PROPOSAL:  
Development of an easy-to-use tool for assessment of macroeconomic impact of vaccine preventable disease targeted at generalist policymakers and country-level ministries of health

CONTACT DETAILS  
Jonathan Weiss, MPH  
15 West 12th Street  
New York, NY 10011  
USA  
Tel: +1 (917) 846-8713  
email: jonathan.weiss@aya.yale.edu

Official Consulting Contracting Through:  
Eleven Liberty Holdings, LLC  
3530 North 45th Avenue  
Hollywood, FL 33021  
USA
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EXECUTIVE SUMMARY

Motivation: During the WHO Consultation on the Broader Economic Impact of Vaccines held in Toronto in July 2011, the discussion following the presentation of results of a survey taken from vaccine policy makers and stakeholders revealed that there is a lack of available and accessible, easy-to-use tools by which the economic impact of vaccines could be easily estimated. Country-level policymakers often are required to rely on studies which are backward-looking and which fail to take into consideration the country-level and context-specific conditions of epidemiology, demographics, and local costing. Consequently, the call by this RFP to specifically address developing “innovative tools to measure and present returns to investments in vaccination” and “field testing tools and instruments to measure and present alternative evaluations of the impact of vaccines” motivates this request for funding for the continued development of the EPIC tool and adaptation of that tool to incorporate epidemic modeling dynamics to yield both the macroeconomic impact of vaccine preventable diseases and other relevant output metrics. The current version of EPIC was presented to the July consultation. Adapting it to include vaccine preventable disease will make it an extremely useful resource for ministries of health, policymakers and stakeholders.

Project Description: WHO has previously developed an easy-to-use Excel-based interface tool, entitled EPIC, primarily aimed at country-level generalist policy makers and top-level ministries of health to quantify the macroeconomic burden of disease and mortality. As the tool currently stands, it includes 11 separate non-communicable diseases and risk factors (including cardiovascular disease, diabetes, cancer, etc). EPIC has begun to be used in both academic and country-level discussions. For instance, the World Economic Forum’s recent headline number for the value of NCDs was predominantly based upon EPIC analysis. Incorporating communicable diseases, especially those now combatted by new and underutilized vaccines requires additional levels of epidemic modeling to be included within the tool and adds additional significant complexity to the model. Clearly, each disease has its own epidemic dynamics which complicates the approach to individual disease modeling. Additionally, accounting for the morbidity of disease and not just the mortality will extend the functionality and relevance of the tool.

Anticipated Deliverables: Per the RFP requirement, by October 31, 2012, the tool will be re-worked to be included in an open-source language format (such as R). Re-writing the tool in R will allow users extremely low barriers to use the program (compared to SAS or STATA based statistical programming). Next, the project will target the inclusion of 2-3 new vaccine-preventable targets by the deadline and will be expandable to include other desirable communicable diseases and interventions. Apart from macroeconomic metrics such as GDP, other relevant RoI-type and potentially even microeconomic level metrics will provide useful (and understandable) evidence for policymakers. Discussions with GAVI-eligible countries and other stakeholders will guide the design of the tool.

Principal Participants:
Jonathan Weiss, MPH + Potentially 1 other individual for R-Programming portion
Will solicit collaboration with relevant WHO staff to determine desired interface and output design
INTRODUCTION

Healthcare interventions, particularly inexpensive prevention strategies (such as vaccines) which keep people alive and otherwise able to work (for those ex ante willing to work), should contribute positively to annual macroeconomic production. Foregone macroeconomic production on account of disease in susceptible populations generates a substantial headwind to country-level productivity, but has historically been a challenge to comprehensively measure. Assessments of the economic impact of disease have typically been classified into three principal approaches: 1) Cost of Illness (CoI) methods, 2) Economic Growth (Growth Accounting) Models which concentrate on the impact on human capital and labour supply and 3) Full-Income Methods which aggregate the value of health-sector income and welfare improvements to national accounts.\(^1\) Traditional Cost of Illness (CoI) studies focus on health spending and foregone labour productivity, but exclude consideration for depleted capital and foregone investment in human capital\(^2\). As an alternative to traditional CoI methodologies, WHO developed a macroeconomic assessment tool entitled EPIC to simulate an alternative perspective to simulate the macroeconomic impact of disease and associated risk factors. Recent analysis using this tool in a high-profile World Economic Forum paper have approximated the world-wide macroeconomic cost caused by NCD-related mortality of all ages from 2011-2030 is projected to total over $46 trillion and penalizes worldwide GDP by an annual average of 5%.\(^3,4\) EPIC provided a significant contribution the analysis in determining that headline number which has received excellent secular press coverage and whose issuance prefaced the recent UN Summit on NCDs. The ease-of-understanding of such analysis makes EPIC a good tool for use for generalist policymakers and senior staff of ministries of health. Much of the feedback from the stakeholder survey presented during the WHO Consultation in July decried the difficulty of communicating and making relevant typical public health-specific metrics, such as DALYs and VSLs. Using macroeconomic impact values however places healthcare on a similar priority measurement basis as other competing country-level commitments (such as infrastructure and finance) and approaches it from the “investment case”.

EPIC currently is limited to analysing the impact of NCDs on macroeconomic production. EPIC utilizes a traditional Cobb-Douglas approach to calculate GDP in both a counterfactual and intervention scenario by including perturbations to previous equilibrium-level status quo. The model adjusts labour

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and capital inputs according to population health, where labour is diminished by disability and death. Averted mortality in a current year is subsequently subjected to a background mortality risk and converted into an incremental impact on both labour force size and consequently accumulation of human capital, thereby creating a cumulative waterfall-impact over the long-term. EPIC approaches the incremental impact from a granular basis, including approximating the effect on every single-year age cohort from 0 to 100. While EPIC calculates the specific burden related to mortality, additional burden remains from the on-going morbidity of non-communicable disease. This remains an area where reliable quantification may provide additional rationale and economic incentive for individual countries to address continuing disease burden. Expanding EPIC’s functionality to include epidemic modelling and communicable diseases will make it an important step forward to providing policymakers the tools by which a payoff in the investment in vaccines can be estimated.

METHODS

The approach and ultimate deliverable suggested here falls into the RFP classification of “Secondary (or derived) Outcome Studies”. In particular, this proposal focuses on the economic modeling aspect of measuring the economic value of vaccination. As mentioned above, a first generation version of EPIC already exists and is focused on NCDs. Choices for which vaccine preventable diseases will be included in the new tool will depend upon an extensive literature review focusing on communicable diseases with vaccine interventions, existing availability of data indicating potential microeconomic, productivity or (if possible) macroeconomic gains per specific vaccination strategies, and finally consultation with WHO (and also GAVI) staff for target preferences, if possible. Upon narrowing the prioritized disease set, feasibility based upon existing mature or validated epidemic modeling will be considered to order the choice of targets addressed. This process should take between 1 and 2 months depending upon accessibility of individual experts at WHO (and GAVI if so desired). As previously mentioned, EPIC results have been recently featured in the World Economic Forum’s assessment of the economic burden NCDs and the methodology has been validated by previous work (see Abegune & Stanciole 2006). EPIC results will also be featured in an upcoming Lancet article (anticipated publishing in April 2012) covering the economics of ageing and health covering both developed and LMIC countries.

EPIC currently resides in an excel-based interface and linked up (using Visual Basic scripts) to a large proprietary Access database (sitting at WHO) which possesses the disease mortality by GBD age group and by sex for all WHO member states in addition to collected macroeconomic and labour related data and epidemiological factors. (Pictures of the easy-to-use interface are included in Annex 1). The individual user is able to control the target country, the target disease and what percentage of disease mortality avoidance is accomplished (in addition to a user-determined input as to the cost per capita of
intervention). Avoided mortality is subsequently subjected to ex-target background mortality over the following decades (depending upon how long economic and epidemic horizon is desired). By creating a granular single-year age group (and by sex), the net cumulative effect is calculated to approximate the number of additional labour equivalents (FTEs for example) that are gained by the intervention. These new population and labour profiles are then included in the Cobb-Douglas analysis utilizing a simple income approximation \( Y_{it} = \gamma_i K_{it}^{\alpha} L_{it}^{1-\alpha} \) and a corresponding human capital (K) building equation whereby \( K_{it} = sY_{it} + (1-\delta)K_{it-1} - xC_{it} \). The iterative nature of the tool establishes new equilibrium values for pro forma national GDP, while taking into consideration country-specific macroeconomic variables of depreciation, saving and re-investment into future production and the net cost of the intervention which is funded (at least partially) from national savings the existing capital base. While interventions on NCDs have tremendous effects, they are not quite as dynamic to model as those for communicable diseases. In order to make the model functional for communicable diseases, the project will require inserting significant layers of communicable disease modeling which sensitize the generated pro forma demographic and labour profile to the temporal, geographic and epidemic dynamics. Clearly, the intervention with vaccine has an incremental effect on the propagation of disease in a community. Each disease has a unique context and epidemic dynamics. For each communicable disease added, reviews and consultations with experts will be required to decide which models are best suited for each disease. Theoretically, the tool may even allow the user to choose which modeling modality the user prefers. Decisions regarding which are the best representative underlying models will likely be a gating item and is best decided as part of collaboration with experts in academia and WHO staff. One of the benefits of such an approach is that, assessments of even microeconomic impact (such as hours of work missed due to target disease) may be able to be predicted, since the labour component is such a large calculation and ultimate input in the model.

After deciding upon the appropriate epidemic models to include within the tool, a substantial improvement to both the knowledge base of CoI and growth accounting will be the assessment of the macroeconomic impact of disease morbidity and its inclusion in the tool. Including a morbidity component will have a magnifying effect on the impact of communicable disease within a community and could motivate additional allocation of country resources, once burden is estimated. Unfortunately, broad global databases with country-by-country-specific data for interventions and their effect on work productivity and days-out-of-work-role are not exhaustively available. However, studies do exist for some countries and some interventions which could be used as approximation and interpolations for other countries and regions. Additionally, adding epidemic modeling will substantially increase the complexity of the modeling that already exists in the EPIC model. For this reason, a portion of project time needs to be devoted to converting the tool from a spreadsheet-based tool, to one which is based in an open-source
programming language such as R. Transferring the entire model to R will prevent execution issues with the tool which could theoretically develop depending upon compatibility with future versions of Microsoft Excel and Microsoft Access. Certain WHO tools do not work properly on non-WHO computers on account of compatibility issues with newer versions of Excel and some of the newer operating systems. Using R (or other open-source language) should generally avoid that issue. R would be a good choice given the ease of statistical analysis and to include already-developed modules. The complexity of modern epidemic modeling necessitates better analytics than the typical spreadsheet analytics upon which EPIC is currently based. Additionally, given inherent uncertainty, using a pure statistical and computational methods will allow for performing Monte Carlo type analyses within subroutines and subsequently using the output generated in the traditional EPIC format (albeit transferred to R). Additionally, writing the tool in R will guarantee that it is available free-of-cost to the largest population possible. Finally, the opportunity to convert the tool to an even more user friendly platform provides the opportunity for WHO to again design EPIC per its preferences and customize the output depending upon desired outcome metrics.

As part of the tool building process, towards both the beginning and end of product development, this proposal aims to solicit feedback on the tool design from stakeholders. Most importantly, one or two members of the collaborating team should visit 2 separate WHO member states, particularly those that are GAVI eligible, in order to gauge interest and to gain some commentary of the preliminary tool design. This will generate the opportunity not only to advertise the tool, but also to react to some end-user feedback before officially finalizing and launching it. The timeline below has a list of expected activities and anticipated milestones. The existing EPIC model has simple output on its user interface for easy access (Appendix 2). It also has graphical interpretations of RoI-like metrics and pro-forma demographic statistics which may be more relevant to specific classes of policy makers (Appendix 3). The next generation EPIC model seeks to maintain the accessibility and easy-interpretation of the first generation model.

**OPPORTUNITY OF EVALUATION**

Design of the tool is anticipated to have multiple outputs which will include not only GDP foregone, but it may also calculate lives saved, deaths averted and differential in hours worked, for example. These estimations will be based upon existing data and will rely on robust modeling. As additional evidence becomes available, WHO and member states will be able to continually evaluate the tool’s usefulness. In cases where inputs may have changed or that new evidence allows better calibration, the tool can be further validated and tuned per the most recent evidence standards, maintaining its long-term relevance.
APPENDIX 1: CURRENT DESIGN OF EPIC USER INTERFACE
### APPENDIX 2: DESIGN OF SIMPLE OUTPUT (GDP FOREGONE)

#### Step 5: Summary of Estimated Macroeconomic Impact

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status Quo - in $Billions</td>
<td>Projected GDP</td>
<td>253.7</td>
<td>301.7</td>
<td>352.3</td>
</tr>
<tr>
<td>Scenario - in $Billions</td>
<td>Projected GDP</td>
<td>254.0</td>
<td>302.4</td>
<td>353.3</td>
</tr>
<tr>
<td>Counterfactual - in $Billions</td>
<td>Projected GDP</td>
<td>254.6</td>
<td>303.9</td>
<td>355.0</td>
</tr>
<tr>
<td>Difference (Counterfactual - Scenario)</td>
<td>$0.7b / $89.19</td>
<td>$1.6b / $216.5b</td>
<td>$2.5b / $342.7b</td>
<td>$35.1</td>
</tr>
<tr>
<td>Difference (Scenario - Status Quo)</td>
<td>$0.9b / $127.36</td>
<td>$2.3b / $309.0b</td>
<td>$3.5b / $488.9b</td>
<td>$15.0</td>
</tr>
<tr>
<td>Annual Tobacco-Attributable Mortality</td>
<td>8,741</td>
<td>9,440</td>
<td>9,856</td>
<td></td>
</tr>
<tr>
<td>Status Quo Population</td>
<td>7,424,159</td>
<td>7,332,020</td>
<td>7,127,430</td>
<td></td>
</tr>
<tr>
<td>Intervention Net Change in Population</td>
<td>+13,192</td>
<td>+29,713</td>
<td>+46,642</td>
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<tr>
<td>Intervention Net Change in Labor Force</td>
<td>+7,344</td>
<td>+14,076</td>
<td>+15,668</td>
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</tr>
<tr>
<td>Intervention Spending ($Billions)</td>
<td>$0.0b</td>
<td>$0.0b</td>
<td>$0.0b</td>
<td>$0.3b</td>
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</tbody>
</table>

#### Database Manual To Use

- Database
- Manual
APPENDIX 3: DESIGN OF COMPLEX ANALYTICS FOR POLICY MAKERS