Mortality reduction in poor countries: exploring the association with health system resources and economic growth

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Improved public health is not only an end in itself – it is also a means to achieve other and wider goals in society.

Freely translated after Røttingen and Kvåle (1)

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Eli Wik Amundrød

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CONTENTS

ABSTRACT

Background: Population health (measured in terms of life expectancy and under-five mortality rate) has improved under the era of the Millennium Development Goals. The aim of the thesis was to examine the association between population health and health care resources in poor countries, to better understand the situation and how to improve it.

Materials and methods: Ecological analysis of aggregate data. The sample consisted of 91 low- and lower-middle-income countries. Changes in life expectancy and in under-five mortality rate from 1995 to 2009 were used as dependent variables. Included as independent variables were gross national income (GNI) per capita, total health expenditures (THE) as percentage of gross domestic product (GDP), governmental expenditures as percentage of THE, external resources as percentage of THE, separate densities of physicians and nurses, and measles vaccination coverage.

Results: The predictors of life expectancy and child mortality rate were in a large degree different. Total health expenditure (% of GDP) and external resources (% of total health expenditure) stood out as the strongest predictors.

Interpretation: Large increase in THE as percentage of GDP and/or large increase in the percentage of THE originating from external resources, independent of the level in 1995, was considered as the most important of the predictors of improved population health.

Keywords: life expectancy, under-five mortality rate, health care resources, GNI per capita

1.0 INTRODUCTION

Public health is about preventing disease, prolonging life, and promoting health in the population through the organized efforts of society (2). The Millennium Development Goals (MDG) can be considered as one such effort. The MDG aim is to improve the status of the poorest populations (3), through promotion of development and eradication of poverty (4). Health was established as a key driver of socioeconomic progress with the introduction of the MDGs in 2000 (5). The importance of the health care systems in improving population health is increasingly recognized. Effective health care interventions contribute to improved population health (in countries at different levels of economic development). Population health can improve, among other things, by increasing health care coverage and by optimizing systems for organizing and providing care (3).

Countries are classified as low-income ($ 1,005 or less yearly), lower-middle-income ($ 1,006 -3,975), upper-middle-income ($ 3,976 – 12,275), and high-income ($ 12,276 or more) by the World Bank based on gross national income (GNI) per capita in U.S dollars[1] (6). Great disparities exist within and across the income groups. 21.85 years life expectancy and 101.15 deaths in children under-five per 1,000 live births separate the richest and the poorest group in 2011[2] (to the richest group's advantage). Although the disparities primari-

[1] According to the 2011 classification which is based on 2010 estimates of GNI per capita

[2] The numbers are calculated with data from the World Bank (GNI per capita and life expectancy) and the UN Inter-agency Group for Child Mortality Estimation (IGME) (child mortality).

ly affect the poor, minority, rural, and remote populations, they also have an impact on society as a whole (2).

Less than four years remain for the MDGs to be achieved. In order to better understand the situation in poor countries I am interested in learning how health care resources influence population health. Inspired by Jeffrey Sachs (7) and the report of the Commission on macroeconomics and health (8), I believe that investing in health care increases access and thus improves population health, in turn leading to economic development and improved living conditions. The aim of this thesis is to examine the association between improved population health and change in level of health care resources in poor countries. Despite the fact that health systems in many low-income countries are failing (5), the evidence base of utilization and coverage of input, the economic dimensions of health systems, and the effect of financial resources on access to health care in low-and middle-income countries is scarce (relative to the high-income countries) (9-11). The limited focus on the situation in the poorest countries supports the theme of this thesis.

1.1 Thesis question

The thesis question to be examined is as follows:

To what extent can the improvement in life expectancy and under-five mortality rate in low- and lower-middle-income countries from 1995 to 2009 be associated with change in GNI per capita and in health care resources?

The hypothesis is that an increased level of health care resources improves access to health care and thus improves population health. The hypothesis will be argued for in the background chapter.

1.2 Clarification of the thesis question

Life expectancy and under-five mortality rate are understood as indicators of population health. Life expectancy refers to the life expectancy at birth which is defined as the average number of years a new-born can expect to live if the current mortality rates continue to apply. Under-five mortality rate refers to the probability of death and is expressed as the number of deaths in children under-five years per 1,000 live births. The term is also referred to as child mortality rate in this thesis (12). Current level of child mortality rate and life expectancy in the income groups are presented in the table below.

Table 1: *Characteristics of the income groups*

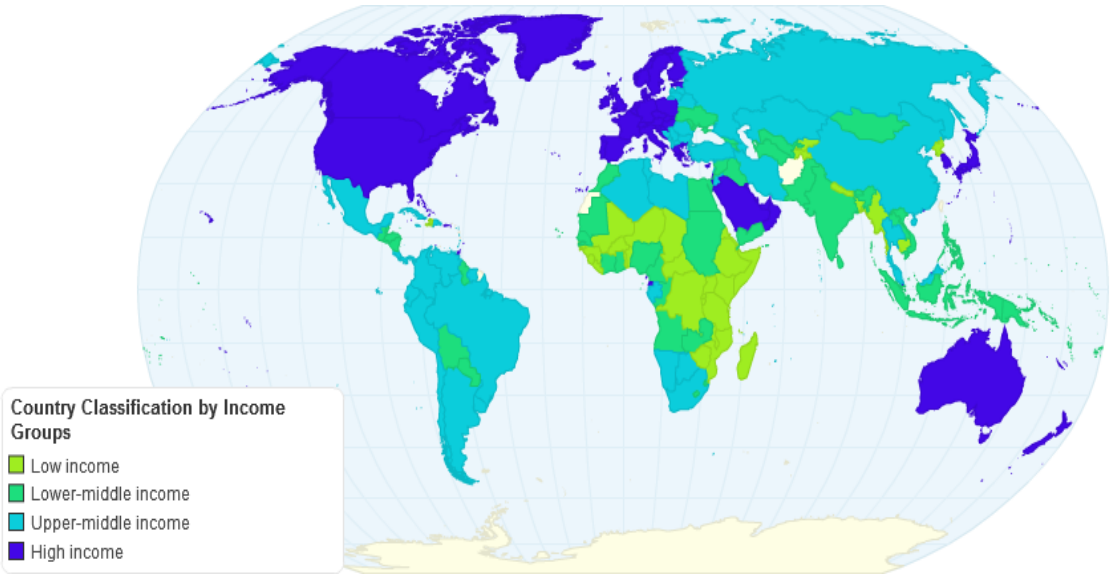
Income classification (n)[a]	**GNI per capita (US$)[a]**	**Life expectancy at birth[b]**	**Under-five deaths per 1,000 live births[c]**
Low-income (35)	< 1,005	56.19	109.90
Lower-middle-income (56)	1,006-3,975	65.71	54.78
Upper-middle-income (54)	3,976 – 12,275	72.50	20.22
High-income (70)	> 12,276	78.04	8.75

Source: [a] World Bank list of economies (6) [b] World Development Indicators (13), [c] Inter-agency Group for Child Mortality Estimation (IGME) (14). I used the latest available data at time of access.

The low- and lower-middle income countries (from now on also referred to as LLMIC) are identified as defined by the World Bank (*see page 3*). By focusing only on LLMIC the range

of countries and health systems is narrowed. The upper end countries of the middle-income group, which share many features in common with high-income countries (9), are excluded in order to focus primarily on the poorest countries (according to the income classification). A considerable number of LLMIC are situated in Sub-Saharan Africa and South-East Asia (see *Map*).

Map: *Geographic distribution of income groups*



Source: Data by World Bank list of economies 2011 (6). The map is made by use of technology provided by http://chartsbin.com/ (accessed 27.02.12).

Changes from 1995 to 2009 are of interest in this study. Initially, 1990 was used because that is the baseline for the MDG number 4 (reduce the mortality in children under-five by two thirds between 1990 and 2015 (15)). As it turned out, several of the independent variables had no reported data before 1995 (e.g. the financial resources). 1995 was then chosen as baseline for this study. 2009 was the year with the latest updates for many of the varia-

bles when the downloading of data was done (January 2012). It was therefore used as comparison to the baseline.

GNI per capita is understood as GNI (formerly referred to as GNP) converted to U.S. dollars by use of the World Bank Atlas method, divided by the midyear population size (13). The Atlas method is used to "smooth fluctuations in prices and exchange rate" (16).

Health care resources are understood as financial and human resources in this thesis. The terms are defined and explained in the next chapter.

1.3 Structure of the thesis

After the thesis' theme and question are described introductorily, the relation between wealth and health is described in the background chapter. Financial and human resources in health care are also described there. The introduction and the background chapters set the context for the thesis. The study design is presented in the material and method chapter. The LLMIC as sample is described further before the included variables are presented and argued for. At the end of the chapter the statistical methods are reviewed. In the result chapter the results from the regression analyses with life expectancy and child mortality as dependent variables are presented. In the following discussion chapter results are interpreted and discussed. The thesis ends with my conclusion.

2.0 BACKGROUND

Health is, as stated by Sen (according to Ong (5)), among the basic capabilities, such as education, that give value to human life. Former director-general in the World Health Organization (WHO), Gro H. Brundtland (17), stated that we will not have economic growth, stability, human dignity, peace, or fulfilment of human rights, unless people are healthy. After more than ten years of targeted work to achieve the MDG's there are still many people, whose health is not improved or, even worse, is reduced (18).

As pointed out in the introduction; the differences in health between rich and poor are enormous. Health inequalities limit the ability of some members of each society to achieve their maximum ability to function (2). Such inequalities are in a large extent avoidable and the resultant health differences are therefore considered to be unjust (19). Detels (2) claims that there is not only an ethical imperative to reduce health disparities, but also a pragmatic rationale. Reducing the inequalities in health, both within and between countries, should lead to better average population health according to Mackenbach, Bakker, Shito et al. (20). To promote and protect health is critical for human welfare and essential for sustained economic and social development (21). Good health is particularly important to the poor; being healthy means the possibility to work and support the family. When the health of the main supporter is reduced, the situation for poor families becomes even worse than it was initially. People are then caught in a vicious circle where poverty leads to ill-health, and ill-health maintains poverty (5). The degree of poverty has, according to Mills (9), pervasive effect on health systems. Lack of access to health care in poor countries contributes to unfavourable population health outcome (3).

2.1 Health care resources and access to health care

Health care refers to, according to Olsen (22), the resources society uses to cure and care for ill people, as well as preventing disease and rehabilitating people. Last (23) emphasize that the concept is not limited to medical care. This thesis focuses on financial and human resources in health care.

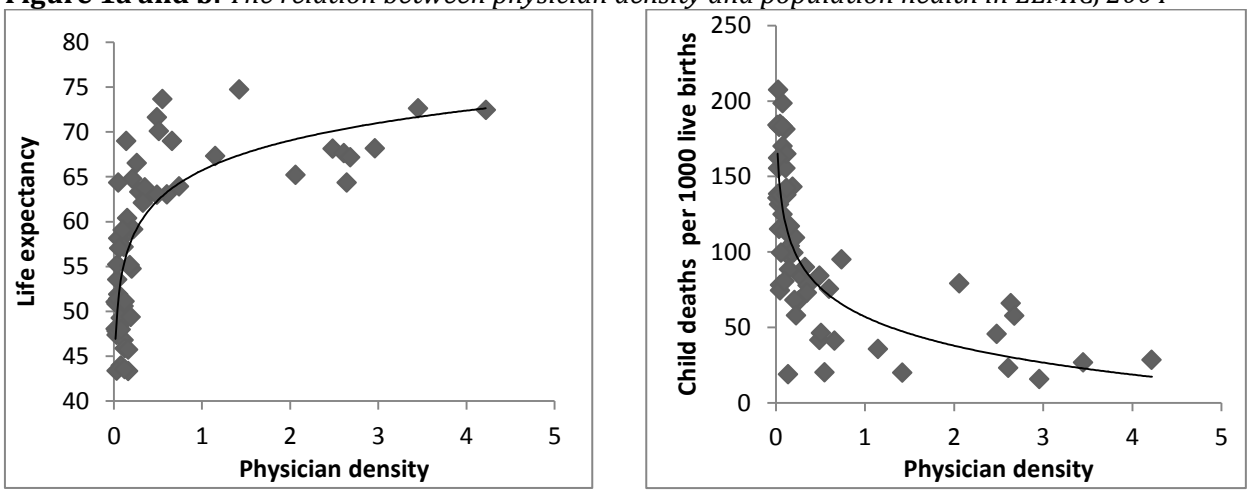
One of the key functions of health care systems is the provision of services (24). Limited access to such services contributes, according to Lagarde and Palmer (10), to reduced population health (10). Access to health care depends of the availability of services (including supply of services (health worker density), geographical proximity or physical accessibility of services), utilization of services when needed, relevant and effective health care services. Obstacles to utilization include personal, physical, financial, or organizational barriers (3). People will utilize health care more to improve their health if the system is more accessible (24).

2.1.1 Human resources

It is widely agreed upon in the literature that human resources are essential to health systems. Human resources should be understood as professional health workers in this thesis. Health workers determine health output and outcome through their knowledge, skills and motivation, thus influencing the performance of health systems (5). They are probably the most important input (24, 25), and thus a necessary resource to improve population health (26). To illustrate the relationship between health workers and population health at one point in time, I have plotted the density of physicians and the two indicators of population health (see *Figure 1*). There is a clear improvement in health status when the density in-

creases up to a certain point after which the trend diminishes. The same pattern is seen for nurses.

Figure 1a and b: *The relation between physician density and population health in LLMIC, 2004*



Source: The figures are based on data from WHO's Global Health Atlas (21), the World Bank World Development Indicators (13), and estimates by the UN Inter-agency Group for Child Mortality Estimation (IGME) (14).

Despite the clear pattern, health workers have been a neglected component of health system development in low income countries (27). The world is facing a global shortage of 4.3 million health workers according to estimates in the 2006 World health report (25). It is claimed by the Health and the Millennium Development Goals report (28) that shortage of health workers is one of the most serious obstacles to the MDGs achievements. Bärnighausen and Bloom (26) argue that health workers are essential in determining access to health care through their provision of services thus necessary to improve population health. In addition to the global shortage, professional health workers are unevenly distributed with concentration in urban areas and migration from poor to wealthier countries (25, 26, 29). It

is not unlikely that the combination of shortage and uneven distribution of health workers contributes to the maintenance or increase of health inequalities.

2.1.2 Financial resources

Revenue collection, pooling of resources, and purchasing of interventions are the crucial functions of health care (24). Financing systems need to be specifically designed to ensure access to key health services and financial risk protection provided for people who need the services (21). This is an important step in the achievement of universal coverage. Universal coverage denotes that everyone has access to appropriate promotive, preventive, curative, and rehabilitative services when needed and at an affordable price (30). A resolution was adopted by the World Health Assembly (member states of WHO) in 2005 encouraging countries to design health financing systems in order to achieve and/or maintain universal coverage (31). Obviously, low and unequal coverage cannot be explained by the financing system alone but, as argued by the World health report for 2010 (21), coverage could be considerably higher if there were additional funds, less reliance on direct payments to raise funds, and more efficiency –all financing issues.

The focus of this thesis is on sources of revenue. Patient payments, private insurance, taxation, and voluntary donations are in principle the four sources of revenue according to Olsen (22). The different sources are briefly described in the next sections.

Taxation

Collection of revenue is organized through taxation (tax-financed health care) or social health insurance systems with payroll contributions. It is made compulsory to keep low-

risk groups from opting out of the system. In this scheme, insurance is based on community rating, and there is a cross-subsidization from high-income to low-income groups (22). Both tax-financed health systems and social insurance schemes are difficult to promote in low-income countries because of limited ability to collect revenues (22, 32).

Private insurance

Private insurance is of voluntary kind and ensures financial protection for the members only. The premium is based on individual rating, as opposed to community rating in the compulsory insurance system. Criticism of this source of revenue points out that the access depends on income and is therefore unfair (22).

Patient payment

The term 'patient payment' covers all expenditures paid by consumer to provider. Terms like *direct payment* and *out-of-pocket payment* are used interchangeably in the literature and are both similar to patient payments (21). Here, the term 'patient payment' is used because it is the most descriptive (payments paid by the patient!). This scheme is the least equitable form of health funding because of its regressive nature. It causes inequity in the way resources are used –it encourages overuse by people who can afford the expenses and underuse by those who cannot (21).

Voluntary donations

Voluntary donations represent in this context cross-subsidized health care where donors give their financial support to health care institutions or health related projects (22). Low-

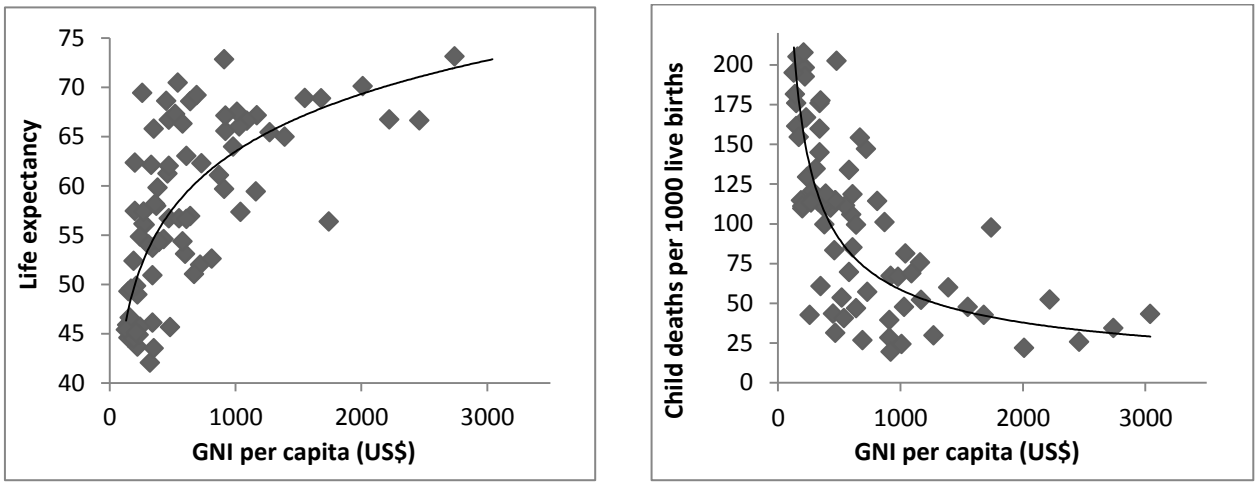
er-income countries are dependent on the support of international donors in order to raise sufficient funds through prepayment and pooling (21).

Combinations of the different arrangements are commonly used, but the trend is that the poorer the country, the higher the share of patient payments, the lower the share of insurance schemes, and the higher the reliance on external resources (9). The expenses attached to patient payment can be so high relative to income that the consumer or the household faces catastrophic costs (21) (i.e. costs exceeding 40 % of a household's income available after basic needs have been met (33)). Every year, approximately 150 million people face catastrophic health care expenditure according to WHO (33). About 100 million people are forced into poverty because they have to pay for health care. Catastrophic payments occur if the following factors are present: the availability of health services requires out-of-pocket payments; the capacity to pay is low; and prepayment mechanisms for risk pooling is lacking (33). In low-income-countries, illness can lead to catastrophic expenditures, thus discouraging people from seeking necessary health care (9).

2.2 Wealth and health

The relationship between improved health, economic development, and poverty reduction is well established (5). The relationship implies that reduction in poverty has a great effect on population health (*Figure 2a and b*) (at one point in time); increase in wealth implies improvement in population health.

Figure 2a and b: *The relationship between wealth and health in LLMIC, 1995*



Source: The figures are based on data from the World Bank World Development Indicators 2012 (13) and estimates by the UN Inter-agency Group for Child Mortality Estimation (IGME) 2011(14).

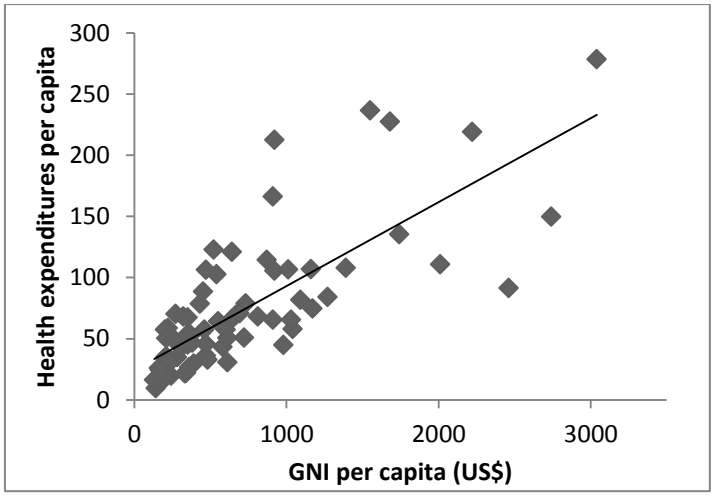
As the figures show; up to a certain level reduction in poverty has a positive impact on life expectancy and child mortality. Beyond this level increased wealth does not affect either longevity or death rate in children under-five. In other words, the relationship is stronger when GNI per capita increases from 500 to 1,000 dollars than from 1,500 to 2,000. These figures are supported by similar findings in the literature by, among others, Olsen (22).

The adverse effects of ill health are greatest for poor people. That is mainly because they are ill more often but also because their income depends exclusively on physical labour and they have no savings "to cushion the blow" (34). Good health enables people to participate in production which leads to development and economic gains (5). Improved health encourages economic development as it has a direct impact on the workers' productivity (35). There are, according to the World development report for 1993 (34), four ways in which improved health contribute to economic growth 1) it reduces production losses due to illness, 2) it permits the use of natural resources that had been totally or almost inaccessible

because of illness, 3) it increases the enrolment of children in school and increases their learning ability, 4) it frees resources that would have been spent on treating illness for other uses. It was suggested by the report of the Commission on macroeconomics and health (8) that every 10% improvement in life expectancy at birth implies a rise in economic growth of at least 0.3 to 0.4 percentage points per year, assuming that other growth factors are constant. A healthy population contributes to stronger economic growth and improved living standards (3).

There is a close relationship between wealth and health care spending, as *Figure 3* shows; the wealthier a country is, the more it spends on health care. The relationship may be self-evident; more is spent on health care because more is available.

Figure 3: *The relationship between wealth and total health expenditures in LLMIC, 1995*



Source: The figure is based on data from the World Bank World Development Indicators 2012 (13) and WHO's Global Health Expenditure Database (36).

One should be aware that the raise in GNI per capita is, according to Gwatkin (37), not equal to the reduction in poverty, as poverty is a multi-dimensional phenomenon and involves more than economic status; such as occupation, gender, education and socioeconomic status.

3.0 MATERIAL AND METHOD

While the background chapter showed the relation between resources (economic and health care) and population health at one point in time, this study examined whether the same relation could be seen from one point in time to another. The choice of theme made it natural to use a quantitative approach as method.

3.1 Ecological study design

This was an ecological study, where the same population was compared at two points in time (1995 and 2009). In ecological studies the units of analysis are groups of people, in contrast to other designs which study individuals (38). This design is useful for generating hypotheses, and it is argued that it is essential in defining the most important public health challenges to cope with (39, 40). Causal relations cannot be concluded in ecological studies.

3.2 Sample

The 91 LLMIC (see *Table 1*) were used as a basis for this thesis. Mills (9) argues that the classification of countries as income groups is vital because it reflects the resources which are available to invest in health. It is a widely used classification and highly relevant for economic analysis (9). It has already been noted why the LLMIC are of interest, but it should be added that the average population health in LLMIC is relatively low compared to the two wealthier groups (see *Table 1*). Note also that by including the lower-middle-income group in the analyses the data basis increased (from 35 to 91 countries).

3.3 Variables

The data sources were accessed between the 23rd and 26th of January 2012. The different sources were chosen because they are all internationally recognized. In cases where different databanks presented data on the same indicators, the databank whose data was based on several sources was considered to be more complementary and precise than the databank with data based on one source only. The data used in this thesis were published in 2011 and were thus the latest available data at time of accessing the databases.

One country (Tuvalu) was excluded from the analysis due to misclassification as income group 2 despite GNI per capita above $ 3,975. The number of lower-middle-income countries was then 55, making it 90 countries in all.

3.3.1 Dependent variables

Life expectancy and under-five mortality rate were included as dependent variables. They are, according to Olsen (22), standard measures of population health and are commonly referred to in the literature. While life expectancy is an indicator of mortality conditions and health conditions (the latter by proxy) (41), child mortality rate is an indicator of child health, obviously, and of overall social and economic development (14, 41).

Life expectancy and child mortality rates were analysed as baseline ($level_{1995}$) in addition to both absolute ($level_{2009} - level_{1995}$) and relative ($[level_{2009} - level_{1995}] / level_{1995}$) change. The methods apply to the independent variables as well. Measurements of change were made separately because of the differences in absolute and relative change in the two

groups (*Table* 2). In other words, there is a far greater difference in a reduction from 200 to 150 than from 20 to 10. In absolute terms, the former is better, while the latter is clearly better in relative terms. The difference in absolute and relative change in life expectancy is not as clear as in child mortality rate, but I wanted to explore whether the predictors were the same for absolute and relative improvements.

Table 2: *Distribution of the dependent variables included*

Variable	**Year**	**LLMIC** *Mean (range)*	***n***	**Low-income** *Mean (range)*	***n***	**Lower-middle-income** *Mean (range)*	***n***
Life expectancy *Years*	1995	57.47 (30.47-73.13)	***89***	50.53 (30.47-66.27)	***35***	61.98 (42.05-73.13)	***54***
	2009	61.92 (46.67-75.62)	***88***	56.19 (46.88-69.10)	***35***	65.71 (46.67-75.62)	***53***
Mean change	*Abs.*	*4.45*	***88***	*5.66*	***33***	*3.73*	***53***
	Rel.	*7.74*	***88***	*11.20*	***35***	*6.02*	***53***
Child mortality *Per 1,000 live births*	1995	112.11 (19.60-270.90)	***88***	160.57 (60.80-270.90)	***35***	80.11 (19.60-221.50)	***53***
	2009	76.70 (13.6-181.60)	***88***	109.90 (33.30-181.60)	***35***	54.78 (13.60-164.30)	***53***
Mean change	*Abs.*	*-35.41*	***88***	*-50.67*	***33***	*-25.33*	***53***
	Rel.	*-31.59*	***88***	*-31.56*	***35***	*-31.62*	***53***

The numbers are rounded off when necessary

Life expectancy is a continuous variable reported in years, and measures the average life expectancy at birth. The average life expectancy for both groups combined increased 4.45 years or by 7.74% from 1995 to 2009. If one looks at the groups separately, the level and the increase differ, and the range within the groups is very wide. One country was excluded in the analysis of baseline, and two in the analysis of change. They were excluded because of incomplete data. Data was taken from the World Bank's databank (13).

Child mortality is reported as a rate. By using rates instead of absolute numbers, the size of the population at risk, and hence the risk of death, is taken into account (42). The average reduction in child mortality rate from 1995 to 2009 was 35.41 deaths per 1,000 live births or 31.59%. If one looks at the two income groups separately, the level and absolute reduction in the low-income group was about twice that of the lower-middle-income group, while the relative reduction was about the same in both groups. Complete data were reported in 88 out of 90 countries which were included in the analysis. Data was taken from the UN Inter-agency Group for Child Mortality Estimation (IGME) (43).

3.3.2 Independent variables

GNI per capita, total health expenditures (THE) as percentage of GDP, government expenditure as percentage of THE, external resources as percentage of THE, density of physicians, density of nurses, and measles vaccination coverage were chosen as independent variables included in the analysis. The distribution of the independent variables included in the analyses is presented in *Table 3*.

Table 3: *Distribution of the independent variables included*

Variable *Reported as*	**Year**	**LLMIC** *Mean (range)*	***n***	**Low-income** *Mean (range)*	***n***	**Lower-middle-income** *Mean (range)*	***n***
GNI per capita *US dollars*	1995	611.67 (130-3040)	***79***	261.03 (130-600)	***29***	923.80 (210-3040)	***50***
	2009	1458.72 (150-3890)	***86***	484.38 (150-870)	***32***	2036.11 (920-3890)	***54***
Mean change	*Abs.*	*847.05*	***79***	*223.35*	***29***	*1112.31*	***50***
	Rel.	*138.48*	***79***	*85.56*	***29***	*120.41*	***50***
THE *% of GDP*	1995	5.06(1.80- 13.85)	***83***	5.07 (2.15-13.45)	***31***	5.06 (1.80-13.85)	***52***
	2009	6.15 (2.02-16.44)	***85***	6.16 (2.02-13.62)	***32***	6.14 (2.27-16.44)	***53***
Mean change	*Abs.*	*1.09*	***82***	*1.09*	***30***	*1.08*	***52***
Government expenditure *% of THE*	1995	48.51 (5.22-96.63)	***83***	38.28 (9.53-71.23)	***31***	54.60 (5.22-96.33)	***52***
	2009	50.74 (9.72-96.98)	***85***	40.22 (9.72-75.48)	***32***	57.09 (19.13-96.98)	***53***
Mean change	*Abs.*	*2.23*	***82***	*1.94*	***30***	*2.49*	***52***
External resources *% of THE*	1995	10.32 (0.00-70.67)	***83***	12.18 (0.13-34.64)	***31***	9.21 (0.00-70.67)	***52***
	2009	18.65 (0.00-99.14)	***85***	30.48 (6.88-99.14)	***32***	11.50 (0.00-68.94)	***53***
Mean change	*Abs.*	*8.33*	***82***	*18.30*	***30***	*2.29*	***52***
Physicians *Per 1,000 inhabitants*	2004	0.60 (0.02-4.22)	***58***	0.27 (0.02-2.48)	***26***	1.15 (0.05-4.22)	***32***
Nurses *Per 1,000 inhabitants*	2004	1.88 (0.19-10.53)	***53***	0.93 (0.19-6.38)	***25***	2.72 (0.32-10.53)	***28***
Measles vaccination *% of 1-year-olds*	1995	69.09 (26.00-97.00)	***85***	61.70 (26.00-97.00)	***33***	73.79 (38.00-97.00)	***52***
	2009	80.17 (23.00-99.00)	***88***	76.00 (23.00-99.00)	***35***	82.92 (41.00-99.00)	***53***
Mean change	*Abs.*	*11.08*	***85***	*14.3*	***33***	*9.13*	***52***

The numbers are rounded off when necessary

As pointed out in the background chapter; there is a strong link between wealth and health. The wealth-health relationship implies that reduction in poverty has great effect on population health at one point in time. I wanted to examine whether the effect was the same over time. GNI per capita was included as indicator of the wealth of a country.

The average GNI per capita in LLMICs was more than doubled from 1995 to 2009, but the differences between the two groups (and also within them) were enormous. The baseline

level and increase was very modest in the low-income-group compared to the lower-middle-income group. The change in GNI per capita is measured as both absolute and relative, because of the great difference in variation between the modes of measurement. Change was calculated in the same way as the dependent variables. 79 observations were included in the analysis while the others were excluded because of incomplete data. Data on GNI per capita was taken from the World Bank's databank (13).

The remaining independent variables measuring change are expressed as percentages, and change in these variables is only analysed in absolute terms. Analysis of relative change of a percentage would have been difficult to interpret and was therefore left out in this study. THE per capita was not included as variable in the analyses because of the strong relationship with GNI per capita (*Figure 3*). The size of the budget is not of interest (in this study) as that depends on the wealth of the country. What is of interest is the structural aspect of health care financing; THE as percentage of wealth, governmental health expenditures as share of THE, and external resources as share of THE.

The wealth of a country can to some extent be reflected in THE measured as percentage of gross domestic product (GDP). The discrepancy between GDP and GNI, according to the definition by Last (44), is that GNI is the GDP plus income from abroad. Ideally the same factor should have been used in the analysis in order to facilitate comparisons. GNI was used here because of the World Bank income classification, while the WHO's Global health expenditure database measure THE as percentage of GDP and not of GNI. The variable was

included in order to examine to what extent the percentage of GDP spent on health can be associated with improvements in population health. It could be understood as an indicator of the prioritizing of health care in a country (i.e. the wealthier country, the higher prioritization in monetary terms). This understanding of the variable is in accordance with arguments by Olsen (22); the richer the country, the more it can afford to spend on health care. The variable was analysed as baseline and absolute change, in accordance with previously statements. The average percentage of GDP spent on health in LLMICs increased by 1.09 percentage points from 1995 to 2009. The average level of and increase in THE as percentage of GDP was about the same in both income groups in 1995 and increased by almost the same. The number of observations at baseline was 83, while it was 82 for change. The remaining countries were excluded because of incomplete data. Data was taken from WHO's Global Health Expenditure Database (36).

LLMIC tend to rely on a combination of scarce government resources, external resources and high level of patient payments. The financial mechanisms affect the access to health care, and limited access to health care contributes to low population health, according to Lagarde and Palmer (10). THE is the sum of private and governmental expenditures on health. Private expenditure on health care mainly consists of patient payments (out of pocket), and only a small fraction is from private insurance. The high share of patient payments can, according to Olsen (22), be explained by lack of institutional arrangements for organization of a 'financial intermediary' to collect and manage funds for risk pooling and redistribution. Suggested by Mills (9), as countries grown richer the public share of THE

increases and the share of patient payments falls. Governmental expenditure on health was included as variable in the analyses because one would expect the share of public entities in total health expenditure to be important for population health as it is likely to increase access, and as an increased share of governmental expenditure is equal to reduction in the private share. It is stated in the report of the Commission on social determinants of health (45) that public investment is important in order to reach all socioeconomic groups. Private expenditure was excluded from the analyses because of the negative effect on population health of imposing financial barriers to health care.

Government health expenditure is expressed as percentage of the THE. The combined average percentage of THE originating from the government had a slight increase from 1995 to 2009. It is striking to note how the range varies from less than 10% to more than 95%. The average is higher within the lower-middle-income countries than in the low-income, which is as expected; the lower-middle-income group is on average wealthier than the poorer group, and, as previously stated, they have more money available to spend on health care. Data was taken from WHO's Global Health Expenditure Database (36).

Another aspect of LLMIC, particularly the low-income countries, is the importance of external resources as an element of total health expenditures. While government expenditure is measured as financing agent, the variable 'external resources' is reported as financing source, thus specifying that it is not considered governmental expenditures. The external sources are channelled through governmental budgets, insurance agencies, and private or non-governmental organizations sectors. Be aware that this does not reflect the total origin

of THE (12). The variable refers to the percentage of THE not originating from internal resources, and was analysed as baseline and absolute change. The average level of external resources in LLMIC increased by 8.33 percentage points to 18.65% of THE. The range varies from 0 to almost 100%. The low-income countries account for the highest level and increase, which is, as expected, because they are the poorest. One would expect that the increase in external resources would lead to improvements in population health as it is likely to increase the health care budget and thus the prioritizing of health care. The number of observations at baseline was 83, and 82 for the absolute change. The remaining countries were excluded because of incomplete data. Data was taken from WHO's Global Health Expenditure Database (36).

It is generally agreed that there is a strong relation between the number of health workers and population health (c.f. *2.1.1 Human resources*). In their study, Anand and Bärnighausen (46) argue that it is the relation between health care as a determinant of population health and health workers as a premise for health care, which generates a link between health workers and population health. The relation, illustrated in *Figure 1a* and *b*, is measured at one point in time, and I wanted to examine the relation from one time to another. According to Hongoro and McPake (27), although data are scarce, there are evidence of depletion of the health workforce in low- and middle-income countries.

Two categories of health workers were included in the analyses; 'physicians', and 'nurses' (referred to as nurses and midwifery personnel in the database, but in this thesis the term 'nurses' is used for simplification), as these two categories account for the largest number of

professional health workers in most countries (46). The Global Atlas of the Health Workforce (21) classification of 'physicians' includes generalists and specialists, and of 'nurses' includes professional nurses, professional midwives, auxiliary nurses, auxiliary midwives, enrolled nurses, enrolled midwives and other personnel, such as dental nurses and primary care nurses. Traditional birth attendants are not counted in this concept (21). Nurses and midwifery personnel have not been separated because in countries where they do exist as separate categories they receive similar training and undertake overlapping tasks, whereas in countries where they are not separate categories nurses do the work of midwifery (46). Densities of physicians and nurses were used as separate independent variables to allow for the possibility that the relation to life expectancy and under-five mortality rate might differ. In order to show the density both physicians and nurses are measured as number per 1,000 inhabitants. Estimates of the density refer to the active health workforce (47).

As it turned out, incomplete data on *physicians* and *nurses* in 1995 and 2009 meant that they only measure the density level at one point in time. The year 2004 had clearly more data than the other years for both health worker categories and was therefore selected for the analyses. One should be very careful when reading and particularly when interpreting the results, because the only one point in time is covered and there are very few observations (58 for physicians and 53 for nurses). In addition, average densities do not provide a full picture of health workers available to the entire population, as the human resources tend to be concentrated in urban areas (48). The data was taken from the Global Health Atlas of the Health Workforce (21).

Measles immunization is an important determinant of child survival (18, 49, 50), as measles is one of the leading causes of death among children (51). The disease is highly infectious and, according to WHO (51), vaccination is the most rational approach to measles control. WHO (49) claims that immunization is one of the most cost-effective public health interventions, and in order to prevent epidemics, the population immunity needs to be > 93-95%. Measles vaccination coverage is used as an indicator of progress towards achieving the MDG number 4 because of its potential to reduce child mortality and because it is a marker of access to child health services (15, 51).

Measles vaccination coverage is measured as the percentage of 1-year-olds immunized (against measles) (12). The variable was included because of the expected positive effect on population health (reducing morbidity and mortality) and because it could be considered as an indicator of access to health care (the higher the access, the higher the coverage). Because of the effect on prevention of death in children under-five, measles vaccination coverage was also expected to be relevant in prolonging longevity. The combined average coverage increased by 11.08 percentage points to 80.17% in 2009. The range varies from 23 to 99% in the LLMIC. The variable was analysed as baseline and absolute change. Data was taken from the Global Health Observatory Data Repository (52).

3.4 Statistical method

All analyses were done with IBM SPSS (version 19) for Windows. Microsoft Office Excel 2010 has been used to produce graphs.

The response variables were continuous and linear regression was thus the most suitable method to use in order to answer the thesis question. Univariate analyses were performed to explore significant baseline ($level_{1995}$) relations and to get information on which direction the coefficients pointed (positive or negative). The variables measuring change were adjusted for baseline in bivariate analyses to check for significant associations undistorted by the baseline level. Multivariate analyses of the economic variables measuring change and (in a different model) the significant bivariate analyses were performed. The selection of variables into multivariate models was done, as recommended by Zuur, Ieno and Smith (53), in order to find the variables which best predict the dependent variables.
The forced method (enter in SPSS) was used as entry method in the univariate analyses to get information on coefficients and significance level. The stepwise procedure was used in all multivariate analyses (including the bivariate) as this is the most thorough method. All reported p-values are two-sided and the significance level is set to 0.05 in all analyses, as recommended by Field (54). The regression results were reported as coefficients, p-value and R^2.

Multicollinearity was examined statistically using the variance inflation factor (VIF) with 10 as threshold. The assumption of normality was examined statistically using Shapiro-Wilk. If the assumption was not met (i.e. Shapiro-Wilk was significant), the histogram and normal q-q plot of standardized residuals were visually examined. The assumption of homogeneity of variance was checked visually by plotting the predicted value against the standardized residual. Possible outliers were checked by use of Cook's distance and leverage. High lever-

age was considered when values twice the average were observed. If the value of Cook's distance was greater than one the observation was considered as influential. The criterion's set for the assumptions are in accordance with recommended standards (53, 54).

4.0 RESULTS

The results from the regression analyses are presented in this chapter. Missing values do exist in the dataset, and one should be particularly careful when reading and interpreting the results in densities of physicians and nurses. The choice of measuring point has already been argued for.

4.1 Model fit

Multicollinearity was not a problem as VIF was far below 10. Analyses of the residuals (test of normal distribution)and overall evaluation of the homogeneity of variance indicated sufficiently good adaptation. Regarding possible outliers; some exist but when further investigated it turns out that they do not have any influence on the coefficients.

4.2 Regression results

The results from the different analyses are presented and the most important findings are described in the following sub-chapters.

4.2.1 Univariate analyses

The independent variables were analysed against the dependent variables in univariate analyses. Only baseline results are presented as it is not known whether the effect of the variables measuring change is dependent on the baseline level. However, the baseline adjusted change variables are of more interest (see bivariate analyses). Non-significant results

are also presented here for the reader to get an impression of the direction of coefficients (i.e. positive or negative).

Table 4*a*: Dependent variable: *absolute change in life expectancy*.

Independent variable	***Mode of measure***	***Coefficient***	***Sig.***	***R^2***
GNI per capita (US$)	***Baseline***	**-.002**	**.008**	**.091**
THE (% of GDP)	*Baseline*	-.229	.344	.011
Governmental expenditures (% of THE)	*Baseline*	-.005	.824	.001
External resources (% of THE)	*Baseline*	< .001	.998	< .001
Physicians	*Point (2004)*	-.972	.122	.043
Nurses	***Point (2004)***	**-.696**	**.012**	**.120**
Measles vaccination coverage	*Baseline*	-.028	.239	.017

Table 4*b*: Dependent variable: *relative change in life expectancy*.

Independent variable	***Mode of measure***	***Coefficient***	***Sig.***	***R^2***
GNI per capita (US$)	***Baseline***	**< -.001**	**.006**	**.097**
THE (% of GDP)	*Baseline*	-.002	.714	.002
Governmental expenditures (% of THE)	*Baseline*	< -.001	.534	.005
External resources (% of THE)	*Baseline*	< -.001	.957	< .001
Physicians	*Point (2004)*	-.029	.083	.053
Nurses	***Point (2004)***	**-.017**	**.022**	**.100**
Measles vaccination coverage	*Baseline*	-.001	.243	.017

Table 4*c*: Dependent variable: *absolute change in child mortality rate*.

Independent variable	***Mode of measure***	***Coefficient***	***Sig.***	***R^2***
GNI per capita (US$)	***Baseline***	**.020**	**< .001**	**.201**
THE (% of GDP)	*Baseline*	.029	.983	< .001
Governmental expenditures (% of THE)	*Baseline*	.254	.057	.044
External resources (% of THE)	*Baseline*	-.016	.942	< .001
Physicians	***Point (2004)***	**10.251**	**.011**	**.109**
Nurses	***Point (2004)***	**4.736**	**.010**	**.124**
Measles vaccination coverage	*Baseline*	.094	.524	.005

Table *4d*: Dependent variable: *relative change in child mortality rate*.

Independent variable	***Mode of measure***	***Coefficient***	***Sig.***	***R^2***
GNI per capita (US$)	*Baseline*	< -.001	.619	.003
THE (% of GDP)	*Baseline*	.002	.770	.001
Governmental expenditures (% of THE)	*Baseline*	< -.001	.755	.001
External resources (% of THE)	*Baseline*	.001	.400	.009
Physicians	*Point (2004)*	-.027	.166	.034
Nurses	*Point (2004)*	-.004	.626	.005
Measles vaccination coverage	***Baseline***	**-.003**	**< .001**	**.147**

The baseline level of GNI per capita and point measure of nurses are significantly associated with life expectancy. The variables are the same for both measures of change in life expectancy. The results of change in child mortality rate depend on how the change is measured. The baseline level of GNI per capita, and point measure of physicians and nurses densities are significantly associated with absolute change in child mortality, while the baseline level of measles vaccination coverage is the only significant variable associated with relative change in child mortality rate.

4.2.2 Bivariate analyses

Only significant variables in the bivariate analyses are presented as these analyses aim at finding the factors which are the strongest predictors of change in life expectancy and child mortality rate.

Table *5a*: Dependent variable: *absolute change in life expectancy*.

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
THE (% of GDP)	*Absolute*	.547	.046	.050

Table *5b*: Dependent variable: *relative change in life expectancy*.

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
THE (% of GDP)	*Absolute*	.017	.017	.071
External resources (% of THE)	*Absolute*	.002	.015	.074

Table *5c*: Dependent variable: *absolute change in child mortality rate*.

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
External resources (% of THE)	*Absolute*	-.649	< .001	.162

Table *5d*: Dependent variable: *relative change in child mortality rate*.

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
Measles vaccination coverage	*Absolute*	-.003	.012	.211

Baseline explained 14.7 of those 21.1%.

The results shows that baseline adjusted change in THE as percentage of GDP was significantly associated with change in life expectancy, and in external resources as percentage of THE was significant in predicting relative change in life expectancy and absolute change in child mortality rate. Baseline adjusted change in measles vaccination coverage was only significantly associated with relative change in child mortality rate.

4.2.3 Multivariate analyses

Multivariate analyses were done to investigate whether any of the following economic factors stood out from the others. All of the variables were analysed as change. Because of my aim of these analyses, only significant predictors are presented in the following tables.

Table 6a: *Dependent variable: absolute change in life expectancy*

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
No significant variables	-	-	-	-

Table 6b: *Dependent variable: relative change in life expectancy*

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
THE (% of GDP)	*Absolute*	.015	.035	.134
External resources (% of THE)	*Absolute*	.002	.016	

#EXT explained 7.9% of the variance.

Table 6c: *Dependent variable: absolute change in child mortality rate*

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
External resources (% of THE)	*Absolute*	-.663	< .001	.177

Table 6d: *Dependent variable: relative change in child mortality rate*

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
No significant variables	-	-	-	-

Change in THE was significant in predicting relative change in life expectancy. Change in external resources was significantly associated with relative change in life expectancy and absolute change in child mortality rate. Concerning the dependent variables absolute change in life expectancy and relative change in child mortality rate no significant predictors occurred.

Multivariate analyses of significant variables in the bivariate analyses (*Table 5b*) were also performed in order to find the strongest predictor. The change variable was adjusted for baseline in the multivariate analyses as well.

Table 7: *Dependent variable: relative change in life expectancy*

Independent variable	***Mode of change***	***Coefficient***	***Sig.***	***R^2***
THE (% of GDP)	*Absolute*	.016	.019	.138
External resources (% of THE)	*Absolute*	.002	.016	

External resource was most significant and accounted for 7.4 of the 13.8 % explained variance.

Both variables turned out significant in the multivariate analysis. Considering the significance level and the explained variance (R^2); the variable 'external resources' was the strongest predictor.

5.0 DISCUSSION

The aim of this thesis was to examine the association between improved population health and health care resources in poor countries, in order to better understand the situation in these countries. The study was conducted by analysing data from 1995 to 2009. There were several variables in the analyses that showed a significant association with change in life expectancy and in under-fives mortality rate. Most of these variables are not significant when included in models with other variables, which indicate mutual correlation. Several of the variables are to some extent indicators of each other. The hypothesis was that an increased level of health care resources improves access to health care and thus improves population health. The main focus for discussion of the results is thus the significant baseline adjusted variables. The significant point variables (including baseline) are therefore only discussed briefly. Still, one should be aware of all the significant results.

Further on in this chapter, the main results are summarised and interpreted alone and together with other findings. Finally, strengths and weaknesses of the study are discussed.

5.1 Main results

There is little available research with a broader perspective on the association between population health and health care resources in LLMIC. Thus, it has been a challenge to find appropriate and updated literature to discuss my findings against.

Overall, the predictors were in a large degree the same for both measures of change in life expectancy. However, the predictors were not the same for both absolute and relative change in child mortality rate. This may be because the differences in the variation in abso-

lute and relative change are considerably larger in child mortality rate than in life expectancy.

The baseline level of GNI per capita was significantly associated with improved population health. The results indicate that the poorest countries in 1995 had the strongest increase in life expectancy and absolute reduction in child mortality rate. The baseline level explained 20.1% of the variance in child mortality rate which is more than twice as much compared to the variance in life expectancy. The enormous disparities in the increase in GNI per capita within and between the two income groups may explain why this measure of the variable was not significant in predicting improved life expectancy and under-five mortality rate. The non-significant association was not further analysed. Baum (55) pointed out that one should not only consider the level of wealth but also the inequalities within wealth to understand the relation to health. This may be why GNI per capita was not a stronger predictor of improvements in life expectancy and child mortality rate, despite the strong relation at one point in time (*Figure 2a* and *b*). Baum argues also on that countries with more equal distribution have better population health than countries with higher overall wealth but more polarised distribution. High level of population health can be achieved without high national wealth through achievements such as social investment in education, protection of livelihoods of small farmers, good primary health services, and meeting basic needs (55).

Change in level of THE as percentage of GDP was significantly associated with change in life expectancy. The results indicate that from 1995 to 2009, the countries with the largest increase in THE as percentage of GDP had the greatest increase in life expectancy, independ-

ent of the baseline level. The variable explained more of the variance in relative (7.1%) than in the absolute (5.0%) increase in life expectancy. Increased level of THE stood out in the multivariate analyses of relative change in life expectancy, which indicate that it is a strong predictor. I did not investigate whether the level of GDP increased from 1995 to 2009, but if one considers how GNI per capita changed (*Table 3*) it seems likely that the level increased. The result seems reasonable; as more money spent on health increases the coverage of health care thus improve population health. As argued in the World health report 2010 (21), provision of health care services is not only dependent of the level of expenditures but also how revenues are raised. This is supported by the Health and the millennium development goals report, which argues that (beyond the level of spending), the way in which health systems are financed and what proportion of contribution comes from users themselves are important forces for improving the situation in developing countries (28). Carrin, Mathauer, Xu et al. (56) concludes that there is no universal formula for how health financing systems should be organized, other than shifting to prepayment, in order to achieve universal coverage. For many countries this will take time. According to Mills (9) and Balabanova, McKee, Mills et al. (57) it is not only the revenue collection which is problematic. Pooling of resources and purchasing of interventions have failed in many of the LLMICs.

The absence of significant associations between governmental expenditures on life expectancy and under-five mortality rate was in accordance with other findings. Rjkumar and Swaroop (58) argue, that governmental expenditure often does not yield the expected improvements in population health. They argue further on that another aspect of public ex-

penditure is that the differences in the efficacy can largely be explained by the quality of governance; governmental expenditure has basically no impact on population health in countries with poor governance (58). Also, as previously stated; it is difficult to promote taxation as financing scheme in poor countries. Recommended by the final report of the Commission on Social Determinants of Health (45) as a method of financing that will ensure health equity is prepayment through general taxation and/or mandatory universal insurance. Increased extent of prepayment and thus reduction of the reliance on patient payment is also recommended in order to ensure universal coverage, according to a technical brief paper by WHO (30). According to the World health report 2010 (21), it is more difficult for countries to meet the two key elements in financing systems (i.e. provision of health services of sufficient quality to be effective, and user liberation from catastrophic expenditures) so as to achieve universal coverage if they rely on patient payment to fund health systems (21). However, the situation is, as Mills states (9) that the lower the income level of countries the higher the share of patient payments tends to be, and the lower the share of taxation and insurance. The impact of patient payments goes beyond catastrophic expenditures (as described under *2.1.2 Financial resources*), as seeking health care is often delayed (among poor people) until the problem is advanced. It is therefore more difficult or impossible to treat, and much more costly (5). In order to considerably reduce the incidence of financial catastrophe in a country, a study by Xu, Saksena, Jowett et al. (59) suggested that patient payments should be 15-20% of total health expenditure and that government expenditure on health should be 5-6% GDP.

The effect of the baseline adjusted change in external resources as percentage of THE was significantly associated with relative change in life expectancy and absolute change in under-five mortality rate. The findings indicate that countries with largest increase in the percentage of THE originating from external resources, independent of the level in 1995, had the greatest increase in relative life expectancy and the greatest absolute reduction in under-five mortality rate. External resources explained more than twice as much of the variance in child mortality (16.2%) relative to life expectancy (7.4%). In addition, the variable stood out in the multivariate analyses, indicating that it is a strong predictor in this dataset. The results are supported by Mishra and Newhouse (60) who present findings that show aid financing contribute to improved health. Mills (9) argues that while external resources are important for financing health, they bring with them some major complications such as predictability (time limited commitments), fragmentation of aid flows (multiple donors and projects), and effects on the politics of donor countries (type of aid, what it is for and who receives it). These complications can affect the performance of the overall health system (9). However, according to the World health report for 2010 (21), external resources is one of the best ways donors can help countries move away from patient payments and improve access to health care and financial risk protection

As previously explained, the two indicators of health worker density failed to measure change from 1995 to 2009, which is why these results must be read and interpreted with great caution. The point measure of nurses in 2004 was significantly associated with change in life expectancy. Both nurse and physician densities were significantly associated with

absolute change in the child mortality rate. The results indicate that countries with low health worker density had the greatest improvements in population health. The result may sound strange, but countries have improved population health not because of the low density but because of increased wealth. Health worker density is then an indicator of a country's wealth. Even though the results of health worker density in this study are vague, they are in accordance with other research. Hongoro and McPake (27) stated in 2004 that there is strong "evidence of a causal link between numbers of health workers and health outcomes such as mortality rates". The statement is supported by other research which have found that population health outcomes and health systems outcomes are affected by the density of health workers in developing countries. Such outcomes can be measured as, for instance, child morality and childhood vaccination coverage, respectively (27, 46, 50). In aggregate terms, an analysis by Anand and Bärnighausen (46) suggested that physicians matter more than nurses and midwives in explaining maternal mortality, infant mortality and under-five mortality rates, and that the effect of the health worker density in reducing maternal mortality is greater than in reducing child mortality.

My findings seem reasonable as access to health care depends on the availability of services (read: appropriate health worker density) (3). The results also agree with the fact that countries with the greatest burden of disease/highest relative need have the lowest number of health workers, while the health workforce in the countries with the lowest relative need is much larger (25). The greatest shortage of health workers in absolute terms is in South-East Asia (Bangladesh, India and Indonesia), and in relative terms in sub-Saharan Africa (25). Factors causing the problems (of shortage) are low training capacity, management,

poor working conditions and remuneration (24, 27, 61). Investing in health workers should, according to a study by Anand and Bärnighausen (46), be considered as part of a strategy to achieve the MDGs, in addition to raising national income per person, reducing absolute poverty, and expanding female education.

Measles vaccination coverage was only significantly associated with relative reduction in child mortality rate. The baseline adjusted variable explained 21.2% of the variance. 14.7% of the 21.2% was accounted for by the baseline level. The findings indicate that countries with the highest increase in coverage had the greatest relative reduction in child mortality rate. The results are in accordance to findings by Mills (9); despite reasonably high immunization coverage-levels, in general due to recent efforts and increased funding, many children and mothers are not receiving lifesaving interventions. In a study by Anand and Bärnighausen (50) measles vaccination coverage was significantly associated with density of nurses, female adult literacy, and land area. GNI per capita had no significant effect on coverage (50). This is supported by an example in a paper by Cappelen, Mæstad and Tungodden (62) where it is stated that high coverage is found in Malawi, while much lower coverage is found in India, where income per capita is threefold the level in Malawi.

5.2 Strengths and weaknesses

Study design

The characteristic of the ecological study design is that the associations found using aggregate data may not apply to individuals (ecological fallacy) (38, 44). This is commonly inter-

preted as a major weakness of ecological analyses. At the same time it can, according to Bhopal (38), be considered as a strength, as these analyses provide a broader perspective. The forces which act on the whole population may be different from those that act of individuals. Another advantage of the ecological study design, according to Bonita, Beaglehole and Kjellström (40), is that data can be extracted from different data sources, as is the case for this thesis.

The applied design for this study is considered appropriate as the aim was to study the effect of change in resource input on population health from one time to another, and the data was extracted from several sources.

Sample

The choice of sample is considered to be rational as the focus of the thesis were poor countries, and as relatively little research is available that offers a broader perspective on factors associated with improvements in population health. However, the analysis does not distinguish between countries, only income groups. Variations between and within the groups are thus ignored. The analysis considers the general trends for LLMIC only, which is in accordance with the aim of the study.

Choice of variables

The level of poverty could have been included, in addition to GNI per capita, according to the statements by Baum (55). Income does not account for the wealth of a country alone (55). GNI per capita was included to account for the major socioeconomic determinants of

population health. Indicators of maternal education and rural households could have been included in the analysis as these are known to be closely related to the inequities in health (2, 18). Female literacy rate was initially included in the analysis as indicator of maternal education but was later excluded because of incomplete data. My understanding of the literature in addition to the vague analytical results is that female literacy seems important in predicting increased population health. However, considering the aim and the thesis question, GNI per capita was the only indicator of the socioeconomic determinants which were included because of the known relation between wealth and health.

As it appears in the discussion of the main results, indicators of governance (e.g. transparency) could have been included in the analysis. However, it was not within the scope of this thesis to investigate further into the field of governmental expenditures than its association to population health.

The two categories of health worker density could have been combined in the analyses, perhaps showing stronger relations with the dependent variables. On the other hand, *physicians* and *nurses* could have been excluded from the analyses because they only measure at one point in time. Still, they were not excluded, as the perspective of the thesis would then almost exclusively have focused on the financial resources. Analyses of health workers were considered important aspects of access to health care and thus to improve population health.

By extension of the time period to include more year than in this study, the changes in both dependent and independent variables would have been greater and perhaps the associations could have been stronger. On the other hand, the master's thesis has certain limitations concerning time and extent, and according to the previous argumentations the time period in this thesis is sufficient.

6.0 CONCLUSION

Incomplete data have made some limitations on the extent of this thesis. I have not been able to study the effect of health workers as wanted. However, increased levels of total health expenditure (as percentage of GDP) and external resources (as percentage of total health expenditure) were important to improvement in under-five mortality rate and life expectancy. The level of wealth was also important but the relation to improved under-five mortality rate and life expectancy is not that clear.

There is need for further studies with systematic approaches to analyse the health care resources in LLMIC. Future research should opt for holding a broader perspective, studying what actions in the health care systems have positive effect on population health in the poorest parts of the world. Investigation of the financial structures in-depth by use of relevant variables such as transparency within governmental expenditures is of interest. In addition, the effect of increased level of input within each country using adequate data should be studied in order to find the best health care strategy for each particular country.

This study has found that it is not only increased level of input which is important to improve population health but also that how the inputs are governed may be just as important. The improvement in under-five mortality rate and life expectancy in LLMIC from 1995 to 2009 are to some extent associated with increased health care resources. Only the baseline level of GNI per capita is associated with the improvements.

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