# New Health Technologies and Health Workforce in Developing Economies

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## Abstract

*A special emphasis is placed in this paper on developing countries where series of constraints limit the provision of access to health care, including shortage of related skilled labor. The need of human resources in healthcare in relation to the deployment of new advanced health technologies is expressed in both developed and developing economies. Emergent and developed countries have generated new instruments to limit the negative effects of the constraints facing human resources in healthcare, while this process is quite new in developing countries. The expansion of access to new health technologies could be achieved within the world global health system framework requirements of increasingly needed human resources and skills are shown. Empirical evidence and data analysis are also provided and support the trends taking place in the health workforce in developing countries.*

Keywords: Medical Human Resources-Medical Technologies-Density of Medical Personnel-Global Health Systems.

JEL: I130, P520, J240

## Introduction

This version is the final one as it replaces the one connected to it on the MPRA site. This paper recognizes that advanced technologies have promising impacts on the health systems in both developed and developing economies. But, in developing countries, health technologies still have limited impacts. In addition, the need for highly qualified medical human resources is pressured by emigration and mobility that accentuate shortages in quantity and in up to date knowledge (Heller, 1998; Gutam et al., 2010 and WHO, 2000). It is recognized also that human resources are major players in this domain. Local health addresses the issues of local specific health problems (neglected diseases) and diseases that are not generally addressed by the global health system (Ghadar and Hardy, 2006; Allotey, Reidpath, & Pokhrel, 2010). Qualified human resources are increasingly becoming crucial given these constraints, the advancement of technologies and their potential positive impacts on health. This is aggravated by the emigration of medical staff from developing to developed economies (Driouchi, 2014; Driouchi and Kadiri, 2010; Rutten, 2007). The latter limitation is related to the risks and uncertainties faced by the overall chain of applying new technologies and new discoveries to human health with human resources playing an important role. There are different types of risks and uncertainties faced by the populations with limitations in the area of safety and anticipation of sources of new hazards. In this area, developed economies can engage quicker than developing economies in identifying new sources of risks, safety nets with the required means to engage in further compensatory mechanisms. The recent cases of some pharmaceuticals with lethal side effects provide examples about

the level of responses in both types of economies. Again, in all these stages, qualified human resources are essential.

The first part of this paper looks at global trends taking place in world human resources in health systems, based on a literature review. The second part focuses on the major factors affecting the health workforce, based on empirical evidence and data analysis.

## I. Literature Review

Different authors show how advanced new technologies are changing the performance and the higher success rates of the Health Care Systems (HCS) and impose also new requirements for human resources. The 2006 report of the World Health Organization (WHO, 2006) has already underlined the magnitude and extent of the importance of qualified human resources in all world health systems but especially in low income countries. Basic questions related to human resources in health are addressed in this important document.

The World Health Organization (2010) defines HCS as the mechanisms that support health and provide health services. These services are not uniquely provided by machines but by increasingly knowledgeable human resources. New technologies in the field of health are referred to as medical technologies. The Office of Technological Assessment (1982) recognized technology as drugs, devices, medical and surgical procedures used in medical care and organizational and supportive systems through which care is provided. Thompson and Tebbens (2006) claim that vaccine against polio saved, for US alone, around $180 billion in the past 50 years. Health threats are constant and new technologies allow diagnosis, awareness, cures and therapies (UNAIDS, 2008). According to FDA

(2006), an average of eight to nine years is needed to test a drug before it is launched to public and even more for vaccines. These trends have been accentuating the roles of human resources and the skills needed at all levels of HCS, in all countries and globally. Branciard (2013) develops new means that could lead to open medical research focusing on pharmaceuticals for developing countries. The open innovation system suggested in this paper addresses the issue of the lagging R&D in most developing economies. Such important initiative could reduce the paradox in R&D with regard to local epidemics but requires more human resources that include larger number of medical doctors.

As implied in series of publications, the introduction and development of advanced new technologies in health systems have induced further involvement of the private sector. This involvement is present in all areas of health, such as medical devices, pharmaceuticals and ways to perform surgery (Rettig, 1994), but also in the health system as a whole with the increasing presence of the private sector as a source of financing and in the system's organization and institutions. The increasing involvement of the private sector comes as a response to the growing cost of health care and the need for trained doctors and specialists to cope with the ever changing technologies. Prior literature such as Berndt et al., (2000) and Cutler et al., (1999) identified that advances in medical technology increases the health costs such as costs of R&D, production costs or costs related to training technicians. In the US, annual costs rose from $297 per individual in 1970 to $3632 in the late 90s (Cowan et al., 1999). The public sector alone could not bear the increase in expenditures, especially in developing countries, thus, the intervention of the private sector was vital. This emergence of the private sector in the area of health care has been creating new challenges to HCS but mainly to different categories of the human

resources operating in this sector but also in public hospitals and laboratories. Furthermore, as health care costs increase, further managerial and planning tools are needed. These trends have certainly induced the expansion of prevention but also diagnosis and curative health functions (WHO, 2010). The world health system has been progressively benefiting from the contribution of the new technologies (MedPac, 2004). Marfula and Winter (2015) provide evidence about the role played by information technology in healthcare through a literature review.

The above technological and institutional changes have had major effects on the human resources in health. WHO (2006) estimates a total of 59.2 million full-time paid health workers worldwide. These human resources operate in health enterprises primary focused on health care provision but also in allied organizations. According to the same source, health service providers represent two thirds while workers in management constitute the remaining third of the global health workforce. Kent, Chopra, Dal Poz and Bennett (2010) consider that human resources account for approximately 70% of recurrent expenditure in most health systems. As it can be observed from the appendices, developed economies have higher numbers of doctors, pharmacists and other health workers. This is also expressed in the density measured per 1000 population. But even with higher figures, the numbers are not that high compared to increasing needs of the populations and to the requirements imposed by advanced health technologies. Developing economies even with major variables do not exhibit satisfactory figures for both total and density of health workforce. Kent, Chopra, Dal Poz and Bennett (2010) show that since human resources account for approximately 70% of recurrent expenditure in most health systems, inadequate human resource training, regulation, distribution and

management can have enormous implications. These trends are related also to the interdependencies that exist between different medical specializations and then to the interferences among different health specialists. Murray and Osman, (2012) show that several challenges facing healthcare and where accounting for palliative practice is likely to have series of benefits. But, shortages in the human resources taking care in palliative medicine do negatively affect the health of patients and their families. This means that when accounting for medical specialties, the shortage can even be worse.

## II. Empirical Analysis and Results

There are many factors and trends that are affecting the shortages in medical doctors in developing economies. Emigration is the consequence of these factors that place pressure on domestic health systems.

**World Distribution of Benefits**

At all level of the health system, developed economies have appeared to be occupying dominant positions in production, use and trade of health care outputs issued from new technologies. As shown in Driouchi and Kadiri (2010), developed countries are also those that have control over different advanced technologies. But, the health benefits of these advances are clearly distributed worldwide and attain most world population.

While developed countries have been ensuring means and instruments to provide full health coverage, this process is still limited in the developing world. Efforts involving different national and international organizations appear to be promoting new means to enhance the level of health benefits in these economies. The millennium development goals framework is a global framework devoted to series of actions to ensure the

attainment of some realistic objectives by 2015. While this overall trend has been developing, some emergent economies have been accelerating the process of production and use of the innovations from the new health system.

**Health Workforce Density per country**

The number of health workforce specialists per country in relation to the population of the country as represented by the density per 1000 people can be used as indicator of the availability per country. But, this is an overall average as different country, regional and global reports by World Health Organization discuss the spatial disparities in distribution of medical personnel.

Regression analysis is conducted to show how different densities of different types of specialists are related. This exercise is conducted respectively for all countries, for the set integrating Arab and Central Eastern European economies (ECE), then for Arab and ECE countries.

***All Countries***

The following table 1 shows the best regressions obtained. Nursing and midwifery besides pharmaceutical personnel appear to have statistically significant effects with respective coefficients of 0.027 and 0.251. The related degrees of freedom are 102 with and $R^2$ of 0.660. This implies that each unit of nursing adds 0.027 physicians while a one unit of pharmacist adds 0.251 physicians. The second regression (table 2) with only 62 degrees of freedom and $R^2$ of 0.611, shows that "laboratory health workers" exhibits also an effect that is statistically significant (0.480).

Table 1: Overall Regression

| Dependent Variables | Independents Variables | Values | t-Stat | $R^2$ | Degrees of Freedom |
|---|---|---|---|---|---|
| Physicians density (per 1000 population) | (Constant) | .133 | 2.528 | .660 | 102 |
| | Nursing and midwifery personnel density (per 1000 population) | .027 | 9.018 | | |
| | Pharmaceutical personnel density (per 1000 population) | .251 | 4.931 | | |
| Physicians density (per 1000 population) | (Constant) | .139 | 1.170 | .611 | 62 |
| | Pharmaceutical personnel density (per 1000 population) | .449 | 2.012 | | |
| | Laboratory health workers density (per 1000 population) | .480 | 4.890 | | |

***Arab and ECE countries***

But, the above global results are changed when looking at the results from the best regressions obtained from the sample of Arab countries and Eastern and Central European economies. The two respective regressions have $R^2$ of 0.765 and 0.301 with 26 and 28 degrees of freedom. Nursing and dentistry have estimated coefficients of 0.044 and 0.434 in the first regression. The second regression shows pharmaceuticals and laboratory workers respectively with coefficients of 0.354 and 0.358.

Table 2: Regressions for Arab and ECE countries

| Dependent Variables | Independents Variables | Values | t-Stat | $R^2$ | Degrees of Freedom |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Physicians density (per 1000 population) | (Constant) | .223 | 1.344 | .765 | 26 |
| | Nursing and midwifery personnel density (per 1000 population) | .044 | 4.337 | | |
| | Dentistry personnel density (per 1000 population) | .434 | 3.803 | | |
| Physicians density (per 1000 population) | (Constant) | .235 | 5.784 | .301 | 28 |
| | Pharmaceutical personnel density (per 1000 population) | .354 | 3.411 | | |
| | Laboratory health workers density (per 1000 population) | .358 | 3.892 | | |

***Arab Countries***

With limited degrees of freedom, the density of physicians is statistically and significantly related to the nursing and midwifery density. It is also related to the density of pharmacists but the other regressions show that the density of dentist has also a statistically significant explanatory power. The same thing applies to explanatory variables such as laboratory health workers, environmental and public health workers besides other health workers.

Table 3: Regression for Arab countries

| Dependent Variables | Independents Variables | Values | t-Stat | $R^2$ | Degrees of Freedom |
|---|---|---|---|---|---|
| Physicians density (per 1000 population) | (Constant) | .166 | .624 | .979 | 3 |
| | Nursing and midwifery personnel density (per 1000 | .096 | 5.883 | | |

| | | | | | |
|---|---|---|---|---|---|
| | population) | | | | |
| | Health management & support workers density (per 1000 population) | .090 | -2.265 | | |
| Physicians density (per 1000 population) | (Constant) | .166 | 4.493 | .746 | 17 |
| | Pharmaceutical personnel density (per 1000 population) | .222 | 6.848 | | |
| Physicians density (per 1000 population) | (Constant) | .207 | 3.022 | .678 | 17 |
| | Dentistry personnel density (per 1000 population) | .412 | 5.800 | | |
| Physicians density (per 1000 population) | (Constant) | .252 | .520 | .930 | 4 |
| | Laboratory health workers density (per 1000 population) | .445 | 6.304 | | |
| Physicians density (per 1000 population) | (Constant) | 1.208 | -4.046 | .961 | 2 |
| | Environmental and public health workers density (per 1000 population) | 17.556 | 4.975 | | |
| | Other health workers density (per 1000 population) | .247 | .334 | | |
| | Laboratory health workers density (per 1000 population) | .247 | 1.786 | | |
| | | | | | |

***ECE countries***

With also limited degrees of freedom, the density of physicians appears to be related mainly to health personnel in dentistry and to nursing.

Table 4: Regressions for ECE countries

| Dependent Variables | Independents Variables | Values | t-Stat | $R^2$ | Degrees of Freedom |
|---|---|---|---|---|---|
| Physicians density (per 1000 population) | (Constant) | .385 | 3.806 | .506 | 13 |
| | Dentistry personnel density (per 1000 population) | .721 | 3.506 | | |
| Physicians density (per 1000 population) | (Constant) | .753 | 1.363 | .298 | 13 |
| | Nursing and midwifery personnel density (per 1000 population) | .119 | 2.255 | | |

The above results show how different densities related to different components of health workforce are inter-related. But, the variable related to physicians has more accurate role in determining the distribution of other components of health personnel.

## Further Evidence

This starts with showing the effect of high technologies on health in developed and developing economies. The constraints related to new technologies in developing countries constitute the second component of this paragraph.

### Medical Human Resources

Human capital is at the center of health care system (WHO, 2006). The number and quality of workers are positively associated with immunization coverage, outreach of primary care and infant, child and maternal survival. Naicker and Tutt (2009) emphasized the state of medical human resources in Africa and the world. According to this study, 1.3% of the global health care workforce is devoted to 25% of the disease burden representing a shortage of 817,992 health workers in Africa. In 2008, Africa had 2.3

health workers (physicians and nurses) for 1,000 individuals when Europe and Americas had 18.9 and 24.3 respectively. When taking the number of physicians per 100,000 people (HDR, 2007), while the highest number of physicians varies from 318 to 591, it is between 2 and 12 physicians per 100,000 people for the lowest number category. Besides, the limited number of medical schools put additional pressure on the available stock of physicians in the home country (FAIMER, 2010; WHO, 2010).

Table 5: Examples of Emerging Diseases in Developed Countries (2008)

| | Diseases (number of reported cases) | | | | |
|---|---|---|---|---|---|
| Countries | Measles | Pertussis | Total Tetanus | Tuberculosis | Rubella |
| Australia | 65 | 14,435 | 4 | 299 | 38 |
| Belgium | 98 | 260 | 2 | 311 | 5 |
| Canada | 41 | 1,961 | 1 | 488 | |
| France | 604 | | 8 | 1,222 | |
| Germany | 917 | | | 954 | |
| Japan | 11,015 | 6,753 | 123 | 8,995 | 303 |
| Spain | 297 | 563 | 15 | 2,333 | 70 |
| Switzerland | 2,022 | | 1 | 64 | 12 |
| United Kingdom | 1,445 | 1,028 | 5 | 1,028 | 31 |
| United States | 140 | 13,213 | 0 | 13,213 | 16 |
| % of the global | 6% | 25.5% | 1% | 1.4% | 0.3% |

These deficits are due to the domestic increases in demand for and emigration of health human resources. Danon-Hersch and Paccaud (2005) considered that since human resources are affected by progress in technology, health care systems should improve education and training for medical human resources and for administrative and management. The increase in demand is also due to the expansion of medical coverage, the extension of hospitals and the shift from traditional medicine and aid systems to modern health systems (Ron, 2008). A study by Driouchi et al., (2009) shows the higher levels of interdependencies between health and education. While there are major needs for medical doctors and nurses, preferences for urban centers (Driouchi, 2008) as well as emigration to other countries are affecting the coverage rate which can be critical in some regions. Emigration of nurses and medical doctors is taking place under the effects of salary differential and living conditions (Driouchi & Kadiri, 2010).

Table 6: Country of medical school of sub-Saharan African international medical graduates (IMGs) in the United States and Canada

| Country of training | Number of African-trained IMGs in USA | Number of African-trained IMGs in Canada | Number of physicians remaining in home country | % of total African-trained now in USA or Canada |
|---|---|---|---|---|
| Nigeria | 2158 | 123 | 22 894 | 9 |
| South Africa | 1943 | 1845 | 23 844 | 14 |
| Ghana | 478 | 37 | 1210 | 30 |
| Ethiopia | 257 | 9 | 1564 | 15 |
| Uganda | 133 | 42 | 722 | 20 |
| Kenya | 93 | 19 | 4001 | 3 |

| | | | | |
|---|---|---|---|---|
| Zimbabwe | 75 | 26 | 1694 | 6 |
| Zambia | 67 | 7 | 676 | 10 |
| Liberia | 47 | 8 | 72 | 43 |
| Other 12 countries | 83 | 35 | 12 912 | 1 |
| Total/Average | 5334 | 2151 | 69 589 | 10 |

Table 6 shows the extent of medical doctors' emigration from sub-Saharan African countries to the US and Canada (10%).

Evidence about the relationship between advanced technologies and knowledge

It is widely known that developed countries are benefiting more from advanced technologies, relative to developing economies. One simple way to test for this evidence is to see how health is responsive to technologies at the overall and in each group of countries. Using technology indices such as the Global Innovation Index (GII) (INSEAD, 2010), the Knowledge Economy Index (KEI) (World Bank Institute, 2010) and the measure of Technology Exports (TE) (World Bank Data, 2010). Only the first two indicators appear to exhibit statistically significant relationships with the life expectancy at birth, taken as a proxy for health performance (Table 7). Estimations difficulties related to this regression have been tackled through using literacy rate per country as instrument for life expectancy at birth.

Table 7: Responsiveness of health to technologies

| GII | | | KEI | | |
|---|---|---|---|---|---|
| All Countries | Developed | Developing | All Countries | Developed | Developing |

| | | | | | | |
|---|---|---|---|---|---|---|
| Coefficient | 0.42 | 0.18 | 0.48 | 0.25 | 0.18 | 0.24 |
| STD Error | 0.05 | 0.02 | 0.17 | 0.02 | 0.01 | 0.04 |
| t-Stat | 8.04 | 7.50 | 2.40 | 15.00 | 6.23 | 6.80 |
| $R^2$ | 0.43 | 0.47 | 0.10 | 0.62 | 0.36 | 0.45 |
| Observations | 130 | 66 | 64 | 141 | 71 | 70 |

The results shown in the above Table 7 clearly indicate that life expectancy at birth is influenced by technologies. The coefficients of sensitivity are respectively 0.42 and 0.25 for GII and KEI for all countries. For developed economies, the coefficient is 0.18 for both GII and KEI. But, given the estimated standard error for each coefficient, the levels of responses appear to not be different between countries. This implies that developed, developing and all countries exhibit the same coefficient as it is confirmed in Table 8 with the calculated t-statistics. Therefore, only higher levels of the technology index (GII and KEI) determine higher life expectancy at birth in developed economies. With lower levels of technologies, lower life expectancies at birth are observed at the level of developing economies.

Table 8: Comparisons of coefficients

| Comparisons/t-stat | GII | KEI |
|---|---|---|
| all/developed | 0.000733107 | 1.39925E-05 |
| all/developing | 0.000161037 | 5.33488E-06 |
| Developed/developing | 0.000802044 | 3.19934E-05 |

These results are confirmed when using healthy life expectancy at birth, overall mortality, mother and children mortality rates as respective measures of health performance. The results confirm that developing countries with limited access to high levels of technologies achieve lower levels of health performance.

## III. Discussion

The pressure of tasks form health care, introduction of new technologies and participation to medical research is enlarged with the constraints described above. These limits create shortages in relation to the increasing and large demand. One of the means to address the above cited shortcomings is to move toward World Health Systems and global linkages, with connections to local areas and countries. This is within a cooperative framework that has been already increasing between developed and developing countries (Gostin et al., 2010). International medical cooperation and access to the outcomes of advanced technologies will help reduce technology and research gaps between developed and developing countries. Neglected diseases should receive enough care from research labs especially that Reidpath et al., (2011) found that neglected tropical diseases (NTD) research is more related to biomedical area than to social sciences. Pokhrel et al., (2011) concluded that more social science based NTD research is needed and funding for it is not as low as it seems.

Technological advancement and research should not be carried without considering the training of human factor implying that medical education is also linked to overall process of improving the health system. Therefore, national education systems should train more medical personnel to satisfy the increasing demand. It should also include integrated medical training and research. To enhance health knowledge and practice

globally, Ruger and Ng (2010) describe the roles that emerging countries play in supplying global health and redressing health inequities.

## Conclusion

The limitations affecting health care even, under higher development of new advanced worldwide technologies are likely to occur in the absence of the skills and size of the health workforce.

These dimensions are developed in the present paper trough looking first, at the trends characterizing the world development of the new health system and its evolution under the impulse of new technologies. This is followed by an overall analysis of the major constraints facing developing economies. The relationships with the health workforce are addressed in the two sections.

Within this context, the features related to the world development of new health technologies and practices under the effects of new technologies are reviewed. They consist in increases in the flows of outputs related to new technologies with their applications in health care, globally. But, these promising trends have generated important shifts where private interests have been increasingly involved in the new health care systems with expanded costs and higher financial requirements to every partner in the chain of the health system, including patients. The implied financial burden is shown to be leading to higher financial requirements and mainly to the expansion of social health care systems where private insurances are progressively developing. This leads to an increasing number of players concerned with the new health systems. While this is true for both developed and developing countries, some economies in the developing

world are finding their way out to ensure better health care systems in the emerging developing economies. But, other countries have more limitations in accessing and benefiting from the global system.

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