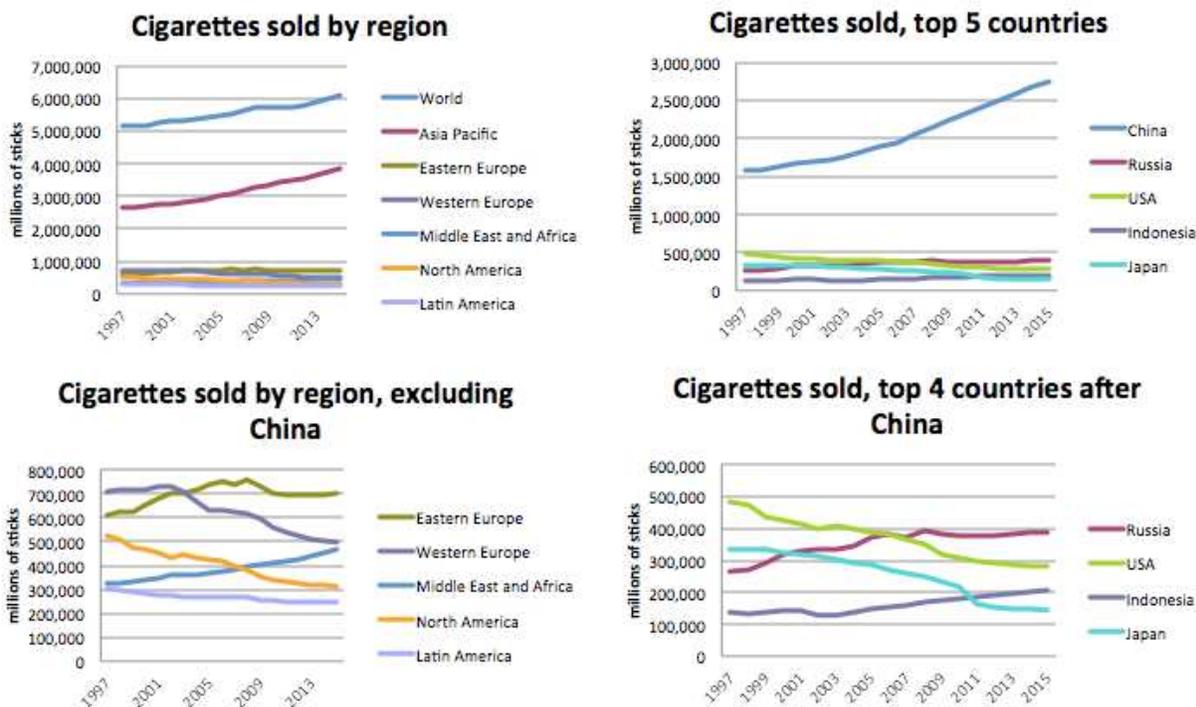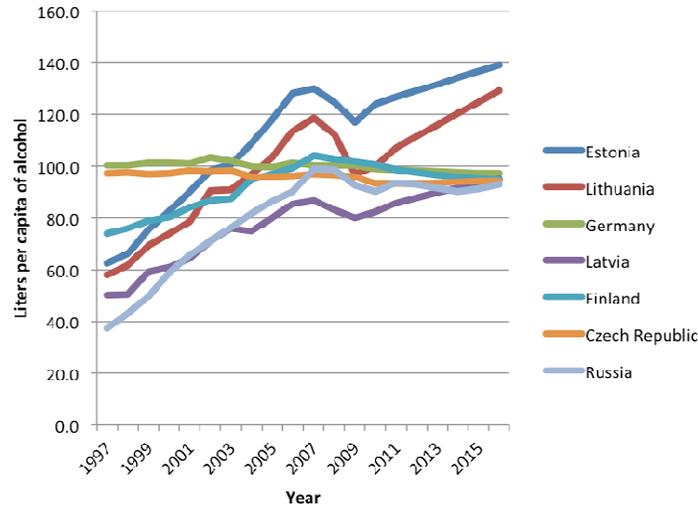

Source: Euromonitor International, 2013.

Worldwide alcohol consumption in 2005 was equal to 6.1 litres of pure alcohol consumed per person aged 15 years or older, on average. Analysis from 2001-2005 showed that countries in the Americas, Europe and Western Pacific regions had relatively stable consumption levels during that time; but marked increases were seen in Africa and South-East Asia during the five-year period (World Health Organization, 2011). Despite widespread consumption, most people in the world actually do not drink according to these World Health Organization alcohol consumption estimates. Almost half of all men and two-thirds of women did not consume alcohol. Abstention rates are low in high-income countries and highest in North Africa and South Asia. But in countries with high abstinence rates, the few people who do drink seem to consume alcohol at very high levels.

Most of the epidemiological research on alcohol focuses on two variables: the total volume of alcohol consumed per person, and the pattern of drinking (e.g., daily drinking versus binge drinking). The total volume of alcohol consumed per capita is easier to track; by comparison, it is difficult to fully tease apart changing patterns in drinking without careful survey-based or ethnographic studies. The data on longitudinal drinking trends is mostly in terms of per capita consumer purchasing of different types of alcohol products (hence, it may be inflated if significant amounts of alcohol are wasted, or an underestimate of drinking in regions where a lot of alcohol is informally or illegally produced and sold).

In terms of overall consumer trends, Estonians and Lithuanians have rapidly become the world's dominant drinking populations over the last few years (Euromonitor International, 2013). When measured by overall litres of alcohol consumed per person, the two countries have rapidly increased their per capita drinking from around 60 litres per person per year in 1997 to over 100 litres per person per year in 2011; industry projections suggest they will near 140 litres per person per year in the near future (see figure VII, where 2012-2016 estimates are industry projections). Latvia, Finland and Russia are close behind,

**Figure VII. Leading countries in terms of litres per capita of
alcohol consumption per year**

Source: Euromonitor International, 2013. *Note:* Estimates for 2012-2016
are industry projections.

but have plateaued their consumption rates at a relative steady-state near 90 litres per person over the last few years, having experienced a rapid increase during their periods of post-Soviet stress. Other heavily-drinking countries like Germany and the Czech Republic have stayed steady during the last decade.

The least drinking seems to take place in Muslim countries of North Africa and South Asia, though drinking is becoming increasingly popular in Egypt and Nigeria. To provide a sense of scale, the worldwide average consumption rate was 19 litres per person per year in the year 1997, 23 in the year 2011, and is projected to rise to 25 in 2016. In the United States, the average consumption rate was 73 litres per person per year (about 19 gallons) in 1997, 70 litres in 2011, and is projected to decline to 67 litres by 2016 (Euromonitor International, 2013).

In contrast to the absolute volume of consumption, if we look at the changes in consumption over the last few years, Estonians and Russians top the list as having increased their per capita litres of consumption of alcohol by more than 50 litres per person between 1997 and 2011. Other Eastern European states were close behind, averaging a 41 litre per person increase between 1997 and 2011. There is increasing evidence to suggest this may have been related to the severity of the economic transition among former USSR territories to the market economy and associated declines in social welfare supports, alcohol treatment programs, social capital and employment opportunities among working-age men. A few countries do, however, appear to reduce their per capita drinking rate substantially, most commonly in countries where alcohol use policies were in effect (the price control policies described further below). The biggest fall was in Denmark, but interestingly this was followed by Slovenia–which despite its proximity to other Eastern European nations with large increases in drinking, actually managed to have social support and alcohol policies in place that buffered its population and reduced net consumption by almost 20 litres per person between 1997 and 2011.

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Some limited data seem to suggest that the greatest risk from alcohol use is among people who engage in binging, or consuming 60 or more grams of alcohol content in a single sitting (World Health Organization, 2010). Data on average per capita alcohol consumption really fails to capture drinking behaviours such as whether people are binging or using alcohol on a daily basis. In an attempt to characterize these more dangerous patterns of drinking behaviours, a group of researchers created a patterns of drinking score (Rehm et al., 2003). The score tries to describe the relative burden of alcohol-attributable disease in a country on a scale of 1 (least risky drinking pattern) to 5 (most risky drinking pattern). The score is based on three different dimensions: four different aspects of heavy drinking occasions (i.e. high usual quantity of alcohol per occasion, festive drinking common at fiestas or community celebrations, proportion of drinking when drinkers get drunk, and proportions of drinkers who drink daily or nearly daily), drinking with meals, and drinking in public places. In addition to Russia, the highest (most worrisome) pattern of drinking score was in the Ukraine; interestingly, some of the countries with low (least worrisome) score—such as Cyprus, Italy, Portugal and Spain—have significant alcohol use, but manage to avoid risky drinking trends. The little data available from sub-Saharan Africa suggest potentially high levels of problem drinking there as well (though the two countries from which reliable data are available have been known to have a high rate of problem drinking among male migrant labourers, such as gold miners). Many Latin American countries also top the list (Rehm et al., 2003).

In terms of absolute mortality attributable to alcohol, Russia stands out as having recorded over 800 deaths per 100,000 men in 1994 (decreasing only to 290 per 100,000 by 2002, still higher than nearly any other country) (Rehm et al., 2003). Russia also has the highest prevalence rate of alcohol dependence among adults, with almost 20 per cent of men currently thought to meet criteria for alcohol dependence (chronic alcoholism). Most of Eastern Europe's increase in consumption actually appears to be in the form of beer consumption (a rise of 39 litres per person per year from 1997 to 2011), in spite of stereotypes about Russian vodka (hard liquor and spirits actually remained fairly constant in consumption in Eastern Europe during this period). Most of the decline in consumption in the United States and North America generally is also from reduced consumption of beer (a drop of about 4.4 litres per person per year from 1997 to 2010) (Euromonitor International, 2013).

5. *Limited data on physical inactivity*

While unhealthy foods, tobacco and alcohol use are the major consumption-driven risk factors for NCDs, the next major risk factor for worldwide NCD mortality is physical inactivity. The social drivers of physical inactivity are fairly clear, and include the decline of agriculture, rise of urbanization, increase in automation and deskwork, and the decline of active transport in favour of automobiles. A 2012 series of articles in the medical journal *The Lancet* attempted to review the state of physical inactivity literature and data to parallel the timing of the summer Olympic Games (Lee et al., 2012). In that series, it was highlighted that while data on physical inactivity were lacking for many years, new surveillance initiatives particularly focused on adolescents and adults had progressed substantially since the year 2000. Most of the information was in the form of cross-sectional data available from standardized self-report instruments from at least 122 countries, hence few longitudinal results can be described to characterize long-term trends (Hallal et al., 2012).

For consistency across surveys, physical inactivity has been defined as not meeting any of three clinical recommendations that correlate to various cardiovascular and metabolic outcomes: 30 minutes of moderate-intensity physical activity on at least 5 days every week, 20 minutes of vigorous-intensity physical activity on at least 3 days every week, or an equivalent combination achieving 600 metabolic equivalent (MET)-min per week (Hallal et al., 2012). One MET is defined as the energy spent when an individual sits quietly, while higher METS are estimated by recording the number of kilocalories that individuals expend per kilogram per hour of moderate-to-vigorous physical activity (Ainsworth et al., 2011).

Using these criteria, about one-third of adults and four-fifths of adolescents do not reach public health guidelines for recommended levels of physical activity. But there are marked deviations within age groups. Most importantly, in most countries inactivity is higher in women than in men, and more intuitively, older adults are less active than are younger adults. A decline in occupational physical activity appears to be a major predictor of overall physical activity declines, particularly in low- and middle-income countries, although some leisure-time physical activity has increased particularly in higher-income nations (Hallal et al., 2012).

The recent calculation of population attributable fractions of major NCDs has attributed physical inactivity to 6 per cent (ranging from 3 per cent in southeast Asia to 8 per cent in the eastern Mediterranean region) of the burden of disease from coronary artery disease, 7 per cent (4 per cent to 10 per cent) of type 2 diabetes, 10 per cent (6 per cent to 14 per cent) of breast cancer, and 10 per cent (6 per cent to 14 per cent) of colon cancer (Lee et al. 2012). This translates to about 9 per cent of premature deaths, but also suggests a rather modest impact on overall life expectancy; if physical inactivity were completely eliminated worldwide (all individuals met the above criteria), such an action would be expected to increase the life expectancy of the world's population by about 0.68 (range 0.41–0.95) years, as compared to at least three times that number from improved nutrition and possibly ten times that number from the elimination of tobacco.

Increasingly, newer surveys are separating physical *activity* from *sedentary* behaviour, as the two appear to potentially predict cardiovascular and metabolic disease outcomes somewhat independently of one another; even individuals who participate in physical activity sufficient to meet exercise guidelines (e.g., professors playing a few games of squash per week), appear to be at higher risk of cardiac and metabolic diseases if they are sedentary for long periods of the day, as compared to individuals who engage in the same amount of vigorous heart rate-increasing exercise per day but are slightly mobile and less completely sedentary during non-exercise periods (Levine et al., 2005; Owen et al., 2011). To date, little is known about the patterns of sedentary behaviour as a different metric from physical activity itself, given that this issue has been recognized in public health only in the past few years.

C. The Distribution of Risk in Populations

1. *Within-country inequalities*

One of the persistent challenges posed by much of the international data on NCD risk factors and NCD prevalence statistics is that they are typically aggregated at the country level. Yet major theories concerning who is most at risk for NCDs are important to consider for policy action and the planning of interventions. Several authors have argued that NCDs are disproportionately diseases of the wealthy in low- and middle-income countries (Subramanian et al., 2013). Their critics have countered that the trajectory of NCD disease burdens in high-income countries reveals that while initially lifestyle disorders associated with a reduced infectious disease burden and higher access to risky commodities is associated with wealth, the prevalence of NCDs rapidly descends the socioeconomic gradient to primarily become disorders of the poor, as now seen in the United States, Latin America, Europe and Australia (Narayan and Ali, 2013). Numerous theories for this abound, but the mechanisms are likely to be multifactorial: as processed foods become cheaper, their primary consumer base expands to lower income groups and wealthier individuals have access to education and resources for ultimately more expensive fresh fruits and vegetables; stresses and social exposures to tobacco and alcohol use concentrate among the poor as tobacco and alcohol are forms of self-medication for social stressors; access to safe spaces for physical activity tends to be concentrated among wealthier groups within urban spaces (e.g., few members of the poor can safely jog or run for exercise, have the time to do so, or have the cultural impetus to engage in such activities, on urban streets in many major cities of developing countries) (Institute of Medicine, 2010).

The expected trajectory of NCD risk factors and burdens towards the poor has already manifested in some middle-income countries with high rates of processed food intake, such as Mexico, where the rate of soft drink intake and prevalence of obesity has eclipsed that of the United States (Basu, McKee, et al., 2013). Similarly, we find that the issue of increasing NCD burdens among the poor is compounded by the lack of effective surveillance due to inadequate healthcare access among lower-income groups. For example, the recent population-representative WHO SAGE study—which took place in India, China, Russia, Ghana, South Africa, and Mexico—revealed that while higher-income populations within these countries more commonly have *diagnosed* NCDs, validated screening instruments applied to the poor reveal the overall *true* prevalence of NCDs to be highest among the lowest income group (figure VIII) (Vellakkal et al., 2013; Basu and King, 2013).

Figure VIII. Prevalence of diagnosed and undiagnosed NCDs in India, by wealth quintile, 2007
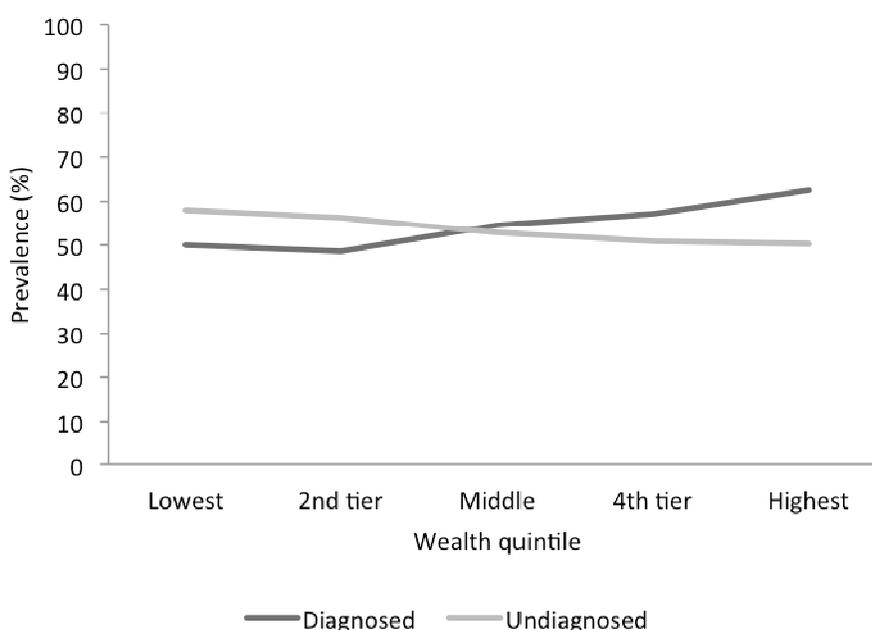
Source: Vellakkal et al., 2013 based on data from the 2007 WHO SAGE study

2. *The dual burden*

A related concern is that the classical theory of the epidemiologic transition from infectious to chronic diseases does not appear to be occurring as smoothly as predicted (McKeown, 2009). As countries developed economically, it was expected that the patterns of disease in countries like India and China would follow a course in which infections such as tuberculosis would decline steadily to near-eradication levels, while chronic conditions associated both with higher incomes (to spend on risky commodities) and aging would lead to NCDs in older age.

The actual patterns of disease are differing from this classical framework in a way that is concerning for the overall stability of social systems. First, increasing evidence suggests that major infectious diseases are reaching steady-state prevalence levels among the poor, and that a dual burden of disease is appearing in poor households in developing countries (Remais et al., 2013). Particularly as unhealthy foods and tobacco enter into poor communities, household surveys are finding both

malnutrition and obesity, sometimes in the same household; typically poor mothers are at increasing risk for obesity while infants are at higher risk for under-nutrition, or young children who experience both abdominal obesity and stunting of height (Fernald and Neufeld, 2006; Nurdiati et al., 1998; Shafique et al., 2007). In this sense, the manifestation of obesity in some households highlights that obesity is itself a state of malnutrition, in that sense that the wrong types of calories (calories from sugars and other non-nutritious sources) are dominating calories from healthier alternative foods. Secondly, substantial evidence reveals that the dual burden of infectious diseases and NCDs has the potential to amplify NCD problems among the poor. Diabetes, for example, significantly increases the risk of tuberculosis infection, as does tobacco smoking (Basu et al., 2011; Baker et al., 2011; Dooley and Chaisson, 2009; Ruslami et al., 2010).

3. *Chronic disability at earlier ages*

As a result of the large number of deaths due to cardiovascular disease among young men in some rapidly-developing countries, such as India and China, the loss of breadwinners related to early myocardial infarctions and type 2 diabetes-related complications (i.e., lower limb loss) has led to increasing burdens of disability and catastrophic medical expenditure (Smith-Spangler, Bhattacharya, and Goldhaber-Fiebert, 2012). Because many of these individuals do not die from these complications immediately, but suffer from chronic disability such as congestive heart failure, which leads to the inability to work, there are several unanswered questions about how households are coping (or facing to cope) in environments with poor social safety nets for older adults. Less than 10 per cent of people in low- and middle-income countries have any form of health insurance or pension, and adults over age 65 are explicitly excluded from most health insurance schemes in many low- and middle-income countries (Yip and Mahal, 2008). In the recent WHO SAGE study, middle-aged men in middle-income countries were found to score highest on standardized and validated WHO disability scales, and these high scores were often associated with chronic cardiovascular diseases and a history of angina (Basu and King, 2013). Among adults over 50 years of age, women and rural populations also had particularly high disability scores, illustrating the importance of including them in research despite being typically excluded or under-sampled in many NCD studies to date. In high-income countries, substantial disability related to chronic cardiovascular and metabolic disease is related to both catastrophic medical expenditures and high government and private insurance system expenditures (Himmelstein et al., 2009). Far less information is available on what is happening with regard to disability in low- and middle-income countries, although numerous economic projections are available that all provide dire predictions for the future (Engelgau et al., 2011; Abegunde and Stanciole, 2006).

One key finding from the GBD study is the increasing years of life spent in disability despite overall rising life expectancies worldwide. The GBD study calculated disability-adjusted life years (DALYs) as the sum of years of life lost (YLLs) and years lived with disability (YLDs), for 291 causes, 20 age groups, both sexes, and for 187 countries, and aggregated to regional and global estimates of disease burden for three points (1990, 2000 and 2010) with comparable definitions and new survey-based tools for defining disability states (Murray et al., 2012a). Although overall, global DALYs remained stable from 1990 (2.5 billion) to 2010 (2.5 billion), the key shift occurred in DALY composition with the contribution of deaths and disability among children (younger than 5 years of age) declining from 41 per cent of global DALYs in 1990 to 25 per cent in 2010. While in 1990, 47 per cent of DALYs lost were from communicable, maternal, neonatal, and nutritional disorders, 43 per cent from non-communicable diseases, and 10 per cent from injuries, by 2010, the mix had shifted to 35 per cent, 54 per cent, and 11 per cent, respectively. Ischemic heart disease was the leading cause of DALYs lost worldwide in 2010 (up from fourth rank in 1990, increasing by 29 per cent), and more years were spent in disabled states rather than having YLL contributing to the majority of lost DALYs for most countries outside of sub-Saharan Africa.

D. WHAT INTERVENTIONS MIGHT WORK?

1. *Lifestyle-oriented approaches versus fiscal and regulatory policies*

Due to the prolonged history of NCD risk factor investigations in Western medical circles, numerous intervention strategies have been tested in high-income countries. Perhaps the first series of population-level trials to reduce NCD risk behaviours such as tobacco smoking and improve dietary behaviour were the Stanford Five-City Trials, which among other findings revealed modest but significant improvements in NCD outcomes from education and health promotion/marketing of information (Fortmann et al., 1990; Winkleby et al., 1996; Young et al., 1996). More heavily cited are the results of the North Karelia project that involved significant tobacco and dietary sodium reduction in Finland (Laatikainen, Vartiainen, and Puska, 2012). While Finland had the highest cardiovascular mortality rates in the world in the 1960's, the project involving social marketing, community-based engagement, and changes in food content dramatically lowered cardiovascular mortality rates by 82 per cent with sustained improvements for over three decades now.

Sadly, such case studies of dramatic community engagement resulting in large nutritional or tobacco use changes have been rare, and many recent meta-analyses and systematic reviews have found attempts to replicate such findings have largely failed when not directed through large, often expensive, and ultimately community-engaging programs. Increasingly interest has therefore turned to fiscal and regulatory strategies, particularly given the marked efficacy of tobacco taxation in reducing smoking rates (Ali and Koplan, 2010; John et al., 2010). There is substantial evidence that taxing risky commodities is effective in reducing consumption if the tax is salient enough to consumers. Fiscal and regulatory strategies for nutrition continue to be debated, particularly due to the unpopularity of the recent Danish fat tax and reports that sugar-sweetened beverages taxes face significant industry opposition in the United States (Brownell et al., 2009). Current taxes in the United States are likely too small to effect meaningful clinical changes, although increasing evidence suggests that larger taxes are efficacious, especially when they are high enough to compensate for the effects of substitution to other high-calorie items (e.g. individuals substituting high-calorie sports drinks or fruit juices when soft drinks are taxed) or when sugar content rather than just a narrow product class are being taxed (Harding and Lovenheim, 2013; Sturm et al., 2010; Wang, Y.C. et al., 2012).

Unlike the less substantive nutritional policy data, alcohol control policy analysis reveals more consistent data on which policy options may be best for alcohol control in coming years. A systematic review incorporating not only the public health implications of reducing risky alcohol use but also the social and economic effects of alternative policies (including potential negative impacts on alcohol-related industries such as restaurants) observed that unlike taxation of alcoholic products, requiring minimum prices on alcoholic products circumvents retailers' ability to absorb price increases, so all alcohol currently sold below the minimum price per unit would become more expensive with the introduction of this policy (Hunt, Rabinovich, and Baumberg, 2011). Since the price effect of this policy is especially strong for low-cost alcohol, minimum pricing has important implications for young and hazardous/harmful drinkers and low-income groups, who are more likely to purchase cheaper drinks. The direct costs to producers and retailers of implementing this regulation are likely to be relatively small, but the government generates no revenue from a minimum price policy. By contrast, the impact of a ban on sales below cost depends on the extent to which retailers engage in this pricing strategy. There is evidence that sales below cost are particularly common in some countries like the United Kingdom in the supermarket sector, and specifically during times of high demand (such as Christmas) (Hunt, Rabinovich, and Baumberg, 2011). It is also possible that retailers (especially large supermarket chains) would lower alcohol prices further in order to circumvent a ban on below-cost sales. The effect on consumption of a ban on sales below cost, therefore, may be relatively small compared with broader restrictions on discounts and promotions, and also with the introduction of certain minimum prices or tax hikes.

Less noticed are the quieter regulatory strategies such as national salt reduction initiatives that have reduced dietary sodium content in processed foods, reducing hypertension rates at a population level (Webster et al., 2011). Such strategies appear increasingly effective, and likely necessary, given the continued failure of purely didactic education-based initiatives to result in substantive population-level change (Taylor et al., 2011). However, there is substantial interest in less intrusive measures such as nudges that involve minimal or no economic cost and go unnoticed—essentially by making the default choice of consumers a healthier choice (e.g., positioning healthier foods in a store more accessibly and generating informal barriers or social norms to discourage unhealthier consumption) (Thaler and Sunstein, 2008). These remain under active investigation and it is unclear what degree of population-level impact such measures might have.

Finally, while prevention is ideally desired for reducing the burden of NCDs, there is substantial evidence that medical treatment, if instituted through effective healthcare provision, can make a large population impact on NCD mortality. The international MONICA study following 10 million people in 21 countries (mostly wealthy European and one middle-income nation) and observed that eight treatments (coronary-artery revascularization before, thrombolytics during, and beta-blockers, antiplatelet drugs, and angiotensin-converting-enzyme (ACE) inhibitors before and during non-fatal myocardial infarction) that explained 72 per cent of the observed decline in coronary heart disease mortality among men and 56 per cent among women over a decade since the mid-1980s (Thorvaldsen et al., 1995; Unal, Critchley, and Capewell, 2004). Paralleling this study, modelling approaches applied to population epidemiologic data have been used to estimate that in many high-income nations, 40-60 per cent of the change in cardiovascular mortality over the past three decades can be attributed to treatments of individuals (treatment of heart failure, acute myocardial infarction, and secondary prevention) and a similar figure to population risk factor reductions (principally smoking, blood pressure, and cholesterol reduction), but with gains partially offset by worsening trends for physical activity, obesity and diabetes (Ford et al., 2007). There is evidence that improved cardiovascular treatment has substantially slowed the increase in deaths driven by changing risk factors in some middle- and lower-income countries, including China, where cardiovascular mortality rose sharply between 1984 and 1999 driven largely by increasing cholesterol levels, but would likely have been much greater without improvements in access to treatments (Critchley et al., 2004). Similar findings have been obtained in Syria and Tunisia (Rastam et al., 2012; Saidi et al., 2013).

2. *Is the evidence from high-income countries sufficient?*

Given the substantial evidence from high-income countries that NCD risk factor interventions have been studied and are likely to require either extensive community engagements, fiscal/regulatory interventions, and/or expansion of medical treatment, is there reason why further studies of risk factors should take place in low- and middle-income countries, or is implementation research the only future path necessary? This question has major implications for defining an agenda for the ICPD beyond 2015.

There are two major reasons why we might argue for caution about immediately translating evidence from high-income countries to act on NCD risks in low- and middle-income countries without further caution and investigation. First, and most importantly, some common NCDs have very different risk factors in low- and middle-income nations than in high-income countries. For example, chronic obstructive pulmonary disease, particularly among women, is not always a consequence of tobacco use in low- and middle-income nations. Rather, recent research establishes the disease as a consequence of dirty cook stoves that use wood-burning fires rather than cleaner sources of petrol and contribute not only to lung disease but also cataracts and an increased risk of tuberculosis among women in many low-income communities (Zhang and Smith, 1999; Fullerton, Bruce, and Gordon, 2008). Similarly, pesticide exposures appear to increase the risks of numerous neurological and pulmonary diseases that have been

essentially ignored due to their limited appearance in high-income nations (Ecobichon, 2001; Jeyaratnam, 1990). The dual burden of diseases such as diabetes with tuberculosis or HIV with cardiovascular disease are less common in high-income countries and therefore optimal clinical approaches to addressing them have been poorly defined (Ebrahim et al., 2013).

Secondly, there are some scientific benefits to re-examining established risk factors in low- and middle-income nations. Some hypotheses established in high-income countries have come into question when retested in populations where there is more heterogeneity in risk factor exposure or social conditions. For example, years ago there was a claim that some levels of blood cholesterol were safe, but research in China revealed increased rates of coronary heart disease even at low levels of blood cholesterol, prompting the studies that eventually led to the discovery of statin drugs (Chen et al., 1991; Cholesterol Treatment Trialists, 2008). Similarly, while studies suggest breastfeeding may lead to lower blood pressure and body mass index in children in high-income nations, failures to replicate this finding in low-income countries suggest that the correlations may have been confounded by associations between breastfeeding, income and education in high-income nations (Brion et al., 2011).

E. MOVING FORWARD

How will the major challenges to mortality reduction beyond 2014 be similar to or different from those faced over the 1994-2014 ICPD Programme of Action implementation period? Reviewing current data, it appears that several changes in morbidity and mortality related to NCDs will affect the ICPD Programme. Rapid changes in NCD risk factor exposure among low- and middle-income countries include dramatic changes in dietary risk factors, which are significant correlates to increasing rates of cardiovascular disease, type 2 diabetes and obesity. These changes are notably increasing the number of households with a particularly young male member who faces high risks of disability that affects both the likelihood of catastrophic health expenditure, burden on the rest of the family, potential cost to health systems, and increasing suffering despite longer life expectancies. Tobacco remains a persistent and dominant risk factor for cardiovascular mortality with little progress towards effectively implementing Framework Convention on Tobacco Control provisions outside of some select high-income countries in Europe and Asia that have aggressively implemented fiscal and regulatory strategies to control tobacco use. Particularly China and India will face a high burden of cardiovascular deaths related to tobacco over the next decade, again dominated by male morbidity and mortality. Harmful alcohol use has similarly increased in several areas, particularly Eastern Europe, where it remains a persistent and poorly addressed cause of premature mortality despite extensive evidence for effective policy strategies to reduce harm.

Examining within-country trends in both middle-income and high-income countries indicate a reduced age of onset of chronic disease, increased disability at younger ages from chronic diseases, and a shift down the socioeconomic gradient towards poorer groups. Major survey efforts must pay further attention to the low probability of effective diagnosis and accurate vital registration systems that have typically under-sampled rural and poor groups who appear to disproportionately bear a burden of disability. Complexities are also arising with the dual burden of both infectious and chronic diseases within the same income groups and even within households, deviating from the classical epidemiological transition framework in which the theorized rise in chronic diseases of the elderly is expected to follow a decline in infectious disease burdens.

Identifying the best strategies to reduce NCD risks is a pressing issue for both middle- and high-income countries. Investigations need to address whether the experiences in high-income countries can be effectively translated into low- and middle-income country settings, but this requires ensuring that local variations in NCD risk and the scientific basis for intervention is applicable to targeted communities. High-income countries have revealed that rapid and sustained improvements to NCD mortality can occur with substantial community engagement and with extensive treatment of cardiovascular risk factors such

as hypertension and hyperlipidaemia. In the absence of large-scale engagement, individual-level interventions to reduce dietary, physical activity and tobacco-related risk factors for NCDs should be supplemented by population-level interventions that are often fiscal and regulatory in nature. The rising obesity prevalence rates in low- and middle-income countries are complemented by increasing rates of hypertension and hyperlipidemia (Finucane et al., 2011; Danaei et al., 2011; Farzadfar et al., 2011), which are highly treatable through effective medical systems (unlike higher obesity rates). Thus, continued enhancement of health systems to provide adequate primary and secondary medical care of cardiovascular disease will also be required.

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