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Morbidity and Economic Growth

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Overview

This brief reviews the current body of peer-reviewed scholarship exploring the impacts of morbidity on economic growth. This overview seeks to provide a concise introduction to the major theories and empirical evidence linking morbidity – and the myriad different measures of morbidity – to economic growth, which is defined primarily in terms of gross domestic product (GDP) and related metrics (wages, productivity, etc.).

Through a systematic review of published manuscripts in the fields of health economics and economic development we further identify the most commonly-used pathways linking morbidity to economic growth. We also highlight the apparent gaps in the empirical literature (i.e., theorized pathways from morbidity to growth that remain relatively untested in the published empirical literature to date).

I. Measures of Morbidity

Morbidity in this brief refers to the overall burden of disease, including both measures of the incidence or prevalence of a specific disease as well as broader measures of more general disease-related health conditions. Disease *incidence* refers to the number of new cases of a disease in the population of those at risk for the disease over a period of time (this can be a proportion or a rate). Disease *prevalence* refers to the overall proportion of people who are living with a particular disease at a particular point in time. Other, more general, measures of disease burden include self-reported health, comorbidity, and disability-adjusted health measures (which estimate productive working life years lost due to morbidity and are often disease-specific). Other broader (often nutrition-related) measures like weight, height, body mass index (BMI), and stunting and wasting are also commonly used to represent overall disease burden. Such measures do not directly measure the burden of disease but rather are broader indicators of the extent of morbidity in a population. Further morbidity indicators surrounding cognition can be either disease-specific or more general, as cognition can be a direct form of morbidity (e.g., mental illness) or the result of a disease (e.g., reduced cognitive function due to childhood diarrhea). Table 1 summarizes the morbidity measures that are commonly used in the health literature.[1]

Table 1: Common morbidity measures

	Assessments of Morbidity	Description or sample measurement
Direct measures	• Disease specific: *Incidence*; *Prevalence* • Disease Index • Life expectancy	Incidence: [number of cases of a disease]/[population at risk] Prevalence: [number of cases of a disease]/[total population]
Self-reported health and self-assessed health (often from survey data)	• International surveys, e.g. Demographic and Health Surveys • Disease-specific, e.g. Malaria Indicator Survey • Country health reports • Morbidity index e.g. Self-Rated Health,	Surveys to tabulate key malaria indicators Self-Rated Health: rating personal health on a scale of 1 (excellent) – 5 (poor) WHO DAS: covers six domains including cognition, mobility,

[1] Definitions drawn from the World Health Organization (WHO) and the Demographic and Health Surveys (DHS). Other references consulted include:
- Malaria Indicator Survey (http://www.malariasurveys.org/)
- Self-Rated Health (SRH) (http://patienteducation.stanford.edu/research/generalhealth.html)
- Global Activity Limitation Index (GALI) (http://www.sciencedirect.com/science/article/pii/S0895435613004320)
- WHO Disability Assessment Schedule (http://www.who.int/classifications/icf/more_whodas/en/)
- Charlson Co-morbidity index (http://www.sciencedirect.com/science/article/pii/0895435694901295)

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	Global Activity Limitation Index • Disability Assessment Schedule (WHO DAS)	self-care, life activities, and participation
Disability adjustment calculations	• Healthy life expectancy (HALE) • Years of Life Lost (YLL), Years Lived with Disability (YLD); Disability Adjusted Life-Years (DALYs), Quality-Adjusted Life-Year (QALY)	YLL: (number of deaths)x(standard life expectancy at death) YLD: (number of incident cases)x(disability severity index from 0-1)x(average duration of disability) DALYs: YLL+YLD
Co-morbidity assessment	• Charlson Co-morbidity Index	Summed score for a total of 22 conditions including heart disease, AIDS, and cancer - risk of death determines level of each disease's component score
Nutritional measures	• Stunting and wasting • Iron Deficiency • Caloric Intake • Outcomes of poor nutrition, e.g. diarrheal disease	• Weight-for-age, stature-for-age z scores (children) • Weight-for-length, head circumference (infants) • Weight-for-height • BMI, BMI-for-age
Cognition: adults	• IQ • Mental health assessments, e.g. Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder 7 (GAD-7)	Executive function, attention, episodic memory, language, processing speed, working memory PHQ-9: questionnaire for a quick depression assessment (e.g. number of days depressed, feeling tired, trouble concentrating)
Cognition: children	• Direct assessment • Ratings and reports	Rating and reports: scales or checklists completed by informants who know the child well answer questions about the child's abilities

Key sources: World Health Organization (WHO); Demographic and Health Surveys (DHS)

II. Measures of Economic Growth

In the household-level literature on the economic impacts of health the main indicator of economic growth is individual or household income (Deaton 2007, Johnson et al. 2007, Russell 2004, Sachs 2002). In the country-level literature the real per capita Gross Domestic Product (GDP) is the most commonly used indicator of economic growth (Hickson 2014, Smith & Keogh-Brown 2013, Orem et al. 2012, Kiriga et al. 2012). Real GDP per capita adjusts for price level and population changes over time. Other measures that appear relatively less frequently but are also relevant to morbidity-growth interactions include investment rates (Asiedu et al. 2011, Azemar & Desbordes 2009) and savings rates (Baranov & Kohler 2014, Alsan et al. 2006).

Both GDP and individual/household income are affected by various other factors beyond morbidity. At the individual and household level, changes in employment and the wage rate, productivity, absenteeism, and human capital development can all affect growth (Sachs 2002). Aggregating these changes over all individuals and households has macroeconomic effects on savings and investment, the labor market, and foreign direct investment (WHO 2009). Each of these factors then leads to a change in GDP. Finally when GDP changes due to any of these or other factors, it affects the entire economy (including all the individuals and households in that economy) creating feedback loops (Deaton, 2003).

The presence of such feedback loops and other sources of measurement error have led to growing criticism of simple GDP-based macroeconomic growth models. Recently, researchers have called for a shift away from aggregate measures like GDP and a move towards measuring people's well-being, via real household income and consumption, measures of income inequality, measures to estimate the level of non-market activities, quality of life indicators, measures of health, education, personal activities and environmental conditions, and measures of sustainability (Stiglitz, Sen & Fitoussi 2010). However, as research in this area is still relatively nascent this brief continues to primarily rely upon studies of economic production like GDP.

III. Links between Morbidity and Economic Growth

A variety of theoretical pathways have been proposed linking morbidity to economic growth (summarized in *Appendix* 1).

One theoretical pathway focuses on the direct loss of well-being to an individual as the result of disease (Sachs 2002). Sick individuals have increased expenditure on health care which reduces household wealth and savings (Bloom and Canning 2008). Household earned income also falls as an individual's health declines, either due to lower productivity or higher absenteeism, both for the individual and household caregivers. Bloom and Canning (2008) describe health as a contributor to human capital, with morbidity leading to lower productivity, wages, and educational attainment. The link between health and productivity may be even more significant in developing countries where the marginal product of improved health is higher due to lower average initial health levels (Thomas and Strauss, 1998) and the dominance of physically demanding jobs (e.g., agriculture). At the macroeconomic level, the declines in

individual productivity, income and human capital development result in lower total output and diminished economic growth (Sachs 2002).

Another pathway between morbidity and economic growth focuses on life cycle consequences of illness and disability. Poor health in childhood has a negative impact on adulthood outcomes, such as adult health, earning potential, and productivity (Sachs 2002). Poor childhood nutrition can reduce cognitive ability, school attendance, and academic achievement (Bloom and Canning 2008), resulting in relatively less-educated and lower-earning adults. Poor health and poor early school performance also reduces opportunities (and incentives) to invest in secondary and tertiary education in later years (Lorentzen et al. 2008).

Intergenerational spillovers of disease represent a third pathway from morbidity to economic growth. When parents die prematurely or are ill over prolonged periods, their children can suffer from a lack of parental care and guidance, weakening the intergenerational transfer of knowledge and capacity (Bell et al. 2004). This may also result in more school dropouts as family resources run out or as children assume caregiving responsibilities (Sachs 2002). Observation of intergenerational spillover impacts of morbidity is especially prevalent in the HIV/AIDS literature, which attempts to predict such long-term effects of the disease on orphaned children. Case et al. (2005) also argue that morbidity is an important channel for the transmission of intergenerational socioeconomic status (i.e., inherited poverty). Child morbidity leads to lower human capital, productivity and earnings in adulthood. Children born to those adults then inherit the same poor health and circumstances (Sachs 2002).

In addition to the aggregate effects of the individual- and family-level pathways mentioned above, other economic consequences of morbidity include both firm-level and economy-wide impacts of disease and disability. At the firm level, morbidity reduces worker productivity and can further reduce profitability for firms due to high turnover in the workforce (Sachs 2002). Overall productivity is directly affected by the combined productivity losses of sick individuals; moreover, the cumulative impact of disease is amplified by the repeated need to reassign and train new workers (WHO 2001). This loss of human capital and associated training costs decreases firm profitability and discourages investment, including both domestic investment and foreign direct investment (Lorentzen et al. 2008).

At the national economy level, when a significant proportion of people in a country or region fall ill there are spillover effects on the entire country/region (see EPAR Brief No. 287). For instance, overall savings rates are likely to fall as households spend more on healthcare, as absenteeism reduces earnings, and as well-trained workers flee disease-stricken areas and create further productivity losses (Sachs 2002). Lower savings rates are often associated with a rise in interest rates, which can further reduce investment by limiting availability of loan funds, restricting economic growth (Odhiambo 2010, McKinnon 1973, Shaw 1973). Reduced national cognitive levels and IQ can also contribute to lower GDP growth by reducing total factor productivity, technological achievement, and innovation (Gelade 2008, Jimoh et al. 2007). And at the government level, in high-morbidity countries public health expenditures may divert scarce public resources from other important services (Bell et al. 2004). Public revenues may also fall as tax collection decreases where economic activity is depressed by high population morbidity (Sachs 2002).

All of these pathways are summarized in the diagram in *Appendix* I. Of course, the interrelatedness of the different pathways between morbidity and economic growth often makes it difficult to identify a clear causal link – and indeed in many cases the links may be bi-directional. For example there is a large literature on aggregate economic growth (e.g., GDP) as a *driver* of aggregate population health (e.g., disease incidence and prevalence) rather than a consequence of health. Rising average per capita income is also understood to be an important *determinant* of household level morbidity and mortality (Ranis, Stewart & Ramirez 2000; Filmer & Pritchett 1999) in addition to being a consequence of improved health.

The literature review method adopted in this brief seeks to clearly differentiate between studies that highlight the consequences of economic growth for improving health (not the focus of this brief) versus studies that focus on the consequences of household and population-level morbidity for economic growth (our focus here). We focus on household-level, firm-level and economy-wide studies of morbidity-growth linkages. As summarized in the following sections, there is a substantial body of evidence linking individual and population morbidity to economic outcomes – although some linkages are relatively better-studied than others.

IV. Findings: Literature on Morbidity and Growth[2]

Most of the published literature linking morbidity and economic growth is relatively recent, with almost 85% of relevant studies published after 2000, although a handful date back to as early as 1979 (see *Appendix* 3, Figure A3.1). Among relevant studies almost 85% were research articles, followed by reviews (8.6%) and conference papers (4.4%) (see *Appendix* 3, Figure A3.2).

[2] For details on the literature search method refer to Appendix 2

Figure 1a: Country of study for the empirical literature linking morbidity to individual, household and firm level growth

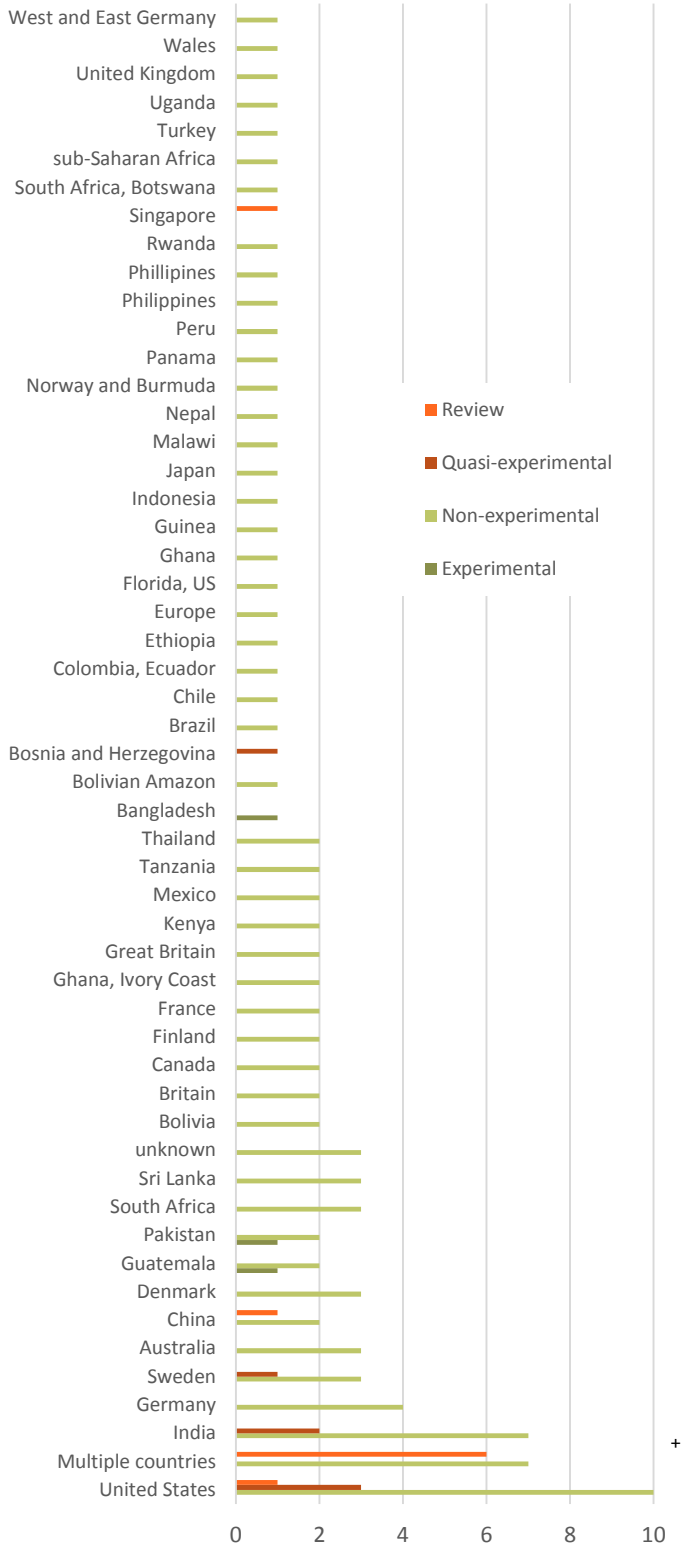


Figure 1a shows that most of the empirical studies at the individual level focus on developed countries including US, Great Britain and Canada, while others focus on developing countries such as India, Brazil, Ghana, Sierra Leone, Sri Lanka, Rwanda, Indonesia, Thailand, Egypt and Guatemala. While the economy-level studies (Figure 1b) also focus mostly on developed countries, the vast majority of them are multi-country analyses. Empirical literature for individual- or economy-level linkages exists for a wide variety of countries, however the number of studies available for any individual country is often very limited.

Figure 1b: Country of study for the empirical literature linking morbidity to economy level growth

Table 2: Studies linking morbidity measures and economic growth measures (all categories).[4]

Economic Growth Indicators	Total relevant & empirical studies: 751	Morbidity Indicators: Direct measures: HIV	Malaria	Rotavirus	Tuberculosis	Polio	Life expectancy	Self-reported health	Disability Adjusted Health Metrics: HALE	DALY	QALY	YLL	YLD	Co-morbidity	Nutritional Measures: Weight, Height, Weight-for-age, stature-for-age	WRL[5], head circumference	BMI	Stunting and wasting	Iron Deficiency	Calorie intake	Other (nutrition)	Cognition: IQ	Mental Health	Other	Vaccination	Other morbidity	Total
	Individual /HH level	41	20	13	8		12	10		33	66			21	33		25	3	5	12	43	4	30	48	34	56	517
	Firm level	8			1									3									3		1	4	20
	Economy-wide level	60	19	2	7		45	3		5	3	4	1	4	8		1	1	1	3	8	14	7	22	7	47	272
	Total	109	39	15	16	0	57	13	0	38	69	4	1	28	41	0	26	4	6	15	51	18	40	70	42	107	

Notes: This table represents results from the searches done using Scopus and Google Scholar databases.
Fields populated by the number of relevant studies (identified using the exclusion criteria defined in footnote 1) obtained in Scopus using different morbidity measures.
"Other" subcategories include results where the paper falls under a general or specific morbidity category but not in any of the coded sub-categories

Table 2 summarizes the use of different morbidity measures by level of analysis (individual/household, firm, or economy) in the published scholarship to date. The majority of studies looking at links between morbidity and growth have used an individual or household-level focus (517 papers) rather than a firm-level (20 papers) or economy-wide lens (272 papers)[3].

Table 2 further highlights the morbidity measures with the most available empirical evidence. The largest literature is for disease-specific research (including 179 papers on the 5 specific diseases considered in this review – a systematic review of diarrhea and pneumonia research is presented in Appendix 5) plus 59 additional papers on life expectancy in general) followed by nutrition (143 papers), cognition (128), and disability-adjusted metrics (112). Papers classified as "other" (96) often focused on prevalence and incidence of other specific diseases (rather than more general morbidity measures).

The shaded cells in Table 2 highlight the most commonly used morbidity indicators. Direct measures of HIV and malaria, as well as the disability-adjusted health metrics DALYs and QALYs are frequently linked to individual and household incomes. Several nutritional measures and mental health/cognition measures were also most frequently studied at the individual or household-level. Meanwhile HIV, life expectancy, "other cognition" and other morbidity measures among those most commonly linked with economy-level economic outcomes. In terms of cognition measures, IQ has been studied with relation to economy-wide growth factors while mental health studies have largely been limited to the links between mental health and individual/household income. The "other cognition" category is mostly comprised of studies of academic achievement as measured by test scores. These measures have been associated with both individual earnings and overall economy level growth.

Some studies discuss more than one measure of morbidity and link it to more than one measure of economic growth (hence the total 809 papers in this table exceeds the total sample size of 751 papers). For instance, Haacker's 2004 paper linked HIV/AIDS prevalence and life expectancy with GDP growth rate, wages, productivity, saving, and human capital development. Jack and Lewis (2009) connect malaria, HIV/AIDS, life expectancy, weight, height, and nutrition to GDP, household income, wages, productivity, savings and human capital. On the other hand, some studies do not make an explicit connection to economic growth (as measured by GDP or individual/household income) and restrict the analysis at some intermediate level. For instance, Isah et al. (2008) link malaria to decreases in productivity and absenteeism, but make no explicit link to GDP or household income growth.

The non-shaded cells in Table 2 include only a limited number of papers, and the empty cells indicate no literature investigating the impact of morbidity on economic growth. These cells represent gaps in the empirical literature, most prominently among firm-level studies in general, and among studies using disability-adjusted health measures.

Notably, although DALYs and QALYs are widely used in the health literature (Campbel et al. 2014; Rao et al. 2013), in the morbidity-and-growth literature such metrics are most often used to measure cost-effectiveness of different health interventions, rather than economic growth consequences of

[3]Some studies discuss combinations of individual, firm and economic level pathways which means that they would be double counted in these numbers.

[4] Other than the studies in this table Scopus searches were undertaken for the keywords health (7331 results) and disease (2231 results).
[5] WRL = Weight-for-Recumbent Length

Table 3: Details of empirical studies linking morbidity measures and economic growth measures – *Individual/HH & firm-level only*.

	Experimental	Quasi-experimental	Non-experimental	Meta-analysis/Systematic Review
# of Papers/ Publications	6	15	135	11
Year of publication	1970-80: 1 1981-90: 0 1991-00: 0 2001-10: 5 2011-present:1	1970-80: 0 1981-90: 0 1991-00: 0 2001-10: 2011-present: 7	1970-80: 0 1981-90: 4 1991-00: 20 2001-10: 65 2011-present: 47	1970-80: 0 1981-90: 3 1991-00: 1 2001-10: 3 2011-present: 7
Geography	Bangladesh (1); Guatemala (1); Pakistan (1); US (1); Kenya (2)	India (3); US (3); Bosnia and Herzegovina (1); Sweden (1); Botswana (1); Kenya (1); Malawi (1); South Africa (1); Paraguay (1); Uganda (1)	US (38); Multiple countries (7); India (8); Germany (4); Britain (4); Australia (3); Bolivia (3); Denmark (3); South Africa (4); Sri Lanka (3); Sweden (3); Ghana (3); Canada (2); China (2); Finland (2); France (2); Guatemala (2); Kenya (2); Pakistan (2); Philippines (2); Tanzania (2); Thailand (2); Brazil (1); Chile (1); Ecuador (1); Ethiopia (1); Europe (1) …	Multiple countries (6); China (1); Singapore (1); US (1); Mali (1)
Morbidity Measures	Disease-specific (2); DALY (1); Iron deficiency (2); Other (nutrition) (1); Mental health (1)	Disease-specific (9); Co-morbidity (1); Weight/height (1); IQ (1); Mental Health (3)	Disease-specific (53); DALY (1); QALY (4); Co-morbidity (13); Weight/height (22); BMI (16); Stunting and wasting (2); Iron deficiency (1); Calorie intake (6); Other (nutrition) (3); IQ (5); Mental health (9); Other (cognition) (17)	Disease-specific (8); DALY (1); QALY (1); Weight/height (2); BMI (1)

morbidity. For example, out of 226 studies reviewed where disability-adjusted health measures were used in some form, only 23 studies looked at links between disability-adjusted health and broader economic growth (summarized in Table 2), while 203 studies used these metrics simply as a measure of cost-effectiveness of various health interventions. Moreover, among the 23 studies linking DALYs and QALYs to economic growth in some form, we found none which provided empirical estimates of the magnitude of links between morbidity and economic growth at the individual, household or firm level or even estimated the magnitude of the economic impact of morbidity as measured by disability-adjusted metrics (as highlighted in Table 4a).

While Table 2 provides an indication of the general level of scholarly attention to the various potential morbidity-growth links, a more detailed coding of the existing literature revealed that for specific morbidity measures and specific links to individual, household or firm-level economic growth (e.g., income, wages, productivity, and human capital development) the subset of studies where empirical estimates of effects are provided is much smaller.[6] The next two sections discuss these in detail.

V. Pathways from Morbidity to Growth: Individual/Household and Firm Level

In this section we discuss the empirical findings that link morbidity to individual or household-level economic growth.

We focus on the following five morbidity measures:

1. Disease-specific morbidity
2. Disability-adjusted health metrics
3. Co-morbidity assessment
4. Nutritional measures
5. Cognitive measures

and the following four household- and firm-level economic growth measures:

1. Household Income
2. Wages
3. Productivity
4. Human capital accumulation

There are 167 studies that focus on the linkages between morbidity and economic growth at the individual, household, or firm level. Table 3 summarizes the characteristics of the 167 empirical studies that provide explicit estimates of the links between morbidity and growth at the individual, household and

[6] For the morbidity focus areas at the individual/household and firm level growth nine additional articles from a Google Scholar search were added to the systematic Scopus search list as studies meeting the criteria for inclusion; these studies are also represented in Table 3 (also see Appendix 2, Tables A2.1 and A2.2).

Table 4: Studies linking specific morbidity measures and specific economic growth measures – *Individual/HH & firm-level only*.

Morbidity Indicators																							
Economic Growth Indicators	Relevant empirical studies: 167	Direct measures						Disability Adjusted Health Metrics					Co-morbidity	Nutritional Measures							Cognition			Total
		HIV	Malaria	Rotavirus	Tuberculosis	Polio	Other diseases	HALE	DALY	QALY	YLL	YLD		Weight, Height, Weight-for-age, stature-for-age	WRL , head circumference	BMI	Stunting and wasting	Iron Deficiency	Calorie intake	Other (nutrition)	IQ	Mental Health	Other	
	HH income	1	3		4		8						3	7			2		3			5		36
	Wages	2	6				38		2	3			9	28		14		2	11	3	6	9	17	150
	Productivity/ Absenteeism/ Employment	5	7		2		60		1	5			9	35		3		1	13	1	1	6	2	151
	Human Capital Development	2	1		1		21							20		1			9	2		2	2	61
	Other	6	2		1		65		3	5			14	33		17	2	3	10	4	6	13	17	201
	Total	16	19	0	8	0	192	0	6	13	0	0	35	124	0	35	4	6	46	10	13	35	39	

Notes: Fields populated by coding on abstracts or texts of the papers.
This table represents results from the searches done using Scopus and Google Scholar databases, manually coded for relevance and content.

firm levels. Most of the empirical studies are non-experimental studies (135), followed by quasi-experimental (15), and experimental (6). An additional 11 studies are systematic reviews of literature and included in this review. The sample sizes of most of the empirical studies are large, exceeding 1,000 subjects, with the exception of the experimental studies which had smaller sample sizes.

As further summarized in Table 4[7], the 167 empirical studies of morbidity-to-individual-household-firm-level-growth links show that the most frequently used morbidity measures are either disease-specific or nutritional measures. Within nutritional measures published empirical studies primarily focus on weight-for height and calorie-intake, with some economic growth-related research on BMI. Mental health measures and other cognitive assessments are also frequently used in the empirical literature.

Household-level Pathways to Economic Impact

Figure 2 summarizes the broad theoretical pathways through which morbidity shapes economic growth, as reported in the household-level empirical literature. Unbroken lines indicate that the effect size has been investigated in the literature, while the broken lines represent links that the empirical literature refers to but for which the magnitudes are not explicitly measured. (These links can also be traced in the highlighted pathways (in yellow) in the diagram in *Appendix* I, which shows the primary pathways for which the magnitude of the effect was measured).

Figure 2: Individual, household and firm level pathways from morbidity to growth

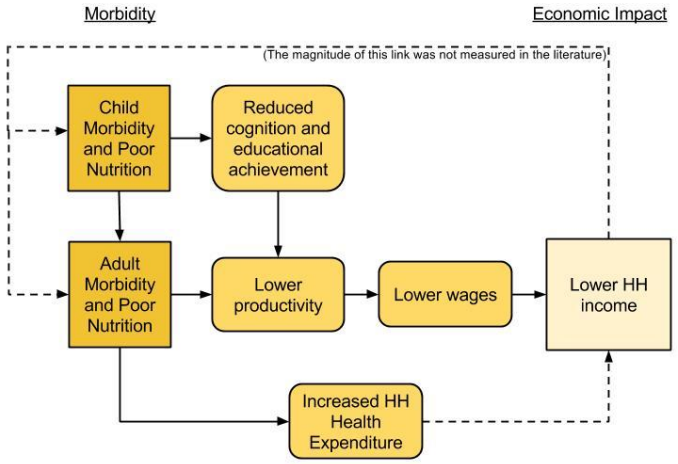


Table A4.1 in Appendix 4 shows the number of times that the various theoretical pathways were investigated in the empirical literature. Among individual and household-level studies, the most common pathway for these studies link morbidity to lost wages (47 studies). Other prominent pathways link morbidity to

[7] This table shows the links that have been identified in empirical literature linking morbidity to growth; some of the economic growth indicators might be an intermediate hypothesized link, the magnitude of which might not have been investigated in that study.

productivity losses (19 studies) and decreased cognitive functions to low wages and education levels (15 studies).

Studies that look at these pathways do not always strictly follow a single route, which means the links are not necessarily mutually exclusive.

The remainder of this section will discuss these individual pathways in greater detail drawing on examples from the most cited literature for each type of morbidity.

Child morbidity ➔ Reduced cognition/education ➔ Lower productivity ➔ Lower wages ➔ Lower household income

In studies of morbidity and economic outcomes morbidity is often divided into adult level and child level morbidity for empirical analysis, as these two morbidity types feed into each other yet also follow different pathways.

Child morbidity is believed to result in lower educational achievement due to school absenteeism and cognitive impacts of morbidity, which is reflected in lower earning potential and household income when that child reaches adulthood. For example, Patrinos and Psacharopoulos (2004) estimate that on average one year of additional schooling increases wages by about 10% in developing countries.

Cognitive problems can also lead to direct impacts on wages, even though this area has not been extensively researched. Goodman, Joyce and Smith (2011) study the impact of childhood physical and mental problems on adult life and find that the negative effect of all childhood problems (psychological, minor physical, major physical and low birth weight) on family income magnifies as the person

Major physical problems lead to a 6.7% decrease in family income at age 23, 9.9% at age 33, and 8.6% at age 50. However, among all age groups, the effects of psychological problems on net family income are found to be even higher, with family income decreases of 19.5% at age 23, 23.2% at age 33, and 30.1% at age 50. The authors believe that mental health issues lead to lower probability of employment and marriage for the individual, which is responsible for the substantial negative effect on family income.

Other studies link nutritional measures like iron deficiency to cognitive outcomes in children, suggesting an intermediate link between childhood morbidity and eventual adulthood earning potential. In a seminal study in this area, Politt (1997) reviews evidence from four countries, Egypt, Thailand, Indonesia and Guatemala, exploring the varying results of iron supplementation interventions. For example, a study in Egypt used several tests to measure cognitive ability, of which only one showed a statistically significant difference between the treatment and control groups - the Matching Familiar Figure Test. This exam tested children's ability to focus on and select visual information for problem solving. The mean number of errors for anemic children in the treatment group decreased by 6.8, whereas the control group did not have a statistically significant change. A similar study in Thailand measured cognition as IQ, Thai language skills, and math performance, but found no statistically significant effect for iron supplementation among Thai children.

A longitudinal study by Lozoff et al. (2006) followed 185 individuals (19 years follow-up, sample age 5-19) in Costa Rica and found that children with iron deficiency in infancy did not catch up with those with good iron status. The cognitive scores difference, measured by composite of standardized scores, remained at 8 to 9 points for middle socioeconomic status and rose to a substantial 25 points for low-socioeconomic status participants. The poor economic status of these families alone could not explain the loss of developmental skills caused by iron deficiency. This indicates a potential for "double jeopardy" or "double hazard" which refers to the chain of worse outcomes for individuals with both poor health and low income (Pampel and Rogers 2004, Conley and Bennett 2001, Parker et al. 1988, Escalona 1982).

Behrman and Rosenzweig find a connection between birth weight, cognitive outcomes, and earnings potential in the US (2004). Increased birth weight is associated with more years of schooling which in turn increased adult wages. The authors explain that birth weight can be affected by maternal weight and nutritional status while pregnant. Specifically, a one pound increase in birth weight is correlated with almost a third of a year more schooling and a 7% increase in wages.

(Child morbidity ➔) Adult morbidity ➔ Lower wages ➔ Lower household income

A few studies link child morbidity to poor adult health, reduced work productivity, and ultimately lower wages. Unfortunately, many of the studies in this pathway are less recent (e.g., Edgerton et al. 1979, Deolalikar 1988). Since theory suggests that this pathway is stronger for manual laborers than non-manual or skilled laborers, most studies of morbidity's impact on wages and productivity have focused on agricultural workers (Isaac et al. 2013, NcNamara, Ulimwengu & Leonard 2012). For example, Edgerton et al. (1979) studied the productivity of tea plantation workers in Sri Lanka as a function of childhood iron supplementation. The treatment group (agricultural workers receiving supplements) showed greater activity and productivity than the control group. Another study found that low birth weight reduced family income as an adult in Britain (Goodman 2011).

Konradsen et al. (1997) estimate the household economic cost of the labor days lost due to malaria and other illness in a rural community in Sri Lanka. They find that the annual economic

loss to the household ranged from 6%, of the annual household net income, for malaria to 18% for all other illnesses. These figures do not include the direct expenditure costs of these diseases. They also estimate that school children lost 10% of school days due to malaria in high transmission season.

Cole and Neumayer (2006) find a significant negative effect of poor health on total factor productivity (TFP), and this result holds within and outside of Africa – consistent for developing countries and the developed world. Undernourishment can decrease TFP by 0.17% - 0.33%. They suggest that the fall in TFP might be a result of fall in productivity as well as the weakened schooling outcomes due to poor health. However, they do not extend this analysis to investigate the effect of poor health on household income.

In one of the few rigorous studies that directly measures productive output as a consequence of morbidity, Deolalikar (1988) differentiates between short-run and long-run productivity effects of nutrition on wages in India. He finds a significant impact of weight-for-height on wages while the impact of calorie intake is found to be insignificant (although Thomas and Strauss (1997) later found this effect to be significant). Deolalikar argues that calorie intake is a short run measure that the body adjusts to within a range by consuming existing health stocks, without any significant effect on productivity or wages. However, weight-for-height is a measure of long-term nutritional effects and the continued depletion of energy resources represented by this measure will lead to substantial decreases in productivity. In a natural log regression on wages, height has a significant positive association with wages: Deolalikar (1988) finds that a 1 kg/cm increase in weight/height is associated with 1% higher agricultural wages in rural India.

A rise in wages due to height, weight, height-for-weight and BMI is, in addition to better nutrition, associated with greater physical strength and capacity (Thomas & Strauss 1997). Therefore this link may be more important for developing countries that have a high proportion of jobs requiring these physical characteristics.[8] However, more recent literature has found that the primary pathway from nutrition and height to wages is through cognitive skills rather than physical strength (Behrman el al. 2005, Vogl 2014).

Adult morbidity ➔ Health expenditure ➔ Lower household income

In addition to lost productivity, some studies investigate the increased medical household costs that can reduce financial assets and decrease household wealth. Bailey et al. (2003) find that chronic illness in Rwanda leads to a fall in savings and an increase in debt (resulting from higher medical costs), which in turn decreases household incomes.

Burke et al. (2013) study the costs of acute pediatric diarrhea in Bolivia and find that indirect costs formed a large part of the total cost incurred by the family. They estimate that the cost burden is very high as 45% of the patients' families spent more than one percent of their annual household income on each diarrheal episode. Rajeswari et al. (1999) estimate the cost of tuberculosis to patients in India and also estimate the indirect costs to be relatively high. The patient on average lost 3 months' worth of wages and11% of the children dropped out of school and an additional 8% took up jobs to support their family. Rouzier et al. (2010) estimate the patient cost for TB is 31%, while that for multidrug-resistant (MDR) tuberculosis is 223% of the average annual income in Ecuador. The high cost for MDR –TB is due to the long length of the illness – 22 months – which results in long unemployment spells.

Attanayake et al. (2002) surveyed households in Sri Lanka to determine their costs associated with malaria. On average, a household incurred a total cost of Rs. 318 (the equivalent of US$ 7, a substantial sum in Sri Lanka) for each family member who had recently recovered from malaria. The participating households had an average monthly per capita income of Rs. 820. Forty-four percent of the total cost represented diseased individuals' foregone wages and output, and another 32% represented their caretakers' loss of wages and output. These indirect costs varied across households based on their economic activities - people involved in the labor force suffered greater economic losses. Thirty-three patients lost an average wage of Rs. 502 due to absence from a paid job. Another fifteen had to hire labor to replace their lost output at a rate of Rs. 530. The average value of lost time from productive work was Rs. 364 per economically active patient.

Attanayake et al. (2002) also found morbidity was associated with increased absenteeism, further depressing earnings and productivity for both patients and their family members.

[8]The interpretation of weight and BMI is different in the developing and the developed world context. The positive relationship between weight and earnings does not always exist in developed countries as the Behrman and Risenzweig (2004) note in their US study. They use data on monozygotic twins and do not find a significant relationship between a child's birth weight and adult earnings. Cawley's main finding was a negative relationship between weight and wages - a two standard deviations difference in weight (almost 65 pounds) is associated with a 9% fall in wages for white females (2004). This is because weight (or BMI) becomes associated with obesity rather than health after a certain threshold. Diminishing marginal returns exist for increases in weight until a point when the returns become negative. Most developing countries have a low base weight which results in increasing wages as weight increases. However, for most developed countries that have a moderate to high base weight, an increase in weight may result in obesity and decrease productivity and wages.

Feedback loop (Lower HH income ➔ Child and adult morbidity)

Bloom (2008) argues that lower household income eventually loops back to affect adult and child morbidity via low educational attainment and early life nutrition. However, the magnitude of this effect has not been measured in the literature. For example, Case et al. (2005) find that infants who had poor health grew up to earn less in middle age. When those same adults became parents, their children also had poorer health and educational achievement.

Decreased mental health ➔ Decreased cognition ➔ Lower wages and employability

Mental health has been found to be an important determinant of wage rate and probability of being employed (Jones, Latreille and Sloane 2006). Studying a sample of the disabled population in Britain, Jones, Latreille and Sloane find that the probability of finding a job is lower for the disabled who have mental health problems than any other single health problems – males with any other health issue are 17% more likely and females are 12% more likely to find a job than a person with a mental health concern. However, with multiple health problems the probability of getting employed decreases by more than probability of employment for people with mental health illness. The authors speculate that employers may, for various reasons, be more reluctant to hire workers with mental health issues. When the mentally ill do find jobs, they are usually earn a lower wage-rate. One of the hypothesized reasons for this is that employers' lack access to information regarding the nature of the health problem and the limitations imposed by the particular morbidity (Jones et al. 2006).

McGurk et al. (2005) studied the effectiveness of a cognitive training program for mentally ill adults in the United States. They designed an RCT in which some participants were randomly assigned to receive both supported employment and cognitive training, while a control group only received supported employment. The cognitive training addressed attention, psychomotor speed, information processing speed, verbal learning and memory, and several other elements of cognition. Sixty-nine percent of the treatment group found employment within one year, whereas only 4.8% of the control group did. Of the employed individuals, the treatment group earned higher monthly wages (US$ 199.11 versus US$ 15.17 for the control group) and worked more hours each month (34.48 versus 2.58 for the control).

Firm-level Pathways to Economic Growth

As previously highlighted in Table 2, few published studies have directly examined productivity losses associated with health status from the perspective of the firm.

The few published firm-level studies (further summarized in Appendix 4, Table A4.2) have focused primarily on productivity, health costs, and employee turnover. Only two firm-level studies make the complete connection between individual-level morbidity, firm-level productivity / competitiveness and broader economic growth. The first is a study of employers' expenditures for asthmatic and non-asthmatic employees in the U.S. (Birnbaum et al. 2002). Annual

Table 5: Details of empirical studies linking morbidity measures and economic growth measures – *Economy-level only*.

	Experimental	Quasi-experimental	Non-experimental	Meta-analysis/Systematic Reviews
# of Papers/ Publications	0	6	106	9
Year of publication		1970-80: 0 1981-90: 0 1991-00: 1 2001-10: 1 2011-present: 4	1970-80: 0 1981-90: 2 1991-00: 12 2001-10: 64 2011-present: 28	1970-80: 0 1981-90: 0 1991-00: 1 2001-10: 4 2011-present: 4
Geography		India (1); US (1); Canada (1); Multiple countries (2); Uganda (1)	Multiple countries (40); US (5); South Africa (5); China (4); India (3); Tanzania (3); Germany (2)' Korea (2); Malawi (2); Southern California (1); Australia (1); Botswana (1); Brazil (1); Europe (1); France (1); Georgia (1); Ghana (1) …	Multiple countries (7); Europe (1); Vietnam (1)
Morbidity Measures		Disease-specific (5); YLL (1); Other (cognition) (1)	Disease-specific(65); DALY (3); QALY(1); YLL (1); Co-morbidity (3); Weight/height (4); BMI (1); Iron deficiency (1); Calorie intake (1); Other (nutrition) (2); IQ (13); Mental health (1); Other (cognition) (4)	Disease-specific (8); Co-morbidity (1); IQ (1)

Table 6: Studies linking specific morbidity measures and specific economic growth measures – *Economy-level only*.

Morbidity Indicators																							
Economic Growth Indicators	Relevant empirical studies: 121	Direct measures						Disability Adjusted Health Metrics					Co-morbidity	Nutritional Measures							Cognition			Total
		HIV	Malaria	Rotavirus	Tuberculosis	Polio	Other diseases	HALE	DALY	QALY	YLL	YLD		Weight, Height, Weight-for-age, stature-for-age	WRL, head circumference	BMI	Stunting and wasting	Iron Deficiency	Calorie intake	Other (nutrition)	IQ	Mental Health	Other	
	GDP	21	6		1		22		1	1	1		3	3				1			10	0	5	75
	HH income						14		1		1			8					5		1	1		31
	Wages	2	3				6				1			4		1					2			19
	Productivity/Absenteeism/Employment	17	6		1		28		1		3		1	11				1		1	2		2	74
	Savings	2	1				7						1											11
	Human Capital Development	7					15													1	1		2	26
	Other	6	5		1		67		3	1	5		4	6		1		1	2	2	14	1	5	124
	Total	42	16	0	2	0	77	0	6	2	11	0	9	32	0	2	0	3	7	4	30	2	14	

Notes: Fields populated by coding on abstracts or texts of the papers.
This table represents results from the searches done using Scopus and Google Scholar databases, manually coded for relevance and content.

per capita employer costs for asthmatic patients were US$ 5385, compared with US$ 2121 for the control subjects. In addition to the increased cost of health care services and disability claims, the employers faced wage-replacement costs for workdays lost by their asthmatic employees. Sporadic absenteeism represented 40% of their total cost, almost as much as the combined cost of medical care expenditures (representing 43% of total cost).

In the second, Rosen et al. (2004) estimate the cost of HIV/AIDS to businesses in southern Africa and find that HIV/AIDS among employees increased companies' annual salaries and wage bills by 0.4-5.9%. They conclude that increases in labor costs would decrease the competitiveness of the African industry, though no specific estimates of this aggregate impact are provided.

VI. Pathways from Morbidity to Growth: Economy Level

In this section we discuss the empirical findings that link morbidity to economy-level growth through a number of channels including GDP, but also wages, productivity, savings, and human capital accumulation. A total of 121 studies empirically examine the linkages between morbidity and economy level growth. As summarized in Table 5, out of these 121 studies none are experimental (not surprisingly), six are quasi-experimental, nine are systematic reviews, and the vast majority (106) is comprised of non-experimental studies. Like the household- and firm-level studies, most of the published economy-level literature on morbidity and growth is relatively recent, published after 2000.

Table 6 shows that most of these 121 studies focus on disease-specific morbidity[9]. The most commonly used nutritional morbidity measures are weight and height, and the most commonly used morbidity measure for cognition is IQ. At the economy level the most common linkage between morbidity and growth is that between GDP and morbidity-related productivity or employment.

In Appendix 4 Table A4.3 further highlights the pathways that link morbidity to economy-wide growth. As anticipated, the most commonly measured pathway considers the impact of morbidity on GDP (or inversely the cost of morbidity as a percentage of GDP). The second most frequently estimated pathway is from morbidity to productivity to GDP growth. However there are several other pathways that have not been investigated in the literature at all – the results of the most comprehensive studies available to date are briefly summarized in the following sections.

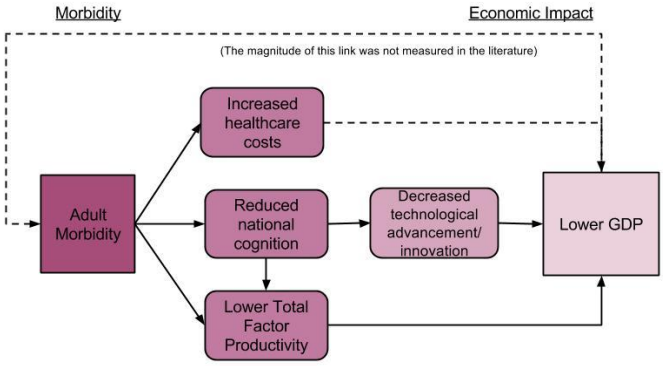
Economy-level Pathways to Economic Impact

Figure 3 summarizes the broad pathways through which morbidity affects economic growth, as they are identified in the popular economy-level empirical literature. These links can also be traced in the highlighted pathways (in pink) in the

[9] This table shows the links that have been identified in empirical literature linking morbidity to growth; some of the economic growth indicators might be an intermediate hypothesized link, the magnitude of which might not have been investigated in that study.

diagram in *Appendix* I, which highlights the pathways for which the magnitude of the effect was measured.

Figure 3: Economy level pathways from morbidity to growth



Research in the economy-level empirical literature does not always focus on just one pathway from morbidity to growth, and also does not necessarily follow these exact intermediate steps. Therefore the linkages here are not actually as clear-cut as the household-level pathways from morbidity to growth shown in Figure 2. The rest of the section will discuss these individual pathways in greater detail.

Adult morbidity ➔ Increased healthcare costs ➔ Lower GDP

Many of the studies that link morbidity to economy-level growth factors focus just on cost measurement, which includes the dollar value of the cost of a certain disease. These studies divide the cost into two categories: direct and indirect costs. Direct costs consist of both healthcare costs and non-healthcare costs like transportation. Indirect costs consist of unemployment, reduced work productivity, lost productivity due to premature mortality, and reduced caregiver productivity (Chang et al. 2008).

Iqbal (2012) examines the effects of cardiovascular disease on GDP in South Asian countries. Based on WHO estimates (WHO 2011), the projected total cost of cardiovascular disease in 2015 in terms of lost GDP will be 1.1% of GDP in Bangladesh and 17% in India. Wu et al. (2005) examine the societal costs of schizophrenia in the United States. They estimate the total cost in 2002 to be US$ 62.7 billion, which includes US$ 22.7 billion in excess direct healthcare costs, US$ 7.6 in non-healthcare excess costs, and US$ 32.4 billion in indirect costs. Muller-Riemenschneider et al (2008) performed a literature review of the societal costs of obesity in Europe. They estimate that obesity-related costs ranged from 0.09 to 0.61% of GDP in Western European countries. This estimate is comparable with the estimated percentage costs in Canada and New Zealand but significantly lower than in the United States. Unfortunately the study does not compare the costs and GDPs of developing countries.

Sobocki et al. (2006) conduct a cost-of-illness study and combine epidemiological and economic data on depression in Europe to estimate the cost. They estimate that around 4.5% of the population of 466 million in the 28 countries suffered from depression, representing a total annual cost of Euro 118 billion in 2004 (approximately Euro 253 per inhabitant). It is the most costly brain disorder in Europe forming almost 33% of the total cost and almost 1% of the total GDP of Europe.

Adult morbidity ➔ Reduced national cognition ➔ Decreased technological advancement/innovation ➔ Lower GDP

In a literature review on the economic effects of iron deficiency, Horton and Ross (2003) find that average annual productivity losses due to iron deficiency are US$ 2.32 per capita, or 0.57% of GDP. The average total losses, which include both physical and cognitive losses, are US$ 16.78 per capita, or 4.05% of GDP. Cognitive losses refer to the present value of future productivity loss associated with current childhood iron deficiency.

Rindermann (2008) examines national data from 113 countries to measure the connection between national cognitive level and GDP. He finds that the two are highly correlated with an r-value of 0.63. National cognitive level is also highly correlated with educational level (r=.78). Rindermann then uses a cross-lagged model to determine the direction of the correlation. Using a sample of 17 nations, she finds that cognitive abilities have a stronger impact on GDP than GDP has on cognitive abilities. Dickerson (2006) examines data from 81 countries and finds an exponential correlation between IQ and GDP per capita. A 10-percentage point increase in average national IQ is associated with a doubling of per capita GDP. In addition, Gelade (2008) finds that the elite group size (percentage of individuals in a population who have an IQ greater than 140) is correlated with the patent index (r=0.83 in the United States and 0.64 outside the United States). Using path analysis, he also determines that a country's elite group size positively affects technological advancement, which in turn increases per capita GDP.

Adult morbidity ➔ Lower Total Factor Productivity (TFP) ➔ Lower GDP

Weil (2007) uses microeconomic outcomes to construct the macroeconomic effect of health on economic growth, as measured by GDP per capita. Using estimates of returns to health, cross-country data as well as historical data, the study estimates that eliminating health differences among countries would reduce the variance of log GDP per worker by a significant 9.9%. Weil uses three indicators of health: average height of adult men, adult survival rate and age of menarche for women. He considers health to be an economically important factor responsible for income differences in

countries but believes that human capital from education and physical capital and residual productivity are the most important determinants of income.

Other studies demonstrate this pathway with disease-specific data. Bonnel (2000) theorizes that HIV/AIDS affects GDP growth by impeding investment in both human and physical capital. Based on data from 80 developing countries, Bonnel estimates that a typical sub-Saharan country with a 20% HIV prevalence rate would grow in GDP by 2.6 percentage points less each year than it would absent the disease. Additionally, after twenty years the country's GDP would be 67% less than otherwise.

Jimoh et al (2007) estimates the total costs of malaria in Nigeria by aggregating household data. In addition to an average of Naira 2,715 per month (US$ 22.6) in treatment costs and lost productivity, households were willing to pay Naira 7,324 per month (US$ 61) for the control of malaria. The willingness to pay approach represents a household's valuation of their intangible costs associated with Malaria. For the population as a whole, the total costs were approximately Naira 880,801 million per year (US$ 120 million), or about 12% of GDP.

Bosello, Roson and Tol (2006) estimate the growth impacts of climate change induced health effects (viz. cardiovascular and respiratory disorders, diarrhea, malaria, dengue fever and schistosomiasis) in the 8 GTAP-EF regions. They estimate the simulation results for the year 2050 in terms of variation from the no-climate-change baseline and find that labor productivity declines in Energy Exporting countries and Rest of World due to a high incidence of respiratory and gastro-enteric diseases, as well as high incidence of malaria. Labor productivity will increase in regions like USA, EU, Eastern European and former Soviet Union Countries, Japan, India and China, as these countries don't have vector-borne diseases and would rather experience a decrease in morbidity due to cold stress, related to cardiovascular diseases and heat stress related diseases. This change in labor productivity is then associated with changes in GDP.

VII. Conclusions and Research Gaps

A rich theoretical literature provides a good sense of the potential routes through which illness and disease affect economic growth. But the existing empirical literature on morbidity and growth discusses some pathways from morbidity to growth much more comprehensively than others, and many measures of morbidity used frequently in the health literature (e.g., DALYs) rarely appear in the economic growth literature.

The diagram in *Appendix* 1 summarizes the pathways found in theoretical literature and also highlights the links that have been empirically tested in the literature as the primary pathway from morbidity to growth (shaded lines). However, the empirical literature does not always consider the entire path while measuring the impact at each intermediate level. Instead the studies often skip steps or end their analysis at an intermediate point. As discussed, Politt (1997) looks at the effect of iron deficiency on cognitive impairment for children but does not link it to a change in wages or household income. In contrast, Goodman, Joyce and Smith (2011) investigate the effect of childhood morbidity on household income and do not measure the intermediate impact on cognitive functions or educational attainment. Patrinos and Psacharopoulos (2004) discuss the impact of educational attainment on wages but do not investigate why attainment might vary for children due to morbidity. In summary, there is little if any literature that rigorously investigates the entire chain of effects.

Indeed, based on this review it appears some pathways have not been examined at all. Firm-level empirical data is the most lacking in our review of the literature, as seen in *Appendix* I, but there are also notable gaps in the household and economy level pathways. For instance, there is no literature that attempts to measure the impact of increased household health expenditure on changes in educational attainment, which would lead to changes in wages and income. Additionally, there was limited empirical information about FDI and tourism, the brain drain of skilled workers as a result of disease, and national budget consequences of morbidity. The magnitudes of intergenerational spillovers were also not estimated by any study in our literature sample. Yet such spillovers clearly amplify pathways from childhood morbidity to adult outcomes, through effects on the following generation of children.

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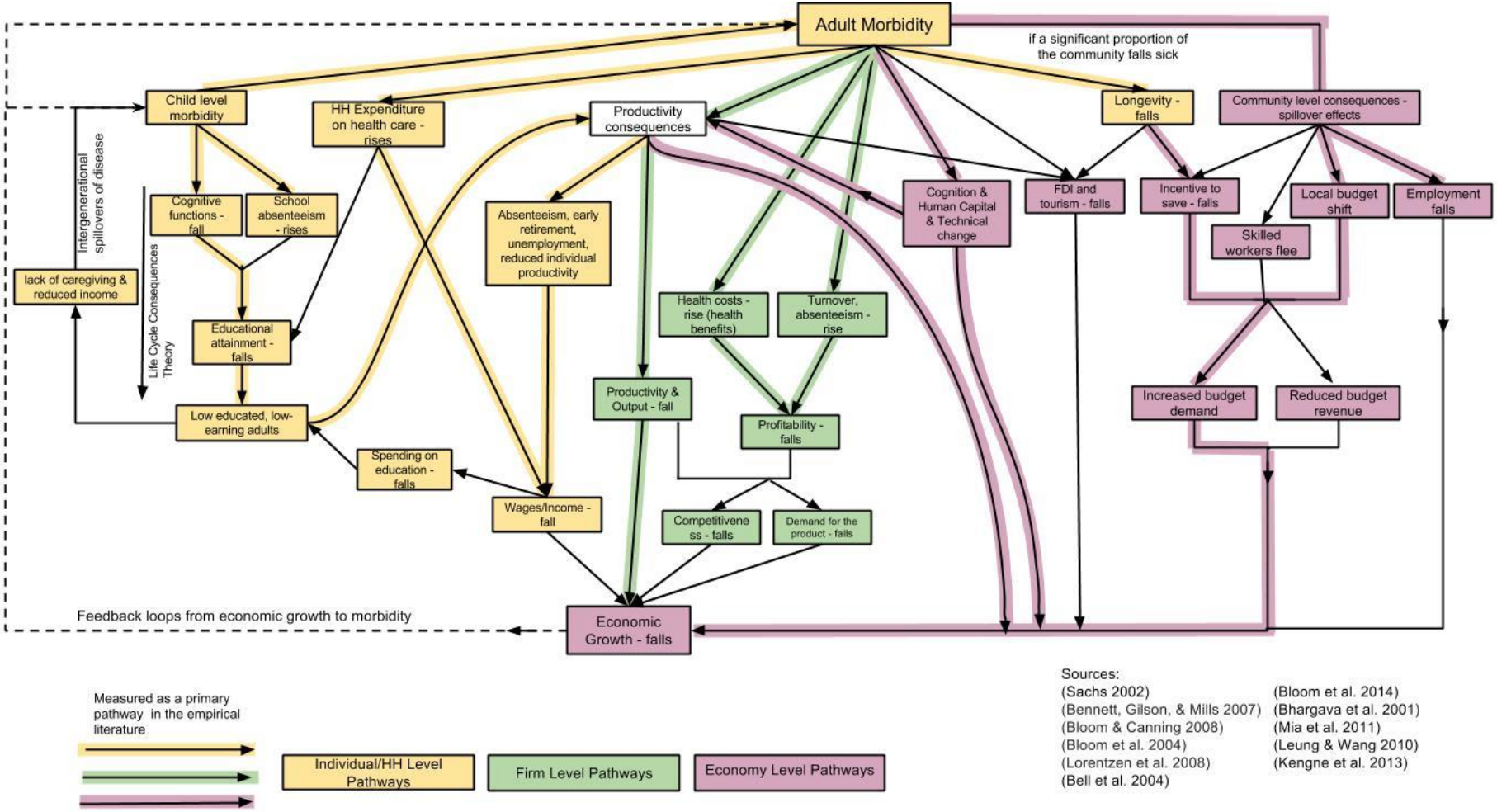
Appendix I. Summary of Pathways from Morbidity to Economic Growth

This diagram differentiates between individual/household-level, firm-level and economy-level channels to economic growth (color-coded). It is not a comprehensive list of pathways but it integrates theory from the core literature in this field.



Appendix 2. Keyword and Search Results

Literature Search Method

In order to identify the pathways from morbidity to growth that have been established in empirical literature, we undertook a systematic literature search using the Scopus academic database, supplemented by the broader (but less reliable) Google Scholar search tool. Boolean search strings were based on each of the different measures of morbidity (from Table 1) and keywords including "economic growth", "GDP", "income", "human capital" and related terms.

For example, the search string

TITLE-ABS-KEY(("Disability Adjusted Life Years" OR DALY) AND ("economic growth" OR GDP OR GNI OR wage* OR (income* AND "economic growth") OR (productiv* AND "economic growth")))*

returns 84 results for published papers in the Scopus database where the title, abstract or keywords include some combination of DALYs and economic growth terms. These 84 papers were then manually coded for relevance to this review as described below (all keyword search terms and summary search results are provided in *Appendix* 2).

Initial Scopus searches using broad keywords such as "health" and "disease" alongside economic growth indicators returned 7,331 results for "health" and economic growth, and 2,231 results for "disease" and economic growth. A narrower search using the specific morbidity search terms drawn from Table 1 returned 3,948 items of published literature. Manually coding these papers for relevance based on titles, keywords and abstracts[10] resulted in a refined sample of 673 empirical studies of the links between morbidity and economic growth.

Of these, 461 studies focused on household and firm-level pathways from morbidity to growth; the 229 studies focused on national aggregates (e.g., GDP growth) with a little overlap where the same study focused on the household-, firm- and economy-level pathways. From the subset of household and firm-level studies we further coded for level of analysis including specific morbidity and growth measures used, and specific morbidity-growth linkages explored and/or measured. This included reading the study in detail to determine if the impact of morbidity was measured using individual income growth (a household-level indicator), GDP growth (a national-level indicator) or some intermediary growth indicator, like productivity, human capital development, aggregate wage rates, foreign direct investment (FDI), or savings rates (*Appendix* 2, Table A2.1).

Finally, a supplementary search using Google Scholar to identify any well-cited literature that may have been missed through the Scopus keywords yielded an additional 106 potentially relevant studies, which were narrowed down to 78 empirical studies of the links between morbidity and economic growth. These studies focused on individual, household, firm and economy level pathways. Of these 95 studies, 48 looked at the individual, household and firm level linkages between morbidity and economic growth and 34 focused on the economy level pathways. (See *Appendix* 2, Table A2.2).

Keywords used for the Scopus searches

morbidity, health, disease, Tuberculosis, Rotavirus, Malaria, Polio, HIV, disease index, life expectancy, self-reported health, self-assessed health, Healthy Life Expectancy (HALE), Disability Adjusted Life Years (DALY), Quality Adjusted Life Year (QALY), Years of Life Lost (YLL), Years Lived with Disability (YLD), comorbidity, Charlson Comorbidity Index, nutrition, weight, height, weight-for-age, stature-for-age, weight-for-recumbent-height, head circumference, BMI, stunting and wasting, iron deficiency, calorie intake, cognition, IQ, mental health, Patient Health Questionnaire, Generalized Anxiety Disorder

10 The exclusion criteria were: (i) Study focused on only health measures; (ii) Study focused on only growth measures; (iii) Study irrelevant to health or growth; (iv) Study focus was links from economic growth to morbidity, rather than morbidity to economic growth; (v) Study was relevant but no empirical analysis undertaken.

Table A2.1: Scopus Keyword and search results

Keywords searched	Total Number of Search Results	First-cut				Second-cut	
		Relevant Studies	Relevant and Empirical Studies	Relevant, Empirical and Individual/HH/ Firm level Studies	Relevant, Empirical and Economy level Studies	Relevant, Empirical and Individual/H H/Firm level Studies - Morbidity Focus Areas	Relevant, Empirical and Economy level Studies - Morbidity Focus Areas
morbidit*	326	104	87	47	44	23	34
health*	7331						
disease*	2213						
Tuberculosis	99	16	15	8	7	4	3
rotavirus	29	13	12	11	1	1	
malaria	109	27	19	9	14	7	11
polio	5	0	0	0	0		
HIV*	309	79	71	32	47	11	29
“disease index”	0	0	0	0	0		
“life expectancy”	572	60	39	6	33		
“self reported health” OR “self assessed health”	25	8	7	6	1		
“Healthy life expectancy" OR HALE*	10	0	0	0	0		
"Disability Adjusted Life Years" OR DALY*	84	38	37	32	5	4	5
"Quality adjusted life year" OR QALY*	119	69	69	66	3	12	2
"Years of Life Lost" OR YLL*	11	4	4	0	4		4
"Years Lived with Disability" OR YLD*	2	1	1	0	1		1
comorbidit* OR co-morbidit* OR comorbid*	85	28	27	23	4	12	4
"Charlson comorbidity index"	4	2	2	2	0	2	
nutrition*	728	66	50	43	8	25	3
"weight-for-age" OR "stature-for-age" OR height OR (weight AND height)	226	33	32	28	5	25	
"weight-for-recumbent length" OR “head circumference”	4	0	0	0	0		3
BMI	92	26	26	25	1	21	
stunted OR stunting OR wasting	66	4	4	3	1	3	
“iron deficiency”	12	7	6	5	1	2	1
“calorie intake” OR calori*	156	16	13	11	2	8	1
cogniti*	397	92	62	47	22	26	15
IQ	65	29	17	4	14	4	12
“mental health” OR “Patient health questionnaire” OR “Generalized Anxiety Disorder”	291	38	37	31	7	17	6
vaccinati*	112	36	32	28	4		
TOTAL	13492	796	673	467	229	207	134

Note: The light grey shaded cells represent the keywords that were used but they were not coded; the dark-grey shaded cells were not part of the morbidity focus area defined in Section VI.
Note: The first-cut refers to the initial level of coding done using the title, keywords and abstract. The second cut refers to the second level of coding done using the text of the studies.

Table A2.2: Google Scholar Keyword and search results

Morbidity Measure	First Cut				Second Cut	
	Relevant Studies	Relevant and Empirical Studies	Relevant, Empirical and Individual/HH/Firm level Studies	Relevant, Empirical and Economy level Studies	Relevant, Empirical and Individual/HH/Firm level Studies - Morbidity Focus Areas	Relevant, Empirical and Economy level Studies - Morbidity Focus Areas
HIV/AIDS	30	24	13	12	8	12
Malaria	15	13	10	4	9	4
Other Disease-Specific	13	12	9	3	6	2
Life Expectancy	19	13	5	10		
Nutrition	8	0	0	0	0	0
Weight and/or Height	4	2	1	1	1	1
Vaccination	12	9	6	3		
Self-Reported Health	5	5	4	1		
TOTAL	106	78	48	34	24	19

Note: The dark-grey shaded cells were not part of the morbidity focus area defined in Section VI.
The first-cut refers to the initial level of coding done using the title, keywords and abstract. The second cut refers to the second level of coding done using the text of the studies.

Appendix 3. Graphs on Literature Descriptives

Figure A3.1: Date of publication of the empirical literature linking morbidity to growth.

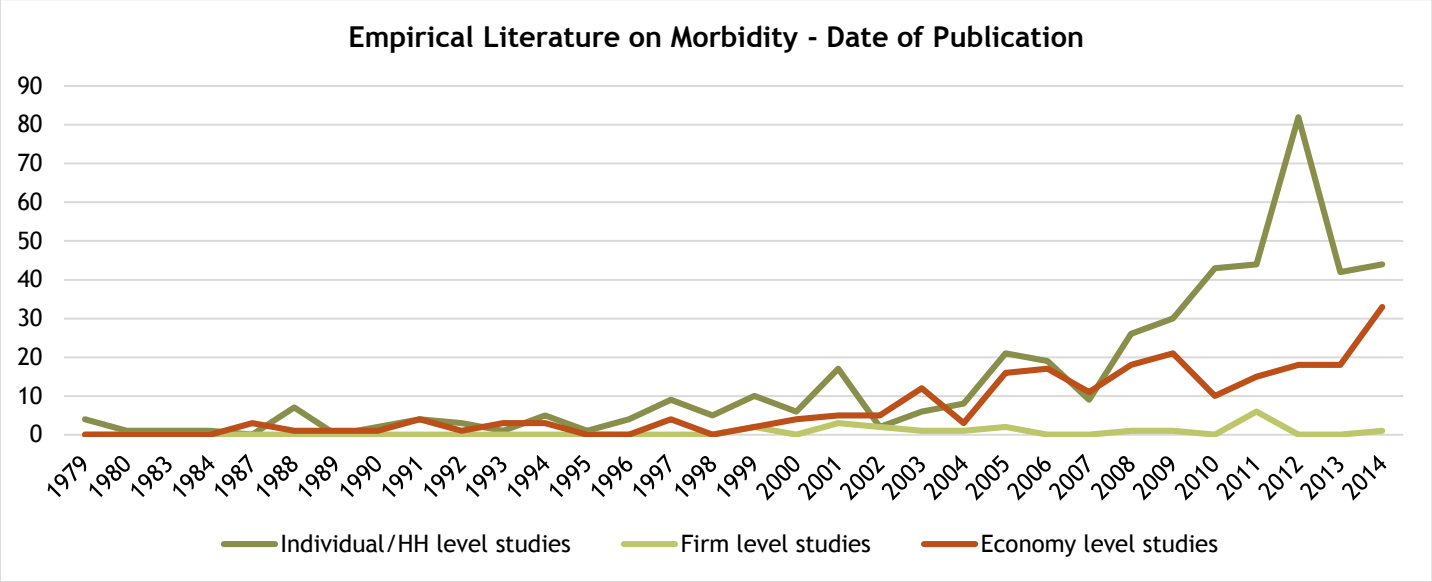
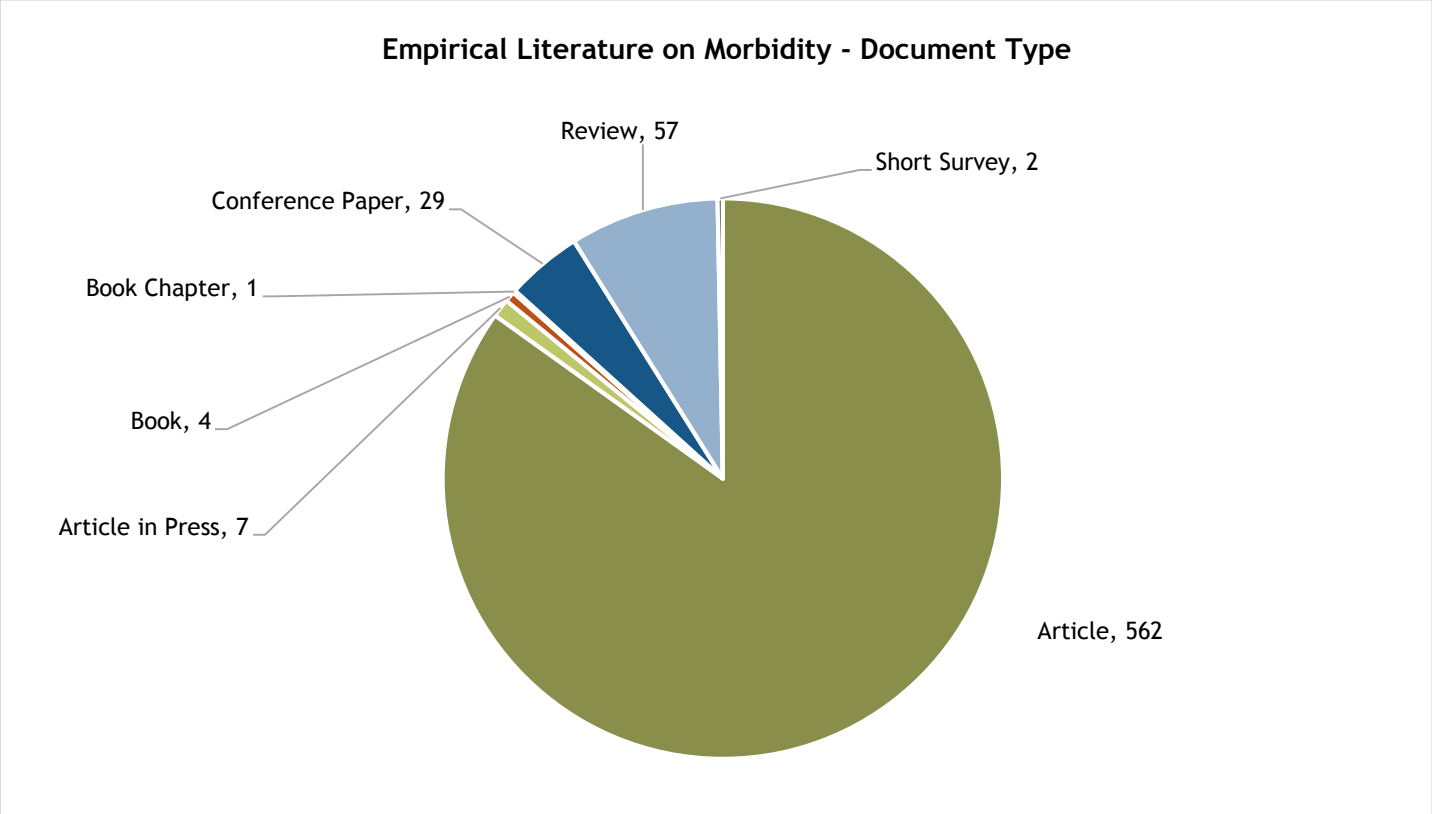


Figure A3.2: Document type among the empirical literature linking morbidity to growth.



Appendix 4. Primary pathways investigated in empirical literature

Table A4.1: Individual/Household-level primary pathways investigated in empirical literature

First Step	Second Step	Third Step	Final Step							
			Income Falls	Lost Wages	Lost Wages (caregivers)	Productivity	Low educated, low-earning adults	Unemployment	Educational Attainment	School Absenteeism
Adult Morbidity	Absenteeism	Lost Wages	1							
		None		2		3				
	Impaired Cognitive Functions						2			
	Early Retirement		1	1						
	Increased Household Expenditure		3							
	Lost Wages		3							
	Low Productivity			3						
	School Absenteeism						1			
	Unemployment			3		1				
	None		1	47	2	19		2		
Child Morbidity	Adult Morbidity	Lost Wages				1				
	Impaired Cognitive Functions	Low Educational Attainment, Low-earning Adults	1							
		None					1			
	Educational Attainment			1			4			
	School Absenteeism				1					
	None		2	2	2		1		1	2
Impaired Cognitive Functions	Low Educational Attainment	Low-earning Adults	1							
	None			1			15			
Low Educational Attainment	None						2			
School Absenteeism	Low Educational Attainment						1			

Table A4.2: Firm-level primary pathways investigated in empirical literature

First Step	2nd Step	Final Step				
		Economic Growth Falls	Health Cost	Productivity and Output Fall	Profitability Falls	Turnover and Absenteeism
Adult Morbidity	Low Productivity and Output	1				
	Health Costs				2	
	Turnover and Absenteeism				2	
	None		1	3		1

Table A4.3: Economy-level primary pathways investigated in empirical literature

First step	Second step	Third step	Final step								
			Cognition	Cost measurement	Employment	GDP	Income	Increased budget demand	Productivity	School absenteeism	Total Factor Productivity (TFP)
Morbidity	Increased Budget Demand					1					
	Impaired Cognitive Functions					4					
	Health Expenditure					1					
	Low Productivity	Impaired Cognitive Functions				2					
		None				14					
	Low Technical Change					1					
	Low Trade, Investment, Savings and Tourism					1					
	None		1	5	5	29	3	1	13	1	
Cognition	Low Productivity					2					
	None					13	1				1

Appendix 5 – Systematic Review of Pathways between Diarrhea and Pneumonia, and Economic Growth

Additional searches were conducted for pneumonia and diarrhea, using Scopus and PubMed[11]. Out of a total of 2439 studies, 38 were relevant (Table A5.1) based on the criteria described in Appendix 2.

Table A5.1: Scopus and PubMed Keyword and search results

Keywords searched		Total Number of Search Results	First-cut				Second-cut	
			Relevant Studies	Relevant and Empirical Studies	Relevant, Empirical and Individual/HH/ Firm level Studies	Relevant, Empirical and Economy level Studies	Relevant, Empirical and Individual/HH/Firm level Studies - Morbidity Focus Areas	Relevant, Empirical and Economy level Studies - Morbidity Focus Areas
Scopus	Pneumonia*	20	1	1	1		1	
	Diarrhea*	88	4	4	3	1	3	1
PubMed	Pneumon*	1460	20	20	14	6	14	6
	Diarrh*	871	13	13	12	1	12	1

Note: The first-cut refers to the initial level of coding done using the title, keywords and abstract. The second cut refers to the second level of coding done using the text of the studies.

As Table A5.2 shows, a majority of the studies that link pneumonia and diarrhea to growth have an individual- or household-level focus (63.1%) rather than firm-level (15.7%) or economy-wide (21%) focus. Most of the evidence linking diarrhea and growth is at the individual level (15 out of 17) while there is a greater mix for studies linking pneumonia and growth (9 for individual/household level; 6 for firm level; 6 for economy-wide level).

Table A5.2: Studies linking morbidity measures and economic growth measures (all categories)

		Morbidity Indicators		
		Diarrhea	Pneumonia	Total
Economic Growth Indicators	Individual/ HH level	15	9	24
	Firm level		6	6
	Economy-wide level	2	6	8
	Total	17	21	

Notes: This table represents results obtained in Scopus and PubMed using different morbidity measures (identified using the exclusion criteria defined in footnote 1).

A more detailed coding of these 38 empirical studies, in Table A5.3, shows that 32 of these were relatively recent non-experimental studies, most of which were published after 2000. The six quasi experimental studies were also published after 2000. Almost half of the studies were conducted in the developing world (four out of the six quasi-experimental studies; 18 out of 32 non-experimental studies). None of the studies were meta-analyses or systematic reviews which points towards a potential gap in these areas.

Table A5.3: Details of empirical studies linking morbidity measures and economic growth measures

	Experimental	Quasi-experimental	Non-experimental	Meta-analysis/ Systematic Review
# of Papers/ Publications	0	6	32	0
Year of publication		1970-80: 0 1981-90: 0 1991-00: 0 2001-10: 1 2011-present: 5	1970-80: 0 1981-90: 0 1991-00: 3 2001-10: 11 2011-present:15	
Geography		USA (3); Netherlands (1); Bolivia (1); India (1)	USA (8); Multi-country (3); Canada (3); Pakistan (2); India (2); Italy (2); Bolivia (1); Thailand (1); Brazil (1); Hungary (1); Fiji (1); Hong Kong (1); Kazakhstan (1); Malaysia (1); Spain (1); Taiwan (1); Thailand (1); Uganda (1); UAE (1)	
Morbidity Measures		Pneumonia (4); Diarrhea (2)	Pneumonia (17); Diarrhea (15)	

[11] Since the search engines that EPAR generally uses may miss some disease-specific literature, we added PubMed for our searches on diarrhea and pneumonia.

As further summarized in Table A5.4, most of these studies link morbidity (for both diarrhea and pneumonia) to effects on productivity, absenteeism, or employment. A small proportion of the studies link morbidity to GDP or household income.

Table A5.4: Studies linking specific morbidity measures and specific economic growth measures

	Morbidity Indicators			
Economic Growth Indicators	Total relevant and empirical studies: 38	Diarrhea	Pneumonia	Total
	GDP	1	1	2
	HH income	4		4
	Wages			
	Productivity/Absenteeism/Employment	12	21	33
	Human Capital Development			
	Other			
	Total	17	22	

Notes: Fields populated by coding on abstracts or texts of the papers. This table represents results from the searches done using Scopus and PubMed databases, manually coded for relevance and content.

Household-level Pathways to Economic Impact

The theoretical pathways through which diarrhea and pneumonia shape economic growth are listed in Table A5.5. Nine of the 24 empirical studies for the individual and household level pathways link child morbidity directly to lost wages of caregivers, while four studies make the connection to lost wages via school absenteeism. Three studies link adult morbidity directly to lost income while one study finds lost income as a result of decreased productivity. Seven studies directly link adult morbidity to a reduction in productivity.

Table A5.5: Individual/Household-level primary pathways investigated in empirical literature

First Step	Second Step	Third Step	Final Step					
			Lost Income (including caregiver wages)	Productivity	Low educated, low-earning adults	Unemployment	Educational Attainment	School Absenteeism
Adult Morbidity	Low Productivity		1					
	None		3	7				
Child Morbidity	School Absenteeism		4					
	None		9					

The remainder of this section will discuss these pathways in greater detail using examples from the most cited literature from developing countries.

Child morbidity ➔ Lower productivity ➔ Lower household income

Lee, Chai and Ismail (2012) investigated the emotional and financial distress suffered by parents of 85 children in Malaysia who were hospitalized due to acute diarrhea. They discovered that the emotional toll on the parents includes worry, mental and physical exhaustion, loss of sleep, and disruption of daily routine. The financial cost (including both out-of-pocket costs and lost income) is estimated at a significant US$ 253, which was almost 16% of average family monthly income in the sample.

Conducting primary research in Pakistan, Malik et al. (2012) also find that, in addition to the direct cost of illness, households bear a substantial amount of indirect cost due to loss of earning. The direct cost of illness can be anywhere between US$ 0.6 to US$ 2.3. On top of that, the indirect cost can be up to US$ 2.3 for the below-poverty-level group that has an average daily income of US$ 1.97. Similarly, for the low income group with an average daily income of less than US$ 3.93, the indirect cost of illness is up to US$ 3.5 a day.

Child morbidity ➔ Lower household income

For 2,600 children hospitalized with diarrhea in Taiwan, Chen et al. (2007) found that a family of unskilled or service workers spent more than 40% of their monthly income on treatment. Similarly, Mendelsohn et al. (2008) state the median household expenditure for rotavirus and all-cause diarrhea in Vellore, India is 2.2% to 5.8% (including the direct medical, non-medical and lost income). A similar estimate for the economic burden (including direct medical and non-medical costs and productivity losses) of childhood diarrhea on the households was studied by Rheingans et al. (2012) using data from Bangladesh, India and Pakistan. They found that the mean household cost is about US$ 1.82 in Bangladesh, US$ 3.33 in India, and US$ 6.47 in Pakistan. A large proportion of this cost is medical cost, but the cost was lower for poorer households than the non-poor households, and it was lower for girls than for boys. This points towards the lower ability of the poorer households to spend on healthcare and also reflects gender discrimination against girls (Chen et al., 2007).

Adult morbidity ➔ Lower household income

Six of the 11 studies focused on developed countries like the US, Netherlands and Italy. Of the remaining studies relevant to developing countries, a cohort study by Ronak et al. (2013) used a systematic longitudinal survey to estimate the household cost of an episode of diarrhea in a Mumbai slum. The direct cost is estimated at Rs. 291, but productivity loss and lost wages increase the total cost to a Rs. 409 for each household. In five weeks' time during the study, the community lost a total of Rs. 163,000 (US$ 3,635) to diarrhea.

Firm-level Pathways to Economic Impact

Table A5.6 shows the firm-level pathways that link diarrhea and pneumonia to economic growth. Most of the studies

reviewed measure the effect of morbidity on total health costs, but one estimates the effect on productivity.

Morbidity ➔ Lower productivity ➔ Firm health cost rises

All studies but one only estimated this pathway for the United States. The only study conducted in the developing world is a cross-sectional study in Brazil with Single Systems of the National Social Security Institute (INSS) and National Register for Social Information data (Ildefonso et al., 2009). Respiratory diseases represent 1.3% of all sickness benefits for employees. In this category, pneumonia, asthma, COPD and diseases of the vocal cords and larynx are the most common. The total sick leave due to these diseases amounts to 5,157,537 days, and represents a cost of R$ 110,570,837. The cost of social security benefits is not included in this figure.

Table A5.6: Firm-level primary pathways investigated in empirical literature

First Step	2nd Step	Final Step				
		Economic Growth Falls	Health Cost	Productivity/ Output	Profitability Falls	Turnover and Absenteeism
Adult Morbidity	Low Productivity and Output		3			
	None		2		1	

Economy-level Pathways to Economic Impact

Table A5.7 summarizes the pathways linking diarrhea and pneumonia to economic growth at the economy-wide level. Three of the nine studies reviewed link morbidity to decreases in income while six link it to fall in productivity. However, only two of the six studies focus on developing countries.

Adult morbidity ➔ Lower productivity

As with the firm-level growth linkages, most of the pathways for economy-level growth also focus on developed countries. One of the studies on developing countries (Tichopad et al., 2013) uses data from the health ministry and insurance reimbursement claims for a pneumonia diagnosis in the Czech Republic, Slovakia, Poland, and Hungary. They find the total healthcare costs to be EUR 12,579,543 (CZ); EUR 9,160,774 (SK); EUR 22,409,085 (PL) and EUR 18,298,449 (HU). They also estimate that almost 90% of this cost is the direct cost of treatment.

Child morbidity ➔ Lower productivity ➔ Fall in income

Latipov et al. (2011) estimates the societal cost of rotavirus cases for children under five in Kazakhstan. The study observed almost 4,000 severe, 30,700 moderate and 122,900 mild cases of rotavirus each year with societal costs of US$ 454, US$ 82, and US$ 21 per case, respectively. They also estimate the total cost at US$ 37.5 million of which 94% was indirect costs due to productivity losses and parents' absences from work.

Table A5.7: Economy-level primary pathways investigated in empirical literature

First step	Second step	Third step	Final step								
			Cognition	Cost measurement	Employment	GDP	Income	Increased budget demand	Productivity	School absenteeism	Total Factor Productivity (TFP)
Morbidity	Low productivity						1				
	None					1	1		6		

From this analysis we conclude that the total cost of diarrhea and pneumonia is substantial for households and developing economies. However, the lack of evidence for the developing world represents major gap in this literature.

Appendix 5 References

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