GLOBAL PUBLIC HEALTH: AND ANALYTICS: A COUNTRY-LEVEL PERSPECTIVE

W. & V. Raghupathi

ABSTRACT

Objectives: Our research investigates the phenomenon of global public health using the emerging field of analytics and a country-level perspective. Analytics technology provides the basic infrastructure for warehousing, reporting and analyzing health data.

Methods: We analyze global public health using income per capita of 214 countries. For the years 2001 to 2010, we downloaded data from the World Bank website for thirteen public health indicators: adolescent fertility rate, child immunization for DPT, child immunization for measles, life expectancy, birth rate, death rate, health expenditure per capita, improved sanitation facilities, incidence of tuberculosis, infant mortality rate, population aged 65 and older, population growth, and prevalence of HIV. The countries were categorized based on income into "low", "lower middle", "upper middle", and "high income".

Results: Our analyses show that income per capita is positively associated with an increase in immunization for DPT and for measles, life expectancy health expenditure, infant mortality rate, and population aged 65 and older; and negatively associated with adolescent fertility rate, birth rate, death rate, improved sanitation facilities, incidence of tuberculosis, population growth, and prevalence of HIV.

Conclusions: Our study has implications for policy makers. That we can draw no positive association between income and the prevalence of HIV and improved sanitation facilities indicates the need to realign public health resources to address the void. Similarly, the increase in

the population of people aged 65 and older indicates the need for policies that address the issues of an aging and older demographic.

1. Introduction

Global public health is an organized effort to deploy scientific and technical knowledge for the purpose of preventing disease and promoting the health of the community (Institute for Medicine, 1998). The defining components of public health efforts are that they are organized and directed at a community not an individual (Novick, 2001). (A community may be a small group or a country's entire population.) Global public health focuses on two key areas—the prevention of disease and the promotion of health. To understand such issues as infant mortality and chronic disease in a particular population, global public health professionals rely on policy and research strategies.

Here we investigate the phenomenon of global public health using an emerging analytics approach and adopting a country-level perspective. The rest of the paper is organized as follows: Sections 2 and 3 give background on the domain of global public health and the role of analytics in it; Section 4 describes the research methodology; Section 5 offers the results of data analyses; Section 6 addresses the scope and limitations of our study; and finally, in Section 7, we highlight the research contributions and policy implications.

2. Global Public Health

The term global public health draws attention to the fact that, with globalization, concerns of public health are not confined to county, state or national boundaries. Responding to public health issues requires world-wide attention to health risks and environmental changes (World Health Organization, 2013). In addition to the traditional concerns of protection from environmental and contagious health hazards, the public health domain now envelops new

concerns regarding such issues as obesity, adolescent pregnancy, injuries, substance abuse, sexually transmitted diseases, and bioterrorism (World Health Organization, 2011). Public health efforts, to be effective in improving community health, need to involve clinical activities as well as population-based activities. While clinical medicine is reactive and focuses on the treatment of an individual after the onset of a disease, population-based health activities are proactive and focus on preventive measures directed towards the social and environmental determinants of disease (World Health Organization, 2011). Both proactive (preventive) and reactive (diagnostic) efforts are required for successful public health. The importance of global public health efforts can be seen in the overall increase in life expectancy in industrialized countries in the 1900s wherein life expectancy rose from 45 to 75 years of age. About 85% of this increase is attributed to the impact of proactive public health measures such as better nutrition, sanitation, and safer housing. The remaining 15% is attributed to clinical medicine (World Health Organization, 2011).

In general, about 50% of premature deaths are preventable, influenced as they are by personal behaviors such as tobacco/substance abuse, poor diet, and sedentary life style. An improvement in the health status quo requires a combination of clinical efforts that focus on individual treatment as well as on public health measures that address social and environmental determinants posing a community-wide risk of disease (World Health Organization, 2011). The breadth of global public health efforts is reflected in the diversity of endeavors that are under way, including but not limited to controlling infectious diseases, improving safety in workplaces and in food and water supplies, providing healthcare to mothers and children, reducing mortality rates in infants/children/adults, and recognizing hazardous consumption products such as tobacco.

Research has emphasized different aspects of public health. Dunn and Hayes (1999) emphasize the importance of measuring not only health outcomes but also the factors that influence such outcomes. Young (2005) identifies public policy in terms of resource allocation. Koplan et al. (2009) focus on achieving health equity in addition to health improvement. Understandably, research on public health and that on population health overlap, sometimes blurring the lines between these two areas of health care. Some researchers view population health as a modern version of public health in that improving the health of the population may be a goal of public health, a measurement system for evaluating public health, or a conceptual framework to analyze the causes for some populations being healthier than others (Young, 2005). However, while public health is more closely tied to governmental health agencies and their efforts, population health includes the healthcare delivery system as a whole. The bottom line, though, is that both public health and population health are about improving the health outcomes of a community (King & Stoddart, 2003).

From an economic standpoint, good public health contributes to reducing healthcare costs, improving economic productivity and enhancing quality of life. And by reducing childhood diseases, public health arguably contributes to an improvement in education by enabling children to attend schools with fewer absences caused by sickness. Public health measures disseminate health information to the population, helping citizens make healthy lifestyle choices. More importantly, effective public health measures prepare the public for the events and effects of catastrophes such as hurricanes, tornadoes and terrorist attacks.

While the overarching goals of public health include disease control and health improvement, equally pertinent are ancillary goals such as health equity. These ancillary goals can be achieved by addressing the social context in which the goals are targeted, or the

conditions in which people live (Blas & Kurup, 2010). The task of achieving health equity is not an easy one. It comes brimming with challenges, such as unequal access to health initiatives and extreme vulnerabilities and exposure to risk factors. Many key public health targets, including the Millennium Development Goals (MDG), are hampered largely due to social and structural factors (Lonnroth et. al, 2010). Even simple and effective measures, such as vaccines against childhood diseases, do not reach those in need due to impending social and structural factors. For example, uneducated mothers are less aware of the health risks and may not avail themselves of the immunization resources (Folbre, 2011). Global health measures, therefore, need to address key areas such as strengthening public health institutions and infrastructure, building workforce capacity, improving research capacity, improving health surveillance systems, and strengthening laboratory systems and networks (Center for Disease Control, 2012). Analytics in global public health initiatives are part of the solution, utilizing information and communication technology solutions to address problem areas and attain sustainable improvements. Such initiatives offer integration and connectivity for global public health by linking health educators, health researchers and policy regulators (http://www.ctisinc.com/assets/files/publications/CEO_Article_96-102-RajShah.pdf).

Each year, the World Health Organization (WHO) compiles the World Health Statistics/Indicator compendium, comprehensive documentation of various indicators of global public health. The World Bank has a database containing worldwide data for the different health indicators. Some key public health indicators proposed by the World Bank include fertility rate for adolescents and women, birth rate, death rate, health expenditure per capita, out of pocket health expenditure from private sector, immunization rate of DPT/measles, access to improved sanitation facilities, prevalence of diseases such as tuberculosis/malaria/HIV, life expectancy,

mortality rate, access to prenatal care, percentage of teenage mothers, and need for contraception (for details, refer to http://data.worldbank.org/topic/health).

The following section discusses the role of analytics as a technology in the domain of global public health.

3. Analytics in Global Public Health

Technology is widely used for public health surveillance to identify and prevent emerging diseases. In the United States, public health surveillance has progressed from monitoring infectious diseases to monitoring non-communicable diseases such as injuries, birth defects, chronic conditions, mental illnesses, illicit drug use, and environmental and occupational exposures to health risks (Buehler, 2012). The phenomenon in the U.S. of the bioterrorism-related spread of anthrax in 2001 ramped up interest in automated surveillance methods that enable early detection, fast characterization of infectious viruses, and continuous monitoring of urgent public health threats (Buehler, 2012). To date, several public health issues have been addressed by effective surveillance. The eradication of small pox was accomplished by a strategic shift from mass vaccination to surveillance with rapid response. The campaign to eradicate poliomyelitis demonstrated worldwide the effectiveness of an integrated surveillance system that rapidly channels specimens to genotypes within days to weeks (St. Louis & CDC, 2012)

Analytics as a technology is used more and more often in public health initiatives. Health analytics involves the application of technology on health data to gain insight and inform decision-making (Raghupathi & Raghupathi, 2013). It provides the basic infrastructure for warehousing, reporting and analyzing health data. It also allows data from disparate health

sources to be integrated and analyzed using a variety of tools that include statistical, business intelligence, and data mining tools (Evans, 2013; IBM, 2012; SAS, 2011). Analytics as an advanced component of business intelligence draws on statistical and quantitative analyses of large sets of data repositories and facilitates fact-based decision-making (Ghosh & Scott, 2011). When applied to public health, analytics focuses on public health decisions relating to health improvement of and disease prevention in the community. Health analytics not only helps resolve health problems. It also offers decision support through the availability of timely, relevant and quality information. In this way, health analytics facilitates achieving public health goals faster, better, and more economically (Savel & Foldy, 2012).

An analytics perspective contributes to the key elements of public health in several ways. In planning and systems design, analytics helps in identifying the sources of information, ascertaining who has access to the information, and in facilitating the interaction of the public (population) with other elements. In data collection, analytics helps in identifying a wide variety of data ranging from unstructured to structured information, and in facilitating the process of ETL (Extraction-Transformation-Loading). In data management and collation, analytics helps in sharing data across platforms, linking new data with data from legacy systems, and in resolving data quality problems while at the same time maintaining privacy and security. In data analysis, analytics helps in identifying appropriate statistical and visualization techniques, generating algorithms that can signal variances and aberrations in public health data, and leveraging high-performance computational resources for large data sets. In information dissemination, analytics offers a variety of methods and techniques for customized display to fit the preferences of the various stakeholders in public health. And in data integration, analytics contributes to linking the

information from surveillance systems with public health intervention systems and in utilizing the information for decisions (Savel & Foldy, 2012).

Effective disease control and prevention necessitates a thorough understanding of the epidemiology of a disease using strong evidence. The evidence usually lies in the raw data from various health sources and needs transforming in order to be useful for making decisions and/or determining policy. This is where analytics comes into play. Through its suite of tools—such as for statistical analysis, querying, reporting and visualization—analytics offers solutions to analyze, transform and interpret a wide range of data for decision making and policy making. Thus, public health analytics plays a role in the acquisition, analysis, and interpretation of data from multiple/varied sources that will be utilized for decision and policy making (Rolka et al., 2012).

With the evolution of electronic health records and electronic health information systems, opportunities exist for analytics in public health surveillance to improve links between healthcare providers and public health departments (Buehler, 2012). These initiatives have given rise to large repositories of health data, including systems for collecting critical disease reports and spontaneous adverse event reports related to drugs and vaccines. There are systems designed for various purposes such as pharmaceutical prescription monitoring, over-the-counter pharmaceutical sales, and emergency service dispatches, that offer the potential to monitor and assess the health of the population (Rolka et al., 2012). In addition, opportunites exist for analytics to help provide real-time public health information in an unstructured or text form from sources. Examples include news media reports and reports from systems like Epix, ProMed, HealthMap, and Argus (Khan et al., 2010). Unstructured data is anecdotal in nature and is

delivered faster than structured data (Rolka et al., 2012). Therefore it is incremental and has the potential to accrue to large volumes with rich potential.

The plethora of data sources and repositories, while offering opportunities for analytics, also poses formidable challenges. Integrating data from new and multiple sources is in itself a problem—the data is heterogeneous and needs to be managed. In addition, differences in data quality exist between new and legacy systems, and these need to be reconciled in order to take advantage of them. Concerns about sharing and exchanging data from varied public health sources are yet another issue. Finally, questions regarding laws and regulations on data collection, sharing, privacy and security must also be considered (Rolka et al., 2012). Moreover, looming too are future challenges related to such issues as changing health data sources and the increased sensitivity to patient data privacy. Analytics in public health needs to develop new data collection and management techniques that take advantage of evolving data sources, while maintaining patient confidentiality (Rolka et al., 2012).

Public health analytics, if efficiently and appropriately deployed, is capable of alleviating the challenges within the public health sector (Koo et al., 2001; Yasnoff et al., 2001). Our research is based on the belief in the dynamism of analytics to utilize the full potential of public health data and deliver efficient public health solutions. The following section discusses our research methodology.

4. Research Methodology

In our research, we use analytics to investigate the phenomenon of global public health, as measured by public health delivery indicators (PHI). We use descriptive analytics to gain insight into the phenomenon of global public health at a country level. An analytics methodology includes the overall steps of data collection, extraction-transformation-loading (ETL) to prepare

data for analysis, analytics platform and tool selection, and analytics implementation. **Table 1** shows our research methodology.

Table 1: Research Methodology

Data Collection PHI Variables: World Bank website Control variables: Income, Region
ETL Process *Extract*: Data extracted from World Bank website in csv format *Transform*: Data transformed and prepared for loading, with Framework Manager *Load*: Prepared data loaded into IBM's DB2 database and IBM's Cognos-8
Analytics Platform/Tools Selection DBMS: IBM DB2 | Analytics: IBM Cognos Analysis: Cognos Analysis and Report Studio
Analytics Implementation Analysis and reports implementation using Cognos

4.1. Data Collection

The data for thirteen PHIs for the years 2001 to 2010 was downloaded from the World Bank website (http://data.worldbank.org/). A total of 214 countries were selected based on the country list from the PHI dataset. The thirteen PHI variables include *adolescent fertility rate, child immunization for DPT, child immunization for measles, life expectancy, birth rate, death rate, health expenditure per capita, improved sanitation facilities, incidence of tuberculosis, infant mortality rate, population ages 65 and over, population growth, and prevalence of HIV.* **Table 2** shows a description of the PHIs and their measurement variables.

Table 2. Measurement variables for Public Health Indicators

Number	PHI Indicator	Measurement variables
1	Adolescent fertility rate	The number of births per 1,000 women ages 15-19

	(births per 1,000 women ages 15-19)	
2	Immunization, DPT (% of children ages 12-23 months)	The percentage of children ages 12-23 months who received vaccination against diphtheria, pertussis, and tetanus (DPT).
3	Immunization, measles (% of children ages 12-23 months)	The percentage of children ages 12-23 months who received vaccination against measles.
4	Life expectancy at birth, total (years)	The number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
5	Birth rate, crude (per 1,000 people)	Crude birth rate indicates the number of live births occurring during the year, per 1,000 population estimated at midyear. Subtracting the crude death rate from the crude birth rate provides the rate of natural increase, which is equal to the rate of population change in the absence of migration.
6	Death rate, crude (per 1,000 people)	Crude death rate indicates the number of deaths occurring during the year, per 1,000 population estimated at midyear. Subtracting the crude death rate from the crude birth rate provides the rate of natural increase, which is equal to the rate of population change in the absence of migration.
7	Health expenditure per capita (current US$)	Yearly expenditure per capita based in US$
8	Improved sanitation facilities (% of population with access)	Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. To be effective, facilities must be correctly constructed and properly maintained.
9	Incidence of tuberculosis (per 100,000 people)	Incidence of tuberculosis is the estimated number of new pulmonary, smear positive, and extra-pulmonary tuberculosis cases. Incidence includes patients with HIV.
10	Mortality rate, infant (per 1,000 live births)	The mortality rate of 1,000 live birth
11	Population ages 65 and above (% of total)	Population ages 65 and older as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the

		country of asylum, who are generally considered part of the population of the country of origin.
12	Population growth (annual %)	Population growth (annual %) is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.
13	Prevalence of HIV, total (% of population ages 15-49)	Prevalence of HIV refers to the percentage of people ages 15-49 who are infected with HIV

The *income* variable for the countries was obtained from the World Bank (http://go.worldbank.org/CWTURYIPS0). This was used as the control variable. The income classifications were: *low income, lower middle income, upper middle income,* and *high income*. High income countries were so categorized on the basis of whether they were members of the Organisation for Economic Co-operation and Development (OECD). The OECD promotes the economic and social well being of people around the world. In our research, income is verified as a benchmark variable to compare the trend of the PHI variables in a time series mode. The countries belonged to the following regions: Middle East, North Africa, and Greater Arabia; Europe; Australia and Oceania; Sub-Saharan Africa; Central America and the Carribean; South America; and Asia.

4.2. Extract-Transform-Load (ETL) Process

There are two ways in which the raw data from the public databases can be prepared and migrated to Cognos for analytics implementation. The first method is to extract the raw data from the public databases in a comma-separated variable format (.csv) and upload it into Cognos Transformer for transformation into cubes. A cube is an aggregation of different subsets of data across various dimensions and measures. The published cube can then be loaded into Cognos for analytics implementation. An alternate method is to extract the raw data into traditional DB2 databases, connect to Cognos Framework Manager to transform the data into a cube, publish the

cube as a package, and then load the published package into Cognos for analytics implementation. For our research, we used the second method. The data was extracted from the World Bank website and downloaded into Framework Manager. Framework Manager transformed the raw data by building cubes using dimensions and measures, and then publishing as a package, after which the published package was loaded into Cognos for analytics implementation.

4.3. Analytics Platform and Tools Selection

Once the data was ready for analytics, we selected IBM's Cognos as the platform and Cognos Studio as the tool for analytics implementation. Cognos Studio has a suite of functions that facilitate versatile querying and reporting of data. It also allows for effective time series analysis of the data.

4.4. Analytics Implementation

Analytic tasks were implemented in Cognos Studio through its query and report tools. In order to generate effective query reports for analysis, some calculation functions were used and some titles of variables were modified for conciseness. Cognos offers the functionality of displaying the results of the analytics in a dual format of chart and table. Charts are useful for displaying results visually and conveying the message graphically, as in a digital dashboard. Tables are routinely used in public health for monitoring health compliance, health regulations, performance and outcomes. Thus, both formats are useful. In the following section on results, we demonstrate this dual display format for one sample output **(Figure 1/Table 4).** We adopt the chart format of display for the remainder.

5. Results and Discussion

Using the built-in algorithmic calculations and visualization techniques of analytics, we analyze global public health in terms of the income per capita of countries. **Table 3** shows a summary of the associations between income per capita and the thirteen PHIs (refer to **Table 2** for an explanation of the variables). The positive, negative and limited/lack of association between the two sets of variables are indicated.

Table 3. Associations between Income per capita and Public Health Delivery Indicators

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Income Per Capita		-	+	+	+	-	-	+	-	-	+	+	-	-
Low Income Countries	Income Per Capita	-	+	+	+	-	-	+	+	-	+	+	O	-
Lower Middle Income Countries		-	+	+	+	-	-	+	+	-	+	+	-	-
Upper Middle Income Countries		-	+	+	+	-	O	+	-	-	+	+	-	-
High Income OECD Countries		-	+	+	+	+	-	+	O	-	+	+	+	O
High Income NonOECD Countries		-	-	+	O	-	+	+	-	-	+	+	+	O

+ *Income per capita is associated with an increase in Public Health Delivery Indicators*
- *Income per capita is associated with a decrease in Public Health Delivery Indicators*
O *Income per capita has no/very limited association with Public Health Delivery Indicators*

A discussion of the results of these analyses follows for each set of variables.

5.1. Income and Public Health Delivery Indicators

The analysis for income per capita with PHIs is shown using the dual display format in **Figure 1/Table 4**.

Figure 1. Income per capita and Public Health Delivery Indicators

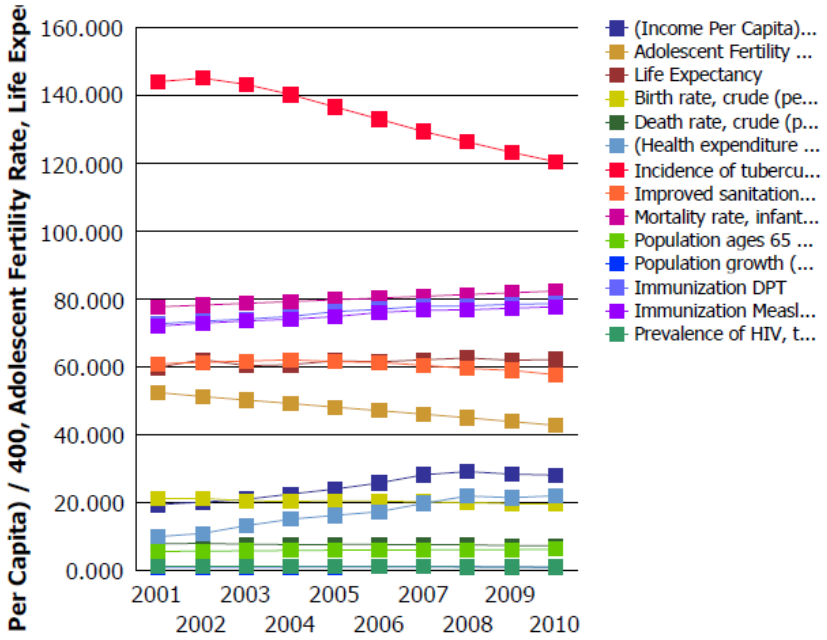


Table 4. Income per capita and Public Health Delivery Indicators

Years	(Income Per Capita) / 400	Adolescent Fertility Rate	Life Expectancy	Birth rate, crude (per 1,000 people)	Death rate, crude (per 1,000 people)	(Health expenditure per capita (current US$)) / 40	Incidence of tuberculosis (per 100,000 people)	Improved sanitation facilities (% of population with access)	Mortality rate, infant (per 1,000 live births)	Population ages 65 and above (% of total)	Population growth (annual %)	Immunization DPT	Immunization Measles	Prevalence of HIV, total (% of population ages 15-49)
2001	19.460	52.514	59.944	21.318	7.930	10.046	144.196	61.028	77.799	5.668	1.061	72.813	72.117	1.238
2002	20.224	51.350	62.229	21.322	8.051	10.975	145.252	61.416	78.318	5.762	1.047	73.556	73.000	1.229
2003	21.064	50.304	60.458	20.561	7.790	13.293	143.374	61.827	78.836	5.841	1.047	74.192	73.659	1.229
2004	22.596	49.294	60.729	20.467	7.687	15.177	140.402	62.164	79.355	5.944	1.112	74.963	74.140	1.206
2005	24.062	48.206	61.907	20.584	7.720	16.321	136.752	61.659	79.874	6.037	1.117	76.388	74.911	1.192
2006	25.843	47.196	61.584	20.533	7.720	17.377	133.164	61.397	80.393	6.084	1.196	77.070	76.150	1.173
2007	28.262	46.154	62.182	20.336	7.631	19.841	129.533	60.551	80.911	6.107	1.154	78.005	76.776	1.131
2008	29.218	45.084	62.715	20.070	7.612	22.008	126.421	59.636	81.430	6.164	1.136	78.051	76.925	1.103
2009	28.465	43.958	62.042	19.743	7.393	21.516	123.369	59.065	81.949	6.187	1.047	78.570	77.383	1.089
2010	28.170	42.855	62.280	19.603	7.341	22.085	120.589	57.766	82.467	6.327	0.967	78.743	77.804	1.084
Summary	**247.363**	**476.916**	**616.070**	**204.537**	**76.874**	**168.038**	**1343.051**	**606.509**	**801.332**	**60.121**	**10.883**	**762.350**	**752.864**	**11.673**

Income per capita shows a decreasing association with some indicators such as adolescent fertility rate, birth rate, death rate, improved sanitation facilities, incidence of tuberculosis, population growth and prevalence of HIV over time. Of these, the decrease in the adolescent fertility rate is not a favorable effect, while the others reflect positive public health.

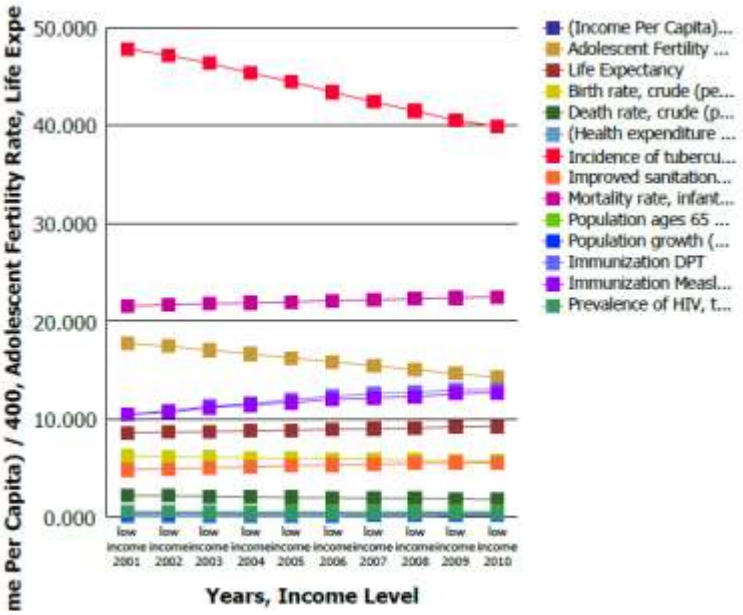
Income per capita has an increasing association with immunization for DPT and measles, life expectancy at birth, health expenditure per capita, mortality rate of infant, and percentage of population aged 65 and older. The increasing association of income per capita with infant mortality is contrary to expectations that higher income per capita will actually have a decreasing association with the infant mortality rate due to increased public health efforts. This anomalous trend is consistent with prior research (Waldmann, 1992).

We now discuss the analysis of public health by different income categories of countries, namely low income, lower middle income, upper middle income, high income-OECD and high income non-OECD countries.

5.2. Low Income and Public Health Delivery Indicators

Figure 2 shows the analysis of public health by income per capita, for countries with low income.

Figure 2. Low Income and Public Health Delivery Indicators

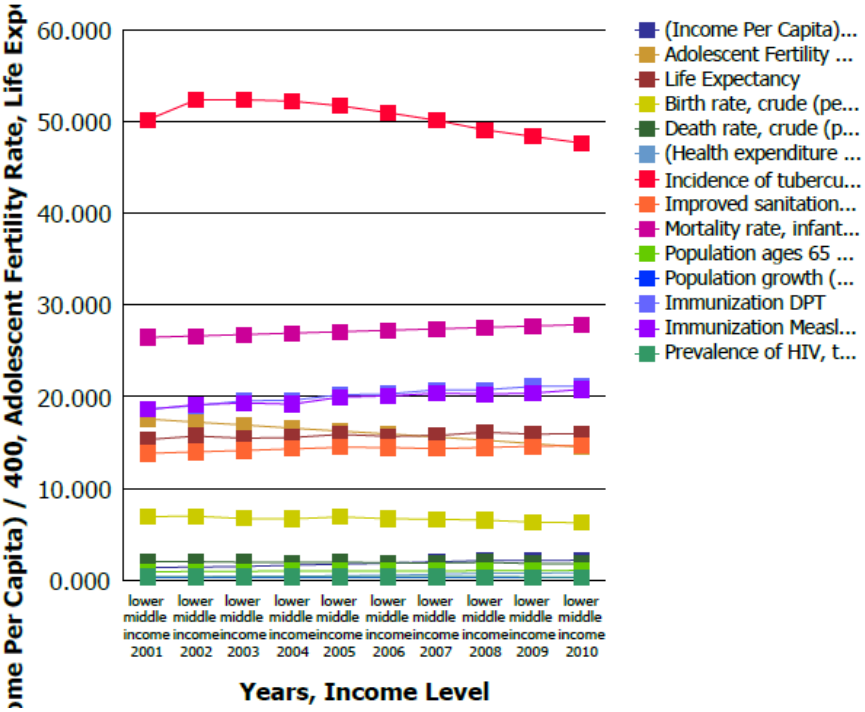


In the category of low income countries, the income per capita is associated with a decrease in adolescent fertility rate, birth rate, death rate, incidence of tuberculosis and prevalence of HIV over time. Income per capita is associated with an increase in improved sanitation facilities, immunization of DPT and measles, life expectancy at birth, health expenditure per capita, mortality rate of infant and % of population aged 65 and older. However, income per capita of low-income countries has no/very limited association with population growth. Again, the association of income with infant mortality rate stands out.

5.3. Lower Middle Income and Public Health Delivery Indicators

Figure 3 shows the analysis for public health by income per capita of countries with lower middle income.

Figure 3. Lower Middle Income and Public Health Delivery Indicators

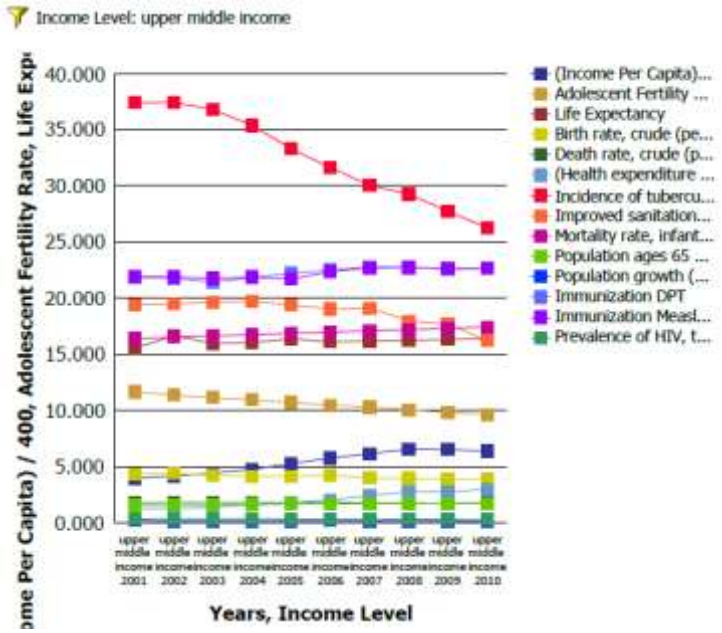


The income per capita of lower-middle-income countries is associated with a decrease in population growth, adolescent fertility rate, birth rate, death rate, incidence of tuberculosis, and prevalence of HIV over time. On the other hand, income per capita is associated with an increase in improved sanitation facilities, immunization of DPT and measles, life expectancy at birth, health expenditure per capita, mortality rate of infants and percentage of population aged 65 and older.

5.4. Upper Middle Income and Public Health Delivery Indicators

Figure 4 shows the analysis by income per capita of countries with upper middle income.

Figure 4. Upper Middle Income and Public Health Delivery Indicators



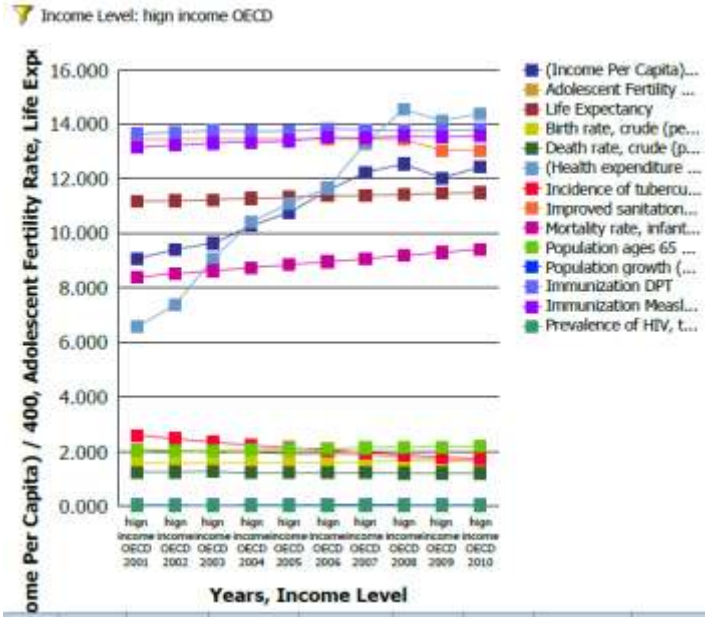
In the upper middle income countries, income per capita is associated with a decrease in improved sanitation facilities, population growth, adolescent fertility rate, birth rate, incidence of tuberculosis and prevalence of HIV over time. On the other hand, income per capita is associated with an increase in immunization of DPT and measles, life expectancy at birth, health

expenditure per capita, mortality rate of infant and % of population aged 65 and older. However, income per capita has no or a very limited association with death rate. This is interesting because one would expect income to have a decreasing association with death rate given increased access to better healthcare.

5.5. High Income OECD and Public Health Delivery Indicators

The analysis for income per capita of high income countries that are members of OECD, with public health delivery is shown in **Figure 5**.

Figure 5. High Income OECD and Public Health Delivery Indicators



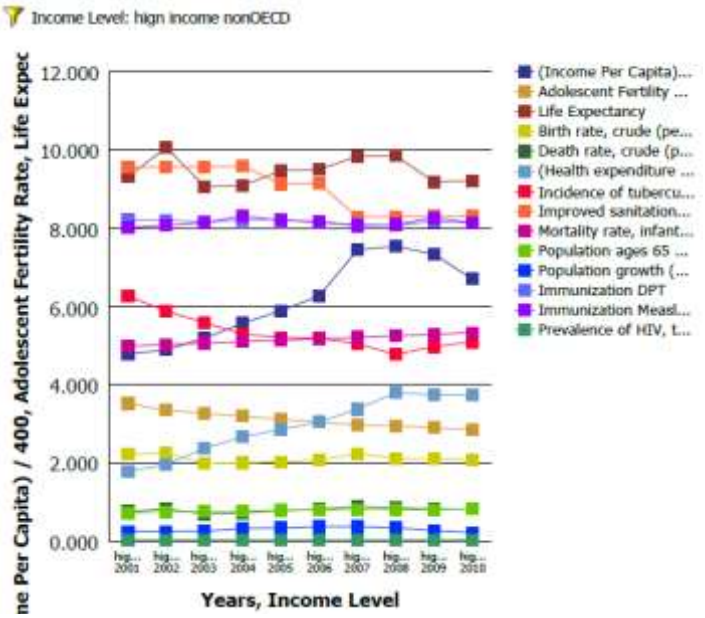
The income per capita of high income countries that are part of the OECD is associated with a decrease in death rate, adolescent fertility rate, and incidence of tuberculosis over time; and an increase in population growth, birth rate, immunization of DPT and measles, life expectancy at birth, health expenditure per capita, mortality rate of infants, and % of population aged 65 and older. However, income per capita has no or very limited association with improved sanitation

facilities and prevalence of HIV. The last result of lack of association with improved sanitation facilities is a surprising revelation since one would expect OECD countries to have better standards for public health infrastructure and disease prevention. A possible explanation could be that since the OECD countries focus on a variety of public health concerns in addition to sanitation, the efforts in a concentrated area may be diffused.

5.6. High Income Non-OECD and Public Health Delivery Indicators

The analysis for income per capita of high income countries that are members of OECD is shown in **Figure 6**.

Figure 6. High Income Non-OECD and Public Health Delivery Indicators



The income per capita of high-income countries that are not members of OECD, is associated with a decrease in improved sanitation facilities, birth rate, immunization of DPT, adolescent fertility rate, and incidence of tuberculosis over time. The income per capita is associated with increase in death rate, population growth, immunization of measles, health expenditure per

capita, mortality rate of infant, and percentage of population aged 65 and older. Income Per Capita has no or very limited association with prevalence of HIV and life expectancy at birth. The decreasing association with improved sanitation facilities is another anomalous result that contradicts the popular belief that high-income countries can afford improved sanitation facilities given an assumption of increased investment in public health.

Our results reveal some interesting general trends about public health. The increasing association of income per capita with infant mortality rate is definitely contrary to the popular belief that higher the income per capita, the higher the quality of efforts directed at healthcare delivery, which should result in lower mortality rates for adults and infants. We see this negative association even for countries that belong to the OECD. Another interesting result is that income per capita does not have increasing association with improved sanitation facilities. Countries that belong to the OECD also show little or no association with improved sanitation facilities, which is counterintuitive to the expectation that OECD countries will focus on improved public health infrastructure. For countries that do not belong to the OECD, income per capita of high-income countries actually shows a decreasing association with improved sanitation facilities. This finding underlines the importance of having social and public health goals in countries that are not members of OECD or a similar organization, and therefore lack the peer pressure to address and direct public health efforts. With regard to disease and infection prevention efforts, our results show that low-income, lower-middle-income, and upper-middle-income countries have a decreasing association with prevalence of HIV. However, for both high-income OECD and non-OECD countries, income per capita showed little or no association with prevalence of HIV. The adolescent fertility rate shows an increased association with income per capita, reflecting the

dark side of higher income and higher quality of life. An important implication to keep in mind with improved public health is the growing segment of the population that is 65 and older.

6. Scope and Limitations

Our study has some limitations. First, the study is a time series analysis covering the years 2001 through 2010. Future studies can be longitudinal and can cover a longer time span so as to reveal more patterns and trends in global public health. Second, the study includes a subset of indicator variables of global public health as defined by the World Bank. There may be more health indicators to consider as intervening variables play a role directly or indirectly in public health. In developing countries, due to the paucity of resources and capabilities, there is a need for a more limited set of indicators that are applicable to monitoring, decision-making and health policy, and are easily measured (Larsen & Mercer, 2004). That said, the larger the range, the more generalizable are the results. Third, our study analyzes the association between income per capita and public health indicators. It is not a study of the causality in the relationship. Further research can explore causality between different sets of country-level variables to further explain the phenomenon of public health. Fourth, the data extracted from the World Bank database is secondary in nature and aggregated from multiple health sources. Additionally, as many of the country-level variables may be interrelated, it is possible for our analyses to be affected by correlated variables that have been omitted. Fifth, we utilize an analytics approach to investigate public health. Future studies can incorporate more theories and models.

7. Contributions and Policy Implications

Despite some limitations, our study contributes to the literature on both health technology and global public health in several ways. By deploying a current and novel technology and

perspective of analytics to investigate the phenomenon of public health, we demonstrate the advantages of incorporating current information and communication technologies in the domain. The availability of large data or big data for public health lends itself very well to the applicability of analytics technology. Use of effective information technology is one of many strategies in improving global public health. Additionally, our study highlights areas in which information and communication technology can be effectively deployed for global public health, such as spread of immunizations and vaccinations, dissemination of health education, and improvement of infrastructure for utilities such as water and sanitation. In the long term, better public health can improve productivity, alleviate poverty, and enhance overall quality of life.

The implication to policy makers of the lack of association of income with the prevalence of HIV and improved sanitation facilities is the realignment of resource allocation in public health to effectively address the void in these sectors, even in some high-income countries. Also, the increasing trend of the population aged 65 and older indicates that future health policies should adequately address the issues of an aging demographic.

The decreasing association of adolescent fertility rate with high income sends important signals for public health. High income, as a proxy of highly productive economies, enables increased access to and usage of technology by adolescents, which in turn adversely impacts the fertility, among other health concerns. Increased cell phone usage or continuous monitoring of electronic screens and gadgets, for example, can result in symptoms of ill health such as headache, impaired concentration and memory (Khan, 2008). Global health policy makers should consider the negative implications of economic development and income.

With globalization, the domain of public health has seen two major trends. One is the increasing repository of public health data worldwide in terms of variety and quantity. The other is the expanding spectrum of public health issues that are in the forefront of global public health. Global public health now not only considers direct measures to improve health and reduce disease, but also indirect measures that target the social and structural foundations for health of countries. This is manifested in the panorama of global health indicators that include not only proximal direct measures of health phenomena such as diseases, deaths, births, life expectancy, and use of services, but also distal indirect measures such as education, poverty, and social development.

We have tried to show through our country-level analysis how a universal perspective to health is necessary for addressing global health problems. Solving global health problems requires a combination of new technologies; resources and capacities such as education, workforce and training; better healthcare and public health systems; and finally, effective global governance. There needs to be a coordinated effort from countries worldwide. A first step in facilitating this coordination is the use of common measures or indicators to evaluate the status quo of global health. As in most things, you have to comprehend the problems in global public health before you can improve the situation.

REFERENCES

1. Blas E, Kurup AS. Equity, social determinants and public health programmes, World Health Organization 2010; 1-291.
2. Buehler JW. CDC's vision for public health surveillance in the 21st century: Introduction, Center for Disease Control and Prevention Morbidity and Mortality Weekly Report 2012; 61: 1-2.
3. Center for Disease Control. CDC Global Health Strategy 2012-2015, 2012; 1-48.

4. Dunn JR, Hayes MV. Toward a lexicon of population health," Canadian Journal of Public Health Supplement November December 1999; S7-10.

5. Evans JR, Business Analytics – methods, models, and decisions; Pearson, 3; 2013.

6. Ghosh B, Scott JE. Antecedents and catalysts for developing a healthcare analytic capability. Communications of the Association for Information Systems 2011; 29(22): 395-410.

7. IBM (2012). The value of analytics in healthcare. Retrieved from http://www.ibm.com/smarterplanet/global/files/the_value_of_analytics_in_healthcare.pdf

8. Institute for Medicine The Future of Public Health. Washington, DC: National Academy Press; 1998.

9. Khan MM. Adverse effects of excessive mobile phone use. International Journal of Occupational Medicine and Environmental Health 2008; 21(4): 289-293.

10. Khan AS, Fleischauer AF, Casani J, Groseclose SL. The next public health revolution public health information fusion and social networks. American Journal of Public Health 2010; 100: 1237-1242.

11. Kindig DA, Stoddart G. What is population health? American Journal of Public Health 2003; 93: 3669.

12. Koo D, O'Carroll P, LaVenture M. Public health 101 for informaticians. Journal of the American Medical Informatics Association 2001; 8(6): 585–597

13. Koplan JP, Bond TC, Merson MH, ReddY KS, Rodriguez MH, Sewankambo NK et al. Towards a common definition of global health. Lancet 2009; 373: 1993-1995.

14. Larsen C, Mercer A. Global health indicators: An overview. Canadian Medical Association Journal 2004; 171(10): 1199–1200.

15. Lonnroth K, Uplekar M, Blanc L. Hard gains through soft contracts: Productive engagement of private providers in tuberculosis control; 2010.

16. Novick LF. Defining public health: historical and contemporary developments. In Novick LF, Mays GP. (Eds). Public Health Administration: Principles for Population-Based Management. Gaithersburg, MD: Aspen Publications; 2001

17. Raghupathi V., Raghupathi W. An overview of health analytics" Working paper; 2013.

18. Rolka H, Walker DW, English R., Katzoff MJ, Scogin G, Xeunaus E. Analytical challenges for emerging public health surveillance, Morbidity and Mortality Weekly Report 2012; 61: 35-39.

19. SAS White Paper. Analytics in healthcare: How the health care industry will uncover the real value of electronic medical records and the emerging electronic health record (EHR) initiative 2011; Retrieved from http://www.sas.com/resources/whitepaper/wp_3500.pdf

20. SAS. What is health analytics 2013; Retrieved from http://www.sas.com/software/health-analytics/, Retrieved on July 10, 2013.

21. Savel TG, Foldy S. The role of public health informatics in enhancing public health surveillance. Morbidity and Mortality Weekly Report 2012; 61(3): 20-24

22. Shah R. Enabling global health through information and communication technology (ICT). http://www.ctisinc.com/assets/files/publications/CEO_Article_96-102-RajShah.pdf

23. St. Louis M., Center for Disease Control. Global health surveillance. Morbidity and Mortality Weekly Report 2012; 61(3): 15-19.

24. Yasnoff WA. et al. A national agenda for public health informatics. Journal of the American Medical Informatics Association 2001; 8(6): 535–545.

25. Young TK. Population health: concepts and methods. Oxford University Press, USA; 2005.

26. Waldmann R. Income distribution and infant mortality. The Quarterly Journal of Economics 1992; 107(4): 1283-1302.

27. World Health Organization. Social determinants approaches to public health: from concept to practice (Eds) E. Blas, J. Sommerfeld, A.S. Kurup, WHO Press: Geneva; 2011.

28. World Health Organization. Trade, foreign policy, diplomacy and health. Public Health; 2013. http://www.who.int/trade/glossary/story076/en/. Retrieved July 26, 2013