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Review

Health of the population in Iran

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ABSTRACT

It is in a great demand to address fundamental questions about the value of the health, and the proper allocation of health related funds. We applied a dynamic programming approach to Grossman's model of health demand and made some changes to fit the socio-economic properties of Iran's economy as a representative developing country. We applied data on Iranian Households Budget Survey to get age-specific information on their income, health and non-health consumption. This study distinguished between various types of measures of value of life which is important in identifying target groups. We valued the life of Iranians by considering age and time variations, and then introduced a method for measuring the health capital that varies by age through time and fits within the framework. The main conclusion was that value of life of an Iranian is estimated to be less than it was during the past decade, while the health capital is higher. We concluded that even if the monetary value of the life of a group of people increases, investing in their health may not be economically justified which is a unique property of a developing country.

Keywords: Health capital, value of life, utility, health production function.

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INTRODUCTION

Valuing health of population is essential to forming public policy for health care. It is frequently discussed that the marginal productivity of the medical system is low, so limiting overall medical spending should improve welfare of the nation. But, measuring the productivity of the health sector requires measuring the output of the health system, which cannot be done without valuing health of population. Similarly, resource allocations must often be made within the medical sector: Should more be spent on the young or the elderly? But these decisions cannot be made without knowing the health consequences or health output. Despite the very importance of health to welfare and the huge role of the government in affecting people's health, little has been written for analyzing the health of the population or its change over time, spatially in developing countries such as Iran. Many facts about health are widely known: Infant mortality has fallen in time, the elderly live longer than they used to and etc, but what is the consequence of these positive health facts? Falling mortality rate and having longer life expectancy would make one think of the changes in value of a statistical life.

Iran as a case study with high health share of GDP[1] and an aging country has some interesting features which would help us to categorize different factors which make mortality decline in time. Iran as a developing country has high health expenditures in macro level (7% of GDP), but per capita health expenditure as a percentage of disposable per capita income is much lower (almost 2%). It could cause health share and health status trend diverge[2] which is an interesting feature about our case study. In other words, health status has not increased as much the health share. Although this divergence could make value of life decline, it could also cause the resource and technology-side share of decline

[1]According to World Bank's databases, health care expenditure as a percentage of GDP in Iran (7%) is higher than the rest of the world.
[2]Because people get almost one third of total resources allocated to health, therefore health status may diverge from health expenditure.

in mortality rates differ from what we expected. It also could make some differences between value of life and health capital trends. These differences may also arise from some unrealistic assumptions (we will address them in theoretical frame work) which we tried to fix them.

Grossman (1972) offers a utility function which counts health as well as consumption. This approach has been applied in some studies such as Hall and Jones (2007). They introduced a different variation of Grossman's approach to capture the rising health share of GDP in time by adding a constant term to the utility function.

They give monetary values to the longevity gains experienced by a hypothetical individual. Following Grossman's framework, we are able to assess various types of age specific monetary values of a statistical life which is widely introduced in the health literature. Social value of life, technology side value of life and quantity and quality of life are various types of monetary valuation of life which we are going to debate further on this paper (Ehrlich and Chuma, 1990; Hammitt et al., 2000; Ehrlich et al., 2004; Costa et al., 2004; Cutler, 2004; Becker et al., 2005; Ashenfelter, 2006; Hall and Jones, 2007). Distinguishing these concepts would help us to get better understanding of how much a life worth and what difference it makes to separate various measures of valuing life: It helps the decision maker to choose the most efficient target to invest on according to her subject of interest.

Although we built on the utility function by following Grossman (1972) and Hall and Jones (2007) who consider the optimal choice of consumption and health spending in the presence of a quality-quantity tradeoff, we made some changes and other Interpretation. This study considers a wider range of preferences for longevity and consumption. Following the earlier works, we chose a Constant Relative Risk Aversion (CRRA) utility function with an additional constant term which its importance is explained in Hall and Jones (2007). Adding a constant term to the utility function permits the elasticity of utility to vary with consumption, therefore we can trace age specific elasticity changes in time. Following Newhouse (1992), Jones (2004) and Hall and Jones (2007), in addition to health related expenditure, we also introduce a technology factor to the health production function alongside with a residual of other factors such as education, behavioral changes, etc. We will identify parameters of the health production function by applying the approach that is introduced by Hall and Jones (2007). We also introduce a new type of mortality based health capital according to this environment.

The main decision, in this framework, is the allocation of total resources between health and non-health consumption. People spent on health because it allows them to live longer and extending life time allows them to enjoy better lives. Health spending also allows them to enjoy a better quality of life (Grossman, 1972). Spending on health to extend life allows individuals to purchase additional utility, as a result, the optimal composition of total spending shifts toward health which is the foundation of this specific model (Hall and Jones, 2007). In this framework as consumption increases, the marginal utility falls but, extending life doesn't face with the same diminishing returns. Standard preferences state the fact that health is a superior good and, as people grow older, consumption rises but, they allocate most of their resources to health (Hall and Jones, 2007). Although we have paid proper attention on the optimal allocation of resources, we will not discuss it further

This paper presents an economic framework for measuring health of the population. The simplest measurement of health capital is the years-of-life (YOL) approach: Individuals who are dead are not healthy and individuals who are alive are healthy. Thus health capital for a person is her expected future number of years alive (or life expectancy). But all years of life are not valued the same. A year of good health is valued more than one with sickness. There is a second measure of health capital: the quality-adjusted life year measure (QALY) that considers morbidity as well as mortality. Because mortality rates have been falling over time, the YOL and the QALY measures of health capital have been rising according to these two measures, while our measure does not give such a straight result. Although these measures have widely used, they have some weaknesses. They take the value of all (or at least some) life years as given, but at the approach we choose, they vary by age and time. Also the dollar value of a life year is taken as given but it is not true for all ages and years. We will see in this paper that value of a life of an age group may vary by time and there are some great age-specific differences for the value of a slight improvement in health: health is extremely valuable for the elderly. This is the reason why we have tried to put the proper dollar value on a life year and then measure the health capital.

This study is related to a bunch of theoretical and empirical studies. On theoretical side, this research is close to Grossman (1972) and Ehrlich and Chuma (1990), Viscusi (2015), Viscusi and Masterman (2017a) who consider the optimal choice of health and consumption spending in a quality-quantity context. This study is also related to the literature on the value of life and willingness to pay to reduce mortality risk. Usher (1973), Arthur (1981), Shepard and Zeckhauser (1984), Murphy and Topel (2003), Ehrlich et al. (2004), Hall and Jones (2007) and more recently Viscusi (2013), Doucouliagos et al (2014), Robinson and Hammitt (2015), U.S. Environmental Protection Agency (2016), U.S. Department of Transportation (2016), Viscusi and Masterman (2017b) and Robinson et al. (2018) are the examples that include simulations of the willingness to pay to reduce mortality risk and calculations of the value of life. The estimated values of life in these studies vary between 2 and 9 million U.S dollars.

We examine age specific marginal utility of health and non-health consumption to get the additional utility which a person gets from a slight increase in health status. We estimate age specific quality and quantity of life, social value of life and technology side value of life of a representative Iranian to see how the monetary value of life changes by age throughout time. We also estimate the health capital based on the value estimated for health. Splitting monetary value of life between these measures helps social planer to get better understanding of the value of health of the population which it leads to better policy. To the best of our knowledge, this kind of categorizing hasn't done in the literature. This study also proposes a way for calculating health capital which is fitted into the approach. To do so, this study used the data on Iranian Households Budget Survey to get information about age specific health and non-health expenditures. Our results are based on a dynamic programming approach on the social planner's problem.

This study shows that even if monetary value of life of a group of people increases, investing in their health (whether to increase longevity or improve health status) may not have economic justification. Results show that after 2009, investing on the living newborn's health is more valuable than giving birth to a child from the social perspective, while before 2009, increase in population of newborns[3] was economically valuable. This is a feature unique to a developing country, where the worth of investing in a group of people may change as time passes. This property arises from fluctuations in the value of life.

We present the age specific decline in mortality rates and increase in life expectancy as basic facts. But who gains more? We see mortality decline for the elderly was faster than the young or the middle aged. In the remainder of this study, we discuss a framework for measuring health. We also present empirical estimates of changes in health and its monetary value. The first section discusses trends in health during the past twenty years. We then represent a theoretical framework for measuring health and health capital. In the third section, we estimate the value of life and then health capital to match the estimated value of life of Iranians.

DATASET AND BASIC FACTS

This section tries to introduce the dataset which we used and highlight some basic facts. We are interested in age-specific health and non-health expenditures along with age-specific mortality rates and income which are not available from national accounts. In order to get these data, we employ information from Households Budget Survey.

To obtain the individual's age-specific health expenditure, we aggregate individual's yearly expenditure on health goods and services with their health insurance premium and government and employer payments for health insurance. Individual's income, in addition to their salary, includes pension salary, rental income, return from deposits, grants, household allowances from social organizations and charities, gaining from the sale of products made by the household at home, transitional receipts from other households and other receipts that are listed in HBS. Then individual's health share is attained by dividing health expenditure to per capita income in every age group.

We organize the data into 19 five-year age groups. The first and last groups are 0–4 and 90–94 year-old individuals, respectively. We consider 20 time periods in the historical period, running from 1996 through 2015.Data on age specific mortality rates and life expectancy are taken from Eini-Zinab (2015). Health expenditure and income are adjusted by Consumer Price Index (CPI).

The most fundamental measures of health are life expectancy and mortality rates (Culter and Richardson, 1997). Figures 1 and Figure 2 show mortality rates and life expectancy for the newborn, the middle aged and the elderly since 1996, respectively.

According to these figures, mortality rates are declining and life expectancies are increasing in time. These facts show that the health of the population has been improving since 1996. Mortality rate for the newborn has been declining with a constant rate (1.4% in average) over time which is along with life expectancy increase. Mortality rate for the elderly has fallen dramatically but the rate of mortality decline has not been uniform. Mortality fell and increased until 2003 (0.17% a year), then fell rapidly until 2006 (2.3% a year) and fell in an almost moderate rate till 2015 (almost 1% a year). But these patterns are absent in terms of life expectancy, which has risen since 1996.

The fact that health status improved more for the elderly than the young is a direct result of the nature of health improvements over this period. The most dramatic change in health in recent decades has been the reduction in cardiovascular disease mortality. Because this change largely affects the elderly, the gains to the elderly are larger.

THEORETICAL FRAMEWORK

We need to put monetary values on life of the population to measure the health of the nation. We begin this section by introducing the framework. Following Grossman (1972), we assume the economy consists of people of different ages who are otherwise identical. This allows us to focus on a representative person. Let x denote the representative person's health status. The mortality rate of an individual is the inverse of the health status, 1/x, therefore $1-\frac{1}{x}$ is the survival probability of a

[3] The newborn, the middle aged and the elderly contain 0-4, 45-49 and 70-74 year-old individuals, respectively.

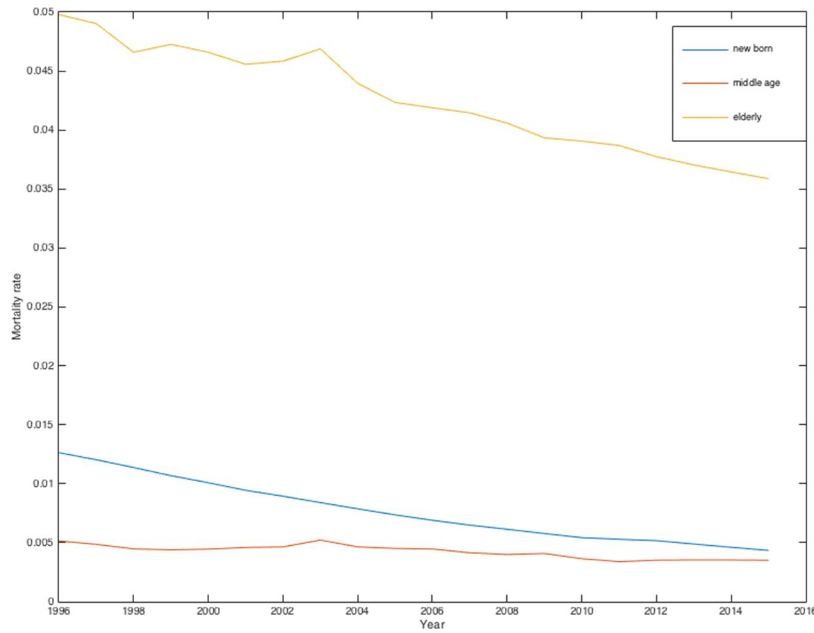

Figure 1. Mortality rates for the newborn, the middle aged and the elderly (1996-2015).

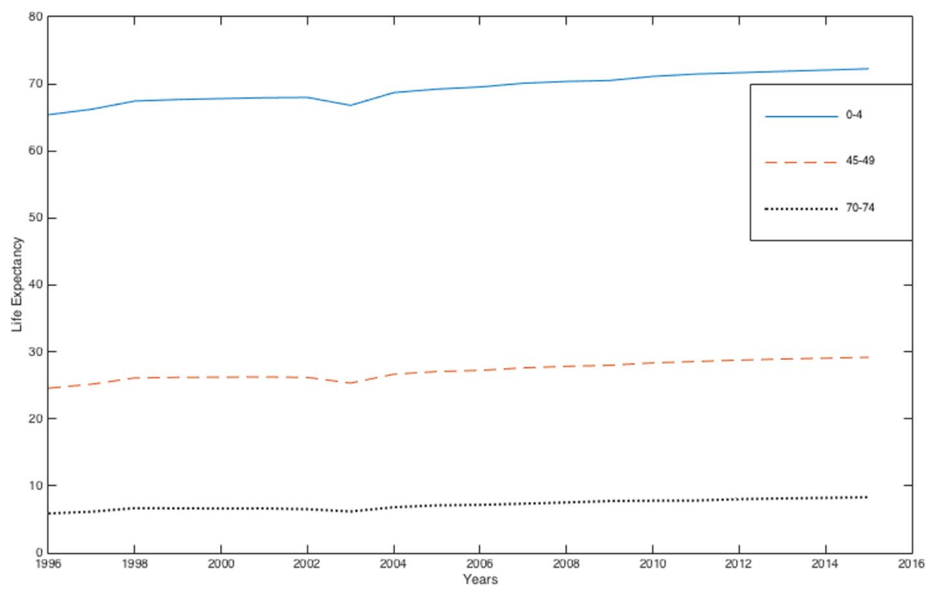

Figure 2. Life expectancy for the newborn, the middle aged and the elderly (1996-2015).

representative individual. Since people of all ages face the same mortality rate, x is also equal to life expectancy (Hall and Jones, 2007).

The expected lifetime utility for the representative individual is:

$$u(c_{a,t}, x_{a,t}) = b + \frac{c_{a,t}^{1-\gamma}}{1-\gamma} + \alpha \frac{x_{a,t}^{1-\sigma}}{1-\sigma} \quad (1)$$

Where γ, α, and σ are all positive and, t and a represents time and age respectively. The first term is the benchmark level of utility. As long as u is positive, preferences are well behaved (Hall and Jones, 2007). This is quarantined by the base level of utility, b. The second and the third terms are the standard constant-elastic specification for consumption and health, respectively.

This type of utility function could explain rising health share of GDP and, more importantly, elasticities are no longer constant. Its importance discussed earlier at introduction. Adding a constant to the utility function permits the elasticity of utility to vary with consumption. In the framework we used, as consumption increase the marginal utility falls but, extending life doesn't face with the same diminishing returns. Standard preferences state the fact that health is a superior good and, as people grow older, consumption rises but, they allocate most of their resources to health.

The representative individual receives a constant flow of resources (y) which can be spent on consumption or health:

$$c + h = y \tag{2}$$

According to this assumption, there is no saving in the economy. A health production function governs the individual's state of health:

$$x_{a,t} = f(h_{at}, a, t) = A_a\left(z_t h_{a,t} w_{a,t}\right)^{\theta_a} \tag{3}$$

In this production function, A_a and θ_a are parameters that depend on age. z_t is the efficiency of a unit of output devoted to health, taken as an exogenous trend; it is the additional improvement in the productivity of health care on top of the general trend in the productivity of goods production. $h_{a,t}$ is the representative individual's health share of income. The unobserved variable $w_{a,t}$ captures the effect of all other determinants of mortality such as education, pollution, etc.

In this environment, we consider the allocation of resources that would be chosen by a social planner who places equal weights on each person alive at a point in time and who discounts future flows of utility at rate β. Let $N_{a,t}$ denote the number of people of age a alive at time t. Then social welfare is:

$$\sum_{t=0}^{\infty} \sum_{a=0}^{\infty} N_{a,t}\beta^t u(c_{a,t}, x_{a,t}) \tag{4}$$

The optimal allocation of resources is a choice of health and consumption spending at each age that maximizes social welfare subject to the production function for health in Equation 3 and resource constraint in Equation 2.

We express this problem in the form of a Bellman equation. Let $V_t(N_t)$ denote the social planner's value function. The age distribution of the population is the vector $N_t = (N_{1,t}, N_{2,t}, \dots, N_{a,t}, \dots)$ .Then the Bellman equation for the planner's problem is:

$$V_t(N_t) = \max_{\{h_{a,t}, c_{a,t}\}} \sum^{\infty} N_{a.t} u(c_{a.t}, x_{a.t}) + \beta V_{t+1}(N_{t+1}) \tag{5}$$

Subject to

$$\sum_{a=0}^{\infty} N_{a,t}\left(y_t - c_{a,t} - h_{a,t}\right) = 0 \tag{6}$$

$$N_{a+1,t+1} = \left(1 - \frac{1}{x_{a,t}}\right) N_{a,t} \tag{7}$$

$$N_{0,t} = N_{0,t} \tag{8}$$

$$x_{a,t} = f(h_{at}, a, t) \tag{9}$$

$$y_{t+1} = e^{g_y} y_t \tag{10}$$

The first constraint is the resource constraint. We assume that people of all ages contribute the same flow of resources, y_t. The secondconstraint is the law of motion for the population. We assume that the number of people ageda + 1 next period can be taken equal to the number aged a today multiplied by the survival probability. The third constraint specifies that births are not constant. The final two constraints are the production functionfor health and the law of motion for resources. Resources grow exogenously at rateg_y which is the average growth rate of last ten years.

Solving the FOCs gives the following equation:

$$\frac{\beta v_{a+1,t+1}}{u_c} + \frac{u_x x_{a,t}^2}{u_c} = \frac{x_{a,t}^2}{f'(h_{a,t})} \tag{11}$$

Where $f'(h_{a,t})$ represents $\frac{\partial f(.)}{\partial h_{a,t}}$ and $v_{a,t} = \frac{\partial V_t}{\partial N_{a,t}}$denotes the change in social welfare associated with having an additional person of age a alive next period. $v_{a,t}$ is the social value of life at age a in units of utility.

The optimal allocation sets health spending at each age to equate the marginal benefit of saving a life to its marginal cost. The left hand side of Equation 11 is the Marginal Benefit (MB) of saving a life and the right hand is the Marginal Cost (MC). The first term in Equation 11 is the social value of life and the second term is the additional quality of life enjoyed by people as a result of an improvement in health status. In other terminology, the first term in Equation 11 represents the value of extending a life[4] (or the value of living an extra year) and the second term is the value of health in terms of utility.

The MC of saving a life is equal to $\frac{dm}{dh} = h.\frac{x}{\theta}$.[5] Combining Equation 11 and $\frac{dm}{dh} = h.\frac{x}{\theta}$ (as the MC of saving a life) gives the following equation which the optimal health spending could be obtained from:

$$\frac{\beta v_{a+1,t+1}}{u_c} + \frac{u_x x_{a,t}^2}{u_c} = \frac{h_{a,t} x_{a,t}}{\theta_a} \tag{12}$$

The derivative of the value function gives us the social value of life that satisfies the recursive equation:

$$\begin{aligned} v_{a,t} = u(c_t, x_{a,t}) + \beta\left(1 - \frac{1}{x_{a,t}}\right) v_{a+1,t+1} \\ + u_c(y_t - c_t - h_{a,t}) \end{aligned} \tag{13}$$

[4]It also represents the value of non-health consumption
[5]One may easily prove this equation.

Now we should calibrate this model to match our dataset. Large literatures on intertemporal choices suggest that γ = 2 is a reasonable choice (Lucas, 1994; Chetty, 2006; Hall and Jones, 2007). The resulting estimates for the utility intercept b, and the quality of life parameters α and $\sigma$are:α =2.58, σ = 1.12 and b = 73.95.

To do so we introduce $s_{a,t} = h_{a,t}/y_t$ and rewrite Equation 3 as: $x_{a,t} = A_a\left(z_t y_t . s_{a,t} . w_{a,t}\right)^{\theta_a}$. First term is $z_t y_t$, the trend due to technological change. Resource allocation is the second cause of a trend decline in age specific mortality ($s_{a,t}$) and the third cause of mortality declination is the unobserved element ($w_{a,t}$). The key assumption that allows us to identify θ_a is that our observed trends in technological change and resource allocation account for a known fraction of the trend decline in age specific mortality ($\mu = \frac{2}{3}$). Logarithmic form of Equation 3 by assuming time trend for $w_{a,t}$ is: $\log\left(x_{a,t}\right) = \log A_a + \theta_a\left(\log z_t + \log h_{a,t} + g_{w,t}.t\right) + \epsilon_{a,t}\big)$. We use a linear time trend as an instrument to estimateθ. Knowing μ let us calculate the trend growth rate $g_{w,t}$from $1 - \mu = \frac{g_{w,t}}{g_z + g_{h,a} + g_{w,t}}$. Then we apply the GMM estimator to estimate θ_a.

The age-specific values for the elasticity of health status with respect to health inputs (θ_a) are represented at Figure 3. Figure 3 also shows that the very young have the highest elasticity and it declines by age.

One may be curious about the discount factor, β. We apply the Envelope theorem for the maximization problem of the social planer which gives the discount factor, β.

$$\beta = \frac{(1+g_c)^{\gamma}}{\bar{R}} \tag{14}$$

$$\bar{R} = \frac{\sum_{t=1996}^{t=2015}(int_t - infl_t \ * 100)}{20} \tag{15}$$

Where g_c is the growth rate of consumption and $\overline{\mathrm{R}}$ is the real return to saving. int_t and $infl_t$ are nominal interest rate and inflation rate at time t, respectively. Taking consumption growth of 1.31 percent per year from our dataset, a standard Euler equation gives an annual discount factor of 0.9683.

Table 1 summarizes the estimated parameter values according to various scenarios. This table implies that our estimations of parameters are robust.

Grossman (1972)'s measure of health capital is the discounted value of the utility from health of a person over time.[6] There are some deficiencies with this approach: 1- It takes the Marginal Rate of Substitution (MRS) between health and non-health consumption invariant by age and time; 2- All years of life are valued the same ($100000 for a life year). These two were the major issues with Grossman's framework, but in our approach the MRS varies by age and time and life years are not taken as given. As we will see, the Marginal Utility (MU) of health depends on age. As people get older the MU of health rises by an increasing rate[7], therefore considering it as given seems farfetched from reality. Although the MU of non-health consumption doesn't vary so much by age, because of the sharp increase in the MU of health, the MRS between health and non-health goods and services change dramatically as the individual gets older. Although the value of life of people does change over time, it changes by age too. By taking these flaws into account, the Health Capital (HC) could be calculated more accurate. The second term in Equation 11 is the value of the utility from health and the discounted value of annual utility over the person's life span would be:

$$HC(a,t) = MRS_{x,c_{(a,t)}}.E_t\left[\sum_{s=0}^{\infty}\beta^s.x^2_{t+s\,(a,t)}\right] \tag{16}$$

For each individual, utility depends on her own mix of health states and expectations about future health. The careful reader may have already noticed the replacement of x by x^2 in conventional definition of the HC. The reason behind this change in the definition of the HCcomes from the framework, more specifically, from the second constraint (Equation 7). It should be noticed that we balanced the definition of health capital based upon both the approach we choose and the constraints we impose to the model. This definition for health capital puts a lot of values on the health of the young, so that the age specific health capital decreases by an increasing rate as people get older. In the health literature, health of the young worth a lot also, as we will see later, marginal benefit of the health of the young (at this study under 25 year-old Iranians) is higher than the other age groups which it makes the health of the young more valuable to invest on and, accordingly, their health capital higher.

DISCUSSION

In order to start measuring the health of Iran's population, we shall report some facts that will help us to get better understanding of the reason behind fluctuations in value of life. To do so, we start by representing age specific marginal utility of consumption and health, then trends in health status and health spending, and finally shares of mortality trend explained by health spending and technology.

In most branches of applied economics, only marginal utility matters but, what matters for the choice of health spending is not just the elasticity of marginal utility, but

[6] It should be noticed that this is based on the definition of human capital. See Waidmann et al. (1995).

[7] Because health is extremely valuable and saturation occurs more rapidly in non-health consumption.

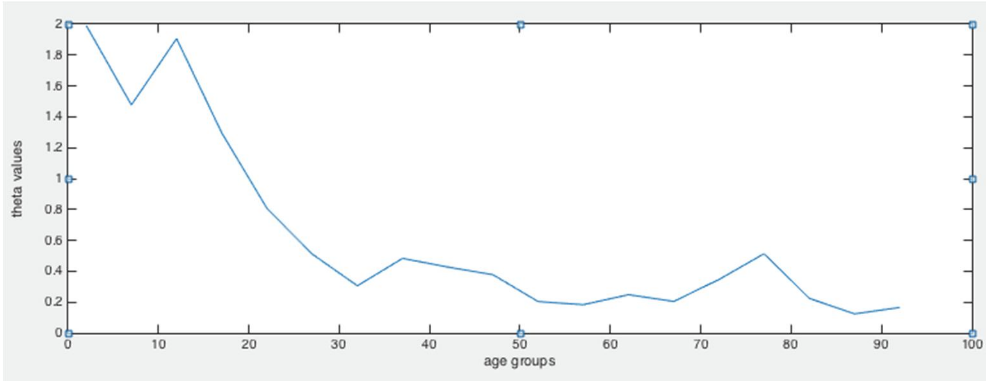

Figure 3. Age-specific elasticity of health status with respect to health inputs.

Table 1. Robustness check.

Scenario	VSL(million USDs, 2015)	γ	μ	g_z	Explanation of change	b	α	σ
1	3	2	0.67	0		71.99	2.53	1.11
2	3	2.5	0.67	0	Vary γ	75.99	2.63	1.11
3	3	1.5	0.67	0	Vary γ	69.99	2.48	1.11
4	3	1.05	0.67	0	Near log quality of life	69.99	2.47	1.16
5	4	2	0.67	0	Vary empirical value of life	70.37	2.81	1.20
6	3	2	0.67	0.01	Vary production of health	71.99	2.53	1.11
7	3	2	0.5	0	Vary μ	71.99	2.53	1.11
8	3.2	2	0.67	0	benchmark	73.95	2.58	1.12
9	2	2	0.67	0	Vary empirical value of life	68.99	2.45	1.08
10	3	2	0.67	0	Without quality of life	1095692	0	1.12

also the elasticity of the flow utility function itself. With the constant term added to the utility function, the utility elasticity declines with consumption for conventional parameter values.[8] The resulting specification is then capable of explaining the rising share of health spending.

Figure 4 shows marginal utility of non-health consumption (MUc) and health status (MUx) of a representative 35-39 year-old person for 1996 and 2015. It should be noticed that the horizontal axis represents age cohorts, so this figure do not show the conventional marginal utility. We should mention that Figure 4 shows change in the MU as a person grows older. As we see from this figure, age differences do not concern the representative person's MU_c that much but, the marginal utility of an extra year of life (MU_x) increases (by an ascending rate) by age. It is obvious, almost after 50s, an extra year of life becomes highly valuable.[9]

According to Figure 4, even with the rising health share, the additional marginal utility that people get from an extra year of life in 2015 is less than 1996. The root to this interesting finding is the aging population. We showed in Figure 3 that the elasticity of health status with respect to health inputs (θ_a) declines by age and the returns in the production of health falls sufficiently slowly for the elderly, therefore higher health spending has relatively lower efficiency in 2015 which it reduces the marginal utility gained from slight improvements in health status.

The other fact that we are going to debate is the percentage of mortality reduction due to resource allocation and technology change. Figure 5 shows that the mortality reduction is mostly explained by allocation of resources to health instead of technology, therefore allocation of resources to health has the dominant role in mortality reduction.[10]

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[8] The elasticity of utility with respect to consumption is $\frac{c^{1-\gamma}}{b+\frac{c^{1-\gamma}}{1-\gamma}}$, accordingly the elasticity of utility with respect to health is $\frac{c^{1-\sigma}}{b+\frac{c^{1-\sigma}}{1-\sigma}}$.

[9] Reader should take care of the meaning of the MU that we are discussing. This figure is representing change in the MU when a person at age a is alive and lives one more year. An extra year of life is less valuable early in life because, an extra year of life doesn't change the MU_x from a slight increase in health status and it becomes more valuable at older ages when a person chooses to value a slight change in health status more.

[10] We should mention that we assumed 66 percent of reduction in mortality rates is due to resource allocation and technology change, by assuming that technology growth as the same rate as the rest of the economy.

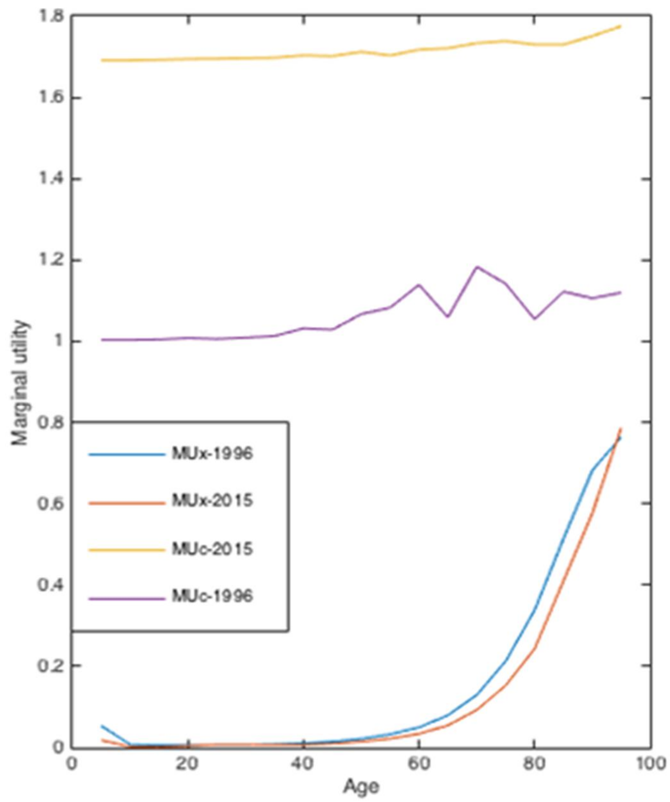

Figure 4. Age specific marginal utility of consumption and health.

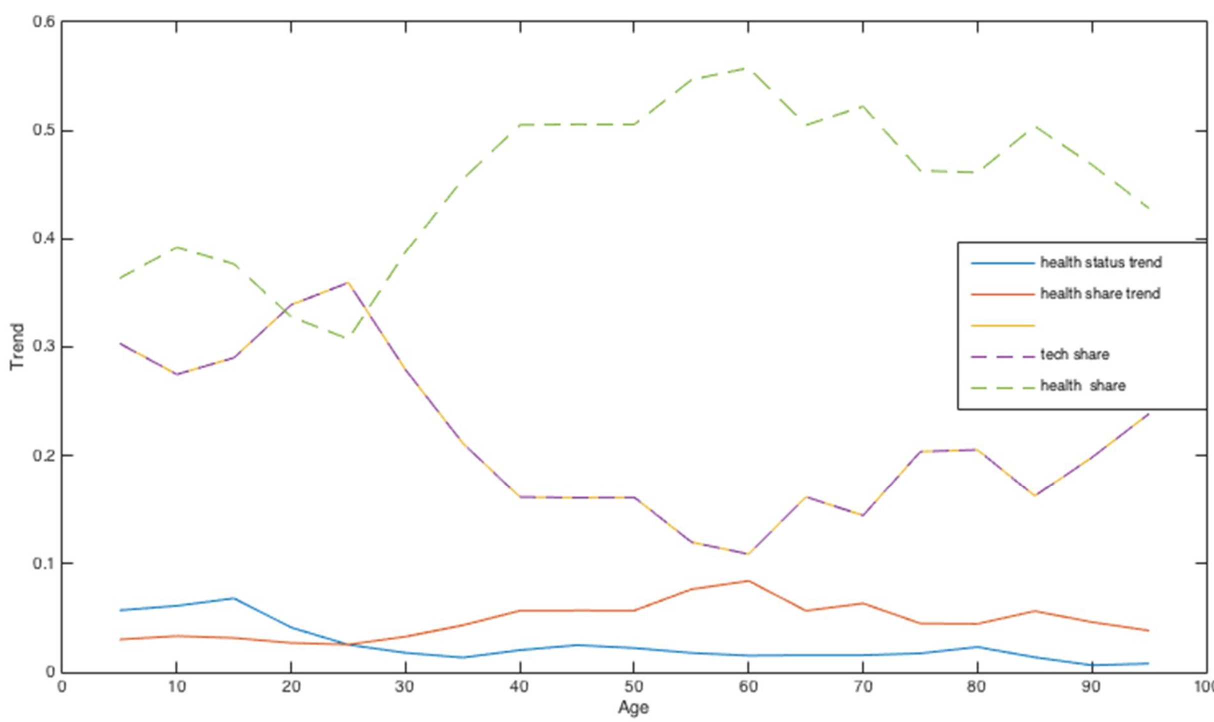

Figure 5. Age specific trends in health status and health spending; and shares of mortality trend explained by allocation of resources to health and technology. **Note** – bottom solid blue and red lines represent trend in health status and health spending and dashed green and purple lines show the share of mortality trend explained by allocation of resources to health and technology.

It should be noticed that the response of the health share to rising income depends on the movements of the two elasticities in health and consumption. The main point of our argument is that the consumption elasticity falls relative to health elasticity as income rises, causing the health share to rise. A reasonable explanation is that health is a superior good.[11] So we are able to explain what fraction of trend decline in age specific mortality is due to resource allocation (45.17% in average) and how much is related to technology change (21.5% in average). It seems the share of resource allocation to health is almost twice the share of technology change, in average. According to Figure 5, allocation of resources to health could explain at least 31% and at most 55% of mortality reduction, respectively. Now we are all set to carry on.

According to Equations 12 and 13 we specified three different types of the VSL. Multiplying technology side value of life in per capita income and dividing to the expected life expectancy, we get the average value of life per year of life saved. Figure 6 represents the age specific average value of life per year of life saved.

The right panel of Figure 6 shows the age specific value of life per year of life saved in 2015 and 1996, and trend in average value of life for a representative newborn, 35-39 year-old and 60-64 year-old person is represented in right hand (Figure 6). Average technology side value of life is maxed out for people on their 50s. We expect the value in 2015 be higher than 1996, but it does not hold for the middle aged. From the right hand figure it is obvious that the average value of life per year of life saved for the middle aged has been declining in time which it causes lower values for the middle aged in 2015.

The representative newborn's technology side value of life has an increasing trend but, a 35-39 year-old has almost a declining trend and the average value of life of a 60-64 year-old person has a slight increasing trend over the last twenty years. Figure 5 shows that the share of mortality trend explained by technology is lower for a 40-60 year-old individual. This solely can reduce the technology side value of life for these age cohorts. The growth rates of technology side value of life for 7th, 8th, 10th and 12th age cohorts[12] are negative but, the overall growth rate is 0.0038.

Figure 7 represents age specific quality and quantity of life along with social value of life in thousands of U.S dollars. Quantity and quality of life are the first and second terms (the left hand side) of Equation 12 respectively and the social value of life is based upon Equation 13. All dashed figures are representing year 2015.

Social value of life and quantity of life are both based on the social welfare associated with having an extra person alive next period. Just the expected term (in Equation 12) distinguishes these two concepts. This is the reason why these two are analogous graphically. As it is clear, these two lines (social value of life and quantity of life) are diminishing from one age cohort to the next one.

The additional quality of life as a result of improvement in health status plays an important role. Health has a great deal with utility gained from life. The additional quality associated with a slight increase in health status reaches the highest point for a 15-19 year-old individual and declines for older ones. It states that investing on the health of people older than 20 has diminishing return. It should be noticed that the average value of life per year of life saved (Figure 6) for the middle aged in 2015 is lower than 1996, but according to these three measures (Figure 7), values in 2015 are higher than 1996. This is the difference between these concepts which makes it interesting to study.[13]

Figure 8 represents quality, quantity and technical value of life for the newborn, the middle aged (35-39 year-old) and the elderly (60-64 year-old) in time. Quantity of life for the newborn is higher than both quality of life and technology side value of life. Quantity of life for newborns exceeds quality of life until 2009. To get a better understanding of what is happening remember (Figure 4).

As we showed in Figure 4, the MU_x is very low early in life which it makes quality of life lower than quantity of life (Equation 12) for the newborn. In other words: increase in utility gained from improvement in health (quality of life) is low early in life which makes quantity of life of a newborn higher than quality. Our debate becomes more interesting from now on.

Quantity of life is the social value of saving a life and according to Figure 8, the newborn worth a lot from the social perspective. In other terminology it represents the value of non-health consumption which is very valuable to the newborn because of the importance of well nutrition. According to Figure 4, it makes quite sense: the marginal utility of non-health consumption is totally above the marginal utility of health. Quality of life is a term which shows the additional quality of life enjoyed by people as a result of an increase in health status which exceeds quantity of life after 2009. It means that after 2009, enhancing the living person's health status worth more than adding a new member to population of newborns. In other terminology, again, it (quality of life term) means the value of health. It shows the value of health to a newborn is far behind the value of non-health consumption which, according to Figure 4, is straightforward. The reason is that the newborn maintain quite huge amount of health

[11]Because saturation occurs more rapidly in non-health consumption.
[12] 7th, 8th, 10th and 12th age cohorts are 30-34, 35-39, 45-49 and 55-59 year-old individuals, respectively.

[13] As we declared, the average value of life per year of life saved (AVLPYLS) is attained by multiplying technology side value of life (TSVL) in per capita income and dividing to the expected life expectancy. The AVLPYLS measure takes the life expectancy into account, so in contrary to the TSVL measure, the AVLPYLS measure captures future effects on the value of life. This could have policy use; as if the policy maker wants to consider long run, he should pick up the AVLPYLS, otherwise the TSVL could be the proper measure.

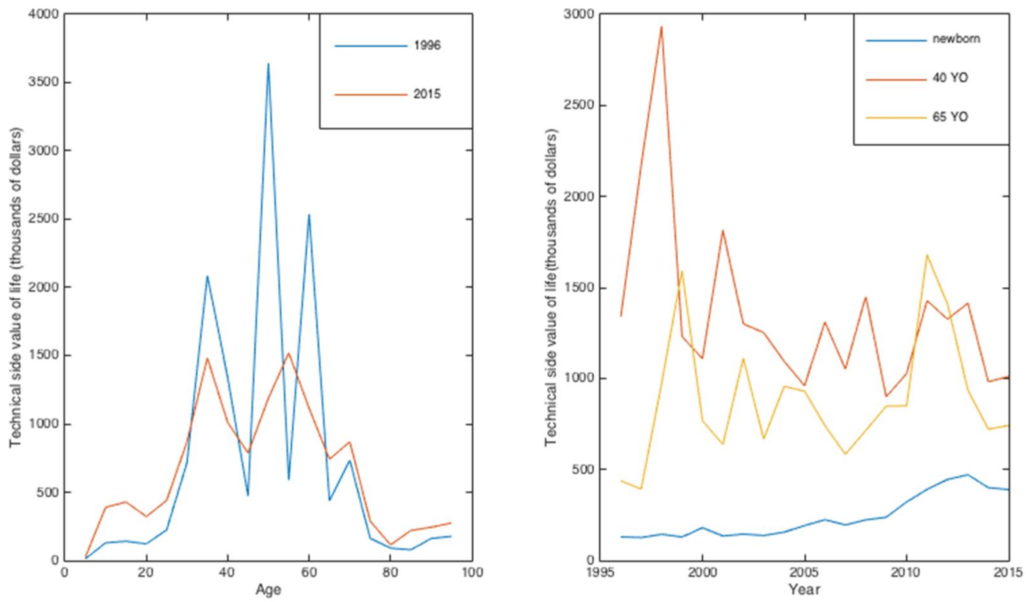

Figure 6. The average value of life per year of life saved.

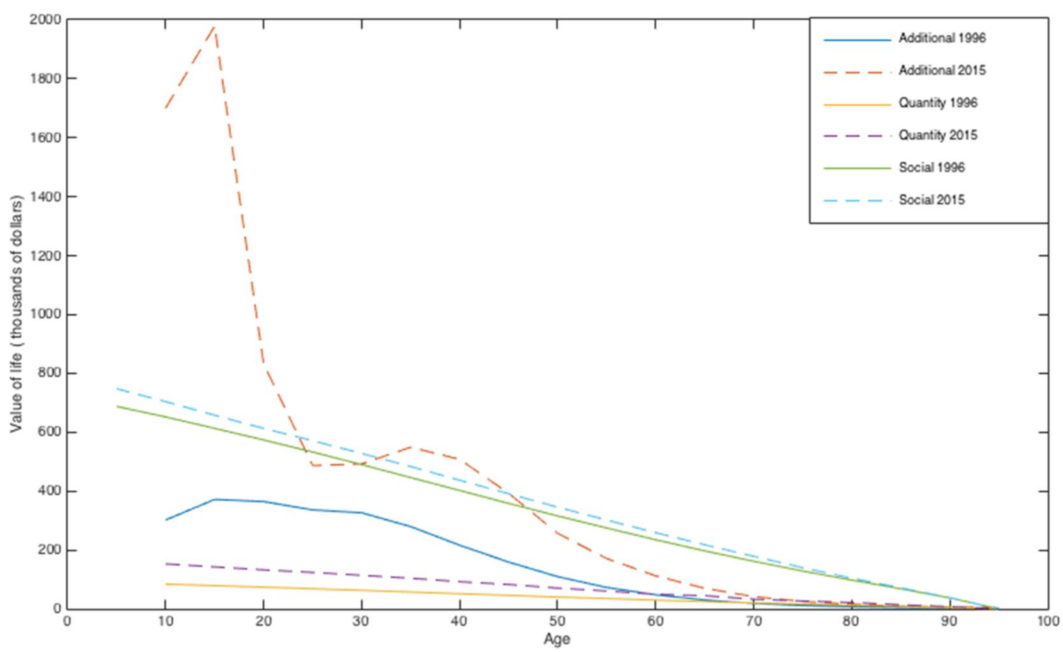

Figure 7. Quantity - quality and social value of life.

capital.[14]

It seems technology side value of life of the newborn is lower than the other two measures. This fact arises from the values we estimated for the elasticity of health status with respect to health inputs (mostly health expenditure), θ_a. According to Figure 3, the estimated values for θ are higher for the newborn which it makes technical value of life underneath the other two measures (based on Equation 12). For newborns, quantity and quality of life reach to maximum point in 2006, but technology side value of life almost has an increasing trend until 2011 and slightly declines after that point. It shows that Iranian newborns worth less today than what they used to (in comparison to 2006).

The middle aged and the elderly have totally different

[14] Figure 10 shows that the HC of the newborn is enormous, compared to the middle aged and the elderly.

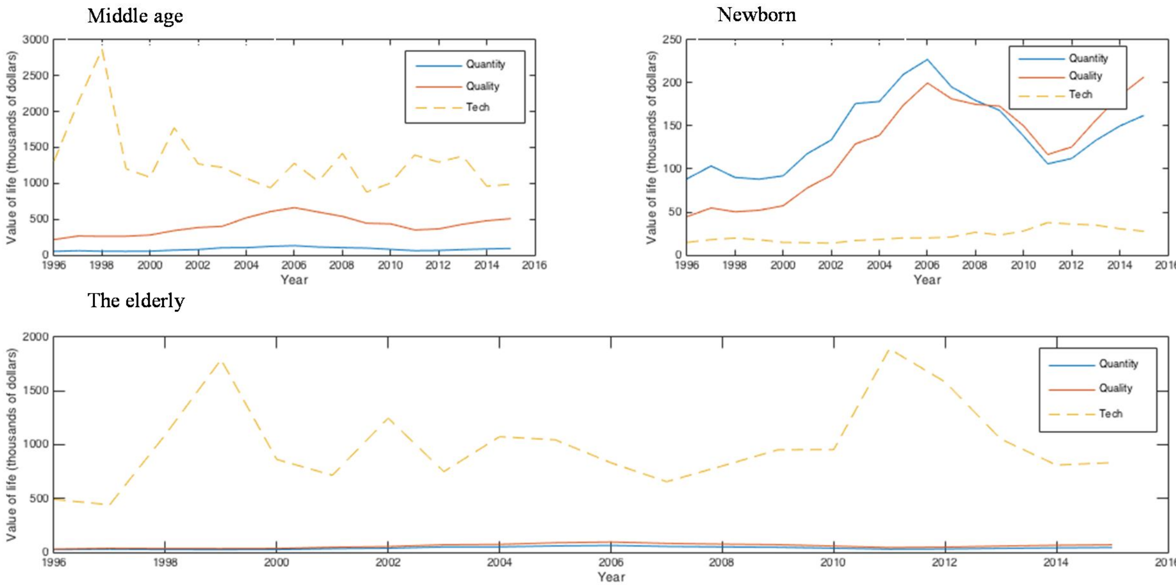

Figure 8. Various types of value of life for the newborn, the middle aged and the elderly since 1996.

stories. Quantity of life of a middle aged is lower than the other two measures. It means in terms of society, having a middle aged alive next period has lower value than investing on a person's health to enhance her health status at that age. In other words, marginal benefit of investing on the health of a middle aged Iranian is higher than marginal cost of having a person alive next period. Technology side value of life is on the top of quantity and quality of life; it means middle aged Iranians technically worth a lot. The reason behind higher technical value of life for middle aged Iranians is that their earnings at midlife are higher than other periods in life so they can afford higher health expenditure. From the other hand, the estimated age specific θ_a is lower for this age cohort (alongside with higher health expenditure and higher health share at mortality trend decline which is shown in Figure 5) which makes their technical value of life higher than quantity and quality of their lives. Technology side value of life for middle aged Iranian has been decreasing in time. Technically, it means the statistical value of life of a middle aged in Iran is lower than they used to. Although this conclusion holds for the other two measures of value of life, there are tiny differences. The difference is: technically, 1998 was the glorious year for a middle aged Iranian because technology side value of life of an Iranian reaches its highest value at that year but from the terms of society, it was 2005 which quality and quantity of life are at their maximum value for the middle aged.

The elderly have also the same trends as well as the middle aged. The difference is that the gap between technology side and society side[15] value of life is higher for the elderly. It is obvious that the elderly worth less today than the past two decades. The higher gap between these three concepts arises mostly from the lower elasticity of health status with respect to health inputs (θ_a) for the elderly. Although shares of mortality trend explained by health spending are lower for the elderly, technology shares of mortality decline are higher for this age cohort and obviously (from Figure 3) it has the dominant role in explaining mortality trend decline which makes their technology side value of life higher than the social value of life. This huge gap could also be the direct result of the value of health related and non-health consumption. As we declared, quality of life in other terminology means the value of health and quantity of life demonstrates the value of non-health consumption, so these figures could also represent the higher value of health related consumption for the elderly.

Results show that saving the newborn's life has economic values because the MB of saving a newborn exceeds the MC[16]; in fact, from the terms of society saving the life of an under 20-24 year-old has social benefits which is clear from Figure 9. Figure 9 demonstrates the age-specific MB and MC of saving a life in 1996 and 2015. According to Figure 9, the MB of saving a life was higher in 2015 while the MC of saving a life was lower just for the middle aged and yet, the cross point has not changed and just under 25 year-old person's life in Iran has economic benefits to invest on and time has not changed this reality.

The monetary valuation of an individual is surrounded by ethical issues. This study does not try to say who is

[15]We simply named Quantity and Quality of life (the MB of having a person alive next period from the terms of society), society side (or social) value of life.

[16]Quality plus quantity of life gives the MB and at the optimal allocation of resources, technology side value of life equates the MC of saving a life.

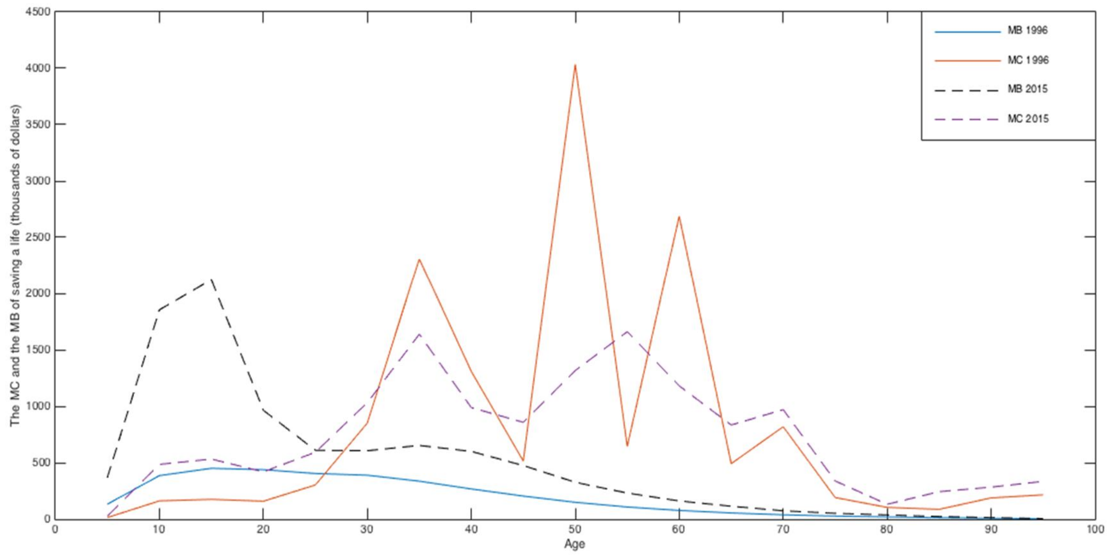

Figure 9. The MB and the MC of saving a life, 1996 and 2015. **Note.** Dashed and solid lines are representing year 2015 and 1996, respectively.

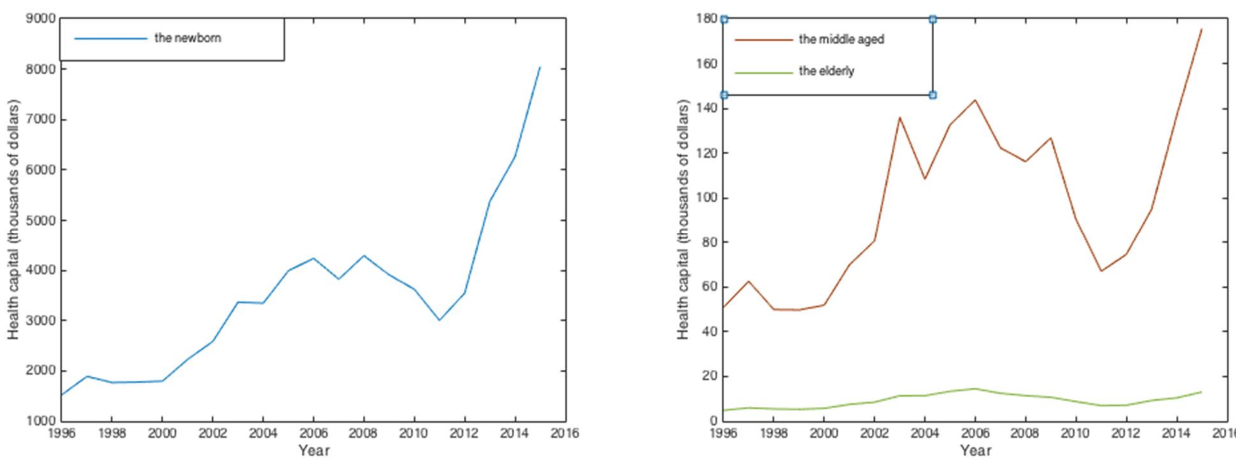

Figure 10. Mortality based health capital for the newborn, the middle aged and the elderly since 1996.

worthy of living and who is not; we are just trying to put monetary values on people's life so the social planner could identify targets to get better results out of the running (hypothetical) policies.

At the end we have calculated mortality based health capital according to Equation 16. Figure 10 demonstrates health capital for the newborn, the middle aged and the elderly over twenty years.[17] Obviously the newborn have the highest health capital, but is has not been rising uniformly. Health capital for the newborn starts from 1.5 million dollars in 1996, rises to 4 million until 2008, decrease until 2012 and rises again to 8 million in 2015. This pattern somehow repeats for the middle aged, but in an almost fifty times smaller scale. Health capital pattern for the elderly is smoother and it has not changed much during the past two decades. These numbers are large if one thinks of the base as income earned during a lifetime, although there is no reason why an individual's earnings cannot exceed or be inferior the value of life over a lifetime.

CONCLUSION

A model based on standard economic assumptions with some small but efficient changes is chosen to this study. The fundamental mechanism in the model is supported empirically in different ways. First, it is consistent with

[17] There was a huge gap between the amount of health capital for the newborn and the other two age groups. We split it into two figures so the reader could easily trace the variation in time.

conventional estimates of the intertemporal elasticity of substitution. Second, the mechanism predicts that the value of a statistical life should rise faster than income.[18] The recent health literature has emphasized the importance of technological change as an explanation for the rising health share. The development of new and expensive health technologies are part of the process of rising health spending.[19] The magnitude of the future health capital depends on parameters whose values are known with relatively low precision, including the value of life, the curvature of marginal utility, and the fraction of the decline in age-specific mortality that is due to technical change and the increased allocation of resources to health care.

At first we attempted to investigate the monetary value of life of Iranians since 1996. To do so, we draw upon the extensive literature on the VSL. We defined three different types of statistical value of life: quantity of life, quality of life and technology side value of life. Aggregation of the first two gave marginal benefit of saving a life and technology side value of life equates marginal cost of saving a life at the optimal allocation of resources. Age-specific quantity and social value of life have shown decreasing trend but, the additional quality of life as the result of slight improvements in health status was maxed out for a 10-14 year-old Iranian. Yearly values for these three measures of “value of life” are reported for three representative age cohorts: the newborn, the middle aged, and the elderly. Quantity of life for a newborn is higher than the other measures throughout time but, the middle aged and the elderly have higher quality and technology side value of life. We conclude that after 2009, enhancing the living person’s health status worth more than adding a new member to the population of newborns. Quantity of life of middle aged and elder Iranians is less than the other two measures for monetary value of life. It means in terms of society, having a middle aged person alive next period has lower value than investing on the living person’s health to enhance her health status. Also technical value of life for these two age cohorts (the middle aged and the elderly) are higher than quality and quantity of their lives which means, technically, the middle aged and the elderly worth a lot while technology side value of life for the new born is lower than the other two measures. In 2005-6, a representative Iranian’s monetary value of life (according to their quantity and quality of life measures) was at highest level but, the highest value for technology side value of an Iranian life refers to 1998. Marginal benefit of having a person alive next period exceeds its marginal cost for under 25 year-old individuals. It means, economically, life of an under 25 year-old individual worth to be saved. This study shows that value of life of all age groups have increased since 2012, but only marginal benefit of the newborn exceeds the MC. Along with measuring different types of value of life for 19 age groups during 20 years, this study tries to say that even if monetary value of life of a group of people increases, investing on their health may not have economic justification and the social planer should consider the differences.

We also estimate mortality based health capital for those three age cohorts and our estimate does not show the rising trend which it would have been the case if we chose the YOL or QALY measures for health capital. Value of life of Iranians has been improving since 2012 which is directly reflected in health capital. As it is expected, health capital for the new born is much higher than the middle aged and the elderly. People are estimated to be healthier than they were in the past, the value of their lives has been fluctuating and it has become less valuable than they used to (in comparison to 2006). Our results show some trends that would not otherwise be apparent.

According to Cutler and Richardson (1997), the discount rate has a large effect on which age group is perceived to be best off over time. How much we discount the future has a direct effect on the value of change in the VSL and then health capital; this is the reason why we did so much efforts to calculate the exact rate of discounting, 0.9683.

It is frequently asserted that the marginal productivity of the medical system is low, so limiting overall medical spending would improve welfare. But Results indicate that the rate of return to medical care is not obviously of such low value that people should clearly spend less on it than they do now. People's health has improved by less than per capita spending on health has increased. This statement is not causal; we do not attribute all of the health improvements we measure to health spending, as we include other measures like technology and the effect of other factors such as pollution, education, etc along with the allocation of total resources to health.

Our analysis opens many questions as well. Changes in health will certainly change people's retirement and savings behavior. People who are healthier may decide to work longer, or they may work less if the healthy elderly can take leisure activities that the less healthy elderly cannot. Changes in health and the induced retirement effect will affect the need for savings for old age.

This study faces some difficulties. One of them is the unavailable data. We did much effort to extract the needed information from the Iranian Household Budget Survey (IHBS). But even with the IHBS we were not able to get information about various diseases, so we were not be able to measure the disease-specific value of development of new technology in health, allocation of resources to health and so on.

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[18]Costa and Kahn (2004) and Hammitt et al. (2000) provide support for this prediction, suggesting that the value of life grows roughly twice as fast as income, consistent with our baseline choice of $\gamma = 2$. Cross-country evidence also suggests that health spending rises more than one-for-one with income; this evidence is summarized by Gerdtham and Jonsson (2000).

[18]As the literature suggests; Jones (2003) provides a model along these lines with exogenous technical change.

Our analysis can also be used to address fundamental questions about the value of the medical care system and the proper allocation of government's health related funds. For example, the value of remaining life years for a middle aged person is about 0.18 million, while this value for a newborn is over 8 million U.S dollars. Each year, per say, about 1,000 middle aged Iranian die of various diseases. Thus, this simple calculation implies that the annual return to eliminating diseases would be about 180 million. One could compare this number to the treatment costs for diseases or the costs of research to eliminate diseases. More generally, this methodology can be used to answer such questions: How much money would it be worth to eradicate diseases? Where public research fund should be spent? What age group is worthy of investing? We consider these questions among the most fruitful avenues for future research.

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