

## ANALYSIS OF SUCCESS DRIVERS OF E-HEALTH INFRASTRUCTURE AND USE: A NATIONAL LEVEL STUDY

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### Abstract

e-Health, in form of websites that contain information on health, is emerging as an important resource for common people in some developed nations. The purpose of the study is to explore the critical factors that drive the e-Health infrastructure of nations and its usage. Research data from a set of more than 40 developed and developing nations were gathered from 8,000 websites to allow analysis of factors driving the e-Health growth. The results suggest that at a national level, cost of health care per capita and perception of health are significant in e-Health infrastructure regression, explaining more than 32-41% of the variability in e-Health infrastructure. Confidence in health care systems, perception of good health, health care costs, and human development index and health infrastructure also explain over 69-78% of the variability in e-Health use.

**Keywords:** E-Health Infrastructure; E-Health Success Drivers; National-Level Analysis

### 1. Introduction

e-Health in form of websites that contain information on health is emerging as an educational and information sharing tool for average people in some developed nations such as the U.S. However, national-level studies of factors, in particular, that impact e-Health adoption and use are non-existent (Lee, et al., 2009). This article tries to fill that gap. The study is important because of the great potential benefits of e-Health systems including healthcare cost reduction, improvement of communication among healthcare professionals and the public at large, enhanced access to advance healthcare information and related resources, and improvement in health as a result of health education and awareness made possible by the new online systems.

The use of the Internet technologies in health care is expected to facilitate patient-focused care and promote transparency in prices and performance (Lee, et al., 2010). For the present paper, Web-based health (e-Health) infrastructure of a nation is defined as the set of web pages from that nation that contains information about health. These web pages could be designed and maintained by governments, hospitals, health care professionals etc. As Rochman (2010) reported, ordinary people are joining together to start websites which help them to find which practitioners to see, which hospitals to avoid, which experimental treatments are not worthy.

In this paper, we thus try to find answer to the research question: what drives the e-Health infrastructure of nations and its usage?

### 2. E-Health Systems and Public Health

The study of e-Health or availability of health-related information over the Internet is important as it may lead to a healthier population (Sheu-Jun, et al., 2009). There may not be a clear evidence linking e-Health to improvements in the health of patients but this benefit is highly desirable and often hypothesized. It is believed that if patients consistently use quality information about their illnesses, cures, drugs, and current research findings, they (the patients) are more likely to behave in ways that lead to improved health condition (Salovey, et al., 2009; Lee, et al., 2010). With advanced e-Health infrastructure, the patients can self-manage their condition by collecting relevant information and using e-monitoring over the Internet; connect electronically to other patients with the same medical conditions; and communicate better and more frequently with their providers (Schweiger, et al., 2007). These types of exposures are likely to lead to improved health for the patients.

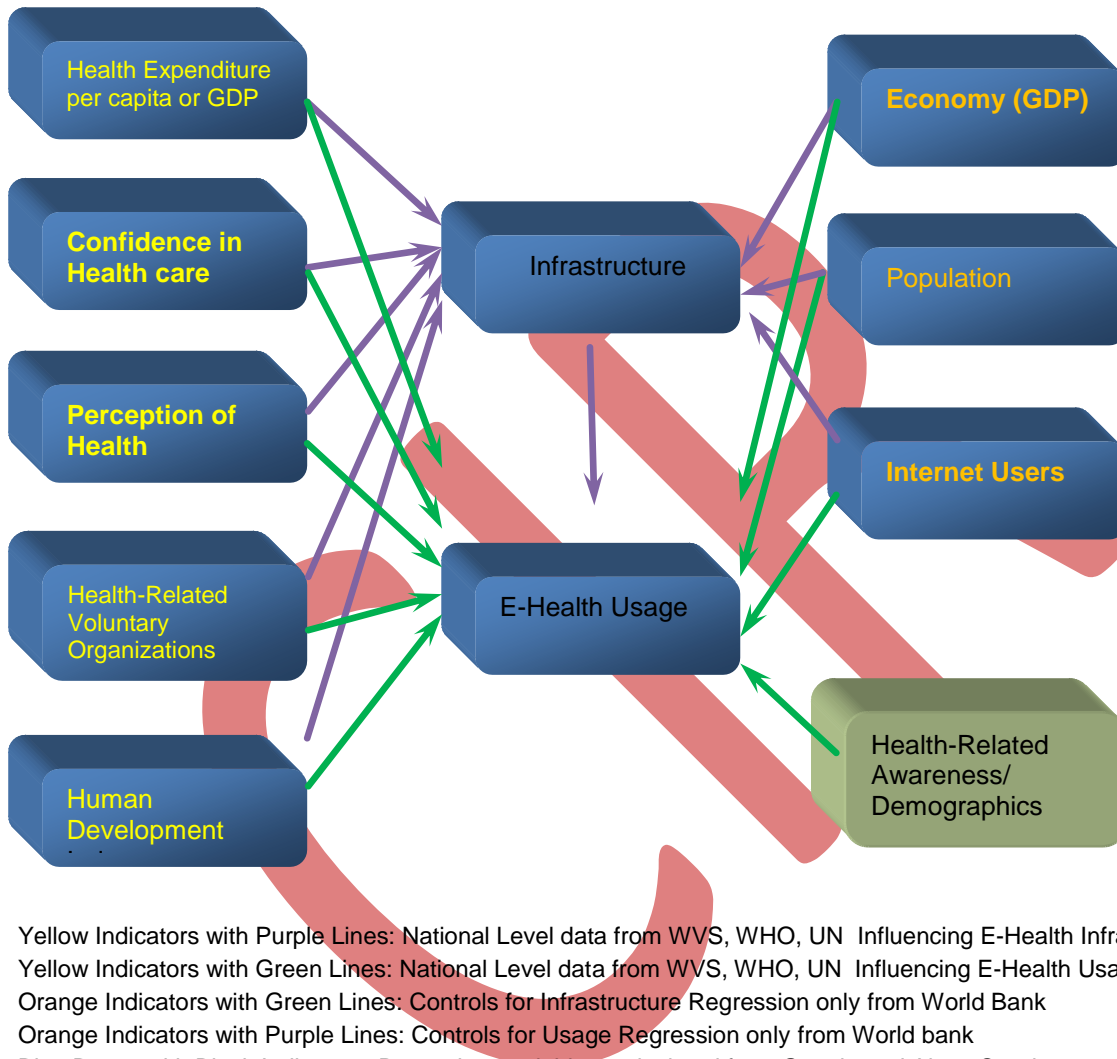
Some studies (Sheu-Jen, et al., 2009; Winkelman & Choo, 2003) actually set out to determine the impact of e-Health usage on the health of the patients. Winkelman and Choo (2003) studied patients in a virtual community who had access to internet based information and observed that "quality of life significantly improved and health service utilization significantly dropped during the study period." Ross et al. (2004) investigated how a patient-accessible online medical record affects patient care and clinic operations. They concluded that this practice can lead to adherence to healthy habits but they failed to demonstrate the effect of the practice on health status of the participants.

As the number of Web servers increased exponentially on the Internet, more users joined the Internet and became users of this new technology. The business community started taking interest in the Web and this has prompted further explosion in the development of the Web. The aim of this study is to use the proposed model described below to investigate factors that affect the infrastructure and use of e-Health systems.

### 3. E-Health Infrastructure and Usage Model

The study model is proposed in Figure 1 which shows how various aspects of health-related issues are impacting the e-Health infrastructure and e-Health use. The study variables shown in Figure 1 are based on the theory of Diffusion of Innovation (DOI) as applied at a national level. Roger's (1995) Diffusion of Innovations has been used to phases of information systems diffusion including e-Health systems. The model presents diffusion as a process by which an innovation is disseminated via some channels to members of a social system. The five elements attributes of the model

include: relative advantage, compatibility, trialability, observability, and complexity. Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. Compatibility is the degree to which an innovation is perceived as consistent with existing values, past experiences and needs of potential adopters. E-health can enable a patient with immediate information sharing with other patients thus consistent with the needs of people. Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use. E-health requires access to Internet and knowledge of Internet use and now-a-days people with less education can also learn to navigate the Internet fairly quickly. Trialability is the degree to which an innovation may be experimented with on a limited basis. E-health web sites are sometimes recommended by a doctor. Observability is the degree to which the results of the innovation are visible to others.



Yellow Indicators with Purple Lines: National Level data from WVS, WHO, UN Influencing E-Health Infrastructure  
 Yellow Indicators with Green Lines: National Level data from WVS, WHO, UN Influencing E-Health Usage  
 Orange Indicators with Green Lines: Controls for Infrastructure Regression only from World Bank  
 Orange Indicators with Purple Lines: Controls for Usage Regression only from World bank  
 Blue Boxes with Black Indicators: Dependent variables, calculated from Google and Alexa Queries  
 Green Box with Black Indicators: Not used in the study due to data availability

**Figure 1. The Conceptual Model**

The elements of Figure 1 are described below.

- **Economy or Personal Wealth** - Social development and economic infrastructure play a role in ICT diffusion of a nation thus personal income (GDP per capita), inflation, income inequality, etc. may play a role for developing nations.
- **Number of Internet Users** - The number of Internet users per 1000 could be positively related to the number of health-related web sites. Internet-based health information access has resulted due partly to Internet-savvy consumers.
- **Health Expenditure** - E-Health may provide an alternative channel for health care in many nations. The Internet provides a low cost universal access to data which is getting cheaper and more accessible as price continues to drop in many nations.
- **Perception of Good Health** - The better the perception of good health of nations, the better the e-Health infrastructure and the higher the e-Health usage.

- **Confidence in Health Care Systems** - As the confidence in health care systems sags, it is expected that the public will look for health information on Web sites, educate themselves with alternatives and various other health information.
- **Voluntary Organizations on Health** - The higher the number of voluntary health organizations in a nation, the better the e-Health infrastructure and the higher the e-Health usage.
- **Human Development Index** - The human development index (HDI) denotes the country's achievement in human development and its index include a factor related to health: life expectancy. The higher the life expectancy, the better the HDI value.
- **Health-Related Awareness/Demographics** - Data and information sharing through this kind of web sites are empowering patients with knowledge that would otherwise be difficult and time-consuming to obtain.
- **E-Health Infrastructure and Usage** - The usage of e-Health will be dependent on e-Health infrastructure. Usage can only occur when the infrastructure is working.

#### 4. Data

Table 1 details the variables used in this study and their sources.

Source of Data	Variable/Year	What it Denotes
United Nations 1999, 2001	HDI	Human Development Index, 2000
World Bank, 2003	INTNT	Internet Users per 1000 in 2001
	GDP POP	GDP per capita in 2002 Population per million in 2002
Alexa Ranking	USAGE	It measures the health-related web site usage. It is the ranking average of 1st 200 Health web sites usages from Alexa, 2005. A ranking with high values is ordered high.
Google Search	INFRASTR	It measures the health-related web site infrastructure and is the number of Health-related Web sites of a nation, 2005
WHO, 2000	HLPERCAP HCOSTGDP	Health Care cost Per Capita Health Care cost Per GDP \$
WVS, 2004	GRHLT	Membership of Voluntary groups concerned with Health (% belong to).
WVS, 2004	HPERCEP	Average of respondents who considered their state of health (% Very good/good)
WVS, 2004	HCCONF	Confidence in Health Care (% responding : A great deal/quite a lot)

**Table 1. Variables and Their Meanings**

In the present study, the World value survey (WVS) data are used for many variables. The World Value Survey (WVS) provides health-related data on 66 countries. The survey has several standard health-related questions along with some variables as mentioned in Table 1, measuring health. The number of nations included in this study was 40 in number, due to data availability and cross-tabulating data from other sources. The set of these nations included developed and developing nations. It also included nations from three major continents. The WVS survey data included more than 1000 people in a nation. The nations included in the study are shown below:

Nigeria, India, China, Romania, Turkey, Poland, Bulgaria, Chile, Czech Republic, South Africa, Lithuania, Hungary, Argentina, Brazil, Mexico, Belarus, Russian Federation, Latvia, Estonia, Portugal, Korea, Ireland, Slovenia, Spain,

Germany, United Kingdom, Italy, The Netherlands, Belgium, Austria, France, Canada, United States, Iceland, Denmark, Finland, Norway, Sweden, Switzerland and Japan.

We employed least square regressions based on national-level data.

### 5. Results and Discussions

We ran a set of regressions on e-Health infrastructure and use on four models with different sets of variables. POP, INTNT and GDP were common in all models as controls. Most of the correlations with e-Health variables (as defined in Table 1 but not shown in this paper) are significant and in expected directions. Table 2 presents the regression results of e-Health usage (USAGE) and e-Health infrastructure (INFRASTR). The power of regression got reduced in models 2 and 4, due to small sample size emanating from missing data. We used the same set of health variables (such as HLPERCAP, HDI in models 1 and 3 and HCOSTGDP, HPERCEP, HCCONF, GRHLT in models 2 and 4). Forward regression was used after introducing the controls (POP, INTNT, GDP). The variable INFRASTR was also entered in models 3 and 4. For the infrastructure regression (model 1), after controlling for POP, INTNT and GDP, we find that HLPERCAP is significant (N=38). The adjusted R-square value was 0.41. For the infrastructure regression (model 2), after controls, we find that HPERCEP and HCCONF are significant in infrastructure regression (N=24). The adjusted R-square value was 0.32. We next did the regression on e-Health use (the last two columns, models 3 and 4 of Table 2). After introduction of controls, we find that INFRASTR and HDI are significant in use regression (model 3). The adjusted R-square value was 0.69 (N=38). In model 4, after controls, we find that INFRASTR is not significant whereas HPERCEP, HCOSTGDP and HCCONF are significant. The adjusted R-square value was 0.78 (N=24).

Independent Variables	Models			
	1	2	3	4
INTNT	N.S.	N.S.	N.S.	N.S.
POP	0.4***	0.53**	0.33*	0.4***
GDP	-0.60***	N.S.	N.S.	-1.95***
HLPERCAP	1.14***	-	N.S.	--
HCOSTGDP	--	N.S.	--	1.66***
HPERCEP	--	0.58*	--	0.92***
GRHLT	--	N.S.	--	N.S.
HCCONF		0.38*		-0.32*
HDI	N.S.		.54***	
INFRASTR	--	--	.49***	N.S.
N	38	24	38	24
Adj. R <sup>2</sup>	0.41	0.32	0.69	0.78
<b>Dependent Variable</b>	<b>INFRASTR</b>	<b>INFRASTR</b>	<b>USAGE</b>	<b>USAGE</b>

Note: \*\*\*:  $P < .001$ , \*\*:  $P < .01$ , \*:  $P < .1$ , N.S.—Not significant, --: Not used

**Table 2. Results of Infrastructure and Use Regressions – National Level**

In summary, we find that even after controlling for population, economic and Internet users, several health-related variables emerge as significant in both infrastructure and usage regressions. A lack of confidence in Health care (HCCONF) leads to more development of infrastructure and use. Perception of good health (HPERCEP) contributes positively to development of e-Health infrastructure and use. In nations where human development (HDI) is high, e-Health use is high. When health care cost per GDP \$ (HCOSTGDP) increases, e-Health use increases.

Voluntary organizations in health (GRHLT) do not play any role in any of these regressions. Nations with higher GDP have less e-Health infrastructure and usage. This result is surprising; however, inclusion of nations such as China and India with high GDP (but not GDP per capita) and low e-Health infrastructure and use may have contributed to this result. It could also be argued that use of e-Health is more helpful among less affluent users. Internet user variable (INTNT) is never significant in the four models considered. This could be due to the influence of GDP in regressions and since GDP and INTNT are correlated. These two results need further investigations. As a control variable, population always emerged as significant.

Our national-level regression results discussed earlier partially provided answers to some basic questions. There are a host of other variables (many of them e-Health related) that can be responsible for explaining e-Health usage and could not be used in the analysis for data unavailability. One of these is Health-related demographics as shown in Figure 1. The results also conclude that many links of Figure 1 are supported at the national level.

## 6. Conclusions

This preliminary study was an attempt to find out what factors affect the development of e-Health infrastructure and usage at a national level. E-Health is one of the emerging areas on which people seek information using the Internet/Web. First, the study explored at a national level, the role of several indicators in explaining the development of e-Health infrastructure and its usage. The study found that after controlling for economic variables GDP, INTNT and POP, e-Health infrastructure and usage are influenced by health-related variables such as health expenditure per GDP, health expenditure per capita, perception of health, and confidence in health care systems. More research is needed to confirm the roles of these e-Health variables.

The implications of the study include:

(a) If public policy makers decide to spend on health care, health web sites will have better information content and functionality which means that the e-Health infrastructure will become well developed in the long run and the populations will use the e-Health systems more.

(b) The more the public perceive their state of health to be good/very good, the more they are likely to use e-Health systems and the infrastructure will be better. This is a common human behavior: citizens with perceived better health would go for a better infrastructure and use e-Health more to stay fit.

(c) Similarly, the better the human development index of a nation, the more the populations will tend to use e-Health. This result seems to indicate that those nations with low human development index will benefit less from e-Health systems. This result implies that although the benefits are real and tangible, e-Health is not a solution to all the problems facing developing countries. Education and economy of the nation, among other factors, need to be developed and maintained at a certain level before the nation is expected to benefit from the emerging e-Health systems.

(d) Since the results indicate that the more confidence the populations have in the healthcare systems, the less developed the e-Health infrastructure and use tends to be, it implies that if the citizens are confident with the existing traditional systems, the healthcare policy makers and others will be less motivated to explore the emerging e-Health systems. This makes sense as the government and other decision makers usually do not attempt to fix a situation if there is no problem or complain.

(e) Nations with low overall GDP are more attracted to e-Health infrastructure and usage because the infrastructure is more affordable to the government of these nations while usage is less expensive and more readily available to the public. It is usually the case that richer nations have better infrastructure and usage. However, our sample included large developing nations like India and China who have high GDP but low GDP per capita and this may have influenced the regression results.

(f) Nations with higher health care costs have better infrastructure, as these are usually richer nations. These nations are motivated to lower health care cost by developing and using less expensive Internet-based systems.

The results also show, as expected, that the higher the population of a nation, the better the e-Health infrastructure and usage. The surprising result was that the number of Internet users of a nation does not impact e-Health infrastructure and use.

Finally, we believe that the findings of this study will be of interest to healthcare policy makers, healthcare workers, the public or potential patients, among many others.

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