Appendix E: Fiscal Health Modeling

Introduction

Most healthcare expenditures in advanced economies are financed with public money collected through taxation (OECD, 2016). Because of the reliance on public funding, health system funding can be viewed within that framework of public finances, which are governed by principles distinct from those of cost-effectiveness analysis (CEA) as applied within health care. Public finances are related to the role of government in the economy and are used to achieve a range of goals, such as income distribution and macroeconomic stabilization. The tools available to a government to achieve these goals are tax collection and efficient reallocation of public resources through programs, including vaccination. Several methodological approaches are available to explore public policy and fiscal impact on resource allocation decisions. One well-established method is generational accounting (GA), that is used to explore the cross-sectorial and intertemporal effect of government policies estimating how much a person is paying over his or her lifetime in taxes, net of transfer payments, and how policy changes might influence the amount of government benefits that a person receives (Kotlikoff et al., 1993).

The fiscal health model (FHM) framework, here presented, is following this approach of GA, but makes it possible to analyze the impact of public money spent on healthcare from cross-sectorial public accounts. For healthcare programs, government policies may determine tax revenues and transfer payments to other departments in need such as education or social affairs, based on changes in population morbidity and mortality rates resulting from the introduction of new healthcare interventions. Therefore, changes in resource use initiated by the government could be broader than those measured in healthcare services only. Also, when morbidity and mortality rates decline for a specific disease with high debilitating consequences because a new healthcare intervention is introduced, tax revenues might increase and transfer costs for the allowances and disability payments may decline as well. These reduced transfer costs resulting in tax and spending benefits for the government, might not be reported in cost-effectiveness or budget impact analyses that only focus on healthcare spending and not on non-health costs. Finally, one should be aware that increased life expectancy resulting from new healthcare interventions might increase costs of transfer payments for government-funded pensions and healthcare services for chronic disease management.

The FHM framework applied to health consists therefore of the effects of healthcare on gross and net tax value over a lifetime. Unlike the statistical value of life, which is based on compensating wage rates, the tax value is based on age-specific average tax payments presented as income (revenue) for the government. Similarly, individuals receive governmental transfer payments (e.g., in the form of education, living allowances, unemployment compensation, disability payments, or pensions) at certain stages of life. The FHM assesses how individuals who develop certain diseases differ from the statistical norms and how these differences influence government revenue and cross-sectorial transfer

payments made by the government. The tax value of life related to health is influenced by the stage of life at which health events (e.g., death or diseases) occur. For example, a child with a permanent disability represents a loss in tax revenue for the government and transfer payments based on available allowances. Consequently, knowing the average age of onset for a health condition is critical for an FHM. Health conditions are then followed in the FHM over time until termination (death or cure), just as the human capital method measures the labor cost by following the work conditions and incomes of people over time. During the period of follow-up, if someone's income declines because of a chronic disease condition, this decline is translated into a reduced tax revenue for the government, possibly with an added transfer cost in the form of social security or disability payment.

With its focus on tax revenue and transfer payments mainly, a limitation of FHM could be that those new interventions will receive higher priority to implement when their benefit occurs among people who can pay substantial taxes and require fewer transfer payments, such as children and young adults. The opposite is true for the elderly. Caution is therefore warranted in using an FHM as it may cause selection bias in implementing new interventions. Meanwhile, because the FHM framework considers revenue (taxes) in relation to costs (transfer), it also helps the user to understand the sustainability of public finances.

Best-Practice Guidelines for Developing an FHM

Communicable diseases can have a significant impact on population health. One way to reduce this disease burden is to implement vaccination programs when possible. These vaccination programs must be applied on a large scale to be successful, which requires a high investment cost.

Because of the huge initial costs, vaccine procurement is often negotiated at national and/or regional levels among numerous budget holders and health service officials. After national advisory groups express support for a new vaccination program, funding often needs to be obtained from finance ministries (Ngcobo, 2012). Experts believe that these ministries should be involved early in the consultation about the introduction of new vaccines (Conway et al., 2008) because they may have different policy goals than ministries of health with their value assessment obtained through cost-effectiveness analysis. An FHM helps translating the health outcomes achieved with public expenditures for vaccination programs into fiscal costs and benefits using a language familiar to those making decisions about public finance and future economic stability.

The analytic approach for taking the decision of investing in healthcare interventions is through the discounted cash flow (DCF) calculation, which treats healthcare costs as an investment that offers a potential tax return to the government. For any healthcare intervention, the future cash flow implications for the government in taxes and pensions paid and disability payments avoided are discounted to estimate a present value. When the discounted present value is higher than the investment cost, implementing the intervention might be worth considering. DCF calculations can also use gross and net taxes to establish the fiscal benefit. Furthermore, the internal rate of return (IRR) from different investments

can be derived and used to compare rates of return from different interventions that may or may not be health-related.

Decision Problem

An FHM uses a public economic framework that estimates the level of return on investment (ROI) of allocation of money to a healthcare intervention, such as a new vaccination program that reduces a disease's mortality and morbidity rates. The ROI is measured as gross or net tax income and transfer payments computed as a net present value (NPV). Because a high initial investment is needed to finance a large vaccination program, the ministry of finance needs estimates of the ROI and the breakeven point reached attributable to changes in future tax revenue and government transfer payments caused by new interventions of publicly financed programs. Each ministry of finance might have its own criteria for investments of public funds based on the IRR.

Perspective

An FHM reflects the government perspective on healthcare spending and outcomes when the monies come from taxation and are allocated by a central government. The government perspective focuses on changes in all public expenditures on healthcare services included in a CEA as well as pensions and other transfer costs that can arise from changes in health-related productivity output and disability. Similarly, benefits are the influences of health on tax payments over the remaining lifetime of individuals. Table D-1 shows how the outcomes of vaccination programs or other health interventions can influence public accounts.

Table D-1. Fiscal Consequences That Are Attributable to Health Conditions

Health-Related Event	Effect on Tax Revenue	Effect on Transfer Costs
Chronic disease that reduces productive activity	Decrease	Increase (for disability and unemployment benefits)
Premature death	Decrease	Decrease
Improved health after a chronic or acute condition in a working-aged adult	Increase	Decrease
Prevented disease	Increase	Decrease
Life expectancy beyond average range	Increase	Increase (e.g. for pensions)

Model Structure

A standard approach for developing an FHM is combining existing deterministic decision tree models and/or cohort models with annual assessment cycles for the cohort's remaining lifetime. The starting age depends on the age when individuals receive the vaccine. Multiple cohorts can be included in a single analysis when catch-up scenarios for vaccinating multiple age-groups at the same time are assessed.

To calculate the FHM results, the lifetime discounted gross taxes and net taxes (gross taxes minus transfers received) over the lifetime of an unprotected cohort are compared with gross and net taxes for a cohort protected by the vaccination program.

The structural assumptions of the epidemic model are the same as for any cohort model whether it is static or estimated using a dynamic-transmission population model. The model projects future health gains and government revenue and transfer costs based on current data of the vaccination program. The data included in the model should be the best predictions of average value even though the distributions could be skewed for cost transfers and tax payments. These parameters should be subjected to extensive sensitivity analyses. Examples of likely intra-sectorial and cross-sectorial transfer costs to be considered in the model are shown in Table D-2.

Table D-2. Effects of Government Transfer Costs on Tax Payments

Government Transfer Costs (Age-Specific Annual Payments)
Education and training
Healthcare
Unemployment payments
Family and child payments
Disability payments
Pension payments
Living or income payments
Impact on Tax Payments
Higher education increases income taxes based on work selection and age-specific earnings
Higher earnings, unemployment and educational attainment contributes to higher consumption taxes
Higher earning contributes more to pension funds
Higher earning contributes more to social insurances (eg, National Insurance payments in the UK and Social Security payments in the USA)

Time Horizon

For vaccination programs, the time horizon used for the FHM will depend on the following criteria:

- The infectious disease prevented whether pediatric or elderly receive the vaccine
- The mortality rate of the disease
- The age-specific disease incidence with and without the vaccination program
- The duration of the vaccine's impact
- When a booster dose of the vaccine is required
- The disease sequelae that would require long-term social support from the government (eg, neurological deficits for meningitis)

The time horizon selected for a vaccination program for the FHM will also depend on the tax revenue implications and the transfer costs. If the new vaccination program prevents deaths, a lifetime horizon should be applied. If there is no impact on mortality, the time horizon should be limited to the time period the vaccine has an impact on tax revenue and transfer costs.

Comparators

FHMs use incremental cost difference comparing the new approach with the current standard management of care. The analysis can be structured as an individual cost-benefit analysis. The research question will be how a specific technology (ie, a vaccination program) impacts public accounts with current public accounts being the comparator.

Data Requirements and Sources

FHMs require similar clinical data to those of CEA for vaccination programs. Outcomes data of CEA models can be used in an FHM. The primary difference from CEA is that outcomes and costs need to be estimated from the government perspective of taxes, revenues and cost transfers to assess the public accounts impact. In CEA we never go to that level of analysis of government spending as we limit the evaluation to the budget available within health care.

For pediatric or adult vaccination programs, the input data for an FHM come from the birth cohort followed until all members of the cohort die or until the vaccination program no longer has an impact on changes in government revenues or payment. The input data include the costs of the vaccination program and those associated with the disease, including disease and complication management cost (cost of illness data), similar to the input data of CEA for a vaccination program (see also the section on data requirement in CEA).

In addition FHM also needs data on the following items:

- The disease's effects on work productivity and disability
- Cost transfers from government by age (e.g., costs of healthcare for all health conditions, education, and subsidies or disability payments for long-term impairments related to the prevented disease as well as other chronic conditions)
- Expected income by age for members of the birth cohort and taxes paid to the government depending on health and disability status
- Potential cross-sectorial government transfer costs

Much of the data needed are not readily available in the published literature although, for some jurisdictions, there will be published data for disease's incidence, prevalence, impact on health outcomes, long-term disability costs, healthcare costs, and productivity losses. Other sources might include reports of such organizations as the World Health Organization, the Organisation for Economic Co-operation and Development, and the United Nations (UN, 2015) about global health or economic indicators or from jurisdiction's statistical reports. Data on the potential government cost transfers to populate an FHM might be available from various government ministries once the different types of cost transfers to and from the government are identified (see Table D-2). The selection of the government ministries depends on the jurisdiction and whether the disease will affect the transfer costs for these ministries and whether the data are available. Estimates of the impact of new interventions on cost transfers might depend on how the ministry of finance or ministry of planning is familiar with Generational Accounting (GA) or modified GA programs.

The number of working years influenced by a health condition is important for estimating lifetime tax contributions and can be estimated by applying a percentage loss to annual

earnings for the number of years in which these losses occur. Tax receipts from retired persons also need to be included in the FHM. These data are based on taxable income, including from asset depletions and pensions.

If data cannot be found, expert opinion should be used to develop credible estimates based on numbers for similar jurisdictions and diseases.An FHM does not include any value that individuals would assign to being healthy. It simply measures the actuarial life and how citizens interact with the government through government transfer payments and taxes paid.

Outcome Measures

An FHM generates outcomes that are financially focused, typically targeting decision makers within the ministry of finance or of treasury. For example, a key outcome might be the DCF and NPV for the government measured as the difference expected in net revenue after the investment spending in a vaccination program. The cash flow can be positive or negative if the net revenue is higher or lower than the investment required for the vaccination program. Furthermore, benefit-cost ratios can be generated that account for all financial investments (e.g., changes in tax, transfers, and ongoing healthcare spending compared with the initial investment in the vaccination program). The benefit-cost ratio is useful for indicating the amount of benefit obtained from the initial investment. Another outcome measure of interest to decision makers is the IRR of the investment in the vaccination program over a specified period.

Analysis Method

The analysis in the FHM consists of simple calculations of the key outcomes, typically for a single cohort targeted by the vaccination program. If a catch-up program of vaccinating different cohorts at the same time, is considered, the outcomes for multiple cohorts might be calculated.

The most commonly used formula for the NPV in an FHM is as follows:

$$NPV = \sum_{t=0}^{T} \frac{R_t - E_t}{(1+r)^t} - K_0$$

R_t = annual gross taxes paid by cohort
E_t = annual sum of age-specific direct government expenditures per cohort (e.g., for education, healthcare, disability payments, and pension)
r = rate of discount
T = life expectancy
K_0 = vaccine purchasing cost at the age targeted by the vaccination

Discounting

The FHM involves a cost-only analysis, and the discounting rate for this analysis should closely match the current interest rate for borrowing money. The outcome measure of the FHM is often the NPV, and the revenues and costs are discounted by this interest rate.

Uncertainty Analyses

Uncertainty analysis should be used in an FHM to understand the impact of changes in the input parameter values on public accounts. As in CEA, univariate sensitivity analysis can be used to explore changes in individual parameters. However, applying probabilistic sensitivity analysis (PSA) in an FHM, as one might do with CEA, is challenging. First, the timeframe used in an FHM is often very long. Consequently, the discount and inflation rates, not typically included in a PSA, have the greatest impact on the results compared with changes in disease incidence rates for instance. Second, many of the input parameters are fiscal and do not involve health. Therefore, the information about the variation to explore in sensitivity analysis, especially on the type of distribution that could be applied in PSA, is often limited. Third, in fiscal terms, prices for technology might be small compared with other fiscal expenditures, such as for pensions, disability allowances, and tax levies (Kotsopoulos, 2013). Therefore, changing the price of a vaccination program might have less an impact on the NPV than the fiscal expenditures.

Validation

Validation is important for all models and should include assessments of the face validity, internal, and external validity. Potential decision makers determine face validity by assessing the credibility of the structure, assumptions, inputs, and results. For the model to have face validity, decision makers must determine that the results seem realistic given the estimated number of deaths avoided or the extent to which the morbidity rate declines.

Assessing internal validity involves extensive checking of the computations in the computer program to ensure that they use the correct input data and that the required calculations are conducted correctly.

Finally, external validation involves, at a minimum, determining that the disease epidemiology data without the vaccination program used in the models results in a pattern of disease outcomes for the population of interest that reflects observed data.

Transparency

To the extent possible, the FHM should be populated with data that are publicly available. A flow diagram should be provided to show the model structure and the calculations should be described clearly. An FHM for a vaccination program should use inputs from government sources that are publicly available and consistent with national account reports (United Nations, 2015).

Reporting

The FHM report should be similar to that for any analysis tool that uses modeling. The report should include an introduction, an explanation of the methodology (model structure, objective function equation, data inputs, data sources and derivation, model assumptions, analytic methods, base-case outputs, and sensitivity analyses performed), description of the results and of the sensitivity analyses performed, followed by a discussion section.

Strengths and Limitations

Decisions on resource allocations in healthcare are often based on priorities determined by unmet needs, illness burden, fairness, equity, and affordability. In that respect an FHM is provocative in that it mainly assesses new investments in vaccination programs or other healthcare interventions based on net tax revenues. This limitation raises questions about how to use this approach to allocate resources. If the selection is only based on net tax revenues it may cause equity access problems to health care for many and approval shifts of new interventions towards guarantees of needed tax benefit by the government. Welfare economics often treats the payment for quality-adjusted life years (QALYs) maximization as the efficiency measure in health care, but the metrics of interest in an FHM are gross and net government revenues and not the QALYs. Gross and net government revenue metrics are factors relevant from a public economic perspective. They provide useful information on the impact of healthcare interventions but seen from a different perspective than other assessments of the value of new healthcare interventions (Jit, 2015). However, considering the full range of impacts on government revenues, especially those that might positively influence public accounts and contribute to economic sustainability, could result in a different set of health priorities. An FHM for a vaccination program can also shed light on the relationship between health and other government priorities, such as fiscal governance, education, infrastructure, employment, and active aging. This analysis method is one of the several approaches that can be used to better understand the effects of specific healthcare interventions on society.

We provided guidelines for an FHM framework to assess the cross-sectorial impact of a new vaccination program based on changes in resource allocation within a single birth cohort. The FHM is used to evaluate future changes in fiscal income and transfer costs based on changes in morbidity and mortality rates that result from the new intervention. By evaluating a single cohort as a closed system, estimating the tax payment and governmental money transfers that happen during and within the total life-time of a cohort under study, the FHM can be used to assess whether a generation pays for itself (i.e., pays for all of the programs it receives). The FHM does not explore interactions between cohorts. It may therefore undervalue the effect of cross-cohort interactions such as herd effects of vaccination programs initiated at a population level. This information of cross-cohort interactions could be critical when the goal of introducing a new vaccine is to eliminate pathogens (e.g. smallpox) from circulation. Doing so will affect future generations that might not need to be vaccinated against the disease under study.

One important limitation of the FHM is that it undervalues the total health benefits for the cohort under study because the monetary value individuals place on being and remaining healthy is not included in the analysis. Only money transfers to and from the government are considered.

References

Conway M, Rizzuto C, Weiss L. A better way to speed the adoption of vaccines. The McKinsey Quarterly, August 2008. Geneva: WHO; 2008.

289 Jit M, Hutubessy R, Png ME, Sundaram N, Audimulam J, Salim S, Yoong J. The broader
290 economic impact of vaccination: reviewing and appraising the strength of evidence. BMC
291 Med. 2015;13:209. doi: 10.1186/s12916-015-0446-9.

292 Kotlikoff L. Generational accounting, knowing who pays, and when, for what we spend. The
293 Free Press, A Division of Maxmillan, Inc.; 1993.

294 Kotsopoulos N, Connolly MP, Postma MJ, Hutubessy RCW. Fiscal consequences of changes
295 in morbidity and mortality attributed to rotavirus immunization. Vaccine 2013; 31 (46), 5430-
296 5434.

297 Ngcobo NJ, Cameron NA. The decision making process on new vaccines introduction in
298 South Africa. Vaccine. 2012;30:Suppl3:C9-13.

299 OECD. Health spending (indicator). doi: 10.1787/8643de7e-en. Accessed on: July 5, 2016.

300 UN Department of Economic and Social Affairs Statistics Division. National accounts
301 statistics: main aggregates and detailed tables, 2014. New York; 2015.