Modified Disability Adjusted Life Years as a Measure for Burden of Diseases: Modification and Application[1]

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Objective To modify DALY formula to be more useful in setting health priorities, especially on the individual level, through reflecting not only the importance of the patient to his society but also his importance to his family.

Methods A dependency weight reflecting the dependency of the family members on the patient was included in the DALY calculations. This weight has two parts: the Social Dependency Weight and the Economic Dependency Weight. The dependency weight is the average of the two parts.

The modified formula of DALY (MDALY) was applied on two diseases, Diabetes and Asthma, using the data of the Saudi Arabia Family Health Survey – 1996.

Findings DALYs and MDALYs of diabetes were less than DALYs and MDALYs of asthma respectively. However, the percent change in DALYs of diabetes after including the dependency weight was greater than the percent change in DALYs of asthma. Patients of each disease were ranked according to DALYs and according to MDALYs. Results revealed that ranks of 88.5% of diabetes patients and 10.8% of asthma patients according to DALYs were different from their ranks according to MDALYs.

Conclusion Including the importance of the patient to his family through the dependency weights changed the number of DALYs of most of the patients and changed their ranks. This asserts that the age weights were not enough to reflect the importance of the patients' role.

MDALYs will be more informative in several applications especially in ranking patients in the waiting lists of transplant surgeries since MDALYs calculations take into consideration the importance of the patient to his family as well as his importance to his society.

Key words Burden of disease; DALY; MDALY; Dependency weight; Diabetes; Asthma; Saudi Arabia Family Health Survey

[1] Session P-5:Poster Session 5: contexts, Poster Number: 116, Poster Room, Royal room wings

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1- Introduction

DALY is a quantitative indicator of burden of disease developed by researchers of the Global Burden of Disease study that was conducted in the early 1990s by researchers of the Harvard School of Public Health and World Health Organization. DALY reflects the total amount of healthy life lost, to all causes, whether from premature mortality or from some degree of disability during a period of time. DALYs could be used in the analysis on both the population level and the individual level.

Section tow of this paper presents the calculations of DALY as per the global burden of disease study. Section three will illustrate the new approach that integrates the dependency weighting function in the calculations. An application for the new approach (MDALY) as well as the original approach (DALY) and a comparison between the results of the two approaches will be presented in section 4. Section five discusses the most important concluding remarks. Finally section six will present the usefulness of the new approach in decision making on individual and population levels.

2- *Global Burden of Disease Study (GBD)* (1,2,3,4,5,6)

Many studies used DALY to measure the burden of diseases and injuries. The most important study is the Global Burden of Disease study as it is the study that developed DALY to measure the burden of disease around the world.

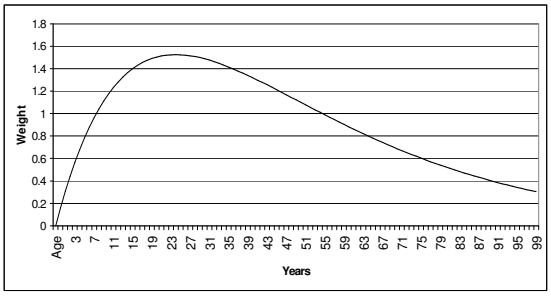
Burden of disease is the gap between a population's actual health status and some "ideal", or reference status. In order to measure burden, society has to decide what is ideal or reference status should be. Some values have to be assessed to estimate the burden of disease. These values are life expectancy, disability weights, age weights and discount rates.

The GBD study used standardized life expectancies at birth of 80 years for men and 82.5 for women. These life expectancies reflect the highest life expectancies observed at the national level (Japan) in this year. The use of the same life expectancies for all countries aims to ensure that a premature death contributes the same number of wasted life years and hence the same amount of the disease burden whether it occurred to a person in a developed country or in an under-developed one. The basic limitation on this choice is that the GBD study assumed that health interventions alone are capable of achieving an increase in life expectancy to these higher levels regardless of the non-health circumstances.

Diseases sequelae were divided into 483 sequelae. To determine the disability weights, severity weights were assigned to each of the 483 disability sequelae using the person trade-off method[4]. The GBD study used the same disability weights for all countries to ensure that observed differences among regions arise from differences in disease prevalence, incidence, onset, etc., and not form the valuation of disability states. However, different societies with different economic levels, cultures and traditions may assign very different weights for the same conditions. This undermines the validity and meaning of using this measure on the global level. It suggests that such analysis may more appropriately be made at the regional, country, or sub-country level where there is sufficient agreement on the relative weights assigned to different health states.

GBD researchers used an age weighting function to assign a different value to time lived at different ages to reflect the social preference. It gives the year lived by a young adult a greater value than the one lived by a very young child or an older adult since adults are widely perceived to play a critical role in the family, community and society. This age-weighting function starts from "0" at birth to a peak in the early twenties after which it steadily declines (Figure 1). Age weighting dissentients see that valuing people's life in terms of a money metric, through their social role, is hard to defend ethically.

Figure 1 Age- weighting curve



The GBD researchers discounted future life years by 3% per year. The reason for discounting future life years is that there is a small uncertainty of survival in future years.

[4] The Person trade-off method is an index for quality of life ranges from 0 (worst imaginable state) to 1 (best imaginable state).

However, using discounting rates makes measures of the time lost due to illness or death depend on when the illness, the death or the calculation occurs.

DALYs Calculations

DALY consists of two parts: YLD which reflects the years lost due to illness and YLL which reflects the years lost due to premature death.

$$YLDs = D\{[KCe^{ra}/(r+B)^2][e^{-(r+B)(L+a)}[-(r+B)(L+a)-1] - e^{-(r+B)a}[-(r+B)a-1]] + [(1-k)/r](1-e^{-rL})\} \quad (1)$$

Where,
D = disability weight,
K = age weighting modulation factor, it takes the values 0 or 1. The value 0 is being used to remove the non-uniform age weighting,
C = constant of age weighting function,
r = discount rate,
a = age of onset of disability,
B = parameter from the age weighting function,
L = duration of disability.

$$YLLs = [KCe^{ra}/(r+B)^2][e^{-(r+B)(L+a)}[-(r+B)(L+a)-1] - e^{-(r+B)a}[-(r+B)a-1]] + [(1-k)/r](1-e^{-rL}) \quad (2)$$

Where,
K = age weighting modulation factor,
C = constant of age weighting function,
r = discount rate,
a = age of death,
B = parameter from the age weighting function,
L = standard expectation of life at age a.

Since discounting future life years starts at the year of onset and discounting in YLLs starts at the year of death, YLLs should be adjusted to take in consideration the years lived from the age of onset to the age of death. These years have to be discounted.

$$YLLs\ at\ Age\ of\ Onset\ (YLLs\ adjusted) = YLLs\ at\ Age\ of\ Death \times e^{-rs} \quad (3)$$

Where,
s = *age of death – age of onset*

$$DALYs = YLDs + YLLs \quad (4)$$

3- Modified DALYs (MDALYs)

DALY as a measure of burden of disease has advantages over other disease measures as it combines the time lost due to premature death with the time lost due to disability. DALY could also be used on the individual level as well as on the population level. Despite the arguments about how ethical to value the individual's life in terms of money, importance of different individuals should be reflected in a measurable way. DALY reflects the importance of the patient to his society through the age weighting function which gives each age a relative importance depending on the productivity of this age, regardless of the patient's socioeconomic circumstances and his importance to his family.

The GBD researchers justified using the age weighting function (Figure 1) by a scenario where there is only one course of antibiotics and two persons with meningitis arriving simultaneously at the emergency room. The only difference between the two persons the doctor knows is their age: one is 2 years old and one is 22 years old. Their prognoses are identical. In this situation, which patient the doctor should chose to treat?[(11)] According to the age weighting function used in the GBD study, the 22 years old patient will get the priority over the 2 years old patient.
However, planning and setting health policies is a process which takes time to study the different alternatives and choose one of them. It is different from the emergency room where the doctor has to take the decision immediately.
Imagine that the 2 patients are 16 and 22 years old, and that the doctor knows both of them. Despite of being young, the first patient is employed and is responsible for taking care of his family members and their expenditures. The second patient does not work and is not responsible for any dependents. According to the GBD age weights, the 22 years old patient will get the priority over the 16 years old patient regardless of the second patient's importance to his family.

In this paper DALYs formula will be modified to reflect the patient's socioeconomic and family circumstances. A Dependency Weight (DepW) reflecting the dependency of the family members on the patient will be included in the DALYs calculation. This weight will reflect the importance of the patient to his family where as the age weight reflects his importance to the society.

Methods

Calculations of modified DALYs depend on multiplying YLDs and YLLs by a weight that reflects the dependency of the family on the patient. The dependency weight has two components: Social Dependency Weight (SDepW) and Economic Dependency Weight (EDepW).

Social Dependency: Social dependency reflects how the family members depend on the patient in taking care. The social dependency weight is a function in the number of years in which other family members will depend on the patient.

To calculate the social dependency weight a number of assumptions were made:

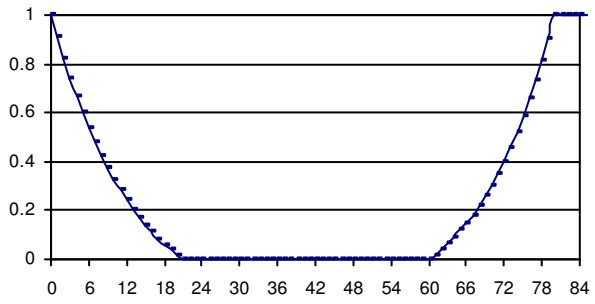
1- Household members in the age groups (0 to < 21) and (60+ years) depend on other household members in the age group (21 to 60) and possibly on the household members outside this age group in taking care.
2- Each member depends equally on the most related male and the most related female in his household. In order to determine the most related members in the family, relation degrees should be calculated.

The following function was suggested to calculate the years of dependency of each member in the household on other members:

$$Dep(x_i) = \begin{cases} (1-(x_i/21))\, e^{-xi/21} & \text{if } x_i < 21 \\ 0 & \text{if } 21 \le x_i \le 60 \\ ((x_i/20)-3)\, e^{-(80-xi)/20} & \text{if } 60 < x_i < 80 \\ 1 & \text{if } x_i \ge 80 \end{cases} \quad (5)$$

where x_i is the age of member i.

Figure 2 Social Dependency Weighting Function



The previous function posits the following hypothesis:

1- The dependency weight ranges from 0 (totally independent) to 1 (totally dependent).
2- The dependency weight declines with a decreasing rate in the age interval (0 , 21) and increases with an increasing rate in the age interval (60 , 80).

If the patient is one of the family members who member i can depend on, then the social dependency weight of member i on the patient will be calculated using the following table:

Table 1 Dependency Weight Calculations

Family Member # i	Age_i	SRY_i	L_a	SDY_i	$SDYW_i$	$SDepW_i$

Where SRY_i, L_a and SDY_i are interpreted differently in the case of morbidity and in the case of premature mortality.

In the case of morbidity:

SRY_i is the remainder years of social dependency for member i,
L_a is the duration of the patient's illness, and
SDY_i is the number of years of social dependency for member i during the illness of the patient (eq. 6).

$$SDY_i = Min\,(SRY_i\ ,\ L_a) \quad (6)$$

To calculate the social dependency weight (SDepW) of the family members on the patient, the number of weighted years of dependency of each member in the family ($SDYW_i$) and the share of the patient from these years should be calculated. To calculate the number of these years for each member, the age of dependency of this member should be calculated (eq. 7), then the dependency function (eq. 5) should be integrated from the current age of this member (a_{0i}) to the age of dependency (a_{1i}) (eq 8).

$$Age\ of\ dependency\ (a_{1i}) = current\ age\ (a_{0i}) + SDY_i \quad (7)$$

$$SDY\,W_i = \int_{a_{0i}}^{a_{1i}} DEP(x_i)\,dx_i \quad (8)$$

where $DEP(x_i)$ is the postulated dependency function (eq5).

The share of the patient from the weighted social dependency years of member i ($SDepW_i$) is calculated by dividing the weighted social dependency years of member i on the number of family members who member i can depend on (eq. 9).

$$SDep\,W_i = \frac{SDYW_i}{N_i} \quad (9)$$

where N_i is the number of family members that member i can depend on (the most related males and the most related females).

The social dependency weight of the patient (SDepW) is the sum of the patient's share in the weighted social dependency years of each member in the family (eq. 10).

$$SDepW = \sum_i SDepW_i \quad (10)$$

In the case of premature mortality:

In the case of premature mortality, the social dependency weight is calculated in the same way as in the case of mortality, but with different definitions for L_a, SRY_i and SDY_i as shown below:

SRY_i is the remainder years of dependency for member i after the patient's death,

L_a is the difference between the life expectancy of the patient at the age of death and his age at the time of death (a), and

SDY_i is the number of years of dependency for member i after the patient's death.

$$SDY_i = Min\ (SRY_i\ ,\ L_a) \quad (11)$$

Age of dependency (a_{1i}) = current age (a_{0i}) + SDY_i (12)

$$SDY\,W_i = \int_{a_{0i}}^{a_{1i}} DEP(x_i)\,dx_i \quad (13)$$

Where $DEP(x_i)$ is the postulated dependency function.

$$SDepW_i = \frac{SDYW_i}{N_i} \quad (14)$$

The social dependency weight of the patient (SDepW) is the sum of the patient's share in the weighted social dependency years of each member in the family (eq. 15).

$$SDepW = \sum_i SDepW_i \quad (15)$$

where N_i is the number of members that member i can depend on.

Economic Dependency: Economic dependency reflects how the family members depend on the patient economically.

Family Income: family income is the sum of all family members' income that goes to the family.

The share of the patient in the family income reflects the economic dependency of the family on the patient.

To calculate the economic dependency weight a number of assumptions were made:

1- The family depends economically on the family income.
2- The family members in the age group < 21 years who do not have income and are not married will depend on the family income until they reach 21 or the patient's income stop (due to natural death or retiring).
3- The family members in the age group 60 years or more will depend on the family income until they die or the patient's income stop (due to natural death or retiring).
4- All ever married members in any age group will depend on the family income till they die.
5- Single members in the age group 21 to 60 do not depend on the family income. However, they may share in the family income.

Economic dependency on the patient will be calculated through the years in which other members in the family will depend on the patient's income as a part of the family income

In the case of morbidity:

ERY_i is the remainder years of economic dependency for member i (eq. 16),

EDY_i is the years of economic dependency for member i during the illness of the patient (eq. 17).

$$ERY_i = \begin{cases} e_{xi} & \text{if marital status = ever married} \\ e_{xi} & \text{if } x_i > 60 \\ 21 - x_i & \text{if } x_i < 21 \text{ \& marital status = single} \\ 0 & \text{if } 21 \le x_i \le 60 \text{ \& marital status = single} \end{cases} \quad (16)$$

$$EDY_i = Min\ (\ ERY_i\ ,\ L_a\ ) \quad (17)$$

Where,

x_i is the age of member i,

e_{xi} is the years remained for the member i to live (life expectancy if healthy or duration of illness if ill), and

L_a is duration of illness of the patient.

Economic dependency weight for the patient (EDepW) is the sum of economic dependency years of all the family members during the illness of the patient multiplied by the relative share of the patient in the family income (eq.14).

$$EDepW = \frac{r}{I} \times \sum_{i=1}^{n} EDY_i \quad (18)$$

Where,

r is the share of the patient in the family income,

I is family total income, and

n is the number of family members who depend economically on the patient.

In the case of premature mortality:
Economic dependency weight in the case of mortality is calculated in the same way as in the case of morbidity, but with different definitions for L_a, ERY_i and EDY_i as shown below:

$$ERY_i = \begin{cases} 0 & \text{if } 21 \le x_i \le 60 \text{ \& marital status = single} \\ e_{xi} & \text{if marital status = ever married} \\ e_{xi} & \text{if } x_i > 60 \\ 21 - x_i & \text{if } x_i < 21 \text{ \& marital status = single} \end{cases} \quad (19)$$

$$EDY_i = Min\ (\ ERY_i\ ,\ L_a\ ) \quad (20)$$

Where,
x_i is the age of member i,
e_{xi} is the years remained for the member i to live after the patient's death (life expectancy if healthy or duration of illness if ill), and
L_a is the difference between the life expectancy of the patient at the age of death and his age at the time of death (a).

$$EDepW = \frac{r}{I} \times \sum_{i=1}^{n} EDY_i \quad (21)$$

Where,
EDepW is the economic dependency weight,
r is the share of the patient in the family income,,
I is the family total income, and
n is the number of family members who depend economically on the patient.

Calculations of Modified DALYs:
Dependency weight (DepW) in the case of morbidity is the average of the social and the economic dependency weights in the case of morbidity (eq. 22).

$$DepW = \frac{SDepW + EDepW}{2} \quad (22)$$

Modified Years Lost due to Disability (MYLDs) will be calculated where,

$$MYLDs = (1 + \frac{1}{e_0} DepW) YLDs \quad (23)$$

Where,
e_0 is the life expectancy at birth, and
DepW is the dependency weight in the case of morbidity.
Note that e_0 is used here to translate the number of years of dependency into a number refers to the net number of persons depend on the patient.

Dependency weight in the case of mortality is the average of the social and the economic dependency weights in the case of premature mortality (eq. 24).

$$DepW = \frac{SDepW + EDepW}{2} \quad (24)$$

Modified Years of Life Lost due to mortality (MYLLs) will be calculated where,

$$MYLLs = (1 + \frac{1}{e_0} DepW) \times YLLs \quad (25)$$

Where,
e_0 is the life expectancy at birth.
DepW is the dependency weight in the case of premature mortality.
Modified Disability Adjusted Life Years (MDALYs) will be calculated where,

$$MDALYs = MYLDs + MYLLs, \quad (26)$$

4- Modified DALYs: An Application

To reveal the effect of including the dependency weight in calculating the burden of disease, the original and modified formulas of DALYs were applied on 2 diseases, Diabetes and Asthma, using the dataset of Saudi Arabia Family Health Survey 1996 (SFHS-96) which was conducted within the framework of the Gulf Family Health Survey (GFHS).

Sample Design:[7] The sample of the SFHS-96 was a two-stage stratified probability designed on the 1992 census as the sample frame. The 1st stage consisted of selecting 370 Primary Sampling Units (PSUs). Sampling at the 1st stage was done by systematic, probability proportionate to size (PPS) selection from a geographically ordered (stratified) listing of the census EAs displaying the number of Saudi households by EA and cumulated. The census count of Saudi households thus constituted the measure of size for establishing the PPS selection probabilities. Non-Saudi households were out of the scope of the SFHS-96. The 2nd stage entailed a selection of 30 Saudi households from each selected PSU, for a total of 11100 households of which 10510 were successfully interviewed.

To apply the modified formula of DALYs on diabetes and asthma cases, two datasets were obtained from the SFHS-96, the 1st contains all households that have a diabetic whose illness year of onset is 1996, and the 2nd contains all households that have an asthmatic whose illness year of onset is 1996.
Diabetes dataset contains 78 patients and asthma dataset contains 176 patients.

Assumptions: Because this data were collected to be used in different studies than the study of the burden of disease, some assumptions were made to cover the shortage of the needed data:

1- The data of the SFHS-96 were collected on the household level. So in this study the MDALYs will be calculated on the household level instead of the family level.
2- SFHS-96 data does not contain any information about the share of working and retired members in family income so their shares in family income will be considered to be equal.
3- Relation degree between each member and other members in the household was calculated on the basis of the relationships. Since the relationships in the data are the relations of each member to the house head, relation degrees were calculated assuming that each grandchild in the individual data file is the son / daughter of the preceding house head's son / daughter and so on.
4- The members with relationships coded as (other relationships or other) were not included in the calculations, since their relation degree could not be calculated.
5- Due to the structure of the data file, households that have multi-wives were omitted since it was difficult to determine who are the relatives of the first wife and who are the relatives of the second wife (children and parents).
6- It is assumed that the share of each member in the family income after retiring will be the same as his share when he was working.
7- Although early marriage and child labour phenomena exist in Saudi Arabia, marital status and working status data were collected only from members in the age group (15 years and above). In this study, members less than 15 years old were considered to be single and unemployed. This assumption will affect the results as it has been assumed that all members less than 15 years old will not be responsible for any dependents in their households and they will depend on other members in their households.

Life Expectancy, Age Weights and Discount Rates: In this study the life expectancy at each age from the life table of Saudi Arabia in 1999[5] published by the WHO was used. GBD age weighting function was used to weight life years at different ages and a 3% discount rate was used to discount future life years.

Duration and Disability Weights: Duration and disability weights of the GBD were used in DALYs and MDALYs calculations (tables 2, 3).

Some of the sample patients have other patients of the same diseases in their households whose year of onset is before 1996. GBD duration of illness was used to calculate their remainder years of life. The GBD duration of illness (years left for the patient to live after the disease occurs) is determined depending on the age of onset regardless of the current age of the patient. So the years left for the patient to live after 10 years from the age of onset = the duration of illness – 10.
As a result, the current age of some of the patients whose year of onset is before 1996 exceeds the sum of the age at onset plus the duration of illness. In this study, years left for each of those patients to live (Mduration) was estimated to be:

$$Mduration = \frac{Duration\ at\ Age\ of\ Onset \times Life\ Expectancy\ at\ Current\ Age}{Life\ Expectancy\ of\ a\ Healthy\ Person\ at\ Age\ of\ Onset} \quad (27)$$

In the future, a table for the duration remaining for the patient to live should be constructed depending on the year of onset and the current age of the patient.

[5] The life table of 1996 was not available.

Table 2 Duration and Disability Weight of Diabetes in EMRO

Age of Onset	Male		Female	
	Duration	Disability Weight	Duration	Disability Weight
0-4	58.62	0.014	58.41	0.014
5-14	50.34	0.014	50.73	0.014
15-29	38.70	0.014	38.65	0.014
30-44	28.67	0.014	29.84	0.014
45-59	19.63	0.014	20.48	0.014
60-69	12.36	0.014	12.77	0.014
70-79	8.12	0.014	8.62	0.014
80+	4.94	0.014	5.33	0.014
Total	24.60	0.014	26.43	0.014

Source: Sarah Bernard, Global Burden of Disease Study

Table 3 Duration and Disability Weight of Asthma in EMRO

Age of Onset	Male		Female	
	Duration	Disability Weight	Duration	Disability Weight
0-4	13.48	0.043	18.05	0.043
5-14	11.18	0.043	18.12	0.043
15-29	12.17	0.043	26.58	0.043
30-44	16.46	0.043	26.70	0.043
45-59	15.74	0.043	15.99	0.043
60-69	8.39	0.043	8.71	0.043
70-79	5.21	0.043	5.24	0.043
80+	2.64	0.043	2.66	0.043
Total	12.31	0.043	20.18	0.043

Source: Sarah Bernard, Global Burden of Disease Study

Findings

DALYs and MDALYs were calculated to a sample of 78 diabetes patients and 176 asthma patients. About 83.6% of asthma patients versus 1.3% of diabetes patients were less than 15 years old. Age differences between the patients of the 2 diseases cause differences between them in marital status and working status.

Number of DALYs and MDALYs of asthma were greater than number of DALYs and MDALYs of diabetes (table 4). This is because of the difference between the 2 diseases in number of patients and patients' characteristics.

Table 4 Disability Adjusted Life Years (DALYs) & Modified Disability Adjusted Life Years (MDALYs) for Diabetes & Asthma

	Diabetes	Asthma
YLDs	19.3	96.2
YLLs Adjusted	236.3	3618.1
DALYs	255.5	3714.3
MYLDs	23.5	98.5
MYLLs Adjusted	240.6	3626.7
MDALYs	264.1	3725.2

To reflect the increase in DALYs after using the dependency weight, percent changes in YLDs, YLLs and DALYs were calculated where,

$$YLDs\ Percent Change = \frac{MYLDs - YLDs}{YLDs} \quad (28)$$

$$YLLs Percent Change = \frac{MYLLs - YLLs}{YLLs} \quad (29)$$

$$DALYs\ Percent\ Change = \frac{MDALYs - DALYs}{DALYs} \quad (30)$$

Table (5) shows the percent change in YLDs, YLLs and DALYs after using the dependency weight function. Although DALYs and MDALYs of diabetes were less than DALYs and MDALYs of asthma respectively, percent change in DALYs of diabetes was greater than percent change in DALYs of asthma.

Table 5 Percent Change in YLDs, YLLs and DALYs

	YLDs	YLLs	DALYs
Diabetes	21.9	1.8	3.4
Asthma	2.4	0.2	0.3

The increase in YLDs, YLLs and DALYs after using the dependency weight reveals that using age weighting function is not enough to reflect the importance of the patients' remain life years or the importance of the patients' role.

Patients of each disease were ranked according to DALYs and according to MDALYs. Results revealed that ranks of 88.5% of diabetes patients and 10.8% of asthma patients have changed from DALYs to MDALYs. This again asserts that the age weights are not enough to reflect the importance of the patients' role.

MDALYs were greater than DALYs of 87.0% and 63.2% of diabetes patients and asthma patients with changed ranks respectively. Most of the changes occurred between the patients aged 20 to less than 60 years, and between married and employed patients as tables (6), (7) and (8) show.

Table 6 Percent Distribution of Diabetes Patients & Asthma Patients by Changing in Rank & Age

Age	Diabetes		Asthma	
	No	Yes	No	Yes
<5 years	0.0	0.0	70.1	0.0
5 -	0.0	0.0	13.4	10.5
10 -	0.0	1.4	7.6	10.5
15 -	22.2	1.4	3.2	10.5
20 -	66.7	79.7	4.5	57.9
60 +	11.1	17.4	1.3	10.5
Total	100.0	100.0	100.0	100.0
Total Number	9	69	157	19

Table 7 Percent Distribution of Diabetes Patients & Asthma Patients by Changing in Rank & Marital Status

Marital Status	Diabetes		Asthma	
	No	Yes	No	Yes
Single	22.2	7.2	94.9	52.6
Married	55.6	78.3	4.5	47.4
Widowed	22.2	14.5	0.6	0.0
Total	100.0	100.0	100.0	100.0
Total Number	9	69	156	19

Table 8 Percent Distribution of Diabetes Patients & Asthma Patients by Changing in Rank & Working Status

Working Status	Diabetes		Asthma	
	No	Yes	No	Yes
Working	33.3	46.3	1.3	26.3
Unemployed or under age of work	0.0	3.0	91.1	21.1
Retired	0.0	6.0	0.0	5.3
In school	22.2	4.5	3.2	10.5
Housework	44.4	38.8	4.5	36.8
Other	0.0	1.5	0.0	0.0
Total	100.0	100.0	100.0	100.0
Total Number	9	67	157	19

Table (9) shows that both males and females witnessed changes in DALYs after using the dependency weight. Percent of diabetic females who witnessed changes was less than the percent of diabetic males who witnessed changes. On the contrary, percent of asthmatic females who witnessed changes was greater than the percent of asthmatic males who witnessed changes.

Table 9 Percent Distribution of Patients of Diabetes & Asthma by Gender & Changing in DALYs

	DALYs Changed	Male	Female	Total
Diabetes	No	10.5	25.0	17.9
	Yes	89.5	75.0	82.1
	Total	100.0	100.0	100.0
	Total Number	38	40	78
Asthma	No	91.7	80.6	87.5
	Yes	8.3	19.4	12.5
	Total	100.0	100.0	100.0
	Total Number	109	67	176

Sensitivity Analysis

One important issue in evaluating a new model is the sensitivity analysis.

To determine the sensitivity of the outcome to changes in the parameters of the economic dependency model, the MDALYs were re-calculated using different values for the age when a youth become independent and the age when an adult become dependent due to ageing. MDALY was estimated for the values 21 and 25 for the first transition and 60 and 65 for the second transition.

Equation (31) shows the model after replacing the age 21 by the age 25.

$$ERY_i = \begin{cases} e_{xi} & \text{if marital status = ever married} \\ e_{xi} & \text{if } x_i > 60 \\ 25 - x_i & \text{if } x_i < 25 \text{ \& marital status=single} \\ 0 & \text{if } 25 \le x_i \le 60 \text{ \& marital status = single} \end{cases} \quad (31)$$

To reflect the change in the results after using age 25 instead of age 21, the percent change in MDALYs were calculated. Table (10) shows that the results changed slightly after using the 25 years model.

Table 10 Modified Disability Adjusted Life Years for Diabetes & Asthma Using Ages 21 and 25

		Age 21	Age 25	Percent change
Diabetes	MYLDs	23.5	24.4	3.8
	MYLLs Adjusted	240.6	241.0	0.1
	MDALYs	264.1	265.3	0.5
Asthma	MYLDs	98.5	98.7	0.2
	MYLLs Adjusted	3626.7	3628.3	0.0
	MDALYs	3725.2	3727.0	0.1

When the MDALYs were re-calculated after replacing the age 60 years by the age 65 years, the results did not change at all since the members in the age group 60+ were not working (table 11).

Table 11 Modified Disability Adjusted Life Years for Diabetes & Asthma Using Ages 60 and 65

		Age 60	Age 65	Percent change
Diabetes	MYLDs	23.5	23.5	0.0
	MYLLs Adjusted	240.6	240.6	0.0
	MDALYs	264.1	264.1	0.0
Asthma	MYLDs	98.5	98.5	0.0
	MYLLs Adjusted	3626.7	3626.7	0.0
	MDALYs	3725.2	3725.2	0.0

The previous results show that the sensitivity of the results to changes of age is not high and that the model is more sensitive to changes of age of the first transition than age of the second transition.

5- Conclusion

DALY as a measure of burden of disease has advantages over other disease measures as it combines the time lost due to premature death with the time lost due to disability. DALY, however, reflects only the importance of the patient to his society through the age weighting function which gives each age a relative importance depending on the productivity of this age, regardless of the patients' socioeconomic circumstances and his importance to his family.

In this study, DALYs formula was modified to reflect the patient's socioeconomic and family circumstances. A Dependency Weight (DepW) reflecting the dependency of the family members on the patient was included in the DALYs calculation. This weight reflects the importance of the patient to his family whereas the age weight reflects his importance to the society. The dependency weight has two parts: Social Dependency Weight (SDepW) and Economic Dependency Weight (EDepW). Calculations of modified DALYs is based on multiplying YLDs and YLLs by the dependency weight.

The preceding presentation of the analysis results reveal that :

1. The age weights were not enough to reflect the importance of the patients' role. Including the importance of the patient to his family through the dependency weights changed the number of DALYs of most of the patients and changed their ranks.

2. Despite that DALYs and MDALYs of diabetes were less than DALYs and MDALYs of asthma respectively – because the number of asthmatics is greater than the number of diabetics- , percent change in DALYs of diabetes was greater than percent change in DALYs of asthma. In other diseases we may find that the DALYs of disease A are equal to or greater than the DALYs of disease B, but the MDALYs of disease B are greater than the MDALYs of disease A. In this case MDALYs will be more useful in determining the disease that should be targeted with health interventions first.

3. MDALYs will be more useful than DALYs in ranking patients with the same symptoms in the waiting lists of transplant surgeries since MDALYs calculations take into consideration the importance of the patient to his family as well as his importance to his society.

4. Sensitivity of the results to changes of age is not high. The model is more sensitive for changes of the age when a youth become independent than the age when an adult become dependent.

6- Using MDALYs in Health Planning

Scarce resources of countries force health policy makers to make many choices as they have to choose between diseases that will be cured first and to choose between the different interventions that will be used. Policy makers need tools that could help them to make these choices. As mentioned before, health and disease measures were obtained to be used as tools to set health priorities. Although DALY is widely used in these activities, DALY takes into consideration only the importance of the patient to his society regardless of his importance to his family. DALY formula was modified in this study to take into consideration the importance of the patient to his family. This measure will be

useful to the authorities which are responsible for health researches and health planning.

This measure is useful in the analysis on the population level in comparing between the burden of different diseases that threaten the population to determine the disease that should be cured firstly. In Egypt, for example, many diseases threaten the population and hence threaten the population capacity and productivity, such as hepatitis, diabetes, and high blood pressure which is considered also as a risk factor for other diseases. Scarce resources may force the government to choose one or two diseases to be targeted with health interventions first. Using MDALY, the government could determine the diseases that will be targeted according to the number of MDALYs that could be saved by targeting these diseases. MDALY could be used also in cost effectiveness analysis to choose between different interventions targeting different diseases.

On the individual level, MDALY could be used to determine the patients who should be cured firstly, especially when the patients have the same conditions with the same symptoms, through ranking the patients according to the MDALYs that would be saved from curing each of them.

References

1- Anand, S. & Hanson, K., (1997), "Disability Adjusted Life Years: A Critical Review", *Journal of Health Economics*, 16, 685-702.

2- Report on the informal consultation on DALYs & Reproductive Health, (1998), WHO, Division of Reproductive Health (Technical Support).

3- Murray, C. & Lopez, A., (1996), *The Global Burden of Disease*, Harvard University Press.

4- Hanson, K. (1999), "Measuring up: Gender, Burden of Disease & Priority Setting Techniques in The Health Sector", *Harvard Center for Population & Development Studies*, http://www.hsph.harvard.edu/grhf/hupapers/gender/hanson.html (Accessed September 2001).

5- Arnesen, T. & Nord, E., (1999), "The Value of DALY Life: Problems With Ethics & Validity of Disability Adjusted Life Years", *The General Medical Journal,* 319, 1423-1430.

6- Technical report on The Victorian burden of disease study, Epidemiology Section of the Health Intelligence & Disease Control Branch in the Public Health & Development Division of the Victorian Department of Human Services.

7- Khoja, T. & Others, (1996), "Saudi Arabia Family Health Survey Report", WHO.