Global economic consequences of selected surgical diseases: a modelling study

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THE GLOBAL ECONOMIC CONSEQUENCES OF SELECTED SURGICAL DISEASES: A MODELLING STUDY

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ABSTRACT

Background

The surgical burden of disease is substantial, but little is known about the associated economic consequences. We estimate the global macroeconomic impact of the surgical burden of disease due to injury, neoplasm, digestive diseases, and maternal and neonatal disorders from two distinct economic perspectives.

Methods

The value of lost output (VLO) approach projects annual market economy losses during 2015-2030 by relating disease mortality to changes in the labor force and gross domestic product (GDP). The value of lost welfare (VLW) approach uses a broader measure of nonmarket losses based on a concept termed the value of a statistical life and estimates the present value of long-run welfare losses resulting from mortality and short-run welfare losses resulting from morbidity incurred during 2010. Sensitivity analyses are performed for both approaches.

Findings

During 2015-2030, the VLO approach projects surgical conditions to result in losses of 1.25% of potential GDP, or $20.7 trillion (2010 USD, PPP). When expressed as a proportion of potential GDP, annual GDP losses are greatest in low- and middle-income countries, with up to a 2.5% loss in output by 2030. When nonmarket losses are assessed (VLW), the present value of economic welfare losses is estimated to be equivalent to 17% of 2010 GDP, or $14.5 trillion (2010 USD, PPP). Neoplasm and injury account for greater than 95% of total economic losses in each approach, but maternal, digestive, and neonatal disorders, which represent only 4% of losses in high-income countries in the VLW approach, contribute to 26% of losses in low-income countries.

Interpretation

The macroeconomic impact of surgical disease is substantial and inequitably distributed. When paired with the growing number of favorable cost-effectiveness analyses of surgical interventions in low- and middle-income countries, our results suggest that building surgical capacity should be a global health priority.

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INTRODUCTION

The global burden of surgical disease has only recently been defined and subsequently estimated. While original estimates suggested that up to 11% of global morbidity and mortality is secondary to surgical disease,1 more recent efforts have suggested that number is a vast underestimate and that up to 33% of the global burden of disease is surgical.2

While an understanding of surgical morbidity and mortality is of paramount concern to researchers and policy-makers alike, the downstream consequences of this burden are also of importance. One manner in which to contextualize the impact of disease is to estimate the economic consequences it imposes. Although there is continued debate in the economic literature regarding how health and income are connected,3 there is strong evidence that improved population health contributes positively to aggregate economic growth.4-10 Broadly speaking, the effect of poor health can be examined at the microeconomic level, in which individuals, households, firms, or other specified economic agents are studied, or at the macroeconomic level, in which the broader impacts on society as a whole are assessed.11

While there have been studies that investigate the economic impact of specific surgical diseases at regional and global levels,12-14 little is known about the global economic impact of a more comprehensive set of surgical conditions. Using two distinct macroeconomic approaches, this study sought to estimate: (a) the effect of surgical disease mortality on annual global economic output during 2015-2030, and (b) the effect of surgical disease during a single year, 2010, on a more broadly defined measure of economic welfare which incorporates a combination of long-run effects of mortality and short-run effects of morbidity.
METHODOLOGY

THE SURGICAL BURDEN OF DISEASE FOR SELECTED CONDITIONS

We examined five major surgical disease categories: neoplasm, injury, maternal disorders, neonatal disorders, and digestive disorders. We assumed that only a portion of the burden of each disease category is surgical. To this end, we used results from a survey instrument by Shrime et al., which asked respondents, "What proportion of patients with the following conditions would, in an ideal world, require a surgeon for management?" for each of the 21 Institute for Health Metric and Evaluation's (IHME) Global Burden of Disease categories.2,15,16

We selected the disease groups listed above as they have been repeatedly acknowledged to contribute to a large burden of surgical disease;1,17 using Shrime's survey instrument, they contribute to greater than 85% of all surgical deaths.2 Table 1 provides the mean responses from the survey, and the specific diseases contained within each IHME category are listed in appendix table 1.18 Table 1 also gives an estimate of the global burden of the surgical proportions of the included conditions for 2010 using IHME estimates.15,16 The survey instrument and the definition of surgical disease are discussed further in the appendix.

OVERVIEW OF APPROACHES

This study uses two approaches to describe the macroeconomic consequences of surgical disease (Figure 1). These approaches were chosen as both allow for global economic modeling in the face of limited data, and each provides different information. The first is based on a model supplied by the World Health Organization (WHO) known as EPIC (Projecting the Economic Cost of Ill-health). We use the EPIC model to project annual market economy losses during 2015-2030, and to be consistent with others who have used it,19 term this approach the value of lost output (VLO). The second approach estimates the value of lost economic welfare (VLW) resulting from surgical
disease in 2010. The counterfactual in both approaches is absence of disease. Estimates from both approaches are gross estimates, as they are not net of the cost of treatment.

The two approaches differ in two important ways: the definition of economic loss, and the time period over which the loss is calculated. The VLO approach relates disease mortality to the labor supply and capital accumulation of a country over time. Changes in these factors result in decreased output of marketed goods and services, as measured in forgone gross domestic product (GDP). The EPIC model does not incorporate disease morbidity, which also affects GDP. In this study, the VLO approach estimates the effects of mortality on output in a given year during 2015-2030. It is therefore a short-run measure, although the annual estimates can be summed to calculate cumulative impacts.

The VLW, also termed the full-income approach,²⁰ relies on a concept known as the value of a statistical life (VSL), which incorporates nonmarket losses, such as forgone leisure, non-health consumption, and the value of good health in and of itself. Consistent with prior studies of a similar scope as this one,¹⁹,²¹,²² we utilize the VSL to value disability-adjusted life years (DALYs), which captures both mortality and morbidity due to a disease in one metric. Due to the manner in which DALYs are calculated,¹⁶ the VLW approach estimates the long-run effects of life-years lost secondary to mortality, which is measured from an incidence perspective. Mortality estimates therefore include the effects in 2010 plus the present value of future effects. Morbidity, however, is measured from a prevalence perspective, and therefore DALYs only capture the effects of poor health in 2010. Although a case of nonfatal surgical disease that occurred in 2010 could have persistent health effects, future morbidity effects of incident cases in 2010 are not what the current global burden of disease approach measures; rather, the prevalence of the disease of interest is estimated for 2010, and consequently this approach includes morbidity from diseases that were diagnosed prior to 2010." ¹⁸ Since the VLW estimates include nonmarket welfare losses due to
mortality and morbidity, and, in the context of mortality represent long-run losses, they can be expected to be many times larger than the VLO estimates, which account only for market losses due to mortality (not morbidity) in the short-term.

Given data availability, a total of 128 countries were evaluated with the VLO approach (Appendix Table 2), and 175 countries were evaluated with the VLW approach (Appendix Table 3). Results are presented in 2010 United States dollars (USD) and adjusted for purchasing power parity (PPP). The PPP method compares the price levels of a fixed basket of goods between countries to establish a currency conversion rate, such that the price of the basket of goods is the same in both countries when stated in the reference currency, usually the United States dollar. For each approach, countries were evaluated by IHME region and their respective 2010 World Bank income classification. The supplementary appendix provides the mathematical details, assumptions, and data sources for each approach.

**Sensitivity Analyses**

For each approach, we account for uncertainty in the estimation of the burden of disease by utilizing the uncertainty intervals given by the Institute for Health Metrics and Evaluation (IHME) in addition to a lower and upper bound estimate of the proportion of disease considered to be surgical, which we derive from 95% confidence intervals from Shrime’s survey. This was performed as a two-way sensitivity analysis in which the models were run with the upper and lower bounds from Shrime and IHME. Although probabilistic sensitivity analysis would have been preferred, the lack of information regarding the distribution and meaning of IHME uncertainty intervals precludes such analysis. Our baseline results are presented with these intervals for comparison. For the VLW approach we also test assumptions regarding the reference VSL and how VSL is correlated with income, discussed in depth in the appendix, to account for uncertainty in VSL estimates. Finally,
for each approach, economic losses are presented without PPP conversion to compare our estimates with results from similar studies.²,₁⁹

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The funding agency played no role in the acquisition or analysis of data, manuscript writing, or the decision to submit.

RESULTS

VALUE OF LOST OUTPUT (2015-2030)
One-hundred and twenty-eight countries with a combined population of 6·4 billion people (2013 population),²³ or 90% of the global population, were evaluated with the value of lost output approach (Appendix Table 3). When aggregated by World Bank income classification, 75% and 90% of low-income countries’ population and lower-middle income countries’ population were assessed, respectively. Greater than 95% of the upper-middle income and high-income groups’ populations were evaluated.

During 2015-2030, and using Shrive’s mean estimates, the surgical component of the diseases included in this study is estimated to result in a cumulative loss of $20·7 trillion (2010 USD, PPP), or 1·25% of projected economic output across the 128 countries included in this study (Figure 2). This aggregate estimate is sensitive to uncertainty with respect to the burden of disease and the proportion of disease that is considered surgical, ranging from $12·1 trillion to $33.2 trillion (Table 2). Annual losses as a share of total GDP are projected to rise, approximately doubling for all income groups between 2015 and 2030 (Figure 3). They are also unevenly distributed by World Bank income classification and IHME region (Figure 3, 4). Ninety-six percent of losses are projected to be secondary to injury and neoplasm, but the drivers of lost economic output vary significantly by region (Figure 4). Results by country and disease are given in appendix table 3.
VALUE OF LOST WELFARE (2010)

One-hundred and seventy-five countries with a population of 6.9 billion (2013), or 97% of the global population, were evaluated with the value of lost welfare (VLW) approach (Appendix Table 4). When aggregated by World Bank income classification, 90% of the population of low-income countries was evaluated, and greater than 97% of the population of the remaining groups was included.

Economic welfare losses (VLW) do not represent actual losses in GDP, but they can be expressed relative to GDP to provide a sense of scale. Our baseline VSL assumptions suggest that the value of economic welfare losses in 2010 for the countries included in this study were equivalent to 17% of their 2010 GDP, or $14.5 trillion (2010 USD, PPP) (Table 3). When burden of disease uncertainty was accounted for, the estimates ranged from $8.7 trillion to $22.4 trillion. Welfare losses secondary to mortality, which are long-run estimates, make up $11.4 trillion of the estimated impact, while the short-run effects of morbidity incurred in 2010 contributed $3.1 trillion in losses. Our aggregate estimates are moderately sensitive to variations in the relationship between VSL and income, and assuming otherwise baseline values range between $12.0 trillion and $16.9 trillion (appendix table 2). If the reference VSL is adjusted from the Environmental Protection Agency's recommendation of $7.6 million (2006 USD) to the Organization for Economic Development and Cooperation's recommendation of $3.0 million (2005) USD, the aggregate estimate falls to $8.2 trillion if all other assumptions are held constant. Injuries and neoplasm contribute to 95% of total economic losses. When stratified by income group, maternal, neonatal, and digestive disorders on average make up 26% and 14% of total losses in low-income and lower-middle income countries, respectively, compared to 4% in high-income countries (Figure 5). Results by country and disease are given in appendix table 4.
DISCUSSION

This study demonstrates that surgical conditions impose a massive and previously unrecognized economic burden on a global scale. The value of lost output (VLO) approach, which accounts for market losses during 2015-2030, suggests that surgical diseases will result in a cumulative loss of 1.25% of potential GDP, or $20.7 trillion dollars (2010 USD, PPP), for the 128 countries we examined (Table 2, Figure 2). These losses are expected to rise over time, and they will have the greatest impact on the most vulnerable populations as low-income and lower-middle-income countries are projected to experience losses that are almost 50% greater than high-income countries (Figure 3). The inequitable distribution of surgical conditions’ economic impact is further magnified when examined by region, as central and southern sub-Saharan Africa are estimated to lose up to 2.5% of GDP in 2030 (Figure 4). While injury is the main driver of these losses, maternal and neonatal disorders account on average for 10% of central sub-Saharan Africa’s foregone GDP; in comparison, maternal and neonatal disorders contribute to only 0.05% of Western Europe’s projected economic losses, a more than 200 fold difference.

While the VLO approach incorporates only market losses, the value of lost welfare approach (VLW) accounts for nonmarket losses, including the intrinsic value of health; moreover, with respect to mortality, it captures losses over the long-run (Figure 1). With the VLW approach, the death and disability incurred in 2010 for the 175 countries we examined are equivalent to roughly 17% of their aggregate 2010 GDP, or $14.5 trillion dollars (2010 USD, PPP). As an equivalent share of GDP, high-income countries are affected most, with up to a 19% loss (Figure 5). These results, however, are driven largely by the crude, or non-age-adjusted, neoplasm-related mortality rates, which are currently more than twice as high in developed countries due in part to their older demographic profiles. When neoplasm is excluded, we find a similar pattern as with the VLO approach, in which low-income countries bear the greatest share of the burden (Figure 5). We would re-emphasize
here that the VLW and VLO estimates should not be compared as they are attempting to measure two conceptually distinct values: the VLW estimates include nonmarket welfare losses and in the context of mortality represent long-run losses and are therefore many times larger than the VLO estimates, which account only for market losses due to mortality (not morbidity) during the time period included in this study.

Not surprisingly given incidence rates, neoplasm and injury account for greater than 95% of the total economic losses attributable to surgical disease in both approaches. However, maternal, digestive, and neonatal disorders make up a significantly greater proportion of losses in low- and middle-income countries—up to 26% of VLW in low-income countries. These estimates reflect in part the lack of access to basic obstetric and surgical care in these countries, as well as the higher burden of non-communicable disease in high-income countries. The stark contrasts in maternal and neonatal mortality rates between the developed and developing world, recently demonstrated by the Global Burden of Disease 2013 study, suggests that much of the burden we identified is avertable.28,29 Although one cannot estimate with certainty the potential economic gains to be realized with scaling up access to surgical services, the relative absence of maternal and neonatal burden in high-income countries suggests there could be substantial economic benefit to low- and middle-income countries in investing in surgical care. Finally, while neoplasm currently results in the greatest losses in the VLW approach for high-income countries, age-standardized rates of mortality are converging between the developed and developing world;27 as populations in low- and middle-income countries age,30 these countries will face a similar if not greater economic impact than high-income countries currently, especially if surgical services are not available as these remain the curative backbone of a large portion of cancer care. These estimates, while concerning from the perspective of economic development, tell only a part of the story. Bickler et. al. assessed the impact of scaling up basic surgical services in low- and
middle-income countries and concluded that up to 1.8 million deaths could be averted annually with access to surgery. From a purely humanitarian perspective, this degree of unnecessary mortality is indicative of striking inequality and the human toll of surgical conditions, falling most heavily on the poor and marginalized. However, policy-makers necessarily require additional information to assist in decision-making, and therefore economic impact estimates such as these can indicate the degree of urgency of different policy problems, and their broader impacts on development. While we recognize that decisions regarding resource allocation cannot be made on the basis of economic burden studies alone, we would argue that our findings regarding the magnitude and inequitable distribution of the economic costs of surgical disease complement the existing global surgery literature on cost-effectiveness and avertable burden. Ultimately, if one is concerned with saving lives and promoting economic growth, surgical conditions cannot be ignored.

Our results are not directly comparable to estimates produced by other studies as the assumptions applied across economic burden studies differ greatly. However, others have performed studies with similar approaches and scope. Most recently, Bloom used the WHO EPIC model to assess non-communicable diseases (NCDs) (cardiovascular disease, neoplasm, chronic respiratory disease, mental illness, and diabetes), and estimated that they will result in $47 trillion (2010 USD) in lost output from 2011-2030. Notably, these estimates did not adjust for purchasing power parity (PPP). When our VLO results are expressed in USD without PPP during 2011-2030, we estimate $16.0 trillion in GDP losses, well in line with Bloom’s estimates given that the attributable burden of disease for the conditions we studied is less than the NCD study, especially since we only account for the surgical proportion of each disease. Bloom also applied a model similar to our VLW approach to NCDs and found $22.8 trillion (2010 USD) in economic welfare losses in 2010; without adjusting for PPP and using baseline VSL assumptions, the VLW for surgical conditions is
$11.4\text{trillion (2010 USD). While the assumptions of the NCD study and our study differ, the similarity of the results is reassuring.}

Our study is notable for several reasons. To our knowledge, it is the first to provide an estimate of the macroeconomic impact of surgical diseases at this scale through two distinct economic lenses. Our results suggest not only that surgical diseases will exact a large toll on the global economy, but that the costs are inequitably distributed with markedly greater impact on poor countries. Finally, the decision to include only countries with available data makes our aggregate estimates conservative.

There are important limitations to the conclusions that can be drawn from economic impact studies, however, and our study is no exception. While such studies can provide an assessment of the magnitude of a problem, they cannot be used in isolation for priority-setting, which requires information regarding the cost and effectiveness of interventions. With that in mind, a robust literature base suggests that surgical interventions can be extremely cost-effective in low- and middle-income countries.

There are also important technical limitations to this study. As with all models, our estimates are limited by data availability. Much of the data we used from low- and middle-income countries is limited and the estimate of a model, as opposed to being measured directly. Data availability has also limited the ability to provide estimates in many countries, especially with the VLO approach, and high-income countries are necessarily over-represented given the relative degree of data availability. An important limitation with any economic model is that it cannot completely account for future technological advances, and the VLO approach in this study follows the EPIC model's crude assumption of assigning a 1% rate of growth to productivity. We also recognize the significant role that uncertainty plays, especially with respect to supporting data and the inherent inexact, speculative nature of projection-based studies. When we incorporate the uncertainty
intervals provided by IHME for their burden of disease estimates in addition to the confidence intervals from Shrime's survey data, the resulting intervals for both approaches are not insignificant (VLO: $12.1-$33.2 trillion, VLW: $8.7-$22.4 trillion) These intervals in large part reflect the underlying uncertainty of IHME burden estimates, which incorporate a significant amount of modeling in addition to primary data.

The VLW approach has a number of limitations. First, VSL studies are based on willingness to pay for small changes in mortality risk, and the linear assumption that is consequently made to determine the VSL is likely an oversimplification. There are further limitations to valuing morbidity, and the small number of formal VSL studies in low- and middle-income countries for either mortality or morbidity makes these estimates best-guesses. We account for the latter by applying a wide range of assumptions regarding how VSL varies with income. We would emphasize the effect of baseline assumptions regarding the VSL; while varying the relationship of income with VSL only moderately affected our results, varying the reference VSL had a significant impact on our results, with our baseline estimate falling from $14.5 to $8.2 trillion. We also emphasize that our estimates can be compared directly to GDP in the case of the VLO approach, but only indirectly in the case of the VLW estimates, which incorporate nonmarket losses. Unlike the VLO estimates, the VLW estimates should not be interpreted as actual GDP lost.

Finally, we have only considered five disease groups, and therefore our estimates may underestimate the total economic impact of surgical disease.

CONCLUSION

Our results suggest the macroeconomic impact of surgical disease is enormous and inequitably distributed, with poor countries often facing the largest burden. The notion that surgery is a necessary component of a fully-functioning healthcare system is rarely in dispute, and yet, surgery's place within the larger global health agenda is ill-defined at best. When considered with the
Evidence of cost-effectiveness of surgical interventions in low- and middle-income countries, our results suggest that investing in surgery not only has the potential to save millions of lives, but could also contribute to improved overall economic welfare and development.

Research in Context
Systematic Review

Prior to initiating the study, we searched Medline and Google Scholar and failed to identify any studies that attempted to estimate the global macroeconomic burden of surgical disease. For this reason, a systematic review was not performed. We would note that prior efforts have been made to identify the global surgical burden of disease, but these studies were specific to morbidity and mortality. As noted by Chisholm in his review of economic burden methodology, there are countless studies that estimate the economic burden of diseases in the literature. We could identify no studies, however, that address surgical diseases at the global level. Although not specific to surgery, others have attempted to identify the global macroeconomic burden of cancer and non-communicable diseases using similar methodology and are discussed further in the discussion.

Interpretation

When market losses secondary to surgical diseases are estimated during 2015-2030, we estimate up to 1.25% of GDP, or $20.7 trillion dollars, will be lost due to surgical disease. If welfare losses are incorporated, surgical diseases are estimated to result in $14.5 trillion dollars in 2010 alone. These losses are inequitably distributed, with low-and-middle income countries facing greater relative costs than high-income countries. While these findings cannot be used in isolation to inform decisions regarding resource allocation, there is a substantial and growing literature that supports the cost-effectiveness of surgical interventions and makes clear that much of the current surgical burden of disease is avertable. Therefore, when the existing evidence is considered with our results, a strong case is made for elevating surgery as a global health priority.
### Tables

**Table 1: Percentage of patients with each condition requiring surgeon for management and implied burden of disease in 2010 for included conditions by deaths (thousands) and DALYs\(^b\) (YLL and YLD)(thousands)**\(^2,15,16\)

| Disease                  | Percentage | Deaths | YLLs\(^b\) | YLDs\(^b\) |
|--------------------------|------------|--------|-------------|-------------|
| Digestive Disorders      | 30·3%      | 337    | 8,246       | 1,658       |
| Injury\(^a\)             | 60·8%      | 3,085  | 141,283     | 30,144      |
| Maternal Disorders       | 36·7%      | 93     | 5,251       | 657         |
| Neonatal Disorders       | 27·3%      | 611    | 52,594      | 2,586       |
| Neoplasm                 | 62·0%      | 4,943  | 113,995     | 2,777       |

\(^a\): The mean surgical burden of disease estimates from Shrim et. al. presented.
\(^b\): DALY = disability-adjusted life year, YLL = non-discounted years of life lost (mortality) using IHME standardized life-expectancy, YLD = years lost to disability (morbidity)

**Table 2: Total value of gross domestic product losses secondary to surgical diseases, 2015-2030 (VLO) (Billions 2010 USD, PPP)**

| Disease                  | Baseline | Lower Bound\(^a\) | Upper Bound |
|--------------------------|----------|-------------------|-------------|
| Digestive Disorders      | $470     | $220              | $1,010      |
| Injury                   | $7,860   | $4,330            | $13,240     |
| Maternal Disorders       | $80      | $20               | $220        |
| Neonatal Disorders       | $190     | $70               | $360        |
| Neoplasm                 | $12,120  | $7,450            | $18,360     |
| Total                    | $20,720  | $12,090           | $33,190     |

\(^a\): The upper and lower bound estimates are the result of accounting for uncertainty in the surgical burden of disease. Please see methods for details.
Table 3: Total value of economic welfare losses by disease\textsuperscript{a} (Billions 2010 USD, PPP)

| Disease             | Baseline Mortality | Baseline Morbidity | Lower Bound Mortality | Lower Bound Morbidity | Upper Bound Mortality | Upper Bound Morbidity |
|---------------------|--------------------|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Digestive Disorders | $297               | $139               | $229                  | $68                   | $570                  | $315                  |
| Injury              | $3,465             | $2,392             | $2,736                | $1,496                | $5,541                | $3,936                |
| Maternal Disorders  | $52                | $27                | $26                   | $8                    | $132                  | $149                  |
| Neonatal Disorders  | $237               | $105               | $1,591                | $73                   | $442                  | $222                  |
| Neoplasm            | $7,383             | $398               | $2,281                | $190                  | $10,668               | $470                  |
| Total               | $11,434            | $3,061             | $6,863                | $1,835                | $17,353               | $5,092                |

\textsuperscript{a}The upper and lower bound estimates are the result of accounting for uncertainty in the surgical burden of disease. Please see methods for details.

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\textbf{CONFLICTS OF INTEREST}

The authors declare no conflicts of interest.

\textbf{AUTHOR CONTRIBUTIONS}

BCA performed the initial data collection and analysis with the guidance of MGS, AJD, JRV and JGM. BCA wrote the first draft of the manuscript; MGS, AJD, JRV, and JGM assisted in revising the manuscripts and provided comments. JRV contributed substantially to the economic analysis. All authors had full access to all data in the study and approved of its submission.
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Figure 1: Overview of economic approaches.
Figure 2: Annual and cumulative gross domestic product losses secondary to surgical disease with baseline assumptions and values.
Figure 3: Percent loss in GDP secondary to surgical disease by World Bank Income Group during 2015-2030.
Figure 4: Percent change in GDP secondary to surgical disease in 2030 by IHME region. The blue bars represent the losses from all five studied diseases, while the lines represent the relative contribution of each condition.
Figure 5: Total value of annual economic welfare losses secondary to surgical disease by World Bank Income classification using baseline assumptions regarding VSL and income; please see appendix for details.
THE GLOBAL ECONOMIC CONSEQUENCES OF SELECTED SURGICAL DISEASES: A MODELLING STUDY

Blake C. Alkire, MD; Mark G. Shrive, MD; Anna J. Dare, PhD; Jeffrey R. Vincent, PhD, and John G. Meara, MD

SUPPLEMENTARY APPENDIX

DEFINING SURGICAL DISEASE

The scope of surgical disease depends heavily on the definition applied. For example, Debas defined a surgical condition as "... any condition that requires suture, incision, excision, manipulation, or other invasive procedure that usually, but not always, requires local, regional, or general anesthesia". This suggests that a disease or injury requires a procedure as intervention to be considered surgical.1 We instead adopted the approach suggested by Bickler et al., in which a surgical condition is "... any disease state requiring the expertise of a surgically trained provider."2 An important implication of this definition is that a disease does not necessarily require a surgical procedure to be considered surgical. For example, serious injuries often require an initial trauma assessment and continued care by an anesthesiologist or surgeon in an intensive care unit, and yet many of these patients do not require a procedure in an operating theater. However, their care is often wholly administered by surgically-trained providers.

The Institute for Health Metrics and Evaluation (IHME) and the World Health Organization (WHO) both provide estimates of the global burden of disease.3,4 We use the IHME estimates of the global burden of disease given the availability of data with enough specificity for the economic approaches employed in this study, and because the survey instrument we relied upon also uses IHME disease categories. IMIIE apportions the burden of disease and injury into 21 cause groups, such as
neoplasms or maternal disorders. As surgical disease is crosscutting in nature, none of the 21 cause
groups wholly excludes surgery, nor does surgical disease make up the entirety of any cause group. To this end, Shrim et al. created a survey instrument to capture provider estimates of surgical
disease. They received responses from 173 providers, of which 51.5% were surgeons or
anesthesiologists; the majority of the remainder of the sample was comprised of non-surgical
physicians (61.0%) and nurses or other midlevel providers (23.2%), with, students, non-clinician
practitioners, and other providers accounting for the remaining correspondents. Notably, 41% of
respondents reported working in more than one region of the world, and 65% reported that they
work some of the time in low-income countries. For each IHME disease cause group, the survey
asked: “What proportion of patients with the following conditions would, in an ideal world, require
a surgeon for management?” The mean results were used for this study.

There are four distinct IHME cause groups related to injury; and this study considers injury as one
category. Therefore, the injuries category required weighting the proportions from the survey for
each of the four IHME injury groups by the number of global annual disability-adjusted life-years to
create a proportion for the more broadly defined injury category assessed in this study.

ECONOMIC APPROACHES: ASSUMPTIONS, DATA SOURCES, AND MATHEMATICAL
SUPPLEMENT

VALUE OF LOST OUTPUT

To estimate the effect of surgical disease on global economic output during 2015-2030, we used the
World Health Organization's (WHO) EPIC (Projecting the Economic Cost of Ill-Health) model. EPIC models how changes in a country's labor force and capital stock secondary to disease would
be expected to affect said country's gross domestic product (GDP) Abegunde and Bloom
have provided an extensive accounting of the EPIC model. Here, we highlight the key assumptions of the model as it pertains to our study.

The EPIC model is based on the Cobb-Douglas\textsuperscript{12} production function:

\begin{equation}
Y_{i,t} = y_{i,t} \cdot A_{i,t} \cdot K_{i,t}^\alpha \cdot L_{i,t}^\beta
\end{equation}

where $Y =$ output (GDP), $A =$ total factor productivity, $K =$ physical capital stock, $L =$ labor force, $\alpha =$ output elasticity with respect to physical capital stock, $\beta =$ output elasticity with respect to labor, $i =$ country, and $t =$ year. Total factor productivity, also termed the “Solow residual,” is a variable that is meant to capture the change in economic growth that is not secondary to variations in the labor force or capital stock and is considered to be a function of technological growth.\textsuperscript{10} $y_{i,t}$ is a scaling or calibration parameter that adjusts the raw model output so that it equals an externally-sourced prediction of GDP for a given country in a given year. As this implies, EPIC does not itself project the future path of GDP; instead, it calculates the difference between a status quo projection obtained from some other source and a counterfactual projection that results from perturbing one or more of the parameters in the model (in our case, disease-related mortality rates, as explained below).

EPIC assumes constant returns to scale, therefore:

\begin{equation}
\alpha + \beta = 1
\end{equation}

Mortality due to disease is assumed to decrease the labor supply and therefore decrease economic output with the relationship as described above. The model is first calibrated to a status quo GDP projection for 2015–2030, and then the status quo projection is compared to projected GDP values for the counterfactual scenario, which we define as absence of disease. The cumulative value of lost output for a given country is therefore:
\[ VLO_i = \sum_{d \in D} \sum_{t=2015}^{2030} Y_{cf,d,t} - Y_{sq,t} \]

where \( d \) = disease, \( cf \) = counterfactual scenario, \( sq \) = status quo, \( VLO \) = value of lost output. Finally, the total value of lost output secondary to surgical disease is given by:

\[ VLO = \sum_{i \in I} \sum_{d \in D} \sum_{t=2015}^{2030} Y_{cf,d,t,i} - Y_{sq,t,i} \]

**Capital accumulation**

The EPIC model utilizes the following capital stock accumulation equation:

\[ K_{i,t} = sY_{i,t} + (1 - \delta)K_{i,t-1} \]

where \( s \) = savings rate (proportion of gross GDP) and \( \delta \) = capital depreciation. Although EPIC allows for inclusion of disease-specific health expenditure per capita, these data are largely unavailable at the country level for the diseases studied. Therefore, in our study as in other applications of EPIC, capital stock is only affected by disease mortality, which decreases the labor supply, which itself decreases annual GDP and therefore decreases accumulation of capital stock.

**Labor Supply**

Surgical disease decreases the available labor supply secondary to associated mortality. Therefore the labor force, defined by EPIC as the employed population greater than 14 years old, increases in our counterfactual in the absence of disease. As EPIC relates the total labor force to economic growth, and the counterfactual is absence of disease, the change in the labor force the model accounts for is the additional labor force that would be expected if the disease of interest did not exist. To estimate changes in the labor force, EPIC first estimates changes in the total population by age, sex, and year.

Status quo population and labor projections are provided by WHO in the EPIC model (see data sources below). The following illustrates how population and labor-force projections are adjusted
in the counterfactual scenario for each disease. The marginal addition to the population for each year in the absence of disease, or \( MP \), is given by:

\[
MP_{a,i,s,t} = AM_{a,i,s,t} \cdot SR_{a,i,s,t}
\]

where \( AM = \) averted mortality, or the number of individuals that survive in the absence of disease, \( SR = \) baseline survival rate in the absence of disease, \( a = \) age and \( s = \) sex. \( AM \) is derived from the mortality projections described below in equations 11 and 12; as it represents the absolute number of individuals that survive in the counterfactual scenario of absence of disease, it is equal to the number of disease-related deaths projected in the status quo scenario. \( SR \) is obtained by adjusting the status quo survival rate to account for the additional survival due to absence of disease; specifically, the counterfactual survival rate is calculated by subtracting the number of averted deaths from all-cause mortality deaths and then dividing by the total population. The additional population that has survived in the absence of disease for each year, or \( AP \), is subsequently given by:

\[
AP_{a,i,s,t} = (AP_{a-1,i,s,t-1} \cdot SR_{a-1,i,s,t-1}) + MP_{a,i,s,t}
\]

Additional labor secondary to the absence of disease in the counterfactual scenario is defined by:

\[
AL_{a,i,s,t} = EF_{a}(AP_{a,i,s,t} \cdot ER_{a,i,s,t})
\]

where \( AL = \) additional labor (number of additional individuals in the workforce), \( ER = \) employment rate, and \( EF = \) experience factor as suggested by Cuddington, where:

\[
EF_{a} = 0.8 + 0.02(a - 15) - 0.0002(a - 15)^2
\]

Therefore, the labor supply in the counterfactual scenario is given as follows:

\[
L_{a,cf,i,s,t} = L_{a,i,sq,t} + AL_{a,i,s,t}
\]
A total of 8 age groups are evaluated in the EPIC model (0-4, 5-14, 15-29, 30-44, 45-59, 60-69, 70-79, and 80+).

**Data Sources**

The EPIC model was used as provided by WHO with the exception of the variables discussed below. First, for each disease, EPIC requires projections of age, sex, and country-specific mortality rates to 2030. Although the model is supplied with disease mortality rates for some conditions, mortality rates for the scope of surgical conditions we examined were not available in the model. Further, the required level of data specificity is not available in the WHO projections of the global burden of disease and therefore necessitated that we derive projections specifically for use with the EPIC model.\(^{14}\)

To create projections of mortality rates for each disease, we first obtained mortality rate estimates for each disease by country, age group, and sex for the years 2000 and 2010 from the Institute of Health Metrics 2010 global burden of disease study.\(^{15}\) The Institute for Health Metric and Evaluation’s (IHME) recently estimated country-specific projections for maternal mortality ratios and under-five mortality rates for the year 2030 using a straightforward rate of change approach, and we adopt a similar methodology.\(^{16,17}\) For each disease \((d)\), we estimated the annualized rate of change \((rc)\) from 2000 to 2010 by country, age-group, and sex with the following formula:

\[
rc_{a,i,d,s} = \frac{\ln \left[ \frac{MR_{2010,a,d,i,s}}{MR_{2000,a,d,i,s}} \right]}{10}
\]

where \(MR\) = mortality rate. Mortality rate projections for year \(t\) were then calculated as follows:

\[
MR_{a,d,t,i,s} = MR_{2010,a,i,s} \cdot e^{rc_{a,i,d,s}(t-2010)}
\]
With the exception of the neoplasm category, if $rc$ was found to be greater than zero, mortality rates were held constant.\textsuperscript{16} We allowed neoplasm mortality rates to increase given that it is the only category we studied with rising global mortality rates.\textsuperscript{15}

Further adjustments to the EPIC model include the use of GDP per capita projections with estimates from the International Futures modeling system\textsuperscript{18} and updated estimates of capital stock and total factor productivity from the latest edition of Penn World Tables.\textsuperscript{19} Labor projections were obtained from the International Labor Organization.\textsuperscript{20} The original EPIC model contained an error in the experience factor formula (equation 9) in which the last term was positive as opposed to negative;\textsuperscript{13} this error was corrected.

Population projections, capital depreciation, the output elasticity with respect to capital stock and labor, and the savings rate were used as supplied by the WHO.\textsuperscript{7,11} The status quo GDP projections to which the model was calibrated were formed by multiplying the GDP per capita projections from the International Futures modeling system times the population projections from the WHO.

\textbf{VALUE OF LOST WELFARE}

\textit{The Value of a Statistical Life}

The value of a statistical life (VSL) is a concept that has been developed by economists over the past half-century\textsuperscript{21} and is used to value changes in health risks. As an example, an individual who accepts $1,000 in decreased wages to change to a safer occupation where the fatality risk is 0.001 lower is implicitly revealing that she values her risk reduction at $1 million (\(= \frac{1,000}{0.001}\)). In this example, the VSL is $1 million.\textsuperscript{22} The VSL can be estimated using various empirical approaches. Comparing the wages of occupations with different risk profiles is an example of a revealed preference approach, which has generally been considered to be more reliable than survey-based stated-preference methods.\textsuperscript{14,15} More recently, however, stated-preference studies have gained traction in the literature as the methodology has been further refined.\textsuperscript{23}
Formal VSL studies have not been conducted in most developing countries; however, economists have devised a method for estimating the VSL in a country in which empirical studies have not been performed. Using the ratio of gross domestic product per capita (GDP per capita) as a conversion factor, one can transfer VSL estimates from a country in which empirical studies have been performed to countries in which they have not (see formula 16). Central to this transfer method is a concept known as the “income elasticity of VSL” (IE-VSL), which dictates how VSL changes in proportion to the relative income of the two considered countries. Increasing the IE-VSL results in decreased VSL estimates when transferring to low- and middle-income countries. Although IE-VSL’s of 0.5-1.0 have traditionally been used when transferring estimates from high-income countries to LMICs, some have argued that an IE-VSL of 1.5, or even 2.5, may be more appropriate for low-income countries. This study uses an IE-VSL value of 1.0 for all countries as the base case. As a sensitivity analysis, an IE-VSL of 0.55 for HICs and UMICs and 1.0 for LMIC and LICs is used as an upper bound, and an IE-VSL of 1.0 for HICs and UMICs and 1.5 for LMICs and LICs is used as a lower bound. While an IE-VSL of 0.55 is commonly used in transferring estimates between high-income countries, there is some debate as to whether this is too low; therefore, we use an IE-VSL of 1.0 as our base case to remain conservative.

We adopt a similar approach to others in modifying VSL to value disability-adjusted life-years (DALY) secondary to each of the five surgical diseases studied at the country level. To use VSL to place an economic value on a DALY, it must be converted to its annualized equivalent, the value of a statistical life-year (VSLY). Assumptions regarding VSLY and how it varies with age, country-specific income, and country- and age-specific life-expectancy are incorporated into the model, and are described below.
Disability-Adjusted Life-Years

The manner in which disability adjusted life-years (DALYs) are calculated has evolved over the course of updates to the Global Burden of Disease Study. The basic formula for calculating the number of DALYs attributable to a disease, \( d \), in country \( i \) during time period \( t \) is:

\[
DALY_{d,i,t} = YLL_{d,i,t} + YLD_{d,i,t}
\]

where \( YLD = \) years lost to disability (morbidity) and \( YLL = \) years of life lost (mortality). In previous global burden of disease studies, the DALY has incorporated various assumptions regarding time and age-preferences. Although the most recent update has abandoned these assumptions, they remain crucial when DALYs are used to assess economic benefit in VSL terms and are therefore discussed further. Discounting is a common practice in economic analyses and is used to determine the present value of value flows that will be realized in the future. As we wish to convert future DALYs to economic welfare losses in present value terms, we utilize discounting in our DALY calculations. The inclusion of discounting results in the following years of life lost (YLL) formula for a disease:

\[
YLL_{a,d,i,t} = \int_a^{LE_{a,i,t}} e^{-r(x-a)} \, dx
\]

where \( a = \) age of death, \( LE = \) country and age-specific life-expectancy, \( x = \) age integrated over years of life lost (YLLs), \( r = \) discount rate. To be consistent with the VSL literature, we used a 3% discount rate when valuing future life-years lost.

Years lost to disability (YLDs) can be calculated from an incidence or prevalence perspective. The former would require discounting, while the latter does not. IHME provides prevalence YLDs. Therefore:

\[
YLD_{d,a,i,t} = P_{a,d,i,t} \cdot DW_d
\]
where $P = \text{prevalence}$ and $DW = \text{disability weight}$. Disability weights attempt to capture morbidity secondary to a disease, with $0 = \text{perfect health}$ and $1 = \text{death}$.

The perspective from which DALYs are calculated (that is, incidence versus prevalence) can produce differences in burden estimates. A complete discussion of different approaches can be found elsewhere, but it is important to clarify which DALYs are used as a basis for this study to understand the meaning of the implied economic losses. We utilize data from the most recent IHME global burden of disease study and therefore rely on their general approach to calculating DALYs. We do not use the global burden of disease YLL estimates as they are not discounted and use a standardized life-table as opposed to country specific life-tables. As discussed below, the valuation of future YLLs necessitates discounting, and country-specific life expectancies more accurately reflect the economic impact specific to said country. We do use the global burden of disease mortality estimates, however, to calculate discounted YLLs that account for country specific life-expectancy. Ultimately, YLLs are calculated from an incidence perspective, such that all deaths from a disease in one year are multiplied by country- and age-specific life-expectancy. YLLs, then, are long-run estimates, account for future years of lost life resulting from premature mortality in a given reference year (2010 in our analysis), and are discounted to apply them to the reference year. YLDs, however, are calculated from a prevalence perspective; only the morbidity incurred during the reference year is taken into account. Note that the prevalence perspective obviates the need to discount YLDs. This specific combination of YLLs and YLDs implies that the total burden of disease is made up of the future years lost due to premature mortality that year plus the morbidity incurred during the reference year.

In summary, for the surgical burden of disease secondary to premature mortality, we calculate YLLs for each surgical condition based on the mortality rates given by the GBD study; our YLLs differ from the GBD study in that (1) we discount future years at 3% and (2) we apply country
and age-specific life-expectancy as opposed to the standardized life-expectancy used for GBD estimates. For the surgical burden of disease secondary to disability, we rely on the YLDs as supplied by GBD without adjustment.

**Converting DALYs averted to Economic Benefit**

VSL varies with age. To value DALYs using the value of a statistical life-year (VSLY) approach, we first estimated the peak value of a statistical life year (VSLp) in each country, \( i \), using the following formula:

\[
VSL_{p,i} = VSL_{p,U.S.} \cdot \left( \frac{YC_i}{YC_{U.S.}} \right)^{IE-VSL}
\]

where \( VSL_p \) = the peak value of a statistical life, \( YC \) = GDP per capita in 2010, \( U.S. \) = United States of America, and \( IE-VSL \) = the income elasticity of VSL. We used GDP per capita estimates based on the purchasing power parity (PPP) approach, and the United States’ Environmental Protection Agency’s estimate for the value of a statistical life in the United States ($7.6 million in 2006 USD, adjusted to 2010 USD). One can then calculate the VSLY by treating VSL as the present value of an annuity, where the VSLY is the payment over the remaining discounted years of life.

Empirical evidence indicates that VSL and VSLY are not constant over an individual’s lifetime, nor do they monotonically decrease with age as intuition might suggest. Instead, both VSL and VSLY follow an inverted U shape – initially rising with age before falling. We incorporate this concept into our model, along with assumptions regarding income, time-preferences for money, and country and age-specific life-expectancy. Therefore, we must calculate age-specific VSLs in each country analyzed. An age-specific VSL (VSLa) can be estimated with the following:

\[
VSL_{a,i} = VSL_{p,i} \cdot f(a)_i
\]
where \( a \) represents age, and \( f(a) \) is a quartic function that adjusts a country’s peak VSL to VSL\(_a\) based on the proportion of life lived. To estimate \( f(a) \), we fit five data points where the explanatory variable is proportion of life lived, and the dependent variable is represented by VSL\(_a\) / VSL\(_p\), (or the proportion one would have to multiply VSL\(_p\) by to derive the age specific VSL). We based our points on Aldy and Viscusi’s 2008 study, “Adjusting the Value of a Statistical Life for Age and Cohort Effects.”\(^{32}\) There is uncertainty regarding the VSL for children; however there is general consensus that the VSL of a child is at least that of an adult.\(^{36}\) To account for this, we set a child’s VSL as equal to the first data point in the Aldy and Viscusi study, or roughly 1/4 of life expectancy. Therefore,

\[
(18) \quad f(a) = \begin{cases} 
19.41(0.236)^4 - 43.170(0.236)^3 + 27.65(0.236)^2 - 4.33(0.236) + 0.44 & \text{if } \frac{a}{LE} \leq 0.236; \\
19.41 \left(\frac{a}{LE}\right)^4 - 43.170 \left(\frac{a}{LE}\right)^3 + 27.65 \left(\frac{a}{LE}\right)^2 - 4.33 \left(\frac{a}{LE}\right) + 0.44 & \text{if } \frac{a}{LE} > 0.236; 
\end{cases}
\]

As discussed above, the total welfare losses (V\(LW\)) of a disease are given by:

\[
(19) \quad VLW_d = VSLY \cdot DALYS_d
\]

Given that we are interested in accounting for age in our model, we must define an age-specific VSLY, or VSLY\(_a\), that would then be used to value DALYs that are incurred at a given age.

The following reveals how to calculate VSLY\(_a\).

Begin by substituting equation (13) into equation (19):

\[
(20) \quad VLW_{a,d,i,t} = VSLY_{a,i,t}(YLL_{a,d,i,t} + YLD_{a,d,i,t})
\]

To define an age-specific economic burden, substitute equation (14) for YLLs into equation (20).

(Recall that age-specific YLDs are supplied by the global burden of disease study and do not need to be calculated).
\[ V_{WL_{a,t}} = V_{SLY_{a,t}} \left[ Y_{LD_{a,t}} \int_a^{L_{E_{a,t}}} e^{-r(x-a)} \, dx \right] \]

where \( V_{WL_a} \) = the age-specific total economic welfare losses, \( V_{SLY_a} \) = the age-specific value of a statistical life-year, \( a = \) age of death or age of incurred morbidity, \( L_{E} = \) age and country-specific life-expectancy, and \( Y_{LD_a} = \) age-specific YLDs given by the global burden of disease study.

If we assume that a disease causes death at age \( a \) in an individual, YLDs are now equal to 0, and the economic burden in equation (21) is equal to \( V_{SL_a} \) (or \( V_{SL} \) at age \( a \)).

\[ V_{SL_{a,t}} = V_{SLY_{a,t}} \int_a^{L_{E_{a,t}}} e^{-r(x-a)} \, dx \]

Substitute equation (17) into (22):

\[ V_{SL_{p,i,t}} \cdot f(a)_i = V_{SLY_{a,t}} \int_a^{L_{E_{a,t}}} e^{-r(x-a)} \, dx \]

Integrate and solve for \( V_{SLY_a} \) to arrive at:

\[ V_{SLY_{a,t}} = V_{SL_{p,i,t}} \cdot f(a)_i \cdot \frac{-r}{e^{r(a-L_{E_{a,t}})} - 1} \]

This is the formula we use to estimate \( V_{SLY_a} \), which is then multiplied by age-specific DALYs.

Total annual welfare losses for time \( t \) are calculated for each age-group and disease in a country, which are then summed to reach a global estimate. Given GBD estimates are from 2010, we estimate the total welfare losses for 2010.

\[ V_{WL_t} = \sum_{i \in I} \sum_{d_i \in D_{i,a_i}} V_{SLY_{a_i,t}} \cdot DALY_{a_{i,d_i,t}} \]

**Data Sources**

Country- and age-specific deaths, years lost to disability, and life-expectancy for the year 2010 were obtained from the IHME global burden of disease study.\(^{15,31,34,37}\) Gross domestic product, GDP per
capita, and country population were taken from the World Bank's World Development indicators.\textsuperscript{38} Finally, for our baseline estimates, we used the United States' Environmental Protection Agency's estimate for the value of a statistical life of the United States ($7.6 million in 2006 USD, adjusted to 2010 USD) as a reference estimate.\textsuperscript{35} As a sensitivity analysis on the reference value of a statistical life, we used the Organization for Economic Cooperation and Development's recommendation of $3.0 million (2005 USD, adjusted to 2010 USD).\textsuperscript{39}
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### Tables

**Appendix Table 1: List of diseases included in each Global Burden of Disease Cause Group**

| Digestive Disorders                       |
|------------------------------------------|
| Peptic ulcer disease                     |
| Gastritis and duodenitis                 |
| Appendicitis                             |
| Paralytic ileus and intestinal obstruction without hernia |
| Inguinal or femoral hernia               |
| Non-infective inflammatory bowel disease |
| Vascular disorders of intestine          |
| Gall bladder and bile duct disease       |
| Pancreatitis                             |
| Other digestive diseases                 |

| Injury                                   |
|------------------------------------------|
| Transport injuries                       |
| Unintentional injuries other than transport injuries |
| Self-harm and interpersonal violence | Forces of nature, war, and legal intervention |
|-------------------------------------|-----------------------------------------------|
| **Maternal disorders**              |                                               |
| Maternal hemorrhage                 |                                               |
| Maternal sepsis                     |                                               |
| Hypertensive disorders of pregnancy |                                               |
| Obstructed labor                    |                                               |
| Abortion                            |                                               |
| Other maternal disorders            |                                               |
| **Neonatal Disorders**              |                                               |
| Preterm birth complications         |                                               |
| Neonatal encephalopathy (birth asphyxia and birth trauma) | |
| Sepsis and other infectious disorders of the newborn baby | |
| Other neonatal disorders            |                                               |
| **Neoplasm**                        |                                               |
| Larynx cancer                       |                                               |
| Trachea, bronchus, and lung cancers |                                               |
| Breast cancer                       |                                               |
| Cervical cancer                     |                                               |
| Uterine cancer                      |                                               |
| Prostate cancer                     |                                               |
| Colon and rectum cancers            |                                               |
| Mouth cancer                        |                                               |
| Nasopharynx cancer                  |                                               |
| Cancer of other part of pharynx and oropharynx | |
| Gallbladder and biliary tract cancer|                                               |
| Pancreatic cancer                   |                                               |
| Malignant melanoma                  |                                               |
| Non-melanoma skin cancer            |                                               |
| Ovarian cancer                      |                                               |
| Testicular cancer                   |                                               |
| Kidney and other urinary organ cancers|                                               |
| Bladder cancer                      |                                               |
| Brain and nervous system cancers    |                                               |
| Thyroid cancer                      |                                               |
| Hodgkin’s disease                   |                                               |
| Non-Hodgkin lymphoma                |                                               |
| Multiple myeloma                    |                                               |
| Leukemia                            |                                               |
| Other neoplasms                     |                                               |
### Appendix Table 2: Total value of economic welfare losses by disease with sensitivity analysis on VSL assumptions\(^{a,b}\) (Billions 2010 USD, PPP)

| Disease                | IE-VSL\(^b\) Assumption: | Reference VSL Assumption: | Baseline | Lower Bound | Upper Bound |
|------------------------|---------------------------|----------------------------|----------|-------------|-------------|
|                        |                           | OECD                       | EPA (Baseline) | EPA (Baseline) |
|                        | Mortality | Morbidity | Mortality | Morbidity | Mortality | Morbidity |
| Digestive Disorders    | $169       | $79       | $238      | $119       | $350       | $160       |
| Injury                 | $1968      | $1,359    | $2,650    | $1,994     | $4,127     | $2,812     |
| Maternal Disorders     | $30        | $16       | $22       | $16        | $57        | $30        |
| Neonatal Disorders     | $135       | $60       | $126      | $75        | $269       | $122       |
| Neoplasm               | $4194      | $226      | $6,347    | $369       | $8,501     | $446       |
| **Total**              | **$6,496** | **$1,170** | **$9,383** | **$2,573** | **$13,304** | **$3,570** |

\(^{a}\): The mean surgical burden of disease estimates from Shrime et. al are applied,\(^{6}\) and baseline reference VSL and baseline IHME results are applied.

\(^{b}\): These analyses test different assumptions regarding how a country's VSL varies with income, or the income-elasticity of value of a statistical life (IE-VSL). We also test our reference VSL value of $7.6 million (2006 USD) against the recommendation of $3.0 million (2005 USD) by OECD. Please see appendix methods for details.

### Appendix Table 3: Cumulative foregone GDP expressed in absolute terms (millions, 2010 USD, PPP) and as a proportion of potential GDP secondary to surgical disease during 2015-2030 (VLO)\(^{a}\)

| Country      | Digestive Disorders | Injury | Maternal Disorders | Neonatal Disorders | Neoplasm | Total |
|--------------|---------------------|--------|--------------------|--------------------|----------|-------|
| Algeria      | $2,118 (0.033%)     | $18,844 (0.297%) | $251 (0.004%)     | $1,874 (0.030%)   | $16,782 (0.264%) | $39,989 (0.636%) |
| Argentina    | $5,154 (0.035%)     | $66,658 (0.456%) | $807 (0.006%)     | $1,430 (0.010%)   | $114,248 (0.779%) | $188,298 (1.29%)  |
| Australia    | $2,893 (0.016%)     | $46,054 (0.249%) | $80 (0.000%)      | $652 (0.004%)     | $139,938 (0.752%) | $189,617 (1.02%)  |
| Austria      | $709 (0.011%)       | $14,413 (0.227%) | $11 (0.000%)      | $126 (0.002%)     | $31,843 (0.497%)  | $47,102 (0.74%)   |
| Bahrain      | $29 (0.007%)        | $635 (0.163%)      | $2 (0.001%)       | $8 (0.002%)       | $489 (0.126%)     | $1,164 (0.30%)    |
| Bangladesh   | $4,674 (0.053%)     | $42,433 (0.483%)   | $2,019 (0.023%)   | $5,559 (0.064%)   | $59,948 (0.676%)  | $114,182 (1.30%)  |
| Barbados     | $30 (0.027%)        | $410 (0.370%)      | $5 (0.005%)       | $17 (0.015%)      | $944 (0.047%)     | $1,406 (1.26%)    |
| Belgium      | $817 (0.012%)       | $21,005 (0.301%)   | $42 (0.001%)      | $128 (0.002%)     | $36,977 (0.528%)  | $58,969 (0.84%)   |
| Benin        | $369 (0.094%)       | $1,893 (0.481%)    | $346 (0.088%)     | $308 (0.079%)     | $1,501 (0.382%)   | $4,417 (1.12%)    |
| Bolivia, Plurinational | $756 (0.058%) | $6,294 (0.484%) | $463 (0.036%) | $466 (0.036%) | $7,143 (0.549%) | $15,122 (1.16%) |

\(^{a}\): The mean surgical burden of disease estimates from Shrime et. al are applied,\(^{6}\) and baseline reference VSL and baseline IHME results are applied.
| State of                                 | GDP (2019)   | GDP PPP (2019) | GDP (2020)   | GDP PPP (2020) | GDP (2021)   | GDP PPP (2021) |
|----------------------------------------|--------------|----------------|--------------|----------------|--------------|----------------|
| Botswana                               | $132 (0.018%)| $4,764 (0.651%)| $520 (0.071%)| $196 (0.027%)  | $2,031 (0.279%)| $7,642 (1.05%) |
| Brazil                                 | $15,872 (0.034%)| $329,909 (0.692%)| $2,100 (0.044%)| $9,050 (0.019%)| $23,960 (0.499%)| $59,381 (1.25%) |
| Bulgaria                               | $403 (0.024%)| $5,548 (0.325%)| $27 (0.002%)  | $4,45 (0.003%)  | $13,780 (0.820%)| $19,803 (1.15%) |
| Burkina Faso                           | $687 (0.089%)| $4,717 (0.608%)| $540 (0.070%)  | $708 (0.092%)  | $2,504 (0.324%)| $9,156 (1.18%)  |
| Burundi                                | $124 (0.077%)| $1,221 (0.758%)| $236 (0.147%)  | $122 (0.076%)  | $784 (0.488%)  | $2,487 (1.55%)  |
| Cameroon                               | $1,266 (0.112%)| $6,663 (0.758%)| $1,460 (0.129%)| $762 (0.067%)  | $4,852 (0.426%)| $17,002 (1.49%) |
| Canada                                 | $4,035 (0.016%)| $60,911 (0.238%)| $144 (0.001%)  | $622 (0.002%)  | $172,134 (0.669%)| $237,845 (0.93%) |
| Central African Republic               | $84 (0.087%) | $1,352 (1.385%)| $376 (0.389%)  | $70 (0.073%)   | $441 (0.456%)  | $2,233 (2.39%)  |
| Chad                                   | $719 (0.132%)| $3,180 (0.581%)| $819 (0.150%)  | $588 (0.108%)  | $2,025 (0.371%)| $7,332 (1.34%)  |
| Chile                                  | $2,258 (0.029%)| $42,596 (0.549%)| $138 (0.002%)  | $317 (0.004%)  | $58,671 (0.755%)| $103,979 (1.34%) |
| China                                  | $69,192 (0.021%)| $1,760,523 (0.519%)| $8,260 (0.002%)| $31,244 (0.009%)| $3,450,784 (1.013%)| $5,320,003 (1.56%) |
| Colombia                               | $3,817 (0.036%)| $78,646 (0.746%)| $499 (0.005%)  | $1,244 (0.012%)| $58,406 (0.555%)| $142,612 (1.35%) |
| Congo                                  | $430 (0.087%) | $5,808 (1.165%)| $683 (0.138%)  | $311 (0.063%)  | $2,530 (0.511%)| $9,763 (1.96%)  |
| Costa Rica                             | $2,65 (0.020%)| $5,416 (0.409%)| $22 (0.002%)   | $66 (0.005%)   | $5,354 (0.404%)| $11,122 (0.84%) |
| Côte d’Ivoire                          | $1,449 (0.137%)| $7,826 (0.736%)| $973 (0.092%)  | $886 (0.084%)  | $3,738 (0.353%)| $14,872 (1.40%) |
| Croatia                                | $246 (0.018%) | $3,687 (0.274%)| $9 (0.001%)    | $28 (0.002%)   | $9,117 (0.676%)| $13,087 (0.97%) |
| Cyprus                                 | $43 (0.010%)  | $562 (0.128%)  | $1 (0.000%)   | $5 (0.001%)    | $1,714 (0.389%)| $2,326 (0.53%) |
| Czech Republic                         | $1,178 (0.027%)| $14,132 (0.326%)| $23 (0.001%)   | $60 (0.001%)   | $36,110 (0.829%)| $51,503 (1.18%) |
| Denmark                                | $813 (0.019%) | $8,222 (0.194%)| $10 (0.000%)  | $84 (0.002%)   | $27,695 (0.649%)| $36,825 (0.86%) |
| Dominican Republic                     | $801 (0.017%) | $11,686 (0.515%)| $170 (0.008%) | $737 (0.033%)  | $8,472 (0.374%)| $21,445 (0.95%) |
| Ecuador                                | $1,067 (0.039%)| $18,232 (0.666%)| $220 (0.008%) | $354 (0.013%)  | $13,710 (0.502%)| $33,584 (1.23%) |
| Egypt                                  | $2,133 (0.021%)| $28,621 (0.280%)| $422 (0.004%) | $1,069 (0.010%)| $29,342 (0.286%)| $61,486 (0.60%) |
| El Salvador                            | $434 (0.046%) | $17,665 (0.440%)| $52 (0.006%)  | $139 (0.015%)  | $5,363 (0.568%)| $23,654 (2.40%) |
| Equatorial Guinea                      | $104 (0.028%) | $3,248 (0.880%)| $305 (0.083%) | $215 (0.059%)  | $929 (0.253%)  | $4,801 (1.30%) |
| Estonia                                | $169 (0.030%) | $2,318 (0.407%)| $2 (0.000%)   | $14 (0.002%)   | $4,064 (0.712%)| $6,567 (1.15%) |
| Ethiopia                               | $3,735 (0.113%)| $25,814 (0.774%)| $2,904 (0.088%)| $2,737 (0.083%)| $15,272 (0.460%)| $50,46 (1.52%) |
| Fiji                                   | $56 (0.076%)  | $399 (0.539%)  | $4 (0.005%)   | $16 (0.021%)   | $431 (0.581%)  | $906 (1.22%)   |
| Finland                                | $716 (0.020%) | $11,722 (0.000%)| $55 (0.002%)  | $18,076       | $30,584       |

21
| Country               | GNI PPS (2021) | GNI PPP (2021) | GNI PPA (2021) | GNI PPP (2021) |
|-----------------------|----------------|----------------|----------------|----------------|
| France                | $3,982 (0.326%)| $98,723 (0.254%)| $347 (0.001%)  | $738 (0.002%)  |
| Gabon                 | $377 (0.074%)  | $8,284 (1.591%) | $538 (0.105%)  | $176 (0.034%)  |
| Gambia                | $77 (0.090%)   | $523 (0.603%)   | $82 (0.095%)   | $62 (0.072%)   |
| Germany               | $9,624 (0.016%)| $109,881 (0.184%)| $280 (0.000%)  | $959 (0.002%)  |
| Ghana                 | $1,540 (0.103%)| $6,841 (0.457%) | $1,054 (0.071%)| $806 (0.054%)  |
| Greece                | $527 (0.012%)  | $8,288 (0.187%) | $21 (0.000%)   | $48 (0.001%)   |
| Guatemala             | $935 (0.057%)  | $18,938 (1.522%)| $232 (0.014%)  | $427 (0.026%)  |
| Guinea                | $269 (0.009%)  | $1,316 (0.476%) | $473 (0.171%)  | $252 (0.091%)  |
| Guinea-Bissau         | $63 (0.103%)   | $391 (0.636%)   | $93 (0.151%)   | $73 (0.120%)   |
| Honduras              | $293 (0.044%)  | $5,309 (0.790%) | $71 (0.011%)   | $136 (0.020%)  |
| Hungary               | $1,062 (0.031%)| $12,977 (0.372%)| $23 (0.001%)   | $98 (0.003%)   |
| Iceland               | $31 (0.013%)   | $376 (0.152%)   | $1 (0.000%)    | $4 (0.002%)    |
| India                 | $80,525 (0.068%)| $1,100,034 (0.925%)| $19,167 (0.016%)| $58,993 (0.049%)|
| Indonesia             | $1,457 (0.005%)| $125,003 (0.436%)| $6,851 (0.024%)| $5,819 (0.020%)|
| Iran, Islamic Republic of| $2,624 (0.015%)| $12,237 (0.681%)| $107 (0.001%)  | $3,068 (0.017%)|
| Ireland               | $549 (0.013%)  | $8,339 (0.195%) | $16 (0.000%)   | $96 (0.002%)   |
| Israel                | $769 (0.016%)  | $9,253 (0.191%) | $31 (0.001%)   | $143 (0.003%)  |
| Italy                 | $2,761 (0.009%)| $66,102 (0.150%)| $83 (0.000%)   | $454 (0.001%)  |
| Japan                 | $33,894 (0.045%)| $357,151 (0.470%)| $358 (0.000%)  | $755 (0.001%)  |
| Jordan                | $65 (0.009%)   | $1,972 (0.262%) | $21 (0.003%)   | $63 (0.008%)   |
| Kazakhstan            | $1,466 (0.032%)| $42,937 (0.937%)| $318 (0.007%)  | $1,016 (0.022%)|
| Kenya                 | $262 (0.014%)  | $10,919 (0.591%)| $1,460 (0.079%)| $854 (0.046%)  |
| Korea, Republic of    | $7,015 (0.026%)| $142,467 (0.517%)| $139 (0.001%)  | $329 (0.001%)  |
| Kuwait                | $244 (0.007%)  | $11,046 (0.298%)| $26 (0.001%)   | $166 (0.004%)  |
| Kyrgyzstan            | $70 (0.027%)   | $1,846 (0.698%) | $25 (0.010%)   | $78 (0.030%)   |
| Latvia                | $279 (0.039%)  | $4,310 (0.593%) | $6 (0.001%)    | $23 (0.003%)   |
| Lebanon               | $100 (0.009%)  | $2,228 (0.192%) | $6 (0.001%)    | $62 (0.005%)   |
| Lesotho               | $38 (0.041%)   | $1,765 (1.853%) | $126 (0.135%)  | $80 (0.085%)   |
| Libya                 | $366 (0.017%)  | $9,699 (0.003%) | $314 (0.015%)  | $6,849 (0.003%)|
| Country                  | Inflation Rate (%) | Unemployment Rate (%) | Consumer Price Index | General Price Index | Per Capita GDP | Per Capita GNI |
|-------------------------|--------------------|-----------------------|----------------------|--------------------|---------------|---------------|
| Lithuania               | 4.4% (0.037%)      | 0.0% (0.002%)         | 8.6% (0.026%)        | 19.2% (0.080%)     | $354 (0.019)  | $367 (0.021)  |
| Luxembourg              | 6.9% (0.008%)      | 0.0% (0.001%)         | 5.3% (0.020%)        | 5.4% (0.062%)      | $354 (0.019)  | $367 (0.021)  |
| Madagascar              | 4.2% (0.038%)      | 0.0% (0.005%)         | 4.2% (0.023%)        | 4.2% (1.000%)      | $224 (0.031%) | $224 (0.031%) |
| Malawi                  | 4.3% (0.041%)      | 0.0% (0.001%)         | 6.1% (0.021%)        | 5.3% (1.047%)      | $520 (0.005)  | $520 (0.005)  |
| Malaysia                | 5.3% (0.051%)      | 0.0% (0.010%)         | 6.0% (0.020%)        | 10.8% (0.033%)     | $108 (0.025)  | $108 (0.025)  |
| Mali                    | 4.0% (0.063%)      | 0.0% (0.003%)         | 6.5% (0.028%)        | 4.7% (0.055%)      | $474 (0.039)  | $474 (0.039)  |
| Malta                   | 1.6% (0.008%)      | 0.0% (0.000%)         | 5.9% (0.003%)        | 9.7% (0.052%)      | $749 (0.037)  | $749 (0.037)  |
| Mauritania              | 2.0% (0.091%)      | 0.0% (0.001%)         | 8.7% (0.033%)        | 2.9% (1.029%)      | $871 (0.037)  | $871 (0.037)  |
| Mauritius               | 0.9% (0.025%)      | 0.0% (0.000%)         | 5.3% (0.019%)        | 2.4% (0.68%)       | $354 (0.019)  | $354 (0.019)  |
| Mexico                  | 6.7% (0.049%)      | 0.0% (0.004%)         | 7.0% (0.009%)        | 3.9% (0.63%)       | $364 (0.021)  | $364 (0.021)  |
| Moldova, Republic of    | 1.8% (0.067%)      | 0.0% (0.001%)         | 4.3% (0.029%)        | 4.6% (1.63%)       | $463 (0.163)  | $463 (0.163)  |
| Mongolia                | 2.7% (0.067%)      | 0.0% (0.004%)         | 3.6% (0.024%)        | 7.4% (1.81%)       | $364 (0.021)  | $364 (0.021)  |
| Morocco                 | 1.5% (0.042%)      | 0.0% (0.000%)         | 9.3% (0.026%)        | 3.1% (0.89%)       | $354 (0.019)  | $354 (0.019)  |
| Mozambique              | 5.4% (0.063%)      | 0.0% (0.007%)         | 5.8% (0.036%)        | 1.8% (0.99%)       | $843 (0.097)  | $843 (0.097)  |
| Namibia                 | 1.3% (0.035%)      | 0.0% (0.004%)         | 6.4% (0.049%)        | 6.1% (1.59%)       | $207 (0.021)  | $207 (0.021)  |
| Nepal                   | 3.7% (0.038%)      | 0.0% (0.003%)         | 3.9% (0.046%)        | 7.3% (0.75%)       | $363 (0.037)  | $363 (0.037)  |
| Netherlands             | 1.8% (0.015%)      | 0.0% (0.000%)         | 5.8% (0.000%)        | 10.4% (0.84%)      | $310 (0.002)  | $310 (0.002)  |
| New Zealand             | 4.4% (0.017%)      | 0.0% (0.004%)         | 7.3% (0.018%)        | 3.0% (1.19%)       | $221,200 (2020) | $221,200 (2020) |
| Nicaragua               | 1.4% (0.028%)      | 0.0% (0.007%)         | 2.3% (0.042%)        | 4.5% (0.86%)       | $207 (0.021)  | $207 (0.021)  |
| Niger                   | 2.1% (0.082%)      | 0.0% (0.007%)         | 19.9% (0.075%)       | 2.2% (0.83%)       | $675 (0.253)  | $675 (0.253)  |
| Norway                  | 1.0% (0.018%)      | 0.0% (0.000%)         | 11.7% (0.212%)       | 5.3% (0.96%)       | $354 (0.019)  | $354 (0.019)  |
| Pakistan                | 4.9% (0.039%)      | 0.0% (0.013%)         | 8.2% (0.727%)        | 3.1% (0.90%)       | $490 (0.036)  | $490 (0.036)  |
| Panama                  | 5.1% (0.032%)      | 0.0% (0.013%)         | 9.2% (0.565%)        | 1.0% (0.91%)       | $108 (0.006)  | $108 (0.006)  |
| Papua New Guinea        | 5.9% (0.127%)      | 0.0% (0.014%)         | 4.3% (0.938)         | 1.5% (1.159)       | $540 (1.059)  | $540 (1.059)  |
| Paraguay                | 3.3% (0.040%)      | 0.0% (0.014%)         | 4.8% (0.571)         | 5.4% (1.24%)       | $540 (1.059)  | $540 (1.059)  |
| Peru                    | 4.2% (0.055%)      | 0.0% (0.011%)         | 2.6% (0.439)         | 1.4% (0.19%)       | $454 (0.058)  | $454 (0.058)  |
| Philippines             | 6.7% (0.067%)      | 0.0% (0.015%)         | 5.2% (0.212)         | 2.6% (0.642)       | $645 (0.064)  | $645 (0.064)  |
| Poland                  | 4.8% (0.029%)      | 0.0% (0.001%)         | 6.4% (0.457)         | 10.1% (1.714)      | $170,922 (1.20%) | $170,922 (1.20%) |
| Portugal                | 1.1%                | 0.0% (0.000%)         | 10.8% (0.000)        | 3.9% (0.555)       | $39,416 (1.20%) | $39,416 (1.20%) |
| Country                      | (0+0.28%) | (0+0.255%) | (0+0.917%) | (1+0.20%) |
|------------------------------|-----------|------------|------------|-----------|
| Romania                      | $2,262   | $21,730    | $80 (0+0.001%) | $97 (0+0.02%) | $58,694 (1+0.064%) | $82,864 (1+0.51%) |
| Russian Federation           | $22,178  | $20,199    | $1,570 (0+0.003%) | $2,954 (0+0.005%) | $351,408 (0+0.625%) | $898,309 (1+0.59%) |
| Rwanda                       | $193 (0+0.036%) | $3,528 (0+0.658%) | $267 (0+0.050%) | $412 (0+0.077%) | $1,575 (0+0.295%) | $5,975 (1+0.12%) |
| Saudi Arabia                 | $1,760   | $60,091   | $90 (0+0.001%) | $1,517 (0+0.010%) | $18,873 (0+0.119%) | $82,331 (0+0.52%) |
| Senegal                      | $553 (0+0.088%) | $2,224 (0+0.353%) | $509 (0+0.081%) | $456 (0+0.073%) | $2,693 (0+0.427%) | $6,435 (1+0.02%) |
| Sierra Leone                 | $404 (0+0.113%) | $1,960 (0+0.548%) | $520 (0+0.146%) | $364 (0+0.102%) | $1,513 (0+0.424%) | $4,761 (1+0.33%) |
| Singapore                    | $1,108 (0+0.18%) | $12,126 (0+0.196%) | $25 (0+0.000%) | $37 (0+0.001%) | $42,644 (0+0.686%) | $55,941 (0+0.90%) |
| Slovakia                     | $572 (0+0.026%) | $7,406 (0+0.339%) | $12 (0+0.001%) | $58 (0+0.003%) | $13,326 (0+0.607%) | $21,334 (0+0.99%) |
| Slovenia                     | $145 (0+0.017%) | $2,322 (0+0.276%) | $3 (0+0.000%) | $11 (0+0.001%) | $4,990 (0+0.592%) | $7,471 (0+0.89%) |
| South Africa                 | $2,916 (0+0.025%) | $116,386 (0+0.992%) | $3,022 (0+0.026%) | $4,286 (0+0.037%) | $37,735 (0+0.324%) | $164,346 (1+0.40%) |
| Spain                        | $2,523 (0+0.011%) | $33,944 (0+0.141%) | $109 (0+0.000%) | $399 (0+0.002%) | $106,407 (0+0.441%) | $143,381 (0+0.60%) |
| Sri Lanka                    | $533 (0+0.021%) | $17,416 (0+0.679%) | $57 (0+0.002%) | $136 (0+0.005%) | $6,883 (0+0.269%) | $25,025 (0+0.99%) |
| Swaziland                    | $42 (0+0.039%) | $80 (0+0.075%) | $50 (0+0.047%) | $559 (0+0.051%) | $2,394 (2+0.20%) |
| Sweden                       | $1,229 (0+0.016%) | $15,192 (0+0.201%) | $20 (0+0.000%) | $108 (0+0.001%) | $43,623 (0+0.576%) | $60,172 (0+0.80%) |
| Switzerland                  | $593 (0+0.009%) | $15,853 (0+0.234%) | $23 (0+0.000%) | $115 (0+0.002%) | $41,340 (0+0.607%) | $57,924 (0+0.85%) |
| Syrian Arab Republic         | $178 (0+0.009%) | $2,364 (0+0.117%) | $7 (0+0.000%) | $202 (0+0.010%) | $2,408 (0+0.120%) | $5,159 (0+0.26%) |
| Tajikistan                   | $95 (0+0.025%) | $1,744 (0+0.454%) | $22 (0+0.006%) | $116 (0+0.030%) | $1,214 (0+0.317%) | $3,190 (0+0.83%) |
| Tanzania, United Republic of | $754 (0+0.037%) | $12,030 (0+0.588%) | $2,506 (0+12.3%) | $1,364 (0+0.67%) | $6,483 (0+3.18%) | $23,137 (1+1.3%) |
| Thailand                     | $5,885 (0+0.047%) | $77,045 (0+0.614%) | $377 (0+0.003%) | $560 (0+0.004%) | $117,200 (0+0.931%) | $201,067 (1+0.60%) |
| Togo                         | $223 (0+0.106%) | $1,274 (0+0.605%) | $166 (0+0.079%) | $199 (0+0.095%) | $859 (0+0.409%) | $2,721 (2+0.29%) |
| Trinidad and Tobago          | $217 (0+0.034%) | $4,217 (0+0.664%) | $15 (0+0.002%) | $95 (0+0.015%) | $2,810 (0+4.44%) | $7,353 (1+1.16%) |
| Tunisia                      | $290 (0+0.014%) | $8,246 (0+0.403%) | $25 (0+0.001%) | $188 (0+0.009%) | $6,728 (0+3.29%) | $15,476 (0+0.76%) |
| Turkey                       | $5,766 (0+0.019%) | $83,960 (0+0.270%) | $467 (0+0.002%) | $6,590 (0+0.021%) | $196,954 (0+0.631%) | $293,737 (0+0.94%) |
| Uganda                       | $576 (0+0.038%) | $11,909 (0+0.776%) | $1,322 (0+0.087%) | $1,188 (0+0.078%) | $5,696 (0+0.373%) | $20,691 (1+0.35%) |
| Ukraine                      | $1,626 (0+0.036%) | $29,319 (0+0.650%) | $67 (0+0.001%) | $220 (0+0.005%) | $31,852 (0+0.706%) | $63,083 (1+0.40%) |
| United Kingdom               | $8,462 (0+0.021%) | $66,281 (0+0.167%) | $77 (0+0.000%) | $1,061 (0+0.003%) | $237,834 (0+0.596%) | $313,715 (0+0.79%) |
| United States                | $68,047 (0+0.023%) | $1,064,929 (0+3.60%) | $4,439 (0+0.002%) | $10,636 (0+0.004%) | $2,209,532 (0+7.44%) | $3,357,582 (1+1.13%) |
| Country                  | Digestive Disorders | Injury     | Maternal Disorders | Neonatal Disorders | Neoplasm | Total          |
|-------------------------|---------------------|------------|-------------------|-------------------|----------|----------------|
| Afghanistan             | $342,516 (0.75%)    | $5,845,223 (12.82%) | $613,181 (1.34%) | $1,185,026 (2.60%) | $1,74,469 (3.82%) | $9,728,415 (21.33%) |
| Albania                 | $126,648 (0.47%)    | $2,325,374 (8.58%) | $2,966 (0.01%)   | $69,106 (0.26%)   | $2,411,516 (8.90%) | $4,935,610 (18.22%) |
| Algeria                 | $2,173,127 (0.48%)  | $19,932,261 (4.39%) | $501,613 (0.11%) | $3,196,237 (0.70%) | $12,575,761 (2.77%) | $38,378,998 (8.45%) |
| Angola                  | $654,966 (0.48%)    | $10,961,250 (8.11%) | $1,400,233 (1.04%) | $1,833,210 (1.36%) | $2,945,218 (2.18%) | $17,794,876 (13.17%) |
| Antigua and Barbuda     | $6,530 (0.37%)      | $135,351 (7.40%)   | $304 (0.02%)     | $5,810 (0.33%)    | $110,691 (6.29%)  | $258,687 (14.71%)  |
| Australia               | $3,958,813 (0.46%)  | $51,310,964 (5.96%) | $76,570 (0.01%)  | $1,239,157 (0.14%) | $93,825,064 (10.90%) | $150,410,568 (17.48%) |
| Austria                 | $1,916,018 (0.57%)  | $25,433,542 (7.50%) | $22,624 (0.01%)  | $427,383 (0.13%)  | $41,542,189 (12.20%) | $69,341,756 (20.46%) |
| Azerbaijan              | $406,959 (0.34%)    | $8,406,843 (5.94%) | $55,377 (0.04%)  | $935,251 (0.66%)  | $7,143,262 (5.04%)  | $17,027,692 (12.02%) |
| Bahrain                 | $107,236 (0.22%)    | $3,233,626 (6.09%) | $29,373 (0.06%)  | $127,136 (0.26%)  | $1,370,087 (2.75%)  | $4,667,458 (9.38%)  |
| Bangladesh              | $1,656,395 (0.52%)  | $18,179,979 (5.75%) | $1,023,747 (0.32%) | $4,303,896 (1.36%) | $16,360,456 (5.17%) | $41,524,473 (13.13%) |
| Barbados                | $21,064 (0.50%)     | $442,946 (10.50%)  | $1,623 (0.04%)   | $14,687 (0.35%)   | $411,728 (9.76%)   | $892,049 (21.15%)   |
| Belarus                 | $945,845 (0.65%)    | $20,246,119 (13.85%) | $23,925 (0.02%)  | $301,892 (0.21%)  | $16,520,588 (11.30%) | $38,038,368 (26.03%) |
| Belgium                 | $2,795,938 (0.67%)  | $34,152,670 (8.20%) | $33,349 (0.01%)  | $489,314 (0.12%)  | $56,825,149 (13.64%) | $94,296,421 (22.64%) |
| Belize                  | $7,581 (0.30%)      | $241,865 (9.65%)   | $1,801 (0.07%)   | $11,763 (0.47%)   | $100,408 (4.01%)    | $363,418 (14.50%)   |
| Benin                   | $97,966 (0.64%)     | $640,179 (4.20%)   | $109,521 (0.72%) | $284,722 (1.87%)  | $346,389 (2.27%)    | $1,478,776 (9.71%)  |

*Baseline VLO assumptions are applied.
| Country                                      | GDP (2021) | GDP Growth (2021) | GDP Per Capita (2021) | GDP Per Capita Growth (2021) | GDP Per Capita Purch. (2021) | GDP Per Capita Purch. Growth (2021) |
|----------------------------------------------|------------|-------------------|----------------------|-------------------------------|-------------------------------|-------------------------------------|
| Bhutan                                       | $19,022    | (0%41%)           | $438,816             | (9%53%)                       | $11,519                       | (0%25%)                             |
| Bolivia, Plurinational State of              | $307,421   | (0%58%)           | $2,809,713           | (5%34%)                       | $156,077                      | (0%30%)                             |
| Bosnia and Herzegovina                       | $167,330   | (0%50%)           | $2,626,680           | (7%84%)                       | $2,788 (0%01%)                | (0%97%)                             |
| Botswana                                     | $78,893    | (0%30%)           | $1,655,945           | (6%45%)                       | $158,797                      | (0%62%)                             |
| Brazil                                       | $13,327,585| (0%50%)           | $192,169,002         | (7%15%)                       | $1,167,595 (0%04%)            | (0%97%)                             |
| Brunei                                       | $99,519    | (0%36%)           | $1,133,725           | (4%09%)                       | $1,849 (0%03%)                | (0%30%)                             |
| Bulgaria                                     | $591,167   | (0%55%)           | $92,592,076          | (9%00%)                       | $16,307                       | (0%02%)                             |
| Burkina Faso                                 | $191,971   | (0%89%)           | $1,466,870           | (6%79%)                       | $165,483                      | (0%77%)                             |
| Burundi                                      | $42,316    | (0%64%)           | $4,512,246           | (6%87%)                       | $92,070                       | (1%40%)                             |
| Cambodia                                     | $182,782   | (0%52%)           | $2,094,958           | (5%92%)                       | $115,884                      | (0%33%)                             |
| Cameroon                                     | $410,673   | (0%82%)           | $3,111,812           | (6%24%)                       | $491,253                      | (0%99%)                             |
| Canada                                       | $7,221,425 | (0%53%)           | $64,660,926          | (4%76%)                       | $325,206                      | (0%02%)                             |
| Cape Verde                                   | $12,845    | (0%45%)           | $126,230             | (4%40%)                       | $9,117 (0%24%)                | $16,961                             |
| Central African Republic                     | $27,563    | (0%72%)           | $486,499             | (12%65%)                      | $125,902                      | (3%28%)                             |
| Chad                                         | $211,121   | (0%94%)           | $1,267,144           | (5%65%)                       | $263,518                      | (1%18%)                             |
| Chile                                        | $1,656,300 | (0%53%)           | $19,444,938          | (6%22%)                       | $82,609                       | (0%03%)                             |
| China                                        | $45,535,137| (0%38%)           | $802,876,993         | (6%63%)                       | $817,54,09                    | (0%07%)                             |
| Colombia                                     | $1,990,707 | (0%41%)           | $34,942,594          | (7%12%)                       | $209,726                      | (0%04%)                             |
| Comoros                                      | $5,115     | (0%51%)           | $74,709              | (7%48%)                       | $11,138                       | (1%12%)                             |
| Congo                                        | $146,000   | (0%65%)           | $2,032,010           | (9%11%)                       | $230,248                      | (1%03%)                             |
| Costa Rica                                   | $242,861   | (0%43%)           | $2,608,388           | (4%62%)                       | $15,092                       | (0%03%)                             |
| Côte d'Ivoire                                | $5,568,847 | (1%09%)           | $3,566,977           | (7%14%)                       | $46,026                       | (0%91%)                             |
| Croatia                                      | $458,236   | (0%55%)           | $7,304,676           | (8%83%)                       | $6,616 (0%01%)                | $123,205 (0%15%)                    |
| Cuba                                         | $1,043,029 | (0%52%)           | $22,994,615          | (11%36%)                      | $61,718                       | (0%03%)                             |
| Cyprus                                       | $98,329    | (0%38%)           | $1,444,701           | (5%60%)                       | $1,340 (0%01%)                | $31,562                             |
| Czech Republic                               | $1,657,038 | (0%61%)           | $24,175,398          | (8%90%)                       | $19,475                       | (0%01%)                             |
| Congo, the Democratic Republic of the        | $234,554   | (0%61%)           | $2,906,594           | (7%54%)                       | $338,846                      | (1%00%)                             |
| Denmark                                      | $1,617,074 | (0%71%)           | $15,879,276          | (7%00%)                       | $10,618                       | (0%00%)                             |

Note: The values are in 2021 USD, and the growth rates are for the year 2021.
| Country                  | GDP 2022 (0-13%) |
|-------------------------|------------------|
| Djibouti                | $9,080 (0•42%)  |
| Dominican Republic      | $294,852 (0•29%)|
| Ecuador                 | $580,575 (0•44%)|
| Egypt                   | $2,570,176 (0•32%)|
| El Salvador             | $203,372 (0•46%)|
| Equatorial Guinea       | $116,747 (0•51%)|
| Eritrea                 | $29,673 (0•49%)  |
| Estonia                 | $170,123 (0•62%)|
| Ethiopia                | $834,462 (0•92%)|
| Micronesia, Federated   | $3,823 (1•13%)  |
| Fiji                    | $51,286 (0•82%)  |
| Finland                 | $1,231,668 (0•63%)|
| France                  | $13,952,100 (0•62%)|
| Gabon                   | $158,489 (0•62%)|
| Georgia                 | $91,968 (0•35%)  |
| Germany                 | $22,183,064 (0•71%)|
| Ghana                   | $533,382 (0•73%)|
| Greece                  | $1,496,080 (0•47%)|
| Grenada                 | $6,968 (0•61%)  |
| Guatemala               | $537,523 (0•56%)|
| Guinea                  | $90,147 (0•41%)  |
| Guinea-Bissau           | $17,094 (0•88%)  |
| Guyana                  | $22,088 (0•52%)  |
| Haiti                   | $118,694 (0•81%)|
| Honduras                | $164,239 (0•51%)|
| Hungary                 | $1,663,078 (0•47%)|
| Iceland                 | $45,304 (0•39%)  |
| India                   | $37,791,806 (0•69%)|
| Indonesia               | $2,564,972      |
| Country                                | Population (2015) | Population (2017) | Population (2018) | Population (2019) | Population (2020) | Population (2021) |
|----------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Iran, Islamic Republic of              | $2,565,071        | $81,592,855       | $682,580          | $5,417,055        | $35,594,270       | $125,857,230      |
| Iraq                                  | $803,316          | $23,482,305       | $635,202          | $5,099,388        | $9,088,711        | $39,019,021       |
| Ireland                                | $921,403          | $10,747,589       | $22,605           | $23,492           | $17,742,354       | $29,667,443       |
| Israel                                 | $855,882          | $10,803,011       | $13,153           | $36,199           | $16,728,709       | $28,762,749       |
| Italy                                  | $11,868,878       | $139,145,798      | $128,656          | $2,311,800        | $290,692,393      | $444,147,525      |
| Jamaica                                | $84,455           | $1,971,459        | $11,038           | $10,782           | $1,166,366        | $3,338,100        |
| Japan                                  | $25,819,351       | $294,563,993      | $542,257          | $3,339,377        | $638,750,376      | $963,217,624      |
| Jordan                                 | $144,741          | $2,845,418        | $75,907           | $274,330          | $2,123,657        | $5,664,052        |
| Kazakhstan                             | $1,553,834        | $37,084,131       | $192,048          | $2,119,176        | $23,600,106       | $64,873,576       |
| Kenya                                  | $140,761          | $4,013,356        | $601,949          | $1,227,232        | $1,548,637        | $7,531,935        |
| Kuwait                                  | $278,649          | $10,881,352       | $104,353          | $580,040          | $4,275,083        | $16,119,477       |
| Kyrgyzstan                             | $52,727           | $1,179,741        | $13,106           | $142,342          | $580,704          | $1,968,619        |
| Lao People's Democratic Republic       | $122,493          | $1,620,292        | $100,609          | $242,748          | $926,374          | $3,012,516        |
| Latvia                                 | $270,498          | $3,860,118        | $4,875 (0.01%)    | $72,709           | $4,722,999        | $8,931,199        |
| Lebanon                                | $108,657          | $3,628,918        | $45,230           | $191,327          | $3,653,794        | $7,627,965        |
| Lesotho                                | $21,073           | $794,930          | $57,593           | $100,369          | $180,332          | $1,154,297        |
| Liberia                                | $17,543           | $123,121          | $41,242           | $70,874           | $60,296           | $313,077          |
| Libya                                  | $368,284          | $9,739,898        | $164,473          | $953,366          | $5,304,303        | $16,530,324       |
| Lithuania                              | $445,708          | $7,801,516        | $6,735 (0.01%)    | $101,286          | $7,786,947        | $16,142,191       |
| Luxembourg                             | $219,999          | $2,916,910        | $4,289 (0.01%)    | $42,090           | $4,942,753        | $8,126,042        |
| Macedonia, The Former Yugoslav Republic of | $83,226          | $1,649,916        | $4,260 (0.02%)    | $55,126           | $2,236,153        | $4,028,681        |
| Madagascar                             | $107,020          | $1,439,606        | $243,202          | $452,059          | $629,987          | $2,871,873        |
| Malawi                                 | $44,440           | $823,496          | $166,249          | $247,427          | $1,156,252        | $1,496,774        |
| Malaysia                               | $2,941,813        | $29,785,927       | $664,749 (0.12%)  | $1,418,329        | $22,034,146       | $56,844,874       |
| Maldives                               | $6,675 (0.20%)    | $133,242 (3.91%)  | $3,232 (0.09%)    | $13,507           | $96,131 (2.48%)   | $252,788 (7.41%)  |
| Mali                                   | $200,875 (0.88%)  | $1,302,847 (5.71%)| $281,805          | $808,454          | $819,016 (3.59%)  | $3,413,997 (14.69%)|
| Malta                                  | $54,882 (0.50%)   | $629,668 (5.69%)  | $91 (0.01%)       | $14,520           | $1,186,272 (10.73%)| $1,886,253 (17.06%)|
| Country                  | GDP (2019)        | GDP Growth (2018-19) | Population (2019) | GDP Per Capita (2019) | PPP GDP (2019) |
|--------------------------|-------------------|----------------------|-------------------|----------------------|----------------|
| Marshall Islands        | $2,191 (1*24%)    | $13,053 (7*38%)      | $557 (7*31%)      | $1,898 (1*07%)       | $10,439 (5*90%) |
| Mauritania               | $66,874 (0*71%)   | $503,050 (5*32%)     | $104,467 (1*10%)  | $168,682 (1*78%)     | $253,786 (2*68%) |
| Mauritius                | $75,665 (0*40%)   | $49,290 (4*96%)      | $21,248 (0*11%)   | $58,854 (0*31%)      | $805,473 (4*21%) |
| Mexico                   | $9,104,000 (0*52%)| $88,965,084 (5*12%)  | $852,850 (0*05%)  | $6,293,418 (0*36%)   | $68,663,862 (3*96%) |
| Moldova, Republic of     | $116,062 (0*85%)  | $1,358,598 (9*94%)   | $2,250 (0*02%)    | $39,802 (9*29%)      | $1,279,673 (9*43%) |
| Mongolia                 | $128,230 (0*74%)  | $1,638,476 (9*51%)   | $21,001 (0*12%)   | $148,057 (0*86%)     | $1,329,297 (7*72%) |
| Montenegro               | $39,841 (0*48%)   | $702,225 (8*50%)     | $1,104 (0*01%)    | $18,962 (0*23%)      | $886,188 (10*72%) |
| Morocco                  | $957,184 (0*47%)  | $9,217,701 (8*27%)   | $331,273 (0*16%)  | $1,665,255 (0*82%)   | $10,675,480 (5*24%) |
| Mozambique               | $99,856 (0*49%)   | $1,719,605 (8*79%)   | $250,158 (0*20%)  | $451,438 (2*17%)     | $677,319 (3*26%) |
| Namibia                  | $76,170 (0*42%)   | $1,468,420 (9*19%)   | $87,068 (0*49%)   | $198,628 (1*11%)     | $739,654 (4*12%) |
| Nepal                    | $288,701 (0*55%)  | $3,475,040 (6*60%)   | $233,595 (0*44%)  | $715,491 (1*36%)     | $1,467,554 (2*79%) |
| Netherlands              | $4,244,449 (0*61%)| $4,327,017 (6*29%)   | $69,419 (0*01%)   | $884,786 (0*13%)     | $95,041,642 (13*89%) |
| New Zealand              | $553,338 (0*42%)  | $7,913,024 (6*54%)   | $19,409 (0*01%)   | $202,977 (0*15%)     | $14,993,831 (10*94%) |
| Nicaragua                | $80,608 (0*35%)   | $901,875 (3*97%)     | $18,367 (0*08%)   | $146,735 (0*65%)     | $744,477 (3*27%) |
| Niger                    | $110,269 (0*84%)  | $589,968 (4*50%)     | $146,111 (1*11%)  | $283,077 (2*16%)     | $290,630 (2*22%) |
| Nigeria                  | $5,745,610 (0*71%)| $60,235,939 (7*47%)  | $7,551,586 (0*94%)| $20,422,353 (2*53%)  | $16,138,876 (2*40%) |
| Norway                   | $1,407,939 (0*50%)| $18,463,768 (6*54%)  | $24,223 (0*19%)   | $293,687 (0*10%)     | $32,200,292 (11*41%) |
| Oman                     | $164,689 (0*12%)  | $8,016,632 (6*08%)   | $64,768 (0*05%)   | $319,177 (0*17%)     | $2,235,106 (1*70%) |
| Pakistan                 | $3,692,728 (0*52%)| $52,394,474 (7*31%)  | $2,445,395 (0*34%)| $13,441,682 (1*88%)  | $27,009,405 (3*77%) |
| Panama                   | $182,409 (0*34%)  | $2,572,047 (4*73%)   | $28,591 (0*05%)   | $191,719 (0*36%)     | $2,407,917 (4*47%) |
| Papua New Guinea         | $125,661 (0*88%)  | $1,287,802 (9*05%)   | $125,122 (0*88%)  | $158,294 (1*11%)     | $949,051 (6*67%) |
| Paraguay                 | $173,458 (0*39%)  | $2,422,776 (5*46%)   | $53,339 (0*12%)   | $283,525 (0*64%)     | $2,016,950 (4*54%) |
| Peru                     | $1,514,017 (0*53%)| $13,294,402 (6*67%)  | $302,010 (0*11%)  | $1,571,698 (0*55%)   | $13,215,598 (4*64%) |
| Philippines              | $2,818,071 (0*55%)| $26,333,549 (5*12%)  | $1,037,791 (0*20%)| $3,734,071 (0*73%)   | $22,413,108 (4*36%) |
| Poland                   | $5,010,184 (0*64%)| $74,432,588 (9*56%)  | $63,306 (0*01%)   | $1,284,488 (0*17%)   | $102,488,154 (13*17%) |
| Portugal                 | $1,658,080 (0*61%)| $20,293,744 (7*42%)  | $22,678 (0*01%)   | $280,424 (0*10%)     | $35,402,530 (12*94%) |
| Qatar                    | $334,365 (0*15%)  | $14,122,744 (6*47%)  | $70,783 (0*03%)   | $360,995 (0*17%)     | $4,058,384 (1*86%) |
| Romania                  | $1,956,238 (0*59%)| $31,944,529 (9*71%)  | $61,285 (0*02%)   | $580,049 (0*18%)     | $40,202,766 (12*22%) |
| Russian Federation       | $22,368,130 (0*76%)| $142,438,240 (14*10%)| $789,180 (0*03%)  | $7,127,759 (0*24%)   | $311,246,427 (10*64%) |
| **Total**                | **$1,188,354,358**| **$14,947,237,956**  | **$1,284,364**    | **$1,665,535**       | **$232,187,215** |

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| Country                      | GNI (2018) | GNP (2018) | GNI (2017) | GNP (2017) | GNI (2016) | GNP (2016) | GNI (2015) | GNP (2015) | GNI (2014) | GNP (2014) | GNI (2013) | GNP (2013) | GNI (2012) | GNP (2012) | GNI (2011) | GNP (2011) | GNI (2010) | GNP (2010) | GNI (2009) | GNP (2009) |
|------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Rwanda                       | $57,434    | $812,670   | $77,114    | $244,569   | $288,857   | $1,480,644 |            |            |            |            |            |            |            |            |            |            |            |            |
| Saint Lucia                  | $6,373     | $262,556   | $1,252     | $9,056     | $126,859   | $406,096   |            |            |            |            |            |            |            |            |            |            |            |
| Saint Vincent and the        | $4,812     | $103,391   | $425       | $6,918     | $71,114    | $186,660   |            |            |            |            |            |            |            |            |            |            |            |
| Grenadines                   |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |
| Samoa                        | $5,336     | $46,619    | $1,612     | $3,996     | $27,541    | $85,104    |            |            |            |            |            |            |            |            |            |            |            |
| Sao Tome and Principe        | $1,840     | $13,802    | $1,500     | $5,575     | $7,212     | $29,929    |            |            |            |            |            |            |            |            |            |            |
| Saudi Arabia                 | $2,289,584 | $70,441,902| $636,064   | $5,522,225 | $19,174,182| $98,063,957|            |            |            |            |            |            |            |            |            |            |
| Senegal                      | $172,873   | $937,755   | $207,532   | $472,175   | $693,975   | $2,484,310 |            |            |            |            |            |            |            |            |            |
| Serbia                       | $636,834   | $8,508,632 | $18,099    | $193,081   | $12,385,777| $21,742,422|            |            |            |            |            |            |            |            |            |
| Seychelles                   | $9,774     | $120,382   | $1,761     | $4,739     | $93,338    | $229,996   |            |            |            |            |            |            |            |            |            |
| Sierra Leone                 | $65,334    | $390,310   | $91,493    | $182,055   | $210,533   | $939,726   |            |            |            |            |            |            |            |            |            |
| Singapore                    | $844,629   | $10,690,570| $42,444    | $230,289   | $17,761,760| $29,569,693|            |            |            |            |            |            |            |            |            |
| Slovakia                     | $836,647   | $11,180,471| $11,781    | $211,745   | $15,683,285| $27,923,928|            |            |            |            |            |            |            |            |
| Slovenia                     | $330,811   | $5,377,172 | $2,858     | $69,522    | $7,563,331 | $13,343,695|            |            |            |            |            |            |            |            |
| Solomon Islands              | $10,162    | $69,235    | $4,106     | $8,353     | $49,153    | $141,008   |            |            |            |            |            |            |            |            |
| South Africa                 | $2,625,120 | $50,422,056| $1,852     | $4,812     | $24,769,634| $84,481,319|            |            |            |            |            |            |            |            |
| Korea, Republic of           | $7,082,148 | $100,423,274| $279,539   | $1,612,640 | $150,806,404| $260,204,006|            |            |            |            |            |            |            |            |
| Spain                       | $8,914,941 | $91,600,291| $122,361   | $1,577,733 | $173,114,154| $275,329,479|            |            |            |            |            |            |            |            |
| Sri Lanka                    | $536,406   | $13,652,547| $174,292   | $470,301   | $5,300,843 | $20,134,388|            |            |            |            |            |            |            |            |
| Sudan                       | $433,191   | $7,568,611 | $1,027,966 | $2,031,236 | $3,445,119 | $14,506,123|            |            |            |            |            |            |            |            |
| Suriname                    | $47,171    | $757,951   | $5,042     | $53,682    | $331,832   | $1,195,678 |            |            |            |            |            |            |            |            |
| Swaziland                   | $34,088    | $956,060   | $65,502    | $92,441    | $280,769   | $1,428,860 |            |            |            |            |            |            |            |            |
| Sweden                      | $2,103,284 | $25,657,997| $21,922    | $369,410   | $43,322,071| $71,474,683|            |            |            |            |            |            |            |            |
| Switzerland                 | $1,412,909 | $28,385,498| $21,370    | $395,567   | $45,342,997| $75,559,341|            |            |            |            |            |            |            |            |
| Tajikistan                  | $46,143    | $808,920   | $9,677     | $143,136   | $426,354   | $1,434,230 |            |            |            |            |            |            |            |            |
| Tanzania, United Republic of| $266,936   | $3,893,308 | $764,095   | $1,218,935 | $7,703,183 |            |            |            |            |            |            |            |            |            |
| Thailand                    | $5,073,342 | $72,203,293| $1,011,498 | $2,328,698 | $72,296,478| $152,913,310|            |            |            |            |            |            |            |            |
| Bahamas                     | $26,598    | $816,482   | $5,746     | $37,246    | $417,427   | $1,301,499 |            |            |            |            |            |            |            |            |
| Gambia                      | $15,320    | $133,716   | $22,910    | $52,999    | $81,648    | $306,593   |            |            |            |            |            |            |            |            |
| Timor-Leste                  | $6,912     | $79,260    | $11,890    | $28,605    | $54,217    | $180,884   |            |            |            |            |            |            |            |            |
| Country                  | Value (Millions) | CB (Percent) | CB (Percent) | CB (Percent) | CB (Percent) | CB (Percent) |
|-------------------------|-----------------|--------------|--------------|--------------|--------------|--------------|
| Togo                    | $60,093         | (4•15%)      | (0•62%)      | (1•50%)      | (2•84%)      | (9•46%)      |
| Tonga                   | $2,953          | (0•58%)      | (5•36%)      | (1.122)      | (2•715)      | (1•53%)      |
| Trinidad and Tobago     | $205,645        | (0•54%)      | (11•76%)     | (12•509)     | (1•527)      | (2•053)      |
| Tunisia                 | $260,963        | (0•24%)      | (5•80%)      | (76•582)     | (4•15•732)   | (4•18%)      |
| Turkey                  | $2,977,804      | (0•25%)      | (5•72%)      | (830•356)    | (6•277,827)  | (72•928•491) |
| Turkmenistan            | $182,770        | (0•37%)      | (6•64%)      | (22•434)     | (272•803)    | (2•167•456)  |
| Uganda                  | $143,717        | (0•33%)      | (6•06%)      | (32•891)     | (790•661)    | (853•313)    |
| Ukraine                 | $2,187,651      | (0•62%)      | (11•08%)     | (55•530)     | (919•022)    | (36•653•680) |
| United Kingdom          | $15,131,395     | (0•70%)      | (6•18%)      | (206•931)    | (2•947•407)  | (270•902•348) |
| United States           | $82,198,590     | (0•55%)      | (5•58%)      | (4•695•417)  | (31•187•699) | (1•678•753•179) |
| Uruguay                 | $362,341        | (0•66%)      | (6•34%)      | (12•295)     | (125•715)    | (6•550•236)  |
| Uzbekistan              | $390,930        | (0•33%)      | (6•33%)      | (53•219)     | (828•782)    | (3•912•850)  |
| Vanuatu                 | $6,954          | (1•03%)      | (7•20%)      | (2•222)      | (6•366)      | (34•418)     |
| Veneuela Bolivarian     | $1,704,131      | (0•36%)      | (9•04%)      | (183•415)    | (1•880•961)  | (23•502•976) |
| Viet Nam                | $2,020,057      | (0•53%)      | (6•23%)      | (40•417)     | (1•494•565)  | (25•146•466) |
| Yemen                   | $281,250        | (0•28%)      | (4•70%)      | (465•811)    | (1•486•274)  | (1•766•132)  |
| Zambia                  | $158,815        | (0•44%)      | (7•32%)      | (256•624)    | (656•301)    | (881•954)    |
| Zimbabwe                | $96,239         | (0•51%)      | (9•58%)      | (134•024)    | (314•761)    | (559•409)    |

a: An IE-VSL of 1.0 was applied to all countries  
b: The trauma estimates for Haiti include the 2010 earthquake, and therefore the VLV due to trauma expressed as equivalent percentage of GDP is an order of magnitude larger than other countries  
c: Data were obtained before the formation of South Sudan, and therefore Sudan is presented as one entity.