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The Days After COVID-19: A Meta-Analysis on the Impact of Epidemics and Pandemics on Long-Term Macro-Economic Performance

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ABSTRACT

During the COVID-19 pandemic, the future of the global economies appears gloomy as policy, industry and academia stakeholders assess the immediate adverse effects. This research meta-analysis studies on the impact of epidemics and pandemics on the longer-term performance of national economies covering the past 30 years. The findings indicate that the impact of pandemics on economies for periods of over two years might move from the immediate adverse effects to small positive effects. Several moderators were found to affect this relationship, including socio-economic and methodological factors. The findings agree with a significant amount of existing literature and are in line with the neo-classic economic theories for a possible return to economic growth after a major economic shock. Nevertheless, issues of publication bias should also be taken into consideration.

KEYWORDS

Meta-Analysis, Pandemics, Macroeconomy, Covid-19

INTRODUCTION

Amidst the COVID-19 pandemic, the topic of the impact of pandemics on the economic performance of national economies around the world has never been more contemporary. Several epidemics occurred during the twentieth century, namely (i) the ‘Spanish’ flu (1918-19), (ii) the ‘Asian’ flu (1957) and the ‘Hong Kong’ flu (1968). The 21st century has been characterized by the outbreaks of ‘Acute Respiratory Syndrome’– SARS (2002), ‘Bird flu’ or ‘Swine flu’ (2009-10), ‘Middle East Respiratory Syndrome’ – MERS (2012), and Ebola Virus Disease – EVD (2013-14) (Gössling et al., 2020), with the current COVID-19 pandemic resembling previously experienced pandemics (Maffioli, 2020).

The first immediate impact of pandemics is on human mortality. The ‘Spanish’ flu infected at least one-third of the world population (≈ 500 million people) (Taubenberger & Morens, 2006) with the total death toll estimated at ≈ 20 -50 million (Taubenberger et al., 1997; Taubenberger et al., 2006). COVID-19 is responsible for 456,973 deaths as of June 20th, 2020 (WHO, 2020). Its impact on national economies has been equally dramatic. The economic crisis caused by COVID-19 could also cause between 5.3 million and 24.7 million people worldwide to lose their jobs by the end of 2020 (International Labor Organization – ILO, 2020). Additionally, the world’s top 5000 multinational enterprises have announced a 9% average decline in earnings, ranging from 6% in developed economies to about 16% in the developing world (UNCTAD 2020a). More recently, the World Bank (2020) reported that exports declined by 5.7% year-on-year in February 2020 due to COVID-19.

An epidemic is an event in which a disease has grown out of control and is actively spreading, often within one country or location (Maital & Barzani, 2020). The World Health Organization (WHO, 2018)

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defines a pandemic as ‘an outbreak of a new pathogen that spreads easily from person to person across the globe’. Based on the WHO study (2018), a total of 1,307 epidemic events (epidemic and pandemic diseases) in 172 countries were registered during the 2011-2017 period. Looking at the continents, the largest number of epidemics occurred in Africa, Asia, and Europe, while on a country level, the USA, the Democratic Republic of Congo, and China had the most epidemic events (≥ 30). As a pandemic starts in a particular location as an epidemic, for this study, the term ‘epidemic events’ will be used for both epidemics and pandemics.

The impact of epidemics and pandemics is a mix of direct and indirect effects on public health, a country’s macroeconomy, and its businesses. The direct impacts of illness, disability, or death can affect a large population over a limited time and create strong pressures on health care and other public services (Maital & Barzani, 2020). Studies on past epidemic events also identified that the loss of a productive workforce through mortality and illness leads to an increase in economic costs, especially during severe pandemics such as the 1918 influenza (Boissay & Rungcharoenkitkul, 2020) and COVID-19 (International Labor Organization, 2020). Although the majority of the studies indicate a sharply negative impact on global economies, companies (Boissay & Rungcharoenkitkul, 2020) and individuals (MacIntyre, 2020; Shigemura et al., 2020), epidemic events are not universal in their nature and type and neither are they homogeneous in the way they affect macroeconomic performance or individual businesses. The amount of disruption generated and the duration depend on the time, location, severity, and duration of the event, as well as its management and the ability of particular actors to prevent damage as well as their resilience in driving the recovery (Liu et al., 2005; Sadique et al., 2007). Additionally, social, political, cultural, economic, and geographical or climate-related factors define the epidemic event’s impact on a particular population or economy (Bleakley, 2010; Carrasco et al., 2011; Kieny et al., 2014; Kalabikhina, 2020).

Due to the various factors mentioned above, which influence the degree and severity of the impact of epidemic events on macroeconomic performance, the findings of individual studies are heterogeneous. A meta-analytical study can offer an opportunity for aggregating and generalizing diverse findings, thus elaborating the impact of epidemic events on macroeconomic performance irrespective of the specific conditional variables (Mamelund et al., 2019; Singh & Misra, 2020). This work is the first on this topic with the research objective of comprehensively investigating the impact of epidemic events on macro-economic performance and identifying the role of key moderators.

In this study, we included a large number of moderating and control variables – socio-economic and methodological – and we ensured that issues such as publication bias were addressed with robust statistical methodology. Theoretically, this study tests and contributes to the neoclassical economic model where the destruction of capital and labor will adversely affect economic growth at least on an immediate and short-term basis before recovery on a long-term basis (Jonung & Roeger, 2006; Brahmabhatt & Dutta, 2008; Bachman, 2020).

Academically, the study will enhance the existing research on the impact of epidemics on macroeconomic performance, unveil gaps, and reveal future research opportunities. Policy and industry stakeholders will benefit from a clear indication of the elements of this impact across geographic, political, or cultural borders, and thereby understand the strategic options available to them.

THEORETICAL CONTEXT

Neoclassical economic theories have a strong presence in the literature on epidemics and pandemics (Eichenbaum et al., 2020; Jordà et al., 2020; Trotter et al., 2020). They explain the relationship between epidemic events and macro and microeconomic performance largely as a disruptive event affecting economic growth by creating a substantial decrease in the available supply of productive factors in

the economy. Solow (1956) and Barro (1991) identified capital accumulation as the engine for growth. Thus, with low capital levels, growth will slow down. The reasons indicated are government expenditure diversion towards prevention and management of the epidemic events (Ma et al., 2020; Souza, 2020). Also, raising the costs of a country's borrowing after a lower rating of their economy following the epidemic event even if the cost of borrowing followed a declined trend before the epidemic. This happened during the years prior to COVID-19 (Hall, 2018; Blanchard, 2019). Nevertheless, adjusted risk evaluations and downgrades in countries' sovereign credit score resulting from the COVID-19 pandemic could further increase the cost of public borrowing and limit countries' ability to mobilize fiscal resources on international capital markets, as suggested by OECD analysis (2020b).

Such shocks can broadly decrease productivity across many economic sectors, with strong immediate and short-term effects, yet with a limited effect on the countries' long-term economic health. Effectively, economies will readjust to their pre-crisis states so long as underlying dynamics and growth factors are intact (Adam et al., 2020). Even more, based on the neoclassic Schumpeterian theory of creative destruction, we hypothesize that the sign of the impact coefficient will be positive due to the adoption of new technologies that promote new growth cycles (Bloom et al., 2018; Bedford et al., 2019; Maital & Barzani, 2020) or due to government spending on the management of the epidemic (Açikgöz & Günay, 2020; Ma et al., 2020; Souza, 2020).

Despite their strong presence in the literature, these theoretical stands have been subject to intense criticism (e.g., Pasinetti, 2000) in explaining the impact of pandemics on economic growth (Eichenbaum et al.; 2020; Estola, 2020). Eichenbaum et al. (2020) found that the neoclassical model does not rationalize the positive co-movement of consumption and investment that is observed in recessions associated with epidemic events. Economists also connect the mass distress of firms during recessions with Schumpeter's creative destruction theory (1934). This suggests that during downturns, the small, less efficient and younger firms are those that exit the market. Accordingly, their exit allows for more efficient firms to expand and prosper, thus lifting overall productivity.

Djankov and Evans's analysis (2020) provided the evidence on balance suggesting that Schumpeter's theory of creative destruction in a distressed economic environment is substantially robust in Western Africa, yet also holds true for a global sample of emerging and developing economies. Larger and more experienced firms with more sales and high numbers of employees are predicted to fare considerably better than younger, less experienced, and smaller firms in the developing world. Nevertheless, the magnitude of the possible corporate insolvency may dictate government intervention and that is something of which Joseph Schumpeter would have disapproved.

Technologies should not only focus on the medical research fields but also on productivity or process improvement (Akpan et al., 2020; Sarkis et al., 2020) if they are to have an impact. However, the investment in tackling epidemic events in developed countries is different compared to the investment in the developing world, thus the impacts are different. Ravallion (2020) suggested that some of the policies employed in wealthy countries are not feasible in poor places or have fewer benefits compared to the costs. Thus, new challenges are emerging as the virus spreads into developing countries. Government spending on long-term innovation and skills development (Abi Younes et al., 2020), investment in security, prevention of future epidemics (Pan et al., 2020), and incentives to SME (Didier et al., 2021) are a way of attempting to mitigate the negative influences of the epidemic events. Faria et al. (2020) suggested a model of macroeconomic determinants (e.g., total income, income per capita, tax burden, infrastructure, and globalization) of self-employment, and that model could potentially be adapted to include epidemics and economic measures to fight it.

Based on the neoclassical model of economic growth, the Cobb-Douglas production function (Cobb & Douglas, 1928) outlines how long-term economic growth results from a combination of three main forces: labor, capital and technology. The neo-classical theory clarifies that these three factors are

particularly related to long-term growth making the model appropriate for this study (Dimand & Spencer, 2009). The Cobb-Douglas production function is often applied (e.g., Hajkova & Hurník, 2007; Alani, 2012; Dritsaki & Stamatiou, 2018) and it presents the key role of technological advancements without which economic growth cannot continue. Technology augments labor productivity and hence increases labor's output capabilities.

The Cobb-Douglas production function is specified as in Cheng & Han (2014):

$$Y = AL^{\beta_1} K^{\beta_2} \quad (1)$$

Where Y denotes output or total production, A represent productivity attributed to existing technology, K represents capital and L denotes labor. β_1 and β_2 represent output elasticities for labor and capital.

The model is a useful tool for calculating the contribution of production factors in the economy, but limited in capturing the influence of a number of variables that moderate the relationship between pandemics and economic performance. Cheng & Han (2014) propose a change in the original equation for including aspects such as a disruptive event, in this case pandemics and issues related to economic policy, development, resources or political environment, education and human capital, presented as dummy variables impacted on output level.

In this modified version of Cobb Douglas model, elasticity coefficients are estimated using a simulated annealing algorithm which provides rapid convergence and precision. Results are then compared with the general C-B production function. Simulated annealing algorithm provides slightly higher R squared as compared to general C-B approach.

The contribution of labor to economic growth:

$$\frac{\Delta Y_L}{\Delta Y} = \beta_1 \left(\frac{1}{y} - \frac{1}{l} \right) \ln(1 + l) + \beta_1 \quad (2)$$

The contribution of capital to economic growth:

$$\frac{\Delta Y_K}{\Delta Y} = \beta_2 \left(\frac{1}{y} - \frac{1}{k} \right) \ln(1 + k) + \beta_2 \quad (3)$$

The contribution of technological progress

$$\frac{\Delta Y_A}{\Delta Y} = 1 - (\beta_1 + \beta_2) - \beta_1 \left(\frac{1}{y} - \frac{1}{l} \right) \ln(1 + l) - \beta_2 \left(\frac{1}{y} - \frac{1}{k} \right) \ln(1 + k) \quad (4)$$

l, k – growth rates of labor and capital.

$$\ln(1 + l) \approx l \quad (5)$$

$$\ln(1 + k) \approx k \quad (6)$$

Elasticity coefficients β_1, β_2 can be estimated by least squares or by simulated annealing for higher precision as in Cheng & Han (2014).

The Cobb-Douglas production function is subject to criticism (Labini, 1995; Gechert et al., 2019), with neoclassicists emphasizing the role of governments in investing in innovation with specific R&D

focus on sectors of the economy, while evolutionary and institutional economists consider the social and institutional environment in their models for the impact of labor, capital, and technology on economic growth (Sredojević et al., 2016).

LITERATURE REVIEW

From the neoclassic theoretical perspective presented above, epidemic events and macroeconomic performance are closely related to the adverse impact evident in both developed and developing countries (Bloom et al., 2018; McKibbin & Fernando, 2020). McKibbin and Fernando (2020) estimated total GDP loss of up to \$9.2 trillion due to COVID-19 in 24 industrial nations, while Gössling et al. (2020) projected that the global economy will shrink by approximately 9%.

In developed countries, the effects are noticed in a reduction of the GDP and FDI, shocks in stock markets, higher inflation, and disruptions in trade and supply chains (Açikgöz & Günay, 2020; OECD, 2020; UNCTAD, 2020a).

The adverse impacts on the GDP, FDI, or stock market can be explained by trade and supply chain disruptions that are also consequences of epidemic events. The COVID-19 pandemic has already influenced changes in consumer expenditure and inflation (Cavallo, 2020; Tokic (2020). In addition, unemployment also increases during epidemic events. As an example, 3.3 million workers filed initial claims for unemployment insurance in the days following the declaration of COVID-19 as a pandemic (Gangopadhyaya & Garrett, 2020). This is no surprise, as studies by Baldwin (2020), Bachman (2020), and Maital and Barzani (2020) showed that COVID-19 and its containment policies have directly reduced the flow of labor to businesses, created a disruption in supply chains and markets, and caused factory closures worldwide. This moved the global economy from one point to another.

Similarly, UNCTAD (2020b), noticed that the containment measures in China will greatly affect the European Union, the US, Japan, Korea and Taiwan (Boissay & Rungcharoenkitkul, 2020) which is in accordance with a previous study by Jonung and Roeger (2006) that showed that production bottleneck effects rose in the EU sectors dependent on inputs from other countries such as China.

The majority of sectors suffer and only a few benefit from epidemic events, as shown by previous research (e.g., Bloom et al., 2018). As countries adopt quarantine measures, their activities are limited in trade, tourism, and aviation (Maliszewska et al., 2020). An example is Hong Kong's decrease in travel, tourism, and retail by 43% due to the SARS epidemic (Siu and Wong, 2004). A substantial effect could be also noticed in public transportation and entertainment due to an increase in people's perceived risk of disease (Sadique et al., 2007).

Correia et al. (2020) estimated that the COVID-19 pandemic curtailed manufacturing by around 20%. On the contrary, the study of Hassan et al. (2020) identified that some firms (e.g., pharmacies) experienced opportunities due to an increased demand for supplies, or others try to adapt to the changed conditions (Maital & Barzani, 2020). Nevertheless, it is mostly the indirect effects of fear and psychological problems that lead to the loss of productivity and decreased consumption due to measures of isolation (Jonung & Roeger, 2006; Boissay & Rungcharoenkitkul, 2020). However, as the study of Smith et al. (2009) showed, a certain 'transition point' has to be reached before fear can induce a behavioral change that will greatly increase the economic impact of a pandemic.

In developing nations, political and economic conditions and poor institutions can scale up the severity of epidemic events (Bleakley, 2010; Kieny et al., 2014). Additionally, Burkle (2020) showed that autocratic nations are the ones that fail to manage health crises.

Social and cultural issues can also influence the consequences of a pandemic and its spread. The most important is the frequency of social contacts, hygiene customs, previous epidemic experience, self-preserving behavior, and the population's response to government measures (Moran & Del Valle, 2016; Kalabikhina, 2020). The educational and skill level of workers can also influence the spread of a

pandemic and economic performance (Sadique et al., 2007). For example, Dasgupta and Murali (2020) showed that containment policies were less effective in controlling disease spread among low-skilled workers because they choose to work more onsite.

The spread of a pandemic among countries can be influenced also by climatic seasonality (Carrasco et al., 2011; Neher et al., 2020), climate change (Bloom et al., 2018), and air pollution (Clay et al., 2018). Finally, the study done by Ma et al., (2020) showed that countries with higher government expenditures during the first pandemic year will suffer smaller declines in output growth and the negative effect on GDP is felt less.

The reasons behind the diverse and dissimilar impact of epidemic events between developed and developing countries can be further elaborated when moderating variables are taken into consideration. The literature indicates that developed countries are in a better position to prevent and manage the impacts of epidemic events by investing resources in surveillance for early disease detection, health care (Daszak et al., 2020), the establishment of international trade policies (Stephens, 2017), the implementation of emergency financial packages (Mallet & Dombey, 2020), and the implementation of airport control measures (Chung, 2015). Previous experience in similar events or technological advancement strongly moderates the way epidemic events impact the economy (Bedford et al., 2019; Bloom et al., 2018).

Further moderating variables identified in the literature related to income level, population growth, the ratio of economically active population, trade openness and FDI activity, education and life expectancy. In health economics, these factors have been primarily conceptualized through the economic resilience and vulnerability indices. For instance, it is suggested that high life expectancy at birth is associated with economic resilience because the former is indicative of social development in the nation (Briguglio et al., 2006). Life expectancy can affect economic growth through the return of investments in human capital i.e., a high life expectancy at birth means a high return of human capital investment through state expenditure and, therefore, stimulated economic growth. On the other hand, life expectancy can also affect the severity of health epidemics within populations (Trias-Llimos, 2020).

Similar to life expectancy, education is regarded as a good indicator of social development which is conducive to economic growth (Briguglio et al., 2006). Nations with high literacy and school enrolment rates are most likely to be socially developed. This leads to a skilled citizenry that can participate in the control of health epidemics. The ratio of the economically active population is crucial because a higher population of economically inactive (aged 0 to 14, and 65 and older) individuals is likely to diminish output/productivity growth and lead to negligible economic growth (Bidisha, 2020). Further, economically inactive individuals are normally vulnerable to health issues leading to a burdened health system (Harwood, 2004).

The level of a country's development relates to economic resilience through macroeconomic stability. Macroeconomic stability is constructed using indices such as fiscal deficit to GDP ratio, unemployment and inflation rate, and the external debt to GDP ratio (Briguglio et al., 2006; Röhn et al., 2015). Developing and undeveloped countries would have lower or least macroeconomic stability and thus, be vulnerable to economic shocks such as health epidemics. Similarly, countries with lower national income would be least stable and consequently, vulnerable.

While trade openness is conducive to economic growth, it is regarded as having a direct impact on economic growth such that when economic shocks like health epidemics occur, countries with the least stock market development are negatively affected (Huang & Chang, 2014; Keho, 2017). Such a relationship would influence the relationship of our study's interest.

Although there is an overall consensus in the literature that the immediate impact of epidemic events on economies is negative, the duration of the impact has been disputed in the academic work and has proven to be short-term (Jonung & Roeger, 2006; Brahmhatt & Dutta, 2008; Dixon et al.,

2010; Sharif et al., 2020). It lasts a few months during the pandemic year with recovery the next year, or long-term (Bloom et al., 2009; Guimbeau 2020; Jordà et al., 2020), lasting from several years or decades after the pandemic has been eradicated. The basis of the argument is the fact that as policy instruments are activated by governments to address the pandemic's economic consequences, rapid growth and recovery are noticed in the quarter following the pandemic with some firms and industries experiencing growth even during the epidemic (Hassan et al., 2020; Maital & Barzani, 2020). The positive impact of epidemics on long term macroeconomic performance with stronger growth is evident in the literature. For example, a sharp GDP decline was followed by a fast rebound in Hong Kong, Singapore, and Taiwan (Brahmbhatt & Dutta, 2008). Also, the study done by Jonung and Roeger (2006) showed that the negative consumption shock in the first quarter of the pandemic represented a positive shock on savings spent in the quarters after the pandemic Jordà et al.'s study (2020) found that real wages were somewhat elevated following the major pandemics that were investigated.

During the COVID-19 pandemic and diverse and thought-provoking discussions in the literature, a meta-analytical study can incorporate all these different positions and attempt to draw clear, comprehensive conclusions on the long-term impact of epidemics, thus guiding further academic research and policy-related decisions. By considering the theoretical context of neoclassical economics and the literature presented above, we postulate the following hypotheses:

H1: Economies will recover from the negative impact of COVID-19 exhibiting positive economic performance in the long-term.

H2: The impact of epidemic events on macroeconomic performance is moderated by the stage of a country's development and respective indicators of:

H2a: Trade openness and FDI (economic indicators)

H2b: Population growth and productive age, education, life expectancy (social indicators)

H3: Authors' methodological choices moderate the results of the relationship between epidemic events and macro-economic performance.

DATA COLLECTION AND METHODOLOGY

SELECTION OF STUDIES

We have heeded the meta-analysis of economic research guidelines developed by Havránek et al. (2020) in conducting a rigorous, reproducible, and systematic present study. The strength of the meta-analytical methods lies with the fact that, if carefully constructed and implemented, it can assist scientists to determine the extent to which published evidence tends to confirm or disagree with a specific subject under investigation (Noble Jr, JH, 2006). Furthermore, the synthesis of knowledge is completely transparent in meta-analysis and it can uncover the relationships between results in primary studies and their methodological characteristics (van Bergeijk & Lazzaroni, 2015).

Eligible studies were selected based on three criteria: a) should be investigating health epidemics/pandemics and economic growth, b) should report estimates of health epidemics/pandemics and economic growth coefficient and t-statistics and c) have replicable estimation methods, sample period, and country.

The search for studies was conducted in ABI Inform, RePEc, EBSCOhost databases, ScienceDirect, EconLit and Google Scholar using the following keywords: 'economic growth', 'GDP', 'GDP per capita', 'growth rate', 'real GDP per capita' with 'AND/OR' Boolean operators to combine the aforementioned search words with the following: 'pandemic', 'health epidemic', 'yellow fever', 'Spanish flu', 'Dengue

fever', 'coronavirus', 'Severe Acute Respiratory Syndrome', 'SARS-cov-2', 'Covid-19', 'MERS-cov', 'HIV', 'Human immunodeficiency virus', 'HIV/AIDS', 'malaria', 'Avian flu', 'swine flu', 'H1N1 flu', 'Ebola virus', 'Zika virus', 'Bubonic plague', 'tuberculosis', 'cholera', 'polio', 'measles', 'viral haemorrhagic fever', 'typhus', 'smallpox'.

This search yielded 121 results across all searched databases. The search was then expanded to linked citations accompanying identified studies on the databases. We identified 16 additional studies by following this approach. We then screened for duplicates and removed 4 studies. Finally, 134 studies remained for further screening, of which 50 were qualitative and thus excluded from further screening as the main interest in meta-analyses is quantitative studies. A further search was performed on the bibliographies of the above studies for extra relevant studies. However, no quantitative studies were identified from this step. Next, we screened the full text of the identified studies for eligibility and removed 49 studies which the researchers found did not entirely meet the study criteria. 35 studies remained eligible for inclusion.

The PRISMA diagram, A1 in Appendix A, shows the process of selecting studies and Table A3 presents the full citation of included studies in this meta-analysis. For each reported estimate in the study, we extracted factors other than the outcome and predictor variables which we conjectured may influence the relationship we were investigating.

Our search ended on April 30th, 2020. The search produced a total of 35 studies published over 23 years. In the sample, the average short-term period was established to be 14.4 months while the average long-term period was found to start from 2 years continuing for decades to periods longer than 35 years.

Detailed information about studies included in the overall meta-analysis is presented in Table A1 including the number of estimates and independent variable(s) extracted from each study. Studies contain 340 empirical estimates on the effect of health epidemics on economic growth. Table A2 presents the full list of variables, including both controlled and methodological variables processed in this study.

DEPENDENT VARIABLE

Economic growth was defined as 'the value of all goods and services produced by a country at a specified time' (Roser, 2013). This variable includes nominal GDP, GDP per capita, and GDP growth rate.

INDEPENDENT VARIABLE

Health epidemics – defined as 'the occurrence of more cases of disease than expected in a given area or among a specific group of people over a particular period of time.' (Dicker et al., 2006). This definition includes pandemics as they begin as epidemics. This variable is coded to include COVID-19, HIV/AIDS, avian influenza, H1N1, Ebola virus, Dengue fever, Zika virus, Spanish flu, polio, measles, smallpox, typhus, cholera, malaria, MERS-CoV, SARS, bubonic plague, and yellow fever.

MODERATING VARIABLES

The term 'moderating variable' indicates a variable that can strengthen, diminish, negate, or otherwise alter the association between independent and dependent variables (Allen, 2017). Used as part of the hypotheses, they are identified in the literature and are required as part of the study to evaluate how the relationship between IV and DV is regulated (Paulssen & Birk, 2007; Vij & Farooq; 2017). They provide the benefit of insight on the issues that influence the relationship between dependent and

independent variables and make it stronger, weaker, or even disappear (Oktaviyani & Munandar, 2017).

Driven by the literature presented earlier, several moderating variables were identified as they explain how the predictor and outcome variables interact and thus, influence the strength of these variables. The detailed list of variables is presented in Table A2. Moderating variables are related to a country's development, income, population level and age, trade openness and FDI activity, education, and life expectancy.

Moderating variables reflecting methodological issues that might impact the findings were also identified and analyzed, such as the methods and data sources of the selected studies and publication bias. Methodological issues need to be controlled as they can not only introduce validity issues through not having appropriately accounted for confounding themselves, but they can also affect the precision of estimates in the study (Nakagawa & Santos, 2012). Several methodological factors were assessed, such as whether the study data was panel, time series or cross-sectional, whether the study considered lags or performed dynamic regression, whether the study analyzed a single region and hence had homogeneity, whether the authors adjusted for endogeneity, and whether the study used Generalized Method of Moments or an Error-Correcting Model regression.

We also included the type of database used as we found that most studies used World Bank in conjunction with World Health Organization data. Sourcing data from one database could negatively influence the study estimates as it may introduce statistical dependence and consequently, be a source of heterogeneity. As such, the data source should be controlled for in the meta-regression. Due to collinearity issues regarding regions and development status, researchers ended up using sub-Saharan Africa and OECD as proxies for regions. These regions are materially different and often grapple with region-specific epidemics. Development status also indicated collinearity with the t-statistic when stratified and constructed independently as 'developed' and 'developing' variables. In the end, we constructed a binary variable equal to 1 if a primary study accounted for development status which was expressed as income level in many instances.

We also had to control for dependent and/or independent variable-specific factors. Factors such as whether the study used nominal GDP, GDP per capita, or growth rate and whether the researchers log-transformed the type of economic growth measure they used. Health epidemic-specific adjustments were related to whether the study used cases per capita, cases per 100 000 population, total cases, mortality rate, or crude number of deaths. The decision to control for these factors was made because using plural measures may have introduced variation or heterogeneity to the study.

ESTIMATING THE AVERAGE EFFECT

Estimating the average effect is a critical step in the meta-analysis as it gives the combined estimate of the impact of health epidemics on economic growth (Harbord & Higgins, 2008). If not applied, a meta-analytic study cannot be conducted.

Due to the variation in estimation methods in primary studies, a standardized measure of effect had to be used to reconcile differences. Therefore, we extracted t-statistics to transform it into a correlation coefficient we could use to estimate the average effect size. T-statistics were often reported in primary studies and in instances when it was not, p-values and standard errors were reported in conjunction with the regression coefficient. For the studies that did not report t-statistics, we calculated them using the reported p-value and coefficient or standard error and coefficient. However, t-statistics are not in themselves a standardized measure as they are largely determined by degrees of freedom in studies. As such, we further standardized t-statistics using the partial correlation coefficient that is a common measure of association in meta-analyses (see Doucouliagos & Larocche, 2009; Klomp & Valckx, 2014). Correlation is calculated as:

$$r = \frac{t}{\sqrt{(t^2+df)}} \quad (7)$$

where t is the t -statistic and df is the degrees of freedom that could be estimated from the primary study. We also computed the standard error (SE) of the partial correlation to reflect the distribution of the partial correlation coefficients as they are limited to the interval -1 and 1. The SE was then calculated as:

$$SE = \sqrt{((1 - r^2))/df} \quad (8)$$

THE AVERAGE EFFECTS RESULT

Table 1 presents this study's average effect estimate which essentially is the main meta-analytical function. This result indicates that the simple average effect of health epidemics on economic growth is 0.111. According to the partial correlation coefficient (PCC) cut-off criteria provided by Doucouliagos (2011), the PCC value suggests that there is a small, positive effect of health epidemics on economic growth. A PCC value is considered 'small' if its absolute value lies between 0.07 and 0.17, 'medium' if the absolute value is between 0.17 and 0.33, and 'large' if the value is greater than 0.33 (Doucouliagos 2011).

Further, the average effect of health epidemics on economic growth was 0.294 and 0.123 for the fixed and random effect on studies, respectively. According to Doucouliagos' (2011) criteria, these results respectively indicate a medium and a small effect of health epidemics on economic growth because the values fall between the absolute values 0.17 and 0.33 for the fixed effect and 0.07 and 0.17 for the random effects of the meta-analysis. Both fixed and random effects indicated that the effect sizes are detrimental with heterogeneity with the I-squared indicator ($I^2 > 75\%$). This indicator is evident in the table below and it means that there is irreconciled variability (heterogeneity) observed in primary studies. Consequently, a meta-regression analysis must be performed to assess and integrate that variability. Therefore, the following sections of this study will be dedicated to assessing and integrating potential sources of the heterogeneity observed. They will investigate the variables that have a stronger impact on the relationship between epidemics and economic growth.

Table 1. Partial Correlation Coefficients for the Effect of Health Epidemics on Economic Growth

Number of Estimates		340	
Averages	PCC	95% Confidence Interval	
Simple Mean	0.111	0.066	0.156
Fixed Effects	0.294***	0.292	0.296
Random Effects	0.123***	0.070	0.176
Tau-Squared Random Effects	0.2291		

Notes: ‘Estimated effect’ refers to the estimated partial correlation coefficient assessing the relationship between health epidemics and economic growth. ‘Average’ is the conventional mean of all primary study estimates. ‘Fixed effects’ refers to the weighted average which is constructed from the inverse of the standard error of the partial correlation. ‘Random effects’ refers to the former but adjusted for heterogeneity across estimates.

META-REGRESSION

The meta-regression technique is an extension of a meta-analysis which is used to assess how identified control variables moderate the average effect estimate. It is necessary in the face of substantial heterogeneity during the meta-analysis (as explained in Table 1). As a result of the observed heterogeneity, a meta-regression has to be conducted as it is an integrative method of reconciling the variability we have been alerted to. It is also used to assess which study factors influence the meta-analysis results so that we can understand the results in their context and within the merit of their methodological framework (Harbord & Higgins 2008).

As the first step towards our meta-regression, we will examine publication bias. Publication bias is a common concern amongst academics and occurs because of institutional preference for certain research outcomes. These research outcomes could be a certain theoretical framework or estimates aligned with the conventional statistical level of evidence (Sutton et al., 2000). The presence of publication bias across primary studies and in a meta-analysis may obscure the true average estimate effect and introduce heterogeneity. To avoid this, we assessed for publication bias using the traditional Egger's regression test and various weighted least squares (WLS) regression methods. This test was originally proposed by Egger (1997) and is based on the linear regression method like the regression methods used alongside it. The reason for using different methods is to ascertain that the result we observe is not only a consequence of chance. If there is a presence of publication bias in this study, the partial correlation coefficient will have a relationship with its standard error and the result will be statistically significant. The Egger's test is similar to most meta regression-based tests and is modelled using the formula:

$$effect_i = \beta_1 + \beta_0 SE_i + a_k Z_k + \varepsilon_i \quad (9)$$

Where $effect_i$ is the t-statistic representing the effect of health epidemics on economic growth, SE_i is the standard error of the partial correlation coefficient, Z^k is a vector of meta-explanatory variables accounting for variations across studies including k elements and a_k represents the meta-regression coefficient which controls for study characteristics effect. ε is the error term.

The WLS regression methods are represented by a similar equation:

$$effect_i = \beta_1 + \beta_0 SE_i + X + \varepsilon_i \quad (10)$$

Where effect j is the t-statistic representing the effect of health epidemics on economic growth, SE_j is the standard error of the partial correlation coefficient, X is the vector of control variables and ε is the error term. This is a basic equation of the WLS regressions though. Others like the fixed and mixed-effects model would include clustering, unknown vector of random effects and a covariance matrix to account for statistical dependence in our estimates.

Secondly, we expand the meta-regression model to adequately account for within-study and between-study variance. An often-cited pitfall of a meta-analysis is that it revolves around the average effect estimate and does not adequately account for study-level factors and variation (Greco, 2013). Equation (3) can alert us to possible heterogeneity through the I-squared and Tau-squared statistics. However, it does not help us to explain the nature of said heterogeneity. So, the model we employ should be able to account for the inherent divergence of empirical estimates. This meta-regression model is given by:

$$\theta_K = \theta + \beta_1 x_1 + \beta_n x_n + \varepsilon_k + \zeta_k \quad (11)$$

Where θ_k is the effect size of the study k , ε_k and ζ_k represent two independent errors usually found in meta-analytic studies i.e., sampling error (represented by ε_k) and the error, represented by ζ_k , from variation in the distribution of the true effect estimate (Harbord & Higgins, 2008). The concept of heterogeneity occurs when individual studies significantly deviate from the center of the true estimates' distribution (Borenstein et al., 2009). In our study, there was substantial heterogeneity observed. Our interest is to explain primary studies' deviation from the center of the distribution by examining study characteristics and estimation methods in eligible studies. The result will be the identification of a) how moderating and control variables moderate the relationship between health epidemics and economic growth, and b) the direction of the influence i.e., whether the variables negatively or positively influence the relationship of our interest. The next section presents the results of these meta-regression tests and models in detail.

META-REGRESSION RESULTS

Figure 1 and Table 2 present the result of publication bias assessment. The funnel plot shows primary studies that all fall within the whole study average effect estimate indicating less likelihood of publication bias. This test, however, cannot be taken as a definite answer as it is visual and thus, subjective to the researchers. As a result, regression tests are explored next.

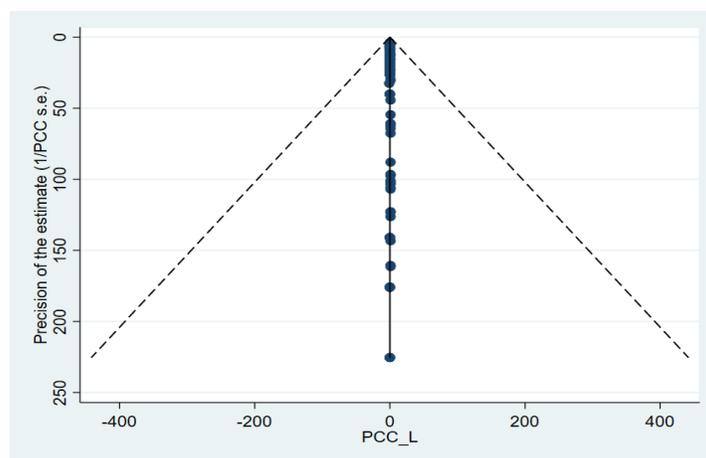


Figure 1.

The robust linear regression, fixed effects, and mixed-effects regressions indicated a statistical presence of publication bias in the study with observed values of -0.034 (p-value < 0.001), -4.381 (p-value < 0.001) and 0.897 (p-value < 0.001), respectively. Both Egger’s test and the PET-PEESE method confirm publication bias, with both p-values being less than 1%. Observing statistically significant regression results, there seems to be publication bias in favor of negative effects. The PET-PEESE method is considered a robust method because it uses the inverse of the PCC standard error to assess for publication bias which means more precision in its estimation (Alinaghi & Reed, 2018).

Table 2. Publication Bias Assessment

	(1)	(2)	(3)	Long-run		(6)	(7)
	WLS Clustered	WLS, Robust	Fixed Effects, Clustered	(4) Mixed- Effects	(5) Instrumental Variable, Clustered	Egger’s Test	PET- PEESE Method
Publication Bias	0.031 (0.29)	-0.034 *** (0.00)	-4.381 *** (0.04)	0.897 *** (0.29)	0.120 (0.15)	35.410 *** (3.87)	-2.386 *** (0.38)
Constant/ True Effect	-0.628 (4.38)	0.951 *** (0.24)	157.835 *** (1.50)	-16.939 *** (6.16)	4.459 (3.69)	-237.971 (196.19)	0.316 *** (0.03)
Number of Observations	327	327	327	327	327	327	327

*significance at 10 per cent level
 ** significance at 5 per cent
 *** significance at 1 per cent

Table 3 presents the second estimations in our meta-regression. All interpretations presented are based on statistical significance thresholds derived from the p-values at 10%, 5% and 1% level and are represented by asterisks.

Statistical significance means the observed relationship or influence on the relationship from study data is not due to chance but can be attributed to a specific factor (Greco, 2013; Harbord & Higgins, 2008). The meta-regression is on region, development status and economic growth indicators. Column

1 presents regional characteristics and development status. The result shows that studies reporting the effect of health epidemics on economic growth in sub-Saharan Africa (SSA) and OECD or studies that considered development status could be regarded as the sources of heterogeneity between and within studies. The impact of the pooled development status on the relationship between epidemics and economic growth is positive. However, when countries were grouped by their actual development status i.e., SSA vs OECD countries, the relationship changed. This indicates variability in the influence of development status on the relationship between health epidemics and economic growth. For instance, a strong negative impact of health epidemics on economic growth was observed in SSA. An opposite effect was observed in OECD countries. The variation in both the SSA and OECD samples reflect differences of political and developmental factors in these regions. As a result, these variables moderate the impact of epidemics on macro-economic performance.

In column 2, all measures of economic growth are associated with heterogeneity and moderate the studies' findings. GDP and GDP per capita were found to moderate the long-term impact of epidemic events on macro-economic performance and have a strong impact on this relationship, though the direction differs which may then explain the observed heterogeneity.

Studies that used GDP growth as an indicator of economic performance found a strong negative impact of epidemics. On the other hand, studies using the nominal GDP and GDP per capita as economic performance indicators mainly reported a positive effect. Although all these indicators can be useful in measuring economic performance, the most precise estimate emerges from GDP growth (Henderson et al., 2011).

Table 3. Region, Development Status, Economic Growth Indicators and Estimation Methods

	(1)		(2)		(3)	
	Coeff. (SE)	Z- value	Coeff. (SE)	Z- value	Coeff. (SE)	Z- value
Constant	-5.56 (2.34) **	-2.38	10.24 (3.09) ***	3.32	12.80 (11.17)	1.15
Inverse Std. Error	0.31 (0.03) ***	10.39	0.27 (0.03) ***	7.87	0.33 (0.04) ***	8.42
Sub-Saharan Africa	-6.98 (2.92) **	-2.39				
OECD Countries	15.46 (3.38) **	4.58				
Development Status	5.63 (2.80) **	2.01				
GDP			14.32 (3.94) ***	3.64		
GDP Per Capita			6.04 (3.20) *	1.89		
GDP Growth			-5.34 (3.10) *	-1.72		
Panel					12.64 (4.54) **	2.79
Cross-Sectional Homogeneity					-7.22 (7.92)	-0.91
Endogeneity					-1.36 (3.27)	-0.42
Dynamic					5.13 (4.02)	1.28
Length					-4.02 (3.67)	-1.09
No of Explanatory Variables					-3.77 (6.47)	-0.58
Time Span					-3.44 (0.59) ***	-5.83
Non-World Bank Database					-0.61 (0.02) **	-2.66
No of Observations	327		327		22.92 (3.23) ***	7.10
Adjusted R-Squared	36.4%		33.6%		298	
					41.2%	

Column 3 indicates that time span within and across studies may be regarded as a source of statistical heterogeneity having a negligible yet statistically significant negative impact on the relationship between the dependent and independent variables in this study with a coefficient of -0.62. This impact could be explained by the change in economic conditions across time contributing to the variation observed. It also alludes to the effect of health epidemics on economic growth being negative but often negligible across time. Likewise, methodological choices such as the number of explanatory variables, the choice of panel data, and choice of database to non-world bank related have a strong and statistically significant moderating effect on the relationship between epidemics and economic growth.

Table 4 presents the third estimations in our meta-regression. The meta-regression is on the variables of social economic and methodological nature. In the first group, we tested the moderating role of education, population growth, the ratio of population on productive age and life expectancy. Methodological moderators included cases of deaths per capita, in total, per 100 thousand population and mortality rate. Economic moderators tested include FDI and trade openness.

Table 4. Meta-Regression on Control Variables and Measures of Health Epidemics

	(1)		(2)	
	Coeff. (SE)	Z-value	Coeff. (SE)	Z-value
Constant	1.03 (2.49)	0.41	-7.87 (4.11) *	-1.92
Inverse Std. Error	0.41 (0.03) ***	14.74	0.27 (0.03) ***	9.23
Ratio of Population on Productive Age	-5.99 (4.89)	-1.22		
FDI	34.45 (4.50) ***	7.66		
Trade Openness	11.68 (2.82) ***	4.13		
Education	-1.87 (2.79)	-0.67		
Population Growth	-32.29 (3.18) ***	-10.14		
Life Expectancy	-16.96 (3.10) ***	-5.49		
Cases per Capita			0.62 (9.51)	0.07
Cases Per 100 000 Pop			12.72 (4.81) **	2.64
Total Cases			6.93 (7.06)	0.98
Mortality Rate			22.05 (3.20) ***	6.89
Deaths			3.52 (4.64)	0.76
Number of Observations	327		315	
Adjusted R-Squared	57.9%		42.2%	

Moderating variables as presented in column 1 are a source of heterogeneity. We observe a positive direction of the coefficients with statistical significance for the variables of FDI, trade openness, population growth and life expectancy indicating that these variables have a strong moderating impact on the relationship between pandemics and economic performance. FDI and trade openness positively affect the relationship between health epidemics and economic growth. The higher the FDI and trade openness, the more positive the impact of pandemics on economic performance, while population growth and life expectancy have a negative impact. There is no clear evidence on the role of education due to statistical insignificance.

In column 2, we observe variables relevant to how the impact of epidemics was measured in the studies included in the sample reflecting the authors' methodological choices. The findings indicate that the use of cases per capita (12.72) and mortality rate (22.05) have a strong positive influence on the relationship between epidemics and economic performance.

ROBUSTNESS TEST

Robustness checks involve robust weight-adjustment using a multi-level robust variance estimation method (presented in Table 5). This method estimates a robust variance while simultaneously taking dependence between and within studies into account. This method increases the study's estimation precision as all estimates in the dataset are statistically dependent due to having been sourced from either one database or primary study (Fisher & Tipton, 2015). In the first model, we included all studies. The main model was then re-estimated using studies that used databases not associated with the World Bank or panel studies for reasons that the former might carry a country-specific weight and the latter for assessment of time-variance repeatedly observed in this study. The third model included OECD countries.

In column 1, we find that although the random-effects meta-analysis indicated a medium positive effect of health epidemics on economic growth, the results suggest that there exists no effect at all. However, due to a p-value greater than 10%, the result of the meta-analysis still stands.

Column 2 shows the results of studies that have used a database not associated with the World Bank. The direction of the effect has changed to negative. This could be a result of the regression structure. In the baseline results, the non-World Bank database variable was in the model with other explanatory variables. We conjecture that the robustness check result may be acceptable. Panel data and OECD countries were found to be not statistically significant. Therefore, the results observed in the above meta-regression tables may be more accurate for these variables.

Table 5. Robustness Checks

	Column 1		Column 2		Column 3		Column 4	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
<u>Standard Error Weighted on all Studies</u>								
Constant	0.0654	0.0913						
Inverse SE	0.0023	0.0041						
<u>Non- World Bank Databases Only</u>								
Constant			-11.32**	2.84				
Inverse SE			1.06 **	0.04				
<u>Panel Data Only</u>								
Constant					0.57	9.18		
Inverse SE					0.29	0.47		
<u>OECD Countries</u>								
Constant							-10.92	2.19
Inverse SE							1.07***	0.05

DISCUSSION

At the height of the COVID-19 pandemic, the world has started coming to terms with its severe adverse impacts on everyday life, and the economic, cultural, political or even environmental impacts that might not be fully evident at the moment but have to be indicated and discussed by both academic and industry policy stakeholders. As it is difficult to say for certain how this epidemic will evolve, the present study aggregated the findings from 35 studies to provide clarity on the pandemic's long-term macroeconomic impact. Both developed and developing countries, with a broad range of epidemic events, were included in the study.

A meta-analytical study has the advantage of aggregating data on a highly contextual topic and hence the studies are not homogeneous. We applied rigorous statistical analysis and meta-regressed the findings from 35 studies. Based on evidence from literature and the neoclassic theoretical principles, we tested three hypotheses that address the research objective. Namely, to find what the impact of epidemic events on macro-economic performance is and what the main moderators are. In the first hypothesis, we stated that national economies will recover from the adverse impact of pandemics and there will be a positive impact on macro-economic performance in the long-term. Both the literature and the sample in this study were divided on this issue, while macro-economics support an increase in growth. Our findings confirm this hypothesis. The post-COVID-19 period will probably be marked by a recovery of the current adverse economic effects. However, this study's findings do not provide evidence of a return to pre-pandemic economic growth and it is questionable whether this positive impact of the pandemic on economic growth found in this study can be interpreted as a long-term return to equilibrium.

Which factors create and sustain economic growth is a topic of debate among politicians and academics (Asher & Novosad, 2017; Rose, 2020). There are elements of political, social, economic or even natural environment conditions that facilitate or prohibit this economic growth as discussed in this study and in previous literature (Ahn & Hemmings, 2000; Van Stel et al., 2005; Gründler, K. & Potrafke, 2019; Vasiev et al., 2020), as well as indicated with the findings on the moderators tested.

The second hypothesis on the moderating role of a country's stage of development on pandemics' impact on economic growth is also confirmed. This finding is profound for politicians, industry stakeholders and academia in different countries. Developed countries are in a position to invest substantial resources in the early detection and control of epidemic events and health care (Stephens, 2017; Daszak et al., 2020), thus moderating epidemics' effects. The moderation of negative effects is further increased by the provision of emergency financial packages in developed countries (Mallet & Dombey, 2020). In contrast, in developing countries, poor political and economic conditions as well as underdeveloped institutions cannot adequately moderate the effects of epidemic events and may even increase the severity of epidemic events (Bleakley, 2010; Kieny et al., 2014; Burkle, 2020). These countries, in general, have lower governmental expenditure for fighting epidemic events, lack of financial support to SME, and lack of investment in technology and innovation. Combined with institutional instability, these lead to increased negative consequences of epidemic events on the countries' economy and population health (Bleakley, 2010; Kieny et al., 2014). In addition, communities' response to epidemic events and their willingness to accept the proposed interventions to mitigate an outbreak's effects can substantially influence the outcome. Considerable challenges have been noticed in developing countries to manage epidemic events due to weak infrastructure (Alhumaind et al., 2020), lack of surveillance (Halliday et al., 2012), or influences of traditional beliefs on the response to the outbreaks and to the proposed measures (Victor & Ahmed, 2019).

Finally, the nature of epidemic events requires regional (Kimura et al., 2020) and global coordination and support approaches (Malik et al., 2020) to moderate their negative effects. The COVID-19 pandemic highlights the necessity of prerequisite multidisciplinary coordination for controlling such apocalyptic events (Malik et al., 2020) by implementing different initiatives that incorporate promising approaches for fighting the negative effects of epidemic events.

Publication bias was found in the sample used for the study. Further, with meta-regression analysis, we tested the possible impact of economic and social variables guided by the existing literature and found in our sample. Apart from the presence of publication bias, our findings indicated that the impact of epidemics on macro-economic performance is moderated by authors' methodological choices. Estimation variables such as the measure of economic growth, measures of health epidemics such as cases per 100 thousand of population, panel of data, timespan, non-World Bank database, and number of explanatory variables were found to moderate the impact of epidemics. Similarly, studies that considered economic and social variables such as trade openness, FDI and life expectancy, also found them to be moderators of the impact of epidemic events on macroeconomic performance.

The findings' credibility was further checked with a robustness test which confirmed the first hypothesis on the positive impact of epidemics on macro-economic performance. The stage of a country's development was also confirmed as a moderator on the impact of epidemics on macro performance. In terms of methodological choices, panel data was confirmed as a moderator while the use of the non-World Bank database as a moderator is unclear as the robustness test indicated different directions of the effect.

Our study was limited by data availability and this work can alert researchers to the need for further studies on this topic with the use of strong data and analysis. Future research can focus on a meta-analytical investigation of the impact of different epidemic events on economic growth. As observed in the current study, there is an issue of heterogeneity as epidemics were merged in the sample irrespective of their characteristics. Further research on the topic will allow for the impact of different epidemics to be identified or epidemics to be compared.

Finally, the focus on the long-term impact of epidemic events on economic growth was dictated by data availability. The results from this study proved the positive impact of epidemic events on the long-term economic growth, yet they do not prove the return to pre-pandemic economic performance. Accordingly, future studies should investigate if epidemic events can influence economic performance

to move back to pre-pandemic level, how soon that would happen and which of the investigated variables would be the strong moderators of that return. Further research on the topic will allow for meta-analytical studies on the short-term impact of epidemics.

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APPENDIX

A1. PRISMA Flow Diagram – Article Selection

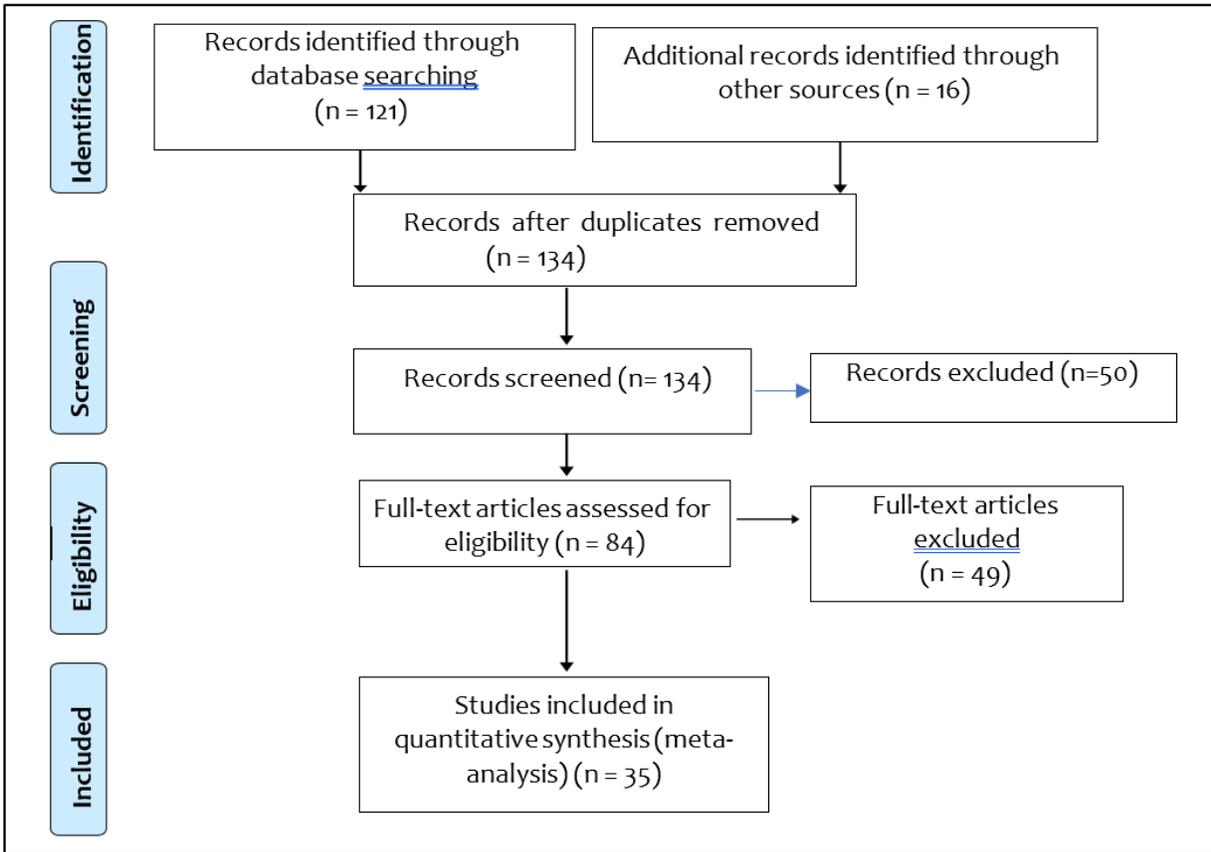


Table A2. Description and Summary Statistics of Variables Used in the Study

Variable	Description	Long-term	
		Mean	St. Dev
T-stat	<i>Estimated t-statistic of the effect size</i>	7.59	1.44
PCC	<i>Partial correlation coefficient</i>	0.11	0.22
Precision	<i>The inverse of the standard error of the partial correlation coefficient</i>	28.11	2.34
Measures of Health Epidemics			
Cases per Capita	<i>dummy variable equal to 1 if the study uses cases per capita to measure the epidemic, 0 otherwise</i>	0.14	0.02
Cases100	<i>dummy variable equal to 1 if the study uses cases per 100 000 population to measure the epidemic, 0 otherwise</i>	0.27	0.02
Total Cases	<i>dummy variable equal to 1 if the study uses the total number of cases in a population to measure the epidemic, 0 otherwise</i>	0.17	0.02
Mortality	<i>dummy variable equal to 1 if study mortality rate/ratio as a measure of the epidemic, 0 otherwise</i>	0.24	0.02
Deaths	<i>dummy variable equal to 1 if the study uses a crude number of deaths as a measure, 0 otherwise</i>	0.13	0.02
GDP	<i>dummy variable equal to 1 if the study uses nominal GDP, 0 otherwise</i>	0.12	0.01
GDPPc	<i>dummy variable equal to 1 if study uses GDP per capita, 0 otherwise</i>	0.42	0.02
Growth	<i>dummy variable equal to 1 if study uses GDP growth rate, 0 otherwise</i>	0.56	0.02
Data and Estimation Methods			
Sample Size	<i>sample size</i>	1823.6	323.8
n_ countries	<i>number of countries in the study</i>	36.2	2.0
Timespan	<i>number of years in the study sample</i>	35.1	21.0
k	<i>number of explanatory variables included in the sample</i>	9.4	0.21
Panel	<i>dummy variable equal to 1 if study uses panel data, 0 otherwise</i>	0.57	0.02
Timeseries	<i>dummy variable equal to 1 if study uses time series data, 0 otherwise</i>	0.20	0.02
cross_sec	<i>dummy variable equal to 1 if study uses cross sectional data, 0 otherwise</i>	0.23	0.02
lag	<i>dummy variable equal to 1 if economic growth is lagged, 0 otherwise</i>	0.62	0.02

Homogeneity	<i>dummy variable equal to 1 if the dataset used is from a single region, 0 otherwise</i>	0.59	0.02
Endogeneity	<i>dummy variable equal to 1 if study controls for endogeneity, 0 otherwise</i>	0.67	0.02
Dynamic	<i>dummy variable equal to 1 if study measures dynamics like time, lag, lagged dep variable, speed etc., 0 otherwise</i>	0.37	0.02
Data source	<i>database used</i>	0.50	0.02
<u>Other Variables</u>			
Dependency Ratio	<i>dummy variable equal to 1 if study controls for dependency ratio, (productive age of population) 0 otherwise</i>	0.08	0.01
Trade	<i>dummy variable equal to 1 if study considers trade openness, 0 otherwise</i>	0.52	0.02
FDI	<i>dummy variable equal to 1 if study considers foreign direct investment, 0 otherwise</i>	0.14	0.02
Development Status	<i>dummy variable equal to 1 if study consider level of development of the region/nation, 0 otherwise</i>	1.97	0.03
Income Level	<i>dummy variable equal to 1 if study consider level of income of the region/nation, 0 otherwise</i>	0.48	0.02
WHO Region	<i>categorical variable equal to 1 if most/all WHO regions are included in the sample, 2 = MENA, 3= Asia, 4 = South America, 5 = OECD Countries, 6 = Sub-Saharan Africa</i>	3.98	0.10
Population Growth	<i>dummy variable equal to 1 if study accounts for population growth, 0 otherwise</i>	0.27	0.02
Education	<i>dummy variable equal to 1 if study accounts for education, 0 otherwise</i>	0.64	0.02
Life Expectancy	<i>dummy variable equal to 1 if study accounts for life expectancy of the nation, 0 otherwise</i>	0.42	0.02

Table A3. List of Articles Included in the Study

Authors (Year Published)	No of Estimates	Period Covered	Dependent Variable	Independent Variable	Moderating and Control Variables
Asante, F.A. and Asenso-Okyere, K., 2003. Economic burden of malaria in Ghana. <i>World Health Organization (WHO)</i> , 1-81.	8	1995 – 2001	Malaria	Growth rate, GDP	Trade openness, income level, education, life expectancy
Barro, R.J., Ursúa, J.F. and Weng, J., 2020. <i>The coronavirus and the great influenza pandemic: Lessons from the “Spanish flu” for the coronavirus’s potential effects on mortality and economic activity</i> (No. w26866). National Bureau of Economic Research	6	1918 – 1930	Spanish flu	GDP per capita	-
Bloom, D.E. and Mahal, A.S., 1997. Does the AIDS epidemic threaten economic growth? <i>Journal of Econometrics</i> , 77(1), 105-124.	25	1980 – 1992	HIV/AIDS	Growth rate	Trade openness, income level, education, population growth
Bonnel, R., 2000. HIV/AIDS and economic growth: A global perspective. <i>South African Journal of Economics</i> , 68(5), 820-855.	5	1990 – 1997	HIV/AIDS	Growth rate	Education
Brainerd, E. and Siegler, M.V., 2003. The economic effects of the 1918 influenza epidemic.	35	1919 – 1930	Spanish flu	Growth rate	Income level, education
Carillo, M. and Jappelli, T., 2020. Pandemics and local economic growth: Evidence from the Great Influenza in Italy.	34	1910 – 1929	Spanish flu	GDP per capita	-

Ceylan, R.F. and Ozkan, B., 2020. The economic effects of epidemics: from SARS and MERS to COVID-19. <i>Research Journal in Advanced Humanities</i>, 1(2), 21-29.	3	2000 – 2015	SARS-cov, MERS-cov	GDP per capita	FDI, life expectancy
Chen, M.H., Jang, S.S., and Kim, W.G., 2007. The impact of the SARS outbreak on Taiwanese hotel stock performance: An event-study approach. <i>International Journal of Hospitality Management</i>, 26(1), 200-212.	16	2003	SARS-cov	GDP	-
Datta, S.C. and Reimer, J.J., 2013. Malaria and economic development. <i>Review of Development Economics</i>, 17(1), 1-15.	10	1985 – 2001	Malaria	GDP per capita	Population Productive age ratio, trade openness, life expectancy
Dauda, R.S., 2019. HIV/AIDS and economic growth: Evidence from West Africa. <i>The International Journal of Health Planning and Management</i>, 34(1), 324-337.	12	1990 – 2011	HIV	Growth rate	Population production age ratio, trade, education, life expectancy
Delfino, D. and Simmons, P.J., 2005. Dynamics of tuberculosis and economic growth. <i>Environment and Development Economics</i>, 719-743.	3	2000	TB	GDP	Population growth
Dixon, S., McDonald, S. and Roberts, J., 2001. AIDS and economic growth in Africa: a panel data analysis. <i>Journal of International Development: The Journal of the Development Studies Association</i>, 13(4), 411-426.	15	1960 – 1998	HIV	GDP per capita	Education, population growth, life expectancy

Gallup, J.L. and Sachs, J.D., 2001. The economic burden of malaria. <i>The American Journal of Tropical Medicine and Hygiene</i>, 64(1_suppl), 85-96.	17	1950 – 1995	Malaria	GDP per capita	Trade openness, income level, education, life expectancy
Grimard, F. and Harling, G., 2004. The impact of tuberculosis on economic growth. <i>Montréal: McGill University</i>.	51	1981 – 2000	TB	GDP, growth rate	Income level, education, life expectancy, population growth, FDI, trade openness
Jordà, Ò., Singh, S.R. and Taylor, A.M., 2020. <i>Longer-run economic consequences of pandemics</i> (No. w26934). National Bureau of Economic Research.	5	1314 – 2018	Spanish flu, bubonic plague, cholera	GDP	-
Karlsson, M., Nilsson, T. and Pichler, S., 2012. What doesn't kill you makes you stronger? The Impact of the 1918 Spanish Flu Epidemic on economic performance in Sweden.	19	1912 – 1930	Spanish flu	GDP per capita	Trade openness, income level
Karlsson, M., Nilsson, T. and Pichler, S., 2014. The impact of the 1918 Spanish flu epidemic on economic performance in Sweden: An investigation into the consequences of an extraordinary mortality shock. <i>Journal of health economics</i>, 36, 1-19.	22	1911 – 1930	Spanish flu	GDP per capita	Trade openness, income level

Kirigia, J.M., Sambo, L.G., Okorosobo, T. and Mwabu, G.M., 2002. Impact of HIV/AIDS on Gross Domestic Product (GGP) in the WHO Africa Region. <i>African Journal of Health Sciences</i>, 9(1), 27-39.	4	1990-2000	HIV	GDP per capita	FDI, life expectancy, education
Lovász, E. and Schipp, B., 2009. The impact of HIV/AIDS on economic growth in sub-Saharan Africa 1. <i>South African Journal of Economics</i>, 77(2), 245-256.	4	1997 – 2005	HIV/AIDS	Growth rate	Population growth, income level
Maijama'a, D. and Kachalla Mohammed, B., 2013. Impact of HIV/AIDS on economic growth and development in Nigeria. <i>Impact of HIV/AIDS on Economic Growth and Development in Nigeria (April 25, 2013)</i>.	2	2012	HIV/AIDS	Growth rate	Income level, education,
McCarthy, F.D., Wolf, H. and Wu, Y., 1999. <i>Malaria and growth</i>. The World Bank.	24	1983 – 1997	Malaria	GDP per capita	Education
McDonald, S. and Roberts, J., 2006. AIDS and economic growth: A human capital approach. <i>Journal of Development Economics</i>, 80(1), 228-250.	24	1960 – 1998	AIDS	Growth rate	Income level, education, life expectancy
Misra, Y., 2011. The economic penalty of dengue. <i>North Carolina: Duke University Durham</i>.	12	1990 – 2009	Malaria	GDP per capita	Trade openness, income level
Nketiah-Amponsah, E., Abubakari, M. and Baffour, P.T., 2019. Effect of HIV/AIDS on economic growth in sub-Saharan Africa: Recent Evidence. <i>International Advances in Economic Research</i>, 25(4), 469-480.	13	2000 – 2015	HIV/AIDS	GDP per capita	Education, population growth

Okorosobo, T., Okorosobo, F., Mwabu, G., Orem, J.N. and Kirigia, J.M., 2011. Economic burden of malaria in six countries of Africa.	20	1990 – 1998	Malaria	Growth rate	Trade openness, education, income level, life expectancy
Orem, J.N., Kirigia, J.M., Azairwe, R., Kasirye, I. and Walker, O., 2012. Impact of malaria morbidity on gross domestic product in Uganda. <i>International Archives of Medicine</i> , 5(1), 12.	4	1997 – 2003	Malaria	GDP per capita	Trade openness, income level
Robalino, D.A., Voetberg, A. and Picazo, O., 2002. The macroeconomic impacts of AIDS in Kenya estimating optimal reduction targets for the HIV/AIDS incidence rate. <i>Journal of Policy Modeling</i> , 24(2), 195-218.	11	1960 – 1998	HIV/AIDS	GDP	Population growth
Roy, S., 2014. The effects of HIV/AIDS on economic growths and human capitals: a panel study evidence from Asian countries. <i>AIDS Care</i> , 26(12), 1568-1575.	1	1990 – 2010	HIV/AIDS	GDP per capita	FDI, trade openness, income level, education, life expectancy
Sharifi, R.H., Akhoondi, N., Honarvar, N. and Mohammadi, M., 2014. Effects of the Human Immunodeficiency Virus (AIDS) epidemic on economic growth in Iran.	4	1990 – 2009	HIV/AIDS	GDP per capita	Education
Sher, C.Y., Wong, H.T. and Lin, Y.C., 2020. The impact of dengue on economic growth: The case of southern Taiwan. <i>International Journal of Environmental Research and Public Health</i> , 17(3), 750.	9	2010 – 2015	Dengue	GDP per capita	Dependency ratio, education

<p>Twumasi-Ankrah, S., Ashaolu, J.T. and Ankrah, I., 2015. HIV/AIDS scourge and economic growth in sub-Saharan Africa. <i>Universal Journal of Public Health</i>, 3(2), 84-88.</p>	12	1995 – 2012	HIV/AIDS	GDP	-
<p>Ukpolo, V., 2004. AIDS epidemic and economic growth: Testing for causality. <i>Journal of Asian and African Studies</i>, 39(3), 169-178.</p>	2	1990 – 1996	AIDS	GDP	Trade openness
<p>Waziri, S.I., Nor, N.M., Abdullah, N.M.R. and Adamu, P., 2016. Effect of the prevalence of HIV/AIDS and the life expectancy rate on economic growth in SSA countries: Difference GMM approach. <i>Global Journal of Health Science</i>, 8(4), 212.</p>	6	2002 – 2012	HIV/AIDS	Growth rate	Life expectancy
<p>Welfens, P.J., 2020. Macroeconomic and health care aspects of the coronavirus epidemic: EU, US and global perspectives. <i>International Economics and Economic Policy</i>, 1.</p>	8	2020	Covid-19	GDP per capita	FDI, trade openness
<p>Yeboah, M.A., Ansong, M.O., Appau-Yeboah, F., Anyan, F.Y., Gyebil, F.J., Antwi, H.A. and Yiranbon, E., 2014. Instrumental variables approach to estimating the continuing effect of HIV/AIDS epidemic on global development. <i>American International Journal of Contemporary Research</i>, 4(6), 159-180.</p>	20	1990 - 2012	HIV/AIDS	GDP per capita, growth rate	Income level, education, life expectancy, population growth, trade openness