Chapter 20

Extended Cost-Effectiveness Analyses of Cardiovascular Risk Factor Reduction Policies

David A. Watkins, Rachel Nugent, and Stéphane Verguet

INTRODUCTION

Recent improvements in prevention and treatment have led to marked reductions in age-standardized mortality rates from cardiovascular disease (CVD) in low- and middle-income countries (LMICs). However, because of rapid population growth and aging in these countries, the number of fatal and nonfatal cases of CVD continues to rise (Roth and others 2015). This increase in the absolute burden of CVD is accompanied by an increase in the economic impact of CVD that includes financial risks related to accessing treatment (Bloom and others 2011; Jha and others 2013). The findings from a systematic review indicate incidence of catastrophic health expenditure (CHE) of greater than 70 percent in patients with CVD or stroke in China, India, and Tanzania, and 68 percent in patients with cancer (Huffman and others 2011).

CVD and its risk factors are frequently distributed across populations in different ways. A popular notion is that CVD is a condition of older, urban males; however, evidence suggests that younger individuals in poorer and rural areas are often disproportionately affected (Gaziano 2009). Furthermore, recent studies have shown that the poorest countries and world regions have the highest incidence and case-fatality ratios from CVD, compared with the wealthiest areas. This observation could be due in part to disparities in access to health services in general and evidence-based interventions in particular (Yusuf and others 2014).

Extended cost-effectiveness analysis (ECEA) is a new economic evaluation method developed as part of the Disease Control Priorities Network grant funded by the Bill & Melinda Gates Foundation and the *Disease Control Priorities, 3rd edition* (*DCP3*, http://www.dcp-3.org). The rationale for ECEA is to extend the scope of cost-effectiveness analysis (CEA) to assess health policies more adequately. CEA centers on the summary metric of incremental cost-effectiveness—cost per amount of health gained—and is a key part of health technology assessment.

ECEA goes beyond simply measuring health outcomes to estimate incremental gains in nonhealth outcomes that are important to health systems, such as financial risk protection (FRP) and distributional consequences like equity and fairness (Verguet, Laxminarayan, and Jamison 2015). ECEA results are usually presented in "dashboard" format, that is, disaggregated into health and nonhealth outcomes per dollar spent on a particular health policy and estimated separately for different socioeconomic groups. ECEA is well designed to respond to the policy questions posed in the *World Health Reports* of 2010 and 2013, specifically, how to move efficiently to universal health coverage (UHC) (WHO 2010, 2013).

Corresponding author: David A. Watkins, Department of Medicine, University of Washington, Seattle, Washington, United States; davidaw@uw.edu.

This chapter summarizes lessons learned from three ECEAs that have been conducted on CVD risk factor reduction policies for *DCP3*. Specifically, it highlights new insights that these ECEAs have provided into the differential impacts of well-established CVD prevention interventions. It also identifies priority issues for future ECEAs to address, and draws some conclusions and implications for public health policy.

SUMMARIES OF THE ECEAs

Each of the three ECEAs on cardiovascular topics addresses a different type of health policy and has a slightly different methodological approach.

- Verguet, Gauvreau, and others (2015) assess an increase in tobacco excise tax in China.
- Watkins and others (2016) assess the regulation of salt content in processed foods in South Africa.
- Verguet, Olson, and others (2015) assess universal public finance of hypertension treatment in Ethiopia as part of a hypothetical bundle of nine health interventions.

The main findings of each of these studies are summarized in table 20.1.

Tobacco Taxation in China

China has the largest number of smokers in the world, and the overwhelming majority of them are male (Yang and others 2008). Cigarette use has become more widespread and affordable over time, which implies that further increases in excise taxes will be necessary to reach target levels recommended by the World Health Organization (WHO) to reduce the prevalence of smoking (IARC 2011). Verguet, Gauvreau, and others (2015) conducted an ECEA with a special focus on the distributional consequences of increased tobacco taxation in response to the frequently cited concern that taxation disproportionately affects the poor (Remler 2004).

This ECEA used a model to assess the impact on tobacco consumption among male Chinese smokers over a 50-year time horizon following a one-time increase in tobacco prices of 50 percent. The authors estimated health outcomes as reductions in years of life lost (YLL). They also looked at four economic outcomes: increases in excise tax revenues, changes in household expenditure on tobacco, changes in tobacco-related health expenditure, and FRP using the money-metric value of insurance approach (Verguet, Laxminarayan, and Jamison 2015). The model incorporated differential effect sizes of the tax based on empirical studies that have found a gradient in price elasticity of demand for tobacco, wherein the poorest are much more price sensitive (price elasticity range, −0.64 to −1.28) than the wealthiest (price elasticity range, −0.12 to −0.24).

The tobacco tax would result in large health gains and FRP over the 50-year period, with the poorest wealth quintile receiving the plurality of the benefits (table 20.1). The tax would generate US$703 billion in new excise tax revenues (14 percent from the poorest quintile); it would reduce household income by 3.9 percent among the poorest and 0.7 percent among the wealthiest. Tobacco expenditures would increase among all wealth quintiles except the poorest, where they would decrease by US$21 billion. Tobacco-related medical expenditures would also be reduced by US$24 billion (27 percent in the poorest quintile). The money-metric value of insurance was calculated to be US$1.8 billion, with US$1.3 billion realized among the poorest quintile. The insurance value, which measures the reduction in financial risk accruing to segments of the smoking population due to the higher price, is large and significantly pro-poor.

The authors also performed several sensitivity analyses. If price elasticity of demand for tobacco were constant rather than varying across quintiles, the health gains and expenditure changes would even out, and the overall structure of the tax would be more regressive;

Table 20.1 Main Findings of CVD Risk Factors

Study	Health gains	Distribution	FRP
Tobacco in China	231 million YLL averted over 50 years	34% of YLL averted and 74% of insurance gained in poorest quintile	US$1.8 billion value of insurance gained
Salt in South Africa	5,600 deaths and 23,000 cases of CVD averted yearly	Health gains relatively even; FRP mostly benefits middle or upper class, depending on metric used	2,000 cases of poverty or 2,400 cases of CHE averted yearly
Blood pressure in Ethiopia	140 deaths averted over one year	n.a.	1,100 cases of poverty averted over one year

Sources: Verguet, Gavreau, and others 2015; Verguet, Olson, and others 2015; Watkins and others 2016.
Note: CHE = Catastrophic health expenditure; CVD = cardiovascular disease; FRP = financial risk protection; n.a. = not applicable; YLL = years of life lost.

however, FRP would still be concentrated among the lowest two quintiles. If the value of the tax increase were 25 percent instead of 50 percent, the distributional consequences would be the same; however, if the value of the increase were 100 percent, the consequences would be slightly more progressive.

Salt Reduction in South Africa

Comparative risk assessments for burden-of-disease studies have consistently found that high blood pressure is one of the top risk factors in South Africa (Norman and others 2007). The contemporary South African diet is high in salt; although this salt comes largely from processed foods, discretionary use of table salt is also high. In 2013, the South African government began to implement a series of mandatory regulations on the salt content in six key groups of processed foods. In parallel, a public media campaign was initiated to encourage reductions in discretionary salt use (Hofman and Tollman 2013). Watkins and others (2016) conducted an ECEA that examined the impacts of South Africa's comprehensive salt policy.

In the spirit of the comparative risk assessment approach, this ECEA modeled a shift in population blood pressure and a resulting shift in age- and sex-specific rates of CVD. The health outcomes were measured as avertable CVD cases and deaths and comprised stroke, hypertensive heart disease, ischemic heart disease, and end-stage renal disease. The authors looked at four economic outcomes: reductions in government subsidies for the treatment of CVD (mostly for the poor), changes in CVD-related health expenditure, and FRP using two metrics: cases of CHE averted, defined as greater than 10 percent of total household expenditure, and cases of poverty averted using a local poverty line. In this model, the distributional consequences were driven by differences in salt intake and CVD risk due to variations in age, gender, and ethnic composition, as well as blood pressure distribution, by income quintile.

The salt reduction policy, once fully implemented, would reduce CVD deaths by about 11 percent per year compared with current rates. Generally, the health gains would be spread evenly across wealth quintiles, although the poorest quintile would benefit slightly less because of lower baseline CVD risk. Most of the health gains would come from preventing stroke and hypertensive heart disease; ischemic heart disease and hypertensive kidney disease in this population are much smaller contributors. Approximately US$4 million in private out-of-pocket expenditures would be averted, counteracting (but not canceling out) the increase in food prices that could occur if the food industry fully passed along the costs of product reformulation to consumers. Still, the increase in food prices would constitute less than 1 percent of yearly household food expenditures.

The South African government heavily subsidizes health care for lower-income households. Hence, the salt reduction policy would save about US$51 million yearly in government subsidies for CVD care, creating fiscal space for further investments in health. From the household perspective, the estimated 2,000 cases of poverty or 2,400 cases of CHE averted yearly by the policy would represent a 12 percent to 15 percent increase beyond the FRP that is currently being achieved through government subsidies. It is important to note that these results are context dependent: a country without preexisting CVD care subsidy arrangements would achieve a higher incremental FRP from a similar salt reduction policy. This nuance is likely to be an important consideration in a number of low- and lower-middle-income countries, since CVD care is largely financed out of pocket rather than by governments in many of these countries (Samb and others 2010).

Hypertension Treatment in Ethiopia

The latest health sector development program for Ethiopia clearly emphasizes development of a pathway to UHC (Alebachew, Hatt, and Kukla 2014). In collaboration with the Disease Control Priorities Network, the Ministry of Health is deliberating essential packages of care that will be made universally available through public finance. Verguet, Olson, and others (2015) conducted an ECEA that assessed the tradeoffs between health gains and FRP from public finance of nine illustrative interventions that would be included in this package. Of relevance to this volume, one of their interventions was public finance of antihypertensive medications to individuals at high risk of CVD. In contrast to the other two ECEAs, this analysis did not include considerations of health equity; rather, it focused on the comparative health benefits and FRP per dollar spent on specific publicly financed interventions.

The model used in this study examined the increase in effective treatment rates that would result from a 10 percent increase in coverage in each of nine selected interventions. The nine interventions were rotavirus vaccination, pneumococcal vaccination, measles vaccination, treatment of diarrhea, treatment of pneumonia, treatment of malaria, cesarean section surgery, treatment of tuberculosis, and treatment of hypertension. The small increase in coverage was chosen as a feasible target in the short term—approximately one year—given the short-term constraints in health system capacity.

The policy to reduce hypertension would publicly finance treatment with up to three medications for high-risk individuals, defined as those having greater than

20 percent CVD risk over 10 years. The health outcome was measured as CVD (ischemic heart disease and stroke) deaths averted; the economic outcomes were changes in hypertension expenditure through public finance and in CVD-related health expenditure through better prevention, as well as cases of poverty averted using a local poverty line.

Public finance of hypertension treatment in Ethiopia would cost US$1.3 million yearly, reducing out-of-pocket expenditures on treatment by US$730,000 yearly. The increase in medication use would avert 140 CVD deaths and prevent 1,100 cases of poverty (table 20.1).

When the results of the nine interventions were standardized to health gains and FRP per US$100,000 spent, the financing of hypertension treatment resulted in relatively low health gains compared with highly effective child health interventions such as measles and pneumococcal vaccination. However, the financing of hypertension treatment resulted in relatively high FRP compared with those interventions, since the treatments are much more costly and the out-of-pocket payments averted would be higher. This contrast also held for other adult conditions, such as tuberculosis treatment and cesarean section delivery, which had similarly high costs. Accordingly, this sort of assessment of tradeoffs between health and FRP could be an important step forward for ministries of health deliberating packages of care and seeking to optimize health and nonhealth impacts in the design of health insurance programs.

NEW INSIGHTS FROM THE ECEAs

These ECEAs contribute several novel insights into the CVD cost-effectiveness literature. The tobacco study is one of the first analyses to demonstrate quantitatively that, contrary to popular opinion, tobacco taxation can be progressive, at least when long-term household expenditures—including health expenditures due to the ill effects of smoking—are considered. This new focus on health equity within economic evaluation is especially relevant to countries like China and South Africa that have committed to developing policies that reduce health inequalities and promote economic development.

FRP has traditionally been regarded as a direct objective of health system financing, using public finance to reduce medical impoverishment. Indeed, with the ECEA approach, medical impoverishment and other FRP metrics can be estimated within a cost-effectiveness framework. The incremental FRP per dollar spent can then be compared across interventions to guide decision making around UHC, as was demonstrated in the Ethiopia analysis. At the same time, although tobacco taxation and salt reduction are nonpersonal, population-level interventions, they can—by preventing disease—result in substantial long-term FRP that complements the gain in FRP through public finance of clinical interventions.

An additional implication of the Ethiopia analysis is that adult-onset chronic noncommunicable diseases may be a relatively higher priority for UHC than previously thought. When only cost-effectiveness metrics are included in decision making, child health interventions and others that produce large reductions in mortality often receive highest priority. However, in economic terms, adults contribute more to society than children and receive more income for their work. Furthermore, CVD and other noncommunicable diseases are usually lifelong and expensive to manage. So while the mortality reduction from adult interventions may be much less impressive than for child interventions, the FRP gains may be much more impressive and relatively more attractive as part of a UHC package.

Finally, the distinct advantage of ECEA over CEA in guiding decision making is that ECEA more readily allows health interventions to be compared with interventions in other sectors that also focus on poverty reduction, such as education, transport, and development. This advantage has the potential to elevate the profile of health interventions within ministries of finance.

CROSSCUTTING THEMES OF THE ECEAs

These three ECEAs share additional conclusions. First, ECEAs have usually confirmed the health benefits of CEAs rather than challenged them, mainly because interventions or policies have been selected for ECEAs on the basis of their cost-effectiveness, and many of the inputs into ECEA models are similar to those of CEAs. To date, ECEAs have not been conducted on interventions that are not generally accepted to be cost-effective. In keeping with the findings of the Ethiopia study, future ECEAs may wish to explore costly interventions that do not have large health benefits but may result in substantial FRP, such as the provision of palliative care services (Powell and others 2015).

Second, one important message from these ECEAs is that an aggregated societal approach may miss important transfers and flows of costs and benefits. For example, from a societal perspective, tobacco taxation would conclude that the policy has a very low (or even zero) cost and high effectiveness and is therefore uninteresting as a topic for a CEA. Yet the tax itself has important economic effects on costs and benefits to households and governments separately that may influence policy decisions—as is seen in the discussion about the regressive

nature of the tobacco tax in China. Indeed, the whole notion of estimating FRP is predicated on disaggregating costs and analyzing them from multiple perspectives.

LIMITATIONS AND FUTURE RESEARCH TOPICS

The CVD ECEAs also demonstrate two important limitations and unresolved methodological issues that will be important topics for research.

First, a consistent approach is needed to modeling the demand for health care (that is, rates of health service utilization) and changes in demand that might occur as a result of the policy in question. Since ECEAs are often used to assess the impact of public finance, they assume a change in health care–seeking behavior that leads to a change in health outcomes. The salt reduction and hypertension treatment ECEAs both assume constant and homogeneous demand across the population. In a sensitivity analysis, the salt study demonstrates that a lower baseline demand for health care at the population level would not affect estimates of the health gains but would reduce FRP; unfortunately, no empirical literature from South Africa examines what level of health care utilization would be reasonable to assume.

Second, the focus of these ECEAs is on direct medical costs as measured by out-of-pocket expenditures and the economic benefits of reducing such expenditures. However, whether this is an adequate foundation for estimating FRP is not clear. For example, using the poverty and CHE metrics, the salt analysis finds little to no FRP in the poorest quintile of South Africans—all of whom live below the poverty line and receive free or highly subsidized medical care. Yet because the health gains in this quintile were similar to the gains in the wealthier quintiles, it is plausible that productivity would be increased and the risk of impoverishment would be reduced as a direct result of the improvement in health without being mediated through a reduction in out-of-pocket expenses. Apart from these human capital considerations, others have noted that financial risk may take many other forms, including forced borrowing and selling of assets (Ruger 2012). Because of limited microeconomic data in LMICs, no attempts to date have been made to construct FRP metrics around these other economic effects.

In the future, the research agenda for ECEAs on CVD should consider other possible applications that could lend valuable insights. For example, some evidence suggests that lower-income households more frequently borrow money or sell assets (hardship financing) to pay for CVD care (Huffman and others 2011). As this empirical literature grows, it might become feasible to incorporate other FRP metrics, such as hardship financing, that appear to be important for CVD. Also, CVD and its risk factors are known to vary widely by age, gender, and geography. Analyses of CVD policy effects across these strata—instead of, or in addition to, income strata—might provide insights into which sorts of policies facilitate the policy objectives of particular governments, for example, which are significantly pro-female or pro-rural.

CONCLUSIONS

Tobacco taxation, salt reduction, and primary prevention of CVD in high-risk individuals are widely regarded as best buys in global noncommunicable disease policy (WHO 2011). The ECEAs presented in this chapter confirm the findings of previous CEAs, namely, that these interventions are likely to result in large health gains in LMICs.

The ECEAs also present new insights into the broader health system and economic impacts of these interventions. By preventing CVD, nonclinical interventions like population-based tobacco and salt reduction can effectively purchase additional FRP beyond what governments can accomplish through public finance of clinical treatments. ECEAs can examine and address some of the concerns about potential economic distortions caused by health policies, such as the alleged regressivity of tobacco taxes. Incorporating equity and FRP considerations into economic evaluation is a critical methodological advance that speaks directly to the UHC movement and its goals. ECEAs are especially pertinent for CVD and related conditions where financial risk is large according to a growing body of research. Finally, ECEAs have the potential to elevate the priority of CVD interventions through direct comparison with the health and nonhealth impact of interventions for infectious diseases, maternal disorders, injuries, and other conditions. In coming years, this comparative approach may become a standard tool for designing and debating the priority elements of UHC benefits packages.

NOTE

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  (a) lower-middle-income = US$1,046 to US$4,125
  (b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

REFERENCES

Alebachew, A., L. Hatt, and M. Kukla. 2014. "Monitoring and Evaluating Progress towards Universal Health Coverage in Ethiopia." *PLoS Medicine* 11 (9): e1001696.

Bloom, D. E., E. T. Cafiero, E. Jané-Llopis, S. Abrahams-Gessel, L. R. Bloom, and others. 2011. *The Global Economic Burden of Noncommunicable Diseases.* Geneva: World Economic Forum.

Gaziano, T. A. 2009. "Is the Horse Already Out of the Barn in Rural India?" *Circulation* 119 (14): 1850–52.

Hofman, K. J., and S. M. Tollman. 2013. "Population Health in South Africa: A View from the Salt Mines." *The Lancet Global Health* 1 (2): e66–67.

Huffman, M. D., K. D. Rao, A. Pichon-Riviere, D. Zhao, S. Harikrishnan, and others. 2011. "A Cross-Sectional Study of the Microeconomic Impact of Cardiovascular Disease Hospitalization in Four Low- and Middle-Income Countries." *PLoS One* 6 (6): e20821.

IARC (International Agency for Research on Cancer). 2011. *IARC Handbook of Cancer Prevention*. Vol. 14 of *Effectiveness of Tax and Price Policies for Tobacco Control.* Lyon: World Health Organization.

Jha, P., R. Nugent, S. Verguet, D. Bloom, and R. Hum. 2013. "Chronic Disease." In *Global Problems, Smart Solutions: Costs and Benefits*, edited by B. Lomborg, 137–85. Cambridge, U.K.: Cambridge University Press.

Norman, R., D. Bradshaw, M. Schneider, J. Joubert, P. Groenewald, and others. 2007. "A Comparative Risk Assessment for South Africa in 2000: Towards Promoting Health and Preventing Disease." *South African Medical Journal* 97 (8 Pt 2): 637–41.

Powell, R. A., F. N. Mwangi-Powell, L. Radbruch, G. Yamey, E. L. Krakauer, and others. 2015. "Putting Palliative Care on the Global Health Agenda." *The Lancet Oncology* 16 (2): 131–33.

Remler, D. K. 2004. "Poor Smokers, Poor Quitters, and Cigarette Tax Regressivity." *American Journal of Public Health* 94 (2): 225–29.

Roth, G. A., M. H. Forouzanfar, A. E. Moran, R. Barber, G. Nguyen, and others. 2015. "Demographic and Epidemiologic Drivers of Global Cardiovascular Mortality." *New England Journal of Medicine* 372 (14): 1333–41.

Ruger, J. P. 2012. "An Alternative Framework for Analyzing Financial Protection in Health." *PLoS Medicine* 9 (8): e1001294.

Samb, B., N. Desai, S. Nishtar, S. Mendis, H. Bekedam, and others. 2010. "Prevention and Management of Chronic Disease: A Litmus Test for Health-Systems Strengthening in Low-Income and Middle-Income Countries." *The Lancet* 376 (9754): 1785–97.

Verguet, S., C. L. Gauvreau, S. Mishra, M. MacLennan, S. M. Murphy, and others. 2015. "The Consequences of Tobacco Tax on Household Health and Finances in Rich and Poor Smokers in China: An Extended Cost-Effectiveness Analysis." *The Lancet Global Health* 3 (4): 206–16.

Verguet, S., R. Laxminarayan, and D. T. Jamison. 2015. "Universal Public Finance of Tuberculosis Treatment in India: An Extended Cost-Effectiveness Analysis." *Health Economics* 24 (3): 318–32.

Verguet, S., Z. D. Olson, J. B. Babigumira, D. Desalegn, K. A. Johansson, and others. 2015. "Health Gains and Financial Risk Protection Afforded by Public Financing of Selected Interventions in Ethiopia: An Extended Cost-Effectiveness Analysis." *The Lancet Global Health* 3 (5): e288–96.

Watkins, D. A., Z. D. Olson, S. Verguet, R. A. Nugent, and D. T. Jamison. 2016. "Cardiovascular Disease and Impoverishment Averted due to a Salt Reduction Policy in South Africa: An Extended Cost-Effectiveness Analysis." *Health Policy and Planning* 31 (1): 75–82.

WHO (World Health Organization). 2010. *World Health Report 2010: Health Systems Financing: The Path to Universal Coverage.* Geneva: WHO.

———. 2011. *Global Status Report on Noncommunicable Diseases 2010*. Geneva: WHO. http://www.who.int/nmh/publications/ncd_report2010/en/.

———. 2013. *World Health Report 2013: Research for Universal Health Coverage*. Geneva: WHO.

Yang, G., L. Kong, W. Zhao, X. Wan, Y. Zhai, and others. 2008. "Emergence of Chronic Non-Communicable Diseases in China." *The Lancet* 372 (9650): 1697–705.

Yusuf, S., S. Rangarajan, K. Teo, S. Islam, W. Li, and others. 2014. "Cardiovascular Risk and Events in 17 Low-, Middle-, and High-Income Countries." *New England Journal of Medicine* 371 (9): 818–27.