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ABSTRACT

The equitable provision of healthcare entails the distribution of resources and other processes to overcome health inequality. The concept of heath equity suggests that it is differences in social and economic backgrounds of people that lead to differences in their ability to access health care. Following a review of what is known about health equity and the role of mobile health, this paper investigates the relationship between Mobile Phone Subscriptions, the United Nation Development Program's (UNDP) Health Index, the Human Development Index, and Gini Index for all the countries of the world. The analysis discovers a significant relationship between the use of mobile phones in the provision of healthcare and human development outcomes. Further cluster analysis offers three groups of countries with certain unique characteristics that help understand the relationship between Mobile Phone Subscriptions, the Health Index and the Human Development Index and the effects of income inequalities within the countries. The contribution of this paper is in understanding the use of mobile phones for the provision of equitable healthcare.

Keywords: Mobile Phone, Health Care, Mobil Health, IT for Development

1. Introduction

Development is seen as improvements in people's lives. In order for people to lead the lives they choose to live, they need access to healthcare despite their social or economic constraints. Equity in healthcare is an ethical concept which ensures that people are not prevented from becoming healthy because of their socio-economic circumstances. Inequities can prevent large segments of a population from being engaged in pursuing better livelihoods. While healthcare is central to the wellbeing of an individual, community and even a nation, it is also a resource that needs to be allocated in a manner that enables the most people to benefit from it. In particular, there is a sense that the the health of individuals permeates the lives of those around them and affects those who may be healthy. When the health of individuals affects that of the community and nation, then the adequate provision of healthcare services become a public responsibility. In this, Information and Communications Technology (ICT) infrastructures can enable more equitable distribution of healthcare resources to be made available (Qureshi, 2016).

Improvements in people's healthcare has to be seen in the context of the individual, community and nation, where the government takes responsibility for ensuring the wellbeing of the individual, not just for the sake of that individual but also for the benefit of the community and society. In response to Walsham's (2012) call for creating a better world with Information and Communications Technologies (ICTs) and the challenges of doing so, this paper offers a specific view into a well-known but often misunderstood topic, the effects of ICTs in the provision of healthcare.

With the ethical dimension, equitable healthcare provision does not necessarily mean that everyone should have the same access to healthcare, but that people should be able to access the care that they require and live the lives that they value (Sen, 2002). Sahay (2016) suggests that studies that conceptualize development based on the "Human Development Index have helped in the reconceptualization of an alternative social future with multiple influences, including relating to classifications of development and with it flows of development aid. In IS, Walsham's writings have helped to introduce the interpretive research paradigm as a challenge to the positivist orthodoxy, and provide the space for researchers to sketch out multiple and alternative interpretively inspired perspectives." (Sahay 2016, p.169).

The questions investigated in this paper are: Do mobile phones and the health index effect development? If so, how does this relationship affect the use of mobile phones for the provision of equitable healthcare? This paper builds upon the work of Qureshi and Afzali (2017) who found a positive significant correlation between both mobile phone penetration and the health index as well as both variables and the Human Development Index (HDI). In their study, five clusters in which the 180 countries of the world were categorized based on their mobile phone subscriptions and health index. In this paper, development will be conceptualized using the HDI, which is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. In order to assess the health of people, we use the Health Index (HI), which is life expectancy at birth expressed as an index using a minimum value of 20 years and a maximum value of 85 years (UNDP, 2017). Mobile phone technology is changing the way in which people can access the health services they need. In order to assess the effects of this, we use Mobile Phone Subscription (MPS) data for all the countries (World Bank, 2017). In order to assess equitable access to healthcare, the Gini Index is used to take into account the disparities in incomes in the countries in our sample.

2. Background Literature

2.1. Health Equity

There is a sense that the equitable provision of healthcare is central to achieving development in any society. The need for health equity arises from inequalities in health status, health care utilization and health care financing (Sen, 2002; SDSN, 2014; WHO, 2015). The concept of heath equity arose from the belief that differences in social and economic backgrounds of people lead to differences in their ability to access health care. On other words, groups of people who are already socially disadvantaged due to their poverty, gender, racial, ethnic or religious backgrounds are further disadvantaged with respect to their health. Braveman and Gruskin (2003) offer a conceptual definition that they operationalize as follows:

"equity in health is the absence of systematic disparities in health (or in the major social determinants of health) between groups with different levels of underlying social

advantage/disadvantage—that is, wealth, power, or prestige…. health is essential to wellbeing and to overcoming other effects of social disadvantage." (Braveman & Gruskin 2003, p.254)

In understanding the concept of health equity, it is important to note that health represents both physical and mental wellbeing in which key social determinants include household living conditions, conditions in communities and workplaces and access to healthcare (Braveman & Gruskin, 2003). They add that health equity is not the same as health equality:

"health equity focuses attention on the distribution of resources and other processes that drive a particular kind of health inequality—that is, a systematic inequality in health (or in its social determinants) between more and less advantaged social groups, in other words, a health inequality that is unjust or unfair. Not all health disparities are unfair…For example, we expect young adults to be healthier than the elderly population." (Braveman and Gruskin 2003, p.255)

This means that having equal opportunities to be healthy is central to the concept of health equity. In essence health, equity is an ethical concept that entails the equal opportunity to be healthy regardless of economic or social standing (Braveman & Gruskin 2003). This ethical concept is followed in countries that offer universal healthcare to all is people where the mental and physical wellbeing of the population as a whole is a social responsibility.

Yet, universal access to healthcare does not necessarily mean that it is equitable. At the same time, the rich are able to live healthier lives because they can afford to pay for basic and often advanced healthcare. Sen (2002) argues that:

"..the violation of health equity cannot be judged merely by looking at inequality in health. Indeed, it can be argued that some of the most important policy issues in the promotion of health care are deeply dependent on the overall allocation of resources to health, rather than only on distributive arrangements within health care" (p. 661).

With the ethical dimension, equitable healthcare provision does not necessarily mean that everyone should have the same access to healthcare, but that people should be able to live the lives that they value. Braveman (2006) notes that since 2003, the World Health Organization (WHO) has removed ethical considerations when calculating health equity and replaced it with a new measurement, which focusses on disparities across groupings. Sen (2002) argues that, since the fact that health is central to our well-being, it is just as important that the equally basic recognition that the freedoms and capabilities that we are able to exercise are dependent on our health achievements. By this Sen means that people are not able to do much if they are disabled or continually troubled by illness, and they can do very little if they are not alive. In this sense, Sen's freedoms include the ability to:

"..do what one sees as one's agency responsibilities and commitments....where health and survival are central to the understanding not only of the quality of one's life, but also for one's ability to do what one has reason to want to do. The relevance of health equity for social justice in general is hard to overstress…in the making of health policy, there is a need to distinguish between equality in health achievements (or corresponding capabilities and freedoms) and equality in the distribution of what can be generally called health resources. While the latter has relevance, I have argued, through process considerations, it is the former that occupies a central territory of equity in general and health equity in particular." (Sen 2002, p663).

There is a sense that the concept of health equity is more than just ensuring that as many people as possible in a society are able to access care. Equality in the distribution of healthcare resources may not necessarily address inequities in healthcare needs. While there are differences in gender, education, financial resources and race/ethnic inequalities that prevent people from being able to access health care, the supply of quality care may also be limited. This means that

if a government with limited healthcare resources were to distribute these over a very large population of people who require healthcare, there would be people who would not be able to have access to care. They would not be able to become healthy for the very reason that the healthcare resources are unavailable to them.

It appears from the disparities in their socio-economic conditions, that poor or disadvantaged people need more and better healthcare, and possibly earlier access to healthcare to receive comparable outcomes than those with wealth or easy access. In this sense, equity in health may entail preventive healthcare programs that offer early access that targets people in communities in need. Another dilemma faced when attempting to offer equitable healthcare is: how does society ensure that healthcare outcomes improve the health of individuals, groups and communities? The following section discusses the dilemma of offering access to healthcare to as many people as possible while ensuring quality of care outcomes.

2.2. Healthcare Access and Outcomes

Governments, individuals, organizations and communities will make choices that fit their views of what would best support their healthcare goals. They will look to see where they can find the best healthcare outcomes. When it comes to understanding disparities in access and outcomes, there is a measurement challenge. Braveman (2006) explains this challenge well:

"Comparing the health of a disadvantaged group with average levels of health may not be very informative about social inequalities in health. For example, in a setting in which a large proportion of a population is disadvantaged, the health of the most disadvantaged may be markedly different from that of the best-off social group but not very different from the average" (p.178)

In order to understand differences between groups, the WHO uses infant mortality as a health indicator to measure inequalities. It also measures differences between the richest and poorest in a country. While the WHO measurement methods show the disparities between the healthiest and sickest in a society, it does not take into account the differences between the poorest and richest or between those in historically disenfranchised and in the dominant racial/ethnic groups. In the United States socioeconomic disparities in populations have generally been categorized according to income or educational attainment, comparing all other groups with the highest income/education group and racial/ethnic backgrounds when assessing health disparities (Braveman 2006).

There is a sense that equitable healthcare can be achieved using ICT to collect, store and analyze data to arrive at treatment options and interventions. In principle, ICTs can improve care through data collection, analysis, and provide transparency required for multiple providers, insurers, and government officials to be able to make informed decisions and arrive at appropriate interventions and treatment options. In practice, the mandated use of electronic health records (EHR) has actually taken physicians away from treating patients and focused their limited attention on manual data entry. Some physicians report that the quality of their care has gone down with the mandated use of the electronic health record largely due to increase in errors, lack of connectivity between systems and restricting physicians from applying their clinical skills (Noteboom and Qureshi, 2014).

Additional challenges to the use of ICTs to support healthcare access and delivery relate to the social and economic conditions in which people find themselves. An InfoDev report by Chetley et. al. (2006) suggests that healthcare can enable poverty to be reduced. They state that while ICTs have a role in addressing the socio-economic conditions that prevent people from

leading healthy lives, there are many challenges which include but are not restricted to lack of power, connectivity and often dangerous environmental conditions. Connectivity problems relate to basic lack of access to electricity, solar power options, and power supply back-ups; insufficient infrastructure and connectivity access; and high costs. Then there are the challenges related to where the local content on disease prevention is created, by whom, the language and its relevance to the local conditions.

While the Internet can provide a wide range of users with timely, accurate, diverse, and detailed health information, a key issue is the quality and reliability of health information. The capacity to have a skilled ICT work force is often needed for the effective use of ICTs in health. Systems professionals and technology products and services providers and project team leaders with high skill levels and experience in working in the sector introducing the ICTs are important components of success. Finally, there is little investment in ICTs for health in most developing countries. Very few government-run health services have properly functioning ICTs within them. If there is no reliable infrastructure to enable inter-organizational transfers of information, then it is difficult to have a national health information and IT infrastructure to underpin the delivery of health care (Chetley et. al., 2006).

2.3. Mobile Health for Equitable Healthcare

There is a sizable opportunity to create a better world with ICTs in the area of Mobile Health. Even with the challenges described above, cell phone usage is transforming health care in Africa. With one in six of the billion inhabitants in Africa who now owns a cell phone, the surveillance, tracking and monitoring of communicable diseases has become much easier. According to Seth Berkley, a medical doctor and an epidemiologist with experience in Africa, the biggest impact may well come from the rich data the network of cell phones can provide. For example, crowdsourcing and automated data aggregation could be used to map the death toll from the Syrian uprising and cell phone data from 15 million people in Kenya could be used to help reveal how human travel patterns can contribute to the spread of malaria (Berkley, 2013).

Mobile Health (mHealth) is an emerging concept in health care in which mobile communications devices are used in health services and information. Mhealth has been defined as the use of portable electronic devices for mobile voice or data communication over a cellular or other wireless network of base stations to provide health information (Kahn et al., 2010). Devices such as mobile phones, patient monitoring devices, tablets, personal digital assistants, and other wireless devices can be part of mHealth systems. MHealth systems use mobile decision support software applications (apps) to assist or direct health care professionals to make decisions, or they can assist patients to make decisions without waiting for input from a clinician (Klonoff, 2013). Mhealth appears particularly advantageous for conditions that require intense and ongoing monitoring, such as diabetes, and where people are of working age and not disabled. With mHealth systems, glucose data can now be automatically collected, transmitted, aggregated with other physiologic data, analyzed, stored, and presented as actionable information (Baron et al., 2012; Klonoff, 2013; Quinn, 2009). In developing countries, mHealth applications present opportunities for combatting infectious, chronic and communicable diseases (Kahn et al., 2010).

An area in which mobile healthcare provision is becoming more equitable is in enabling care to become more patient centered. Studies have shown that the outcomes of patient centered care have reported better recovery from their discomfort and concern, better emotional health, and fewer diagnostic tests and referrals (Oates et al., 2000; Cliff, 2012; Gabriel & Normand, 2012).

Additional studies have also shown that the use of mHealth applications for patient centered care reduce the cost of care significantly (Boulos et al., 2011; Payne et al., 2012).

Medical applications make smartphones useful tools in the practice of evidence-based medicine at the point of care (Mosa et al., 2012). Motivated by rising costs of healthcare, patients can achieve significant improvements in their health outcomes at reduced costs when they use mobile applications. There are currently between 3,000 to 7000 mobile healthcare applications available through Google Playstore and Apple Store to patients all over the world that support lifestyle changes such as fitness, calorie counting and Body Mass Index (BMI) calculation used to control diabetes (Boulos et al., 2011; García-Gómez et al., 2014; Kailas et al., 2010). Such uses of mobile health applications give people more choices as to how they may go about leading heathier lives. Kahn et al. (2015) argues that mHealth may also have a non-health benefit: fostering local economic development beyond health care.

Evidence suggests that motivated patients can achieve significant improvements in their health outcomes when they use mobile applications (García-Gómez et al., 2014). Internet enabled mobile applications allow active patient participation in decisions affecting their health status, health information, linking people and information through multiple digital devices to allow for person-to-person communication, and participating in support groups (Anderson et al., 2003; Boulos et al., 2011). The use of such mobile applications is transforming the relationship between physicians and patients offering greater equity in outcomes.

While the successful cases of mHealth offer hope to those in need to basic healthcare, it is not clear if at all they can be sustained, scaled up, or even replicated in communities around the world. There are as yet few if any studies that evaluate the success of mHealth in offering equitable healthcare to individuals and communities in need. Here in lie the opportunities for research in the use of ICTs to support health equity. The growing use of mHealth applications have offered opportunities to address some of the individual, community and public health challenges that current ICTs do not address and often complicate the quest for better healthcare provision (Qureshi, 2016). The following section investigates the relationship between mobile phone usage and health. It also investigates the relationship between these two variables and human development. In order to understand the role of mobile phones in achieving equitable health outcomes. Overall, the research investigates the effects of Mobile Phone Subscription and the Development on the Health Index.

3. Methodology

In order to investigate the relationship between mobile phone usage and health, the data used for this analysis was collected from the World Bank on Mobile Phone Subscription (MPS) and the United Nations Development Program (UNDP) on the Health Index (HI). MPS indicates the number of mobile phone subscribers per 100 people in the country. The Health Index was selected for this analysis because it offers a measure of "Life expectancy at birth expressed as an index using a minimum value of 20 years and a maximum value of 85 years" (UNDP 2017 p.1).

In order to assess the effect of the two variables on development, data on the Human Development Index (HDI) is used. The HDI "is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions" (UNDP 2017).

The dataset downloaded from World Bank and UNDP HDI had data from 188 countries. After cleaning the data, we had 180 countries for cluster analysis. Mobile Phone Subscriptions: the country ranking for this variable based on mobile cellular subscriptions (per 100 people). Health Index: the life expectancy at birth having a minimum value of 20 and maximum 85 years. HI covered a longer time span, 1980 to 2014. \MPS data ranged from the year 2000 to 2014. We created MPSHI as an index by combing the average of MPS and HI for 180 countries. It was calculated for this analysis. The Gini Index was used to assess the levels of inequality in each country. Note 41 countries in this sample did not have Gini Index and were not used for the rest of the analysis.

4. Results and Analysis

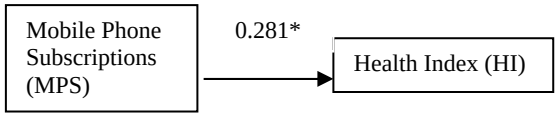
4.1. Assessment of Relationships

The first step of the analysis is to discover the relationship between mobile phone usage and health. Then their combined effect on human development. Regression analysis was carried out for the 180 countries of the world indicated on the UNDP's Human Development Index. The analysis took place in two steps: first in order to find out if the use of mobile phones affect the health index, linear regression was carried out. This analysis gave us the following results:

Table 1. ANOVA and Regression for MPS and HI

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.501	1	1.501	142.460	.000[b]
	Residual	1.844	175	.011		
	Total	3.346	176			
a. Dependent Variable: HI						
b. Predictors: (Constant), MPS						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.512	.020		25.277	.000
	MPS	.281	.024	.670	11.936	.000
a. Dependent Variable: HI						

The regression results indicate a significant correlation between the use of mobile phones (MPS) and health. As depicted in the following model, there is a significant direct relationship between Mobile Phones Subscriptions and the Health Index. For every 1% increase in MPS, HI increases by 0.281%. This indicates that there may be an effect on health equity from the use of mobile phones. As both variables are secondary data, we cannot conclude that there is a casual relationship between the two variables. The effect on mobile phone usage on health is depicted in the model below:



*Significant at 0.05

Figure 1: Mobile Phone Subscriptions and Health

While the above model suggests there may be an effect of using mobile phones on health outcomes. We cannot tell if there are improvements in people's lives from such uses of mobile phones to achieve better health outcomes. In order to understand the effects of this relationship on development, a second regression analysis is carried out.

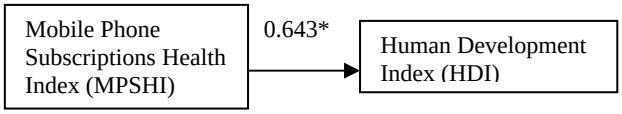
This entails understanding if the use of mobile phones for access to healthcare may bring about development where development is measured in terms of the HDI. In order to do so a mobile phone health index (MPSHI) variable was created. The results are as follows:

Table 2. ANOVA and Regression for MPS and HDI

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.411	1	3.411	586.309	.000[b]
	Residual	1.018	175	.006		
	Total	4.429	176			
a. Dependent Variable: HDI						
b. Predictors: (Constant), MPSHI						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.185	.021		8.761	.000
	MPSHI	.643	.027	.878	24.214	.000
a. Dependent Variable: HDI						

These results suggest that there is a significant direct relationship between Mobile Phones Subscriptions Health Index and the Human Development Index. This relationship is illustrated in the model below:



*Significant at 0.05

Figure 2: Mobile Phone Subscriptions Health Index and the Human Development Index

For every 1% increase in MPSHI, HDI increases by 0.643%. This means that the use of mobile phones for achieving improvements in health does bring about significant improvements in people's lives.

The above analysis confirms our research question that mobile phone usage and health outcomes are significantly correlated. We also found that together these variables as an index also have a significant positive relationship to human development.

Gini Index, which is the normalized value of Gini coefficient was utilized to understand how the wealth distribution could potentially impact the development. Based on the Gini Index data from the World Bank, there are 136 countries that have recent valid data. Multiple regression was conducted to investigate the relationship between MPSHI and Gini Index with HDI. In other words, this model further investigate how MPSHI and Gini Index may affect the HDI.

Table 3. ANOVA and Regression for MPSHI, Gini, and HDI

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.892a	.796	.793	.074349362400000
a. Predictors: (Constant), Gini Index, MPSHI				

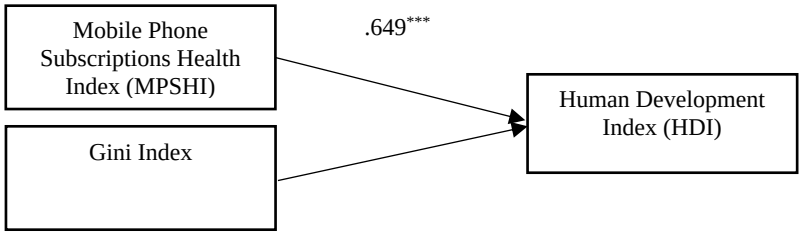
Based on the model summary, 79.6% of the data can be explained by this model.

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.874	2	1.437	259.965	.000b
	Residual	.735	133	.006		
	Total	3.609	135			
a. Dependent Variable: HDI						
b. Predictors: (Constant), Gini Index, MPSHI						

ANOVA further suggests the model is a good fit for the data. It is significant at .0001 level. Finally, the beta coefficients provide the model we have.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.261	.045		5.808	.000
	MPSHI	.649	.032	.851	20.603	.000
	Gini Index	-.002	.001	-.112	-2.705	.008
a. Dependent Variable: HDI						

HDI=.261+.649(MPSHI)-.002(Gini Index).



-.002**

*** Significant at .001 level
** Significant at .01 level

Figure 3: Mobile Phone Subscriptions Health Index, Gini Index and the Human Development Index

Based on the regression model, for every .649 unit increase of MPSHI, HDI will increase by 1 unit while Gini Index stays constant. For every .002 unit decrease of Gini Index, HDI will increase 1 unit while MPSHI stays constant.

Cluster analysis was conducted to further understand the data. Based on MPSHI, HDI, and Gini Index, there are three clusters identified. The information of each cluster can be found below.

Table 4. Number of Cases in each Cluster

	Cluster 1	**Cluster 2**	**Cluster 3**
Number of Countries	63	55	18
Cluster Center: MPSHI	.8277	.6917	.6830
Cluster Center: HDI	.7317	.6162	.5935
Cluster Center: Gini Index	31.68	42.95	54.16
Sample Countries	Canada, Denmark, Iceland, United Kingdom, Bangladesh, Estonia, Tunisia, Ukraine and Sweden.	China, United States, Russian Federation, Israel, Costa Rica, Mexico, Bolivia, Maldives, Jamaica, Thailand, Turkey, Bhutan, Philippines, Zimbabwe.	South Africa, Brazil, Panama, Namibia, Honduras, Haiti, Rwanda and Zambia.

There are 63 counties in cluster 1, which is the largest cluster. Based on the data, cluster 1 consists of countries that have high MPSHI, high HDI, and low Gini Index. With 55 countries, Cluster 2 consists of countries that have median MPSHI, median HDI, and median Gini is the largest cluster Index. Finally, cluster 3 consists of countries that have median MPSHI, median HDI, and high Gini Index. A list of those countries and clusters is provided at the end of the paper. It is important to note that while the Gini Index is a significant indicator of equity, this data is not available for all the countries in this sample.

Based on the initial exploratory analysis, there is a strong positive relationship between the MPSHI and HDI indices. There is also a negative relationship between Gini Index with HDI. The question remains, how does this relationship effect the provision of equitable healthcare? The following section investigates this second question.

4.2. Equitable Healthcare Provision –Cluster Categories

Access to healthcare in and of itself does not enable people to lead to better lives. It is the surrounding socio-economic factors and the capability of healthcare providers to identify and treat diseases this is key. Thus, equal healthcare distribution does not necessarily mean equity in health if outcomes are inferior. In fact, equality of distribution may in fact lead to a loss in the quality of care bringing about epidemics that could be contained had resources been allocated in a more equitable manner. The following cluster analysis attempts to throw light into the characteristics of countries that were grouped together on the basis of their mobile phone penetration and health index, their human development index and income inequalities measures through the Gini index.

Equitable Access to Healthcare Cluster 1 consists of countries that have high MPSHI, high HDI, and low Gini Index. This suggests that while not all the countries in this cluster are rich, they do have lower income inequalities than the rest of the countries in this sample. These are aggregate numbers and do not necessarily reflect the specific instances of countries that may have other specific healthcare needs. Some of the countries close to the center of this cluster are Bangladesh, Switzerland, Mongolia, Poland, Japan, Mauritania, Croatia, Ireland and the United Kingdom. The United Kingdom a country in this cluster is considered to be a developed country which has a healthcare system that provides universal access to all its people. In its efforts to ensure equality of healthcare, the government takes responsibility for distributing its healthcare resources to every segment of its population. Recently, the British Broadcasting Corporation (BBC) reported that:

"Parts of London, in the United Kingdom (UK) have higher Tuberculosis rates than Rwanda, Iraq or Guatemala." The article noted that healthcare provision was "Prevention poor" and that, "The borough with the highest rate per 100,000 people was Newham, with 107 cases….. Figures for 2013 from the World Health Organisation showed in Rwanda the figure was 69, while in Iraq it was 45. The average rate per 100,000 in the UK was 13." (BBC 2015, p.1). It turns out that London was infected by a particularly drug-resistant strain of Tuberculosis. The question arises: why does London, perhaps one of the richest cities in the world, have the worst healthcare outcomes in the country? The reasons given for such low healthcare outcomes are socio-economic:

"Poor housing, chronic ill health and poor nutrition trigger latent Tuberculosis (TB) into active TB. Specific health complaints, including diabetes and HIV, weaken the immune system - the capital has high rates of both. More than 80% of London TB cases occur in people who were born abroad. It is not known how many people arrive with latent TB and it is not deemed cost-effective to screen for it. Low levels of awareness and late diagnosis by General Practitioners [lead to such high rates of infection]." (BBC 2015, p.2). Figure 4 provides the cluster information for the first group. The number suggests the distance of each country towards the cluster center. See below an illustration of this cluster:

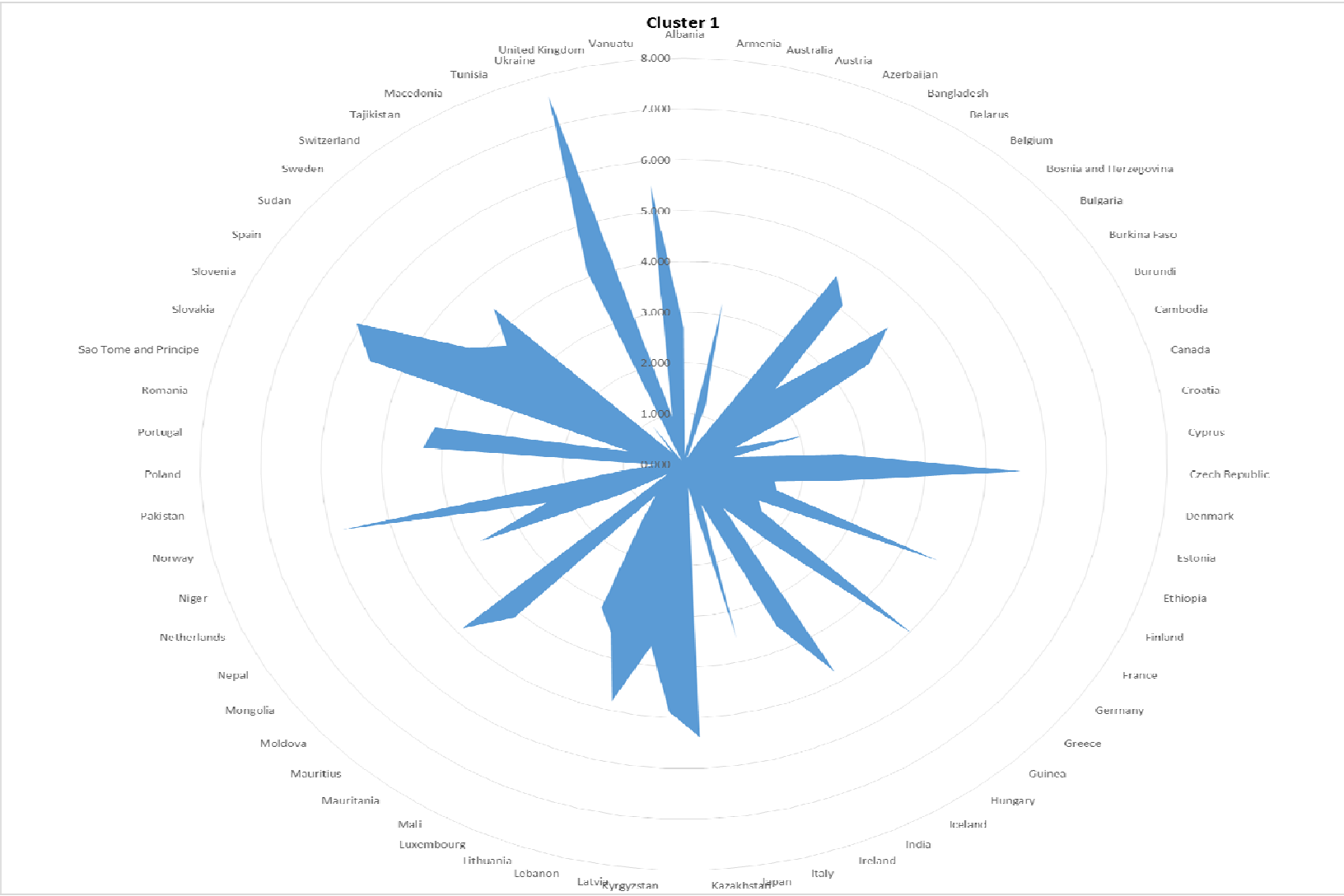


Figure 4: Cluster 1 high MPSHI, high HDI, and low Gini Index

Bangladesh is also a country in this cluster. It is ranked much lower on the human development index, and is prone to epidemics such as swine flu, appears in the same cluster. Like Pakistan, India, Italy, Estonia, Lebanon and Ethiopia, also appear in this cluster, Bangladesh is not a rich country but have similar levels of inequality, the Gini Index of 32. It is important to note that while the Gini Index is a significant indicator of equity, this data is not available for all the countries in this sample. This suggests that the role of mobile phone subscriptions in enabling people to access health resources plays a role in increasing equitable access to healthcare.

Access to Healthcare Cluster 2 consists of countries that have median MPSHI, median HDI, and median Gini Index. The characteristics of countries in this cluster are that there is income inequality and while people use their mobile phones to access healthcare, people do not

necessarily get the care they need. The majority of countries in this cluster are considered middle income. The United States, China, Russia, Brazil, Israel, Turkey, Thailand and the Philippines are some of the countries in this cluster. Figure 5 provides the cluster information for the second group. The number suggests the distance of each country towards the cluster center. The following figure illustrates the countries in cluster 2:

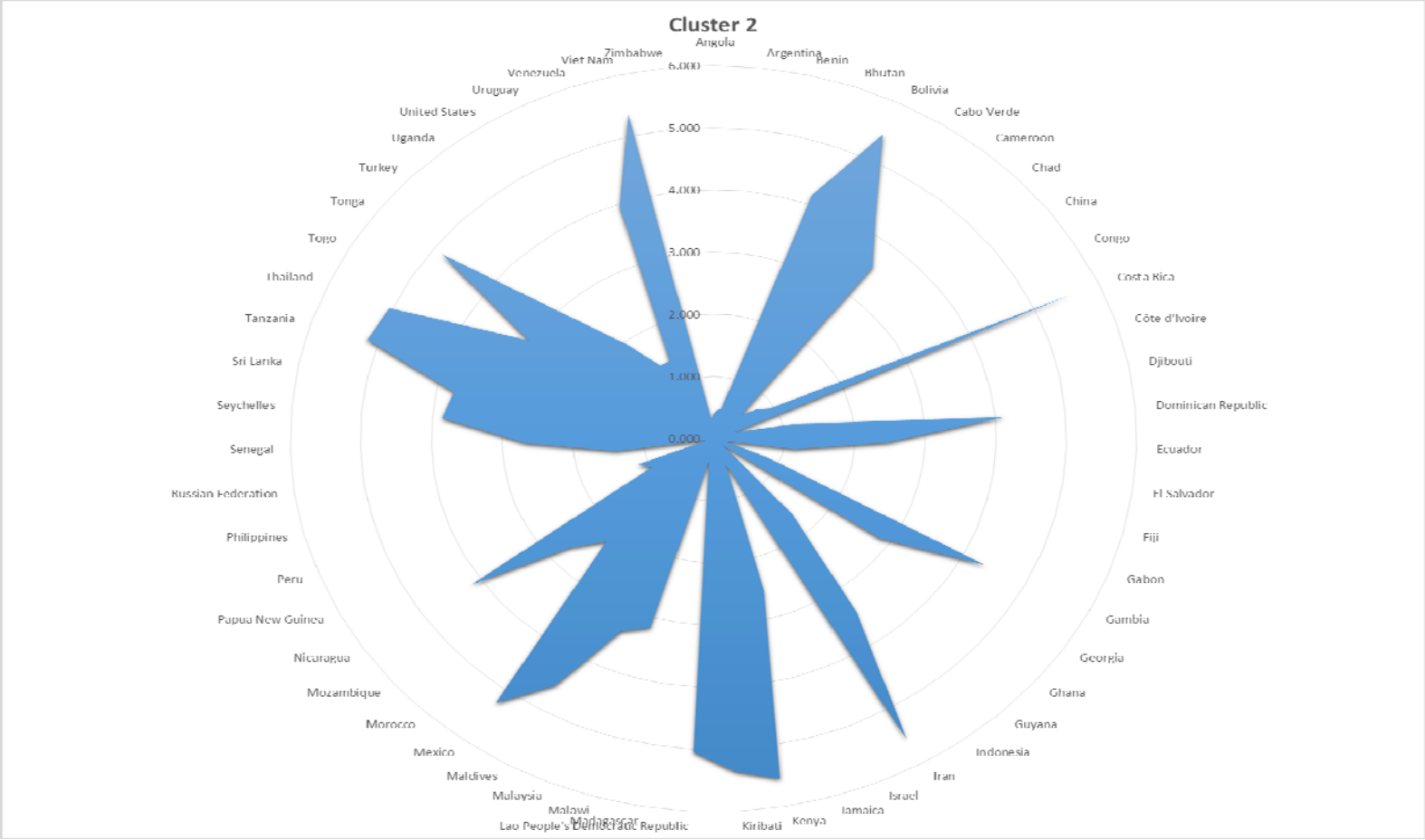


Figure 5: Cluster 2 medium MPSHI, medium HDI, and medium Gini Index

In China, every citizen is able to receive basic health care service provided by the health authorities (Fang, 2017). Overall, local government is responsible for the health insurance. In 2014, 992 Billion USD was spent on health care, which is about 5.6% of its GDP (Fang, 2017). Nearly all the major hospitals are owned and managed by the government with little private sector. Based on the data from the World Health Organization (WHO), 95% of the population in China have basic health insurance coverage (CHINA-WHO, 2017). There were about 1.9 practicing physicians per 1000 population in 2014 (Fang, 2017). Electronic health record (EHR) system was set up by each health care provider, which is not integrated or interoperable (Fang, 2017). Most of the time patients will need to bring a printed copy of the report and record if they want to switch to another health care service provider. Patients' usage of EHR system of scheduling appointment and accessing information is rare (Fang, 2017).

Access to healthcare in the United States is currently undergoing a transformation that promises to address the high cost and decreasing quality of care. At the center of this transformation is the Electronic Health Records (EHR) technology, mandated by the Health Information Technology for Economic and Clinical Health Act (HITECH). This act authorizes incentive payments through Medicare and Medicaid to clinicians and hospitals when they use EHRs privately and securely to achieve specified improvements in care delivery. The transformation of health care through the use of ICTs continued with the passing of the Patient Protection and Affordable Care Act of 2010, which mandated the integration of physician quality reporting and Electronic Health Record reporting. In requiring the creation of measures and reporting of the meaningful use of the electronic health record and quality of care furnished to an individual, the law links the adoption of the electronic health record with quality of care to the patient through objectives that measure the adoption of technology by eligible providers (Blumenthal and Tavenner, 2010, Noteboom and Qureshi 2014). The result has been an increase in the number of people insured, access to healthcare is still not available for the entire population as the political process continues to create uncertainty in the healthcare system.

Limited Access to Healthcare Cluster 3 consists of countries that have median MPSHI, median HDI, and high Gini Index. High income inequality has meant that the poor people in these countries increasingly rely on government healthcare infrastructures for their survival. At the same time, there is a private healthcare industry that caters for the wealthy. Examples of countries in this cluster are South Africa, Brazil, Botswana, Haiti and Rwanda. Figure 6 provides the cluster information for the third group. The number suggests the distance of each country towards the cluster center. The following figure illustrates the countries in cluster 3:

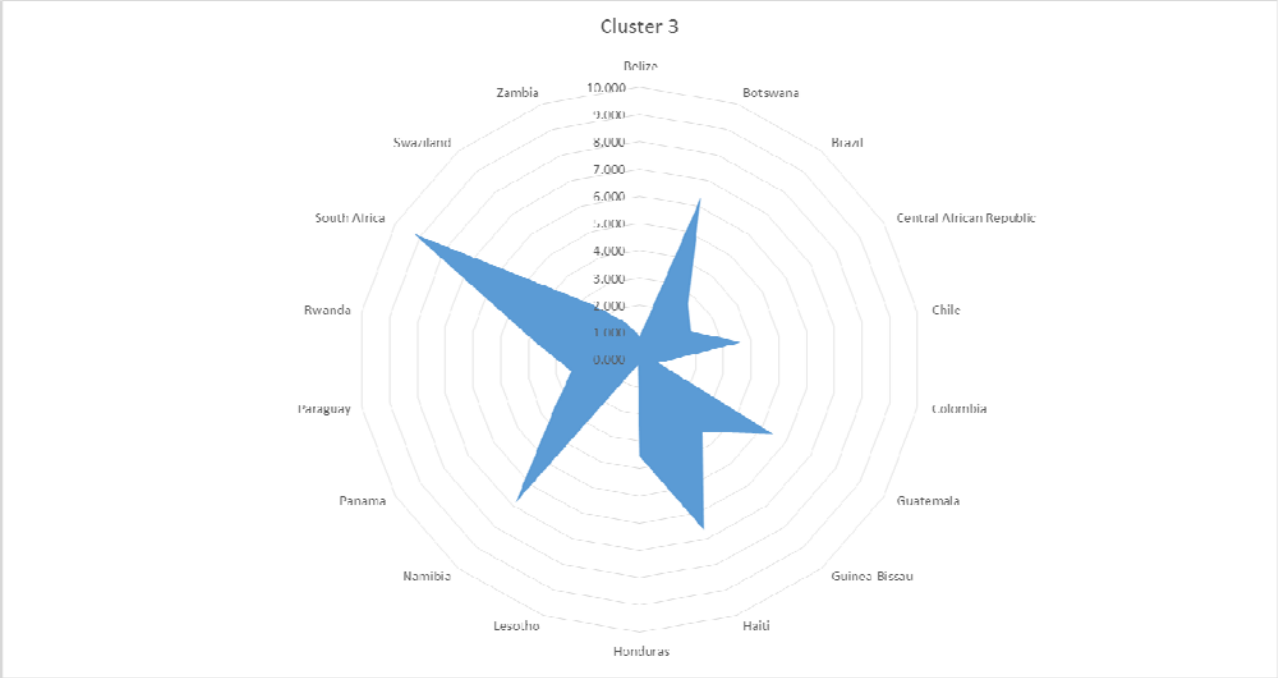


Figure 6: Cluster 3 low MPSHI, low HDI, and high Gini Index

An example of a country in this cluster is Brazil. Brazil's health system is a decentralized universal access model, with municipalities providing comprehensive and free health care to each individual in need financed by the states and federal government. Primary health care is at the center of Brazil's public healthcare system which involves promoting health, preventing sickness, treating the sick and injured, and tackling serious disease. About 70% of Brazil's population receives care from this system, while those who can afford to avoid the queues and inconvenience of the public system can access care through private health insurance (Jurberg, 2008). In recent years, Brazil has been faced with budget shortfalls and political turmoil which has lead to a shortfall in access to quality care. In fact, the majority of Brazilians rely on state run care. Universal healthcare in Brazil is actually very inequitable. As Khazan (2014) reports:

> "Brazilians in the wealthy south tend to live better, healthier lives than their poorer northern countrymen. The infant mortality rate of the north is twice as high as that of the south. That poor northeastern area of Maranhao has only about 0.58 doctors per 1,000 people, while the richer Rio de Janeiro has 3.44. The richest fifth of Brazil's population is twice as likely to receive prenatal care as the poorest fifth. In 2012, between 62 and 75 percent of people in the south who needed kidney transplants received one, but only 13 to 27 of those living in the rest of Brazil were able to." (Khazan 2014, p.3)

Brazil is a good example of how inequity in healthcare provision is actually an unintended consequence of the universal healthcare system. Although high-earners tend to visit private doctors, they flock to the public system to get costly procedures, crowding out poor people who have no choice but to use the public system. And rich Brazilians take their right to free healthcare seriously demanding that costly procedures be provided to them by the state for free. Another consequence is that the under-resourced communities get even less access to healthcare as funding gets drained.

Similarly, in South Africa, both private and public health care systems exist. About 70.5% of the patients went to public health care system in South Africa (South African Government, 2017). The disparities in health care system is widening. 30% of the doctors are serving 84% of the national population in the public sector, and the remaining 70% of the doctors are serving 16% of the population (8 million people) in the private sector (Mayosi & Benatar, 2014). While poverty, HIV/AIDS Pandemic, and Tuberculosis are still considered as major national challenges (Mayosi & Benatar, 2014), National Health Insurance (NHI) was launched in 2016, aiming to provide equal and affordable access to the health care services for all South Africans (South African Government, 2017; Bulletin of the World Health Organization, 2010). Electronic Health Record (EHR) demonstrates potential to improve health care system in South Africa. However, the development is limited (Akanbi et al., 2012).

5. Implications for the use of Mobile Applications for Equitable Healthcare

Equitable access to healthcare involves addressing the disparate needs of people while not necessarily offering universal public access to healthcare. While public private partnerships may be suitable for some regions, other areas may require more targeted support for epidemics or community healthcare needs. The above analysis suggests that regardless of level of income, in countries where income inequality is low, equitable access to healthcare can be offered through mobile phone subscriptions.

In order to achieve equitable access to healthcare, the spread of diseases can be curtailed through the use of mobile communication infrastructures by public health authorities. As human travel is one of the key factors affecting the spread of disease in Africa, a group of researchers, including Caroline Buckee, an epidemiologist at the Harvard School of Public Health, have mapped precisely how human travel affects the spread of malaria in Kenya by using cell-phone location data. By capturing the anonymized travel habits of nearly 15 million Kenyans by gleaning their movements from 11,920 cell towers, and then mapping the data against the incidence of malaria as recorded by health officials, future outbreaks can be contained (Talbot, 2012).

Location based mHealth applications can further assist the independent living of persons with disabilities and/or multiple chronic conditions and in epidemiology/public health surveillance, community data collection and remote monitoring of patients. (Boulos et al., 2011; Mosa et al., 2012). Disease diagnosis, drug reference, and medical calculator applications were reported as most useful by healthcare professionals and medical or nursing students (Mosa et al., 2012). Their reliability for making clinical decisions, protection of patient data with respect to privacy; impact on the doctor–patient relationship; and proper integration into the workplace remains limited (Ventola, 2014; Boulos et al., 2011; Mosa et al., 2012). In their review of mobile applications for community based health reporting, Freifeld et. al, (2010) found that mobile applications, often available free through open source platforms, Examples include but are not limited to (pages 1-2):

- FrontlineSMS allows citizens in remote areas to communicate their specific problems and needs directly to health workers who would not otherwise have the capacity to interact with the remote populations.
- Ushahidi gained broad recognition and acclaim as an important resource for citizens and responders in the aftermath of the earthquake in Port-au-Prince, Haiti. This system provides an open-source platform for collecting individual reports from users through SMS, Web, and email and provides tools for translating, classifying, and georeferencing these reports; the newest version of the platform further allows for submission via voice message—essential for illiterate users. Aggregated information is presented on a map-based interface accessible via Web and mobile phone.
- GeoChat, also of a suite of open-source software tools aims to achieve faster and more coordinated responses to disease outbreaks and natural disasters. GeoChat enables team members to communicate their position and important information using text messages, email, or a Web browser, with data instantly synchronized on every user's mobile.

The above mobile applications are examples of a large number of tools that are being used to support equitable healthcare provision around the world. Mobile applications and internet access continue to transform healthcare by offering patients greater knowledge about their condition and the ability to actively participate in health-related decisions that affect them (Ventola, 2014; Anderson et al., 2003; Boulos et al., 2011). Physicians and medical students are also increasing their usage to support their education and clinical practice (Payne et al., 2012; Ventola, 2014).

The increased popularity of smartphones has led more patients to proactively manage their care while on the go using specific mobile applications containing functionalities such as GPS tracker for Alzheimer's patients, not available on desktop computers. In particular, the rise of open source software development communities has meant that mobile applications for

healthcare have enabled access to basic healthcare easier. As can be seen from the analysis above, there are still some challenges that need to be overcome before such mobile applications can be more widely used for the provision of equitable healthcare.

6. Summary, Conclusions, and Contributions

In this paper the concept of health equity, mHealth and human development are investigated in relationship to income inequalities. Following a review of what is known about health equity and the role of mobile health, this paper has investigated the relationship between Mobile Phone Subscriptions, the UNDP's Health Index and the Human Development Index for 180 countries of the world. The analysis discovered a significant relationship between the use of mobile phones in the provision of healthcare and human development outcomes. It also found that there is an inverse relationship between income inequalities in the sample of countries investigated and mobile phone subscriptions and health index for human development. Based on these analyses, this paper offers a contribution to what is known about the use of mobile phones for the provision of equitable healthcare. The concepts explored in this paper have offered a means of understanding the challenges and opportunities for creating a better world with ICTs. In particular, the concept of health equity is used to understand the duality between healthcare access and equitable outcomes.

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Appendix

Cluster 1		Cluster 2		Cluster 3	
Country	Distance	Country	Distance	Country	Distance
Albania	2.681	Angola	0.387	Belize	0.865
Armenia	0.182	Argentina	0.454	Botswana	6.348
Australia	3.227	Benin	0.487	Brazil	2.666
Austria	1.226	Bhutan	4.153	Central African Republic	2.092
Azerbaijan	0.130	Bolivia	5.449	Chile	3.673
Bangladesh	0.525	Cabo Verde	4.249	Colombia	0.675
Belarus	4.481	Cameroon	3.558	Guatemala	5.458
Belgium	4.086	Chad	0.553	Guinea-Bissau	3.468
Bosnia and Herzegovina	2.120	China	0.754	Haiti	6.648
Bulgaria	4.322	Congo	0.932	Honduras	3.556
Burkina Faso	3.654	Costa Rica	5.553	Lesotho	0.211
Burundi	1.824	Côte d'Ivoire	0.314	Namibia	6.844
Cambodia	0.914	Djibouti	1.200	Panama	3.481
Canada	2.026	Dominican Republic	4.150	Paraguay	2.458
Croatia	0.827	Ecuador	2.454	Rwanda	3.767
Cyprus	2.621	El Salvador	1.168	South Africa	9.245
Czech Republic	5.582	Fiji	0.181	Swaziland	2.663
Denmark	2.593	Gabon	0.803	Zambia	1.460
Estonia	1.539	Gambia	4.354		
Ethiopia	1.629	Georgia	2.856		
Finland	4.594	Ghana	0.171		
France	1.428	Guyana	1.651		
Germany	1.596	Indonesia	3.452		
Greece	5.022	Iran	5.552		
Guinea	2.084	Israel	0.454		
Hungary	1.087	Jamaica	2.556		
Iceland	4.786	Kenya	5.552		
India	3.531	Kiribati	5.360		
Ireland	0.844	Lao People's Democratic Republic	5.053		
Italy	3.537	Madagascar	0.378		
Japan	0.463	Malawi	3.175		
Kazakhstan	5.383	Malaysia	3.363		
Kyrgyzstan	4.882	Maldives	4.564		
Latvia	3.624	Mexico	5.251		
Lebanon	4.820	Morocco	2.256		
Lithuania	3.528	Mozambique	2.677		

Luxembourg	3.135	Nicaragua	4.149
Mali	1.380	Papua New Guinea	0.992
Mauritania	0.778	Peru	1.156
Mauritius	4.119	Philippines	0.088
Moldova	4.882	Russian Federation	1.389
Mongolia	0.331	Senegal	2.658
Nepal	1.175	Seychelles	3.863
Netherlands	3.689	Sri Lanka	3.753
Niger	2.399	Tanzania	5.157
Norway	5.787	Thailand	5.055
Pakistan	1.037	Togo	3.061
Poland	0.458	Tonga	4.852
Portugal	4.322	Turkey	2.754
Romania	4.181	Uganda	1.977
Sao Tome and Principe	0.938	United States	1.391
Slovakia	5.582	Uruguay	1.391
Slovenia	6.083	Venezuela	3.953
Spain	4.223	Viet Nam	5.355
Sudan	3.740	Zimbabwe	0.326
Tajikistan	0.906		
Macedonia	0.081		
Tunisia	4.119		
Ukraine	7.581		
United Kingdom	0.953		
Vanuatu	5.526		