POPULATION HEALTH STATUS MEASURE: A COMPARATIVE STUDY BETWEEN DALY AND MIMIC-HEALTH STATUS INDEX

Stella C. Kaltjob [1], Hans Späth [1,2], Gérard Duru [2]

[1] Département Droit et Economie de la santé, Faculty of Pharmacy, Lyon, France

[2] LASS (Laboratoire d'Analyse des Systèmes de Santé), University of Lyon I, France

Abstract

Objective:
Improving population health through planning and priority setting in health systems requires the development of practical population health status measures. The objective of this paper is to compare two different indexes for the assessment of the level of population health status: (1) DALY (Disability-Adjusted Life Years), a WHO (World Health Organisation) composite health index and (2) MIMIC-HSI (Multiple Indicators MultIple Causes - Health Status Index).

Methods:
First, a review of concepts behind DALY and MIMIC-HSI is presented. Then the respective models are described along with the models specifications and their underlying assumptions. Validity and reliability of both indexes are compared. Finally using their positive characteristics a conceptual framework for the development of a new population health status measure, Multiple Indicators MultIple Causes – Burden of Disease Index (MIMIC-BDI) is presented.

Results:
The MIMIC-HSI assumes that health is not directly measurable and can be characterized by its causes (health determinants) and by its effects (health indicators). On the other hand, DALYs index quantifies population health status by a direct measure of health outcomes. The MIMIC model uses only traditional indicators such as life expectancy and does not assess non fatal health outcomes, while the DALY combines both fatal and non fatal health outcomes into a single value. Another major disadvantage of MIMIC-HSI is the lack of disease-related variables such as disease incidence. However, variables related to health systems functions such as health services supply have been introduced in the model, unlike the DALYs approach.
The DALYs approach presents two methodological weaknesses: (1) the multiplication of disability duration by severity used for its computation has not been validated and (2) the valuation method used for the assessment of disability weight (i.e. disability severity) is hardly reliable and valid. Therefore, the results depend greatly on the severity scale chosen. In contrast, the MIMIC-HSI offers an interesting property of independence from the health level unit of measurement and origin point. This property enables interpretation of ratios of differences between MIMIC-HSI values.
Both indexes are derived from static models, and do not express the dynamic relationship between health systems efficiency and population health level.

Conclusion:
MIMIC-HSI and DALYs index seem to be complementary for population health status measure, as each could benefit of the others strengths to overcome their respective weaknesses. The dependence of the DALYs index on the selected severity scale should be reduced by the specification of each disability weight as a single latent variable in a simultaneous equation model. Nevertheless, this valuation method still has to be validated and does not free the DALY from its non valid multiplicative specification. As regards to MIMIC-HSI, we propose to introduce non fatal health outcomes and disease-related variables in the model in order to enhance its validity and applicability in public health. Thus MIMIC-HSI could be transformed into a burden of disease index, MIMIC-BDI, which benefits from the DALY and the MIMIC-HSI respective strengths. A further study might investigate MIMIC-BDI reliability and validity. In addition, a dynamic transformation of the model should be considered.

Keywords: population health, health states valuations, health status index

1 - Introduction

Improving population health is one of the primary objective of health systems [WHO, 2000]. Thus population health status measures (PHSM) are evidence required for decision makers to monitor the performance of health systems and adjust accordingly their health policies [McKenna et al, 2002]. In the perspective of public health policy, two potential uses of PHSM are particularly expected : (1) comparison of the average level of health in different populations or subgroups, or in the same population over time and (2) assessment of the contribution of different diseases or injuries to the overall population health status level [Murray et al, 2002d]. To meet these expectations, validity and reliability of the metric used, are critical [Richardson, 2002].

A commonly used measure is the Disability-Adjusted Life Years (DALY); a summary measure of population health (SMPH) developed by the World Health Organization (WHO) [Mathers et al, 2002]. It can be considered as a standardized “variant of Quality-Adjusted Life Years (QALY)” [Murray et al, 1997]. For the DALY metric estimation, fatal health outcomes indicators such as mortality rates and life expectancy are combined with non-fatal health outcomes indicators such as disability severity. Another radically different metric for population health status assessment is the Multiple Indicators Multiple Causes – Health Status Index (MIMIC-HSI), developed by Robinson and Ferrara [1977]. Its relevance for population health status measures is due to its conception of health as unobservable and its specification of health status as a latent variable in a structural equation model [Van de Ven and Hooijmans, 1991].

The objective of this paper is to compare the DALY and the MIMIC-HSI metrics for the assessment of population health status with respect to their validity and reliability. The analysis of their respective strengths and weaknesses is a preliminary stage in the development of a new population health status metric: Multiple Indicators Multiple Causes – Burden of Disease Index (MIMIC-BDI), proposed here. This new health status index should be tested and validated in a further study.

This comparative study is based on literature review through Embase and Medline. First a review of concepts behind DALY and MIMIC-HSI is presented. Then the respective models are described along with models specifications and underlying assumptions. Validity, and reliability of both indexes are compared. Finally, using their positive characteristics a conceptual framework for the development of a new population health status measure, MIMIC-BDI, is presented.

2- Conceptual Basis

The following definitions are presented to ease the understanding of population health status measure in the subsequent sections. In this study the term "health indicator" is used for specific measures such as mortality rates, life expectancy; and health index corresponds to a combination of several health indicators [Berg, 1973]. Population health is defined by Kindig and Stoddart [2003] as "the health outcomes of a group of individuals, including the distribution of such outcomes within the group". Population health status measures (PHSM) are health indexes that assess the average level and/or the distribution of population health status level among individuals. SMPH (Summary measures of population health) are PHSM that combine fatal health indicators and non-fatal health indicators into a single value that represents the health of a particular population [Field et al., 1998]. A health gap SMPH quantifies the difference between the observable health status of a population and some normative population health status such as 100 years of life in perfect health for all individuals of the population [Murray et al, 2002]. In other words, it represents the loss of health of a particular population. "True" level of health status is the value of health status that is free from model specifications errors, random errors and measurement errors. It "may be reflected by tested health (measured through laboratory or functional tests), observed health (based on professionals' clinical assessments or other ratings), and perceived health (based on individual's knowledge and beliefs)" [Sadana et al, 2002] . Perceived health is estimated through self-reported health (i.e. what individuals report within a survey through an interview or a questionnaire) [Sadana et al, 2002].

Disability-Adjusted Life Years (DALY)

The DALY is a health gap SMPH based on the concept that health is an individual attribute consisting of a multidimensional set of domains (e.g. mobility, pain, sleep) [Chatterji et al, 2002]. It is derived from the aggregation of a set of individuals health states levels [Murray and Acharya, 1997]. The existence of an ordering between different health states is admitted. An individual health state level can be measured on a single cardinal scale. First it is described by a generic instrument [e.g. Euroquol] as a combination of levels of health domains. Then this combination is translated into a single cardinal value by a specific valuation method such as standard gamble, which elicit through some form of interview the health states preferences of an individual. For health gap measures, 0 is set for a state of complete health (no loss) and 1 is set for a state comparable to death. For practical purposes, the health concept has to be reduced to a core set of health domains that are defined by WHO on the basis of an international consensus

[Chatterji et al, 2002]. The assessment of an individual health state level depends on the instrument and the method of valuation used because they are respectively determinants for the description of health domains and the health states cardinal values derived.

However, there are difficulties facing this population health measurement approach including: (1) the definition of a universal normative health function and the choice of core domains of health, and (2) the challenges in measuring the level of each domain and aggregating the resulting levels in a single health status value.

Multiple Indicators Multiple Causes – Health Status Index (MIMIC-HSI)

The MIMIC-HSI is based on the concept that health theoretically is not directly measurable [Van de Ven and Hooijmans, 1982] but rather is an unobservable link between observable causes (health determinants) and observable effects (health indicators) [Robinson and Ferrara, 1977]. Here, the existence of a rank in different health states is intuitively admitted. In the MIMIC model, health status is specified as a latent variable, health indicators as endogenous variables and health determinants as exogenous variables [Van de Ven and Hooijmans, 1991]. Depending on the nature of the health indicators included in the model, MIMIC-HSI can be qualified as a PHSM or more specifically as a SMPH. A challenge for MIMIC-HSI assessment is the choice of health causes and effects variables that are determinant for the accuracy of the estimation of the true health status level (i.e. value of health status that is free from model specifications errors, random errors and measurement errors).

3- Models Specifications

Disability-Adjusted Life Years

The DALY is a health gap SMPH which represents the loss of health of a particular population in units of time. Two functions are required for its computation: (1) a normative health function that specifies a target level of health at each age and (2) a health state valuation function that translates a combination of levels of core health domains into a single value. Two assumptions are critical prerequisites for DALYs computation : (1) the normative health function is the same for all individuals of the same sex [Murray and Acharya, 1997] and (2) the valuation function is invariant across populations (i.e. identical health states are assigned the same value in all regions of the world) [Essink-Bot and Bonsel, 2002]. An important point to notice is that only health states related to disease or injury sequelae (disabilities) are considered.

The DALY is computed for a specific disease or a group of diseases such that, the total time lost due to premature mortality in a population is added to the total time lost due to a disability (disease or injury sequelae) [Mathers et al, 2001]. Diseases and injuries are considered here as determinants of health states while risks factors are considered as determinants of diseases [Murray et al, 2002d]. For the DALY estimation, individuals age and sex are the only socio-demographic parameters considered. And time lost at different age is valued either with a uniform value or with unequal age-weights [Murray and Lopez, 1994]. The use of unequal age-weights has been presented as "an attempt to capture different social roles at different ages" [Murray, 1994]. The introduction of this social values remains very controversial [Anand and Hanson,1997] because it potentially legitimates the prioritization of health care delivery to age-groups of high social values.

In the WHO World Health Report 2000, an aggregate DALY for all diseases and injuries and for both sex, has been calculated to construct a rank of 191 countries on the basis of their population health status level. The formula used for DALYs estimation is given by [Mathers et al, 2001]:

$$\text{DALYs} = \text{YLLs} + \text{YLDs} \qquad (1)$$

where YLLs are years of life lost due to premature mortality, and YLDs are the equivalent healthy years lost due to a disability related to a disease or an injury. DALYs are computed for groups of age. In YLLs computation, the method of standard expected years of life lost, based on the highest national life expectancy observed in the world is used while for YLDs computation, the disabilities incidence, duration, age of onset and weights are used [Mathers et al, 2002]. A disability weight reflect its severity. A simplified formula of YLDs is given by [Mathers et al, 2001]:

$$\text{YLD} = I * DW * L \qquad (2)$$

where, I is the number of incident cases, DW is the disability weight estimated by a valuation function of the combination of levels of J core domains of health and L is the average duration of disability (in units of years). Age weighting and future discounting are not considered in this simplified formula.

The multiplicative specification of the YLD construct is based on the assumption that disability weights and duration in that disability are independent [Essink-Bot et al, 2002] . The major difficulty in DALYs computation is disability weights evaluation. Fixing a standard health states description profile is the preliminary stage. Thus the WHO has conducted a series of surveys in each six WHO regions in order to define core domains and design a specific instrument inspired from EUROQOL for health states description. Then the choice of the appropriate method to elicit health states preferences from individuals is the next critical step because it determines the disability weights values. For the GBD 2000 project version 2, disability weights were first derived from general population health surveys by using the visual analog scale technique on a set of health state descriptions. Then detailed survey on highly educated respondents were conducted on the same set of health states descriptions, using in a deliberative form a "multi-method protocol", which is combining ordinal ranking, standard gamble, time trade-off, and person trade-off techniques. Finally health states valuations elicited from the surveys were used to "estimate by econometric methods the relationship between domain levels and valuations" and construct a valuation function [Mathers et al, 2001].

Multiple Indicators Multiple Causes – Health Status Index (MIMIC-HSI)

MIMIC-HSI represents the true health status level considered here to be unobservable. It is computed by a latent variable in a structural equation model. The MIMIC model is expressing the relationship between unobservable true health status level and observable health indicators. It takes into account the fact that health indicators variability is not explained solely by true health status level variations but also by external variables such as health services supply. The MIMIC model is given by Van de Ven and Hooijmans (1991):

$$\text{MIMIC-HSI} = \sum_{k=1}^{K_2} \beta_{2k} X_{2k} + \sum_{k=1}^{K_3} \beta_{3k} X_{3k} + u \tag{3}$$

$$HI_l = \sum_{k=1}^{K_1} \alpha_{1kl} X_{1k} + \sum_{k=1}^{K_2} \alpha_{2kl} X_{2k} + \delta_l \,\text{MIMIC-HSI} + v_l \tag{4}$$

$l = 1,2,\ldots L$

X_1 : K_1 –vector of variables that influence health indicators but without direct effect on MIMIC-HSI

X_2 : K_2 –vector of variables with direct influence on health indicators and MIMIC-HSI

X_3 : K_3 –vector of variables that influence MIMIC-HSI, but without direct effect on health indicators

α_{1kl}, α_{2k1}, β_{2k}, β_{3k}, and δ_l : parameters to be estimated

u, v_l : disturbance terms

Except MIMIC-HSI, all variables are measurable. To identify all the parameters, a normalization is required. In most of the applications of MIMIC-HSI, it was done by setting arbitrarily a unit of measurement (δ_l =1) and an origin point (β_{2k} = d for X_{2k} =1 for a particular k, d is then a constant parameter in eq. 3). As stated in the conceptual comparison part of this study, the choice of health indicators and their explanatory variables in the theoretical phase is critical.

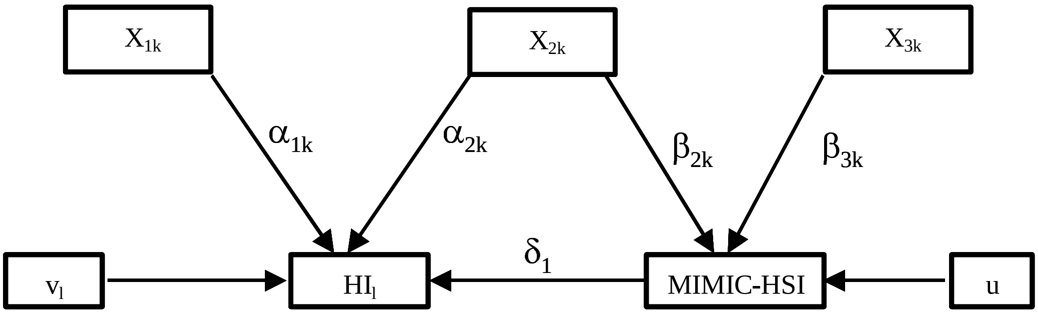

Figure 1: MIMIC-HSI Model (Adapted from Van de Ven and Hooijmans, 1991)

In 1986, Tibouti used a MIMIC-HSI to determine an ordering of 93 countries population health status. The health indicators were health expectancy at birth (E_0) and infant mortality (MO-INF). Health determining factors were included as explanatory variables. As structured in Figure 2, the Tibouti MIMIC model is:

$$E_0 = \alpha_{211} + \alpha_{111}\, M15A + \alpha_{221}\, HMED + \alpha_{231}\, CALOR + \delta_1\, MIMIC\text{-}HSI + u_1 \quad (5)$$

$$MO\text{-}INF = \alpha_{212} + \alpha_{112}\, M15A + \alpha_{222}\, HMED + \alpha_{232}\, CALOR + \delta_2\, MIMIC\text{-}HSI + u_2 \quad (6)$$

$$MIMIC\text{-}HSI = \beta_{21} + \beta_{22}\, HMED + \beta_{23}\, CALOR + \beta_{31}\, URB + u \quad (7)$$

where M15A is the percentage of individuals of age between 0 and 14 years in the population (X_1 type variable), HMED is the number of inhabitant per physician (X_2 type variable), CALOR is the percentage of essential calories consumed per inhabitant per day (X_2 type variable), URB is the percentage of urban population (X_3 type variable).

In Tibouti study, the numerical properties of the MIMIC-HSI are outlined. The MIMIC-HSI is an interval variable index. Although the index cardinal values depend on the arbitrarily chosen unit of measurement and origin point, the resulting ordering of populations health status of different countries is not disturbed by the switch of unit of measurement (δ_1 = 1 or δ_2 = -1) or by the change of origin point [Tibouti, 1986]. To interpret the cardinal values of MIMIC-HSI, ratios of difference between cardinal values can be used, because they are independent from unit of measurement and origin point [Van de Ven and Hooijmans, 1991]. For example, if MIMIC-HSI values for France, Indonesia and Portugal are respectively A, B and C, then the ratio (A-C) / (B-C) is invariant no matter which unit of measurement and origin point are chosen.

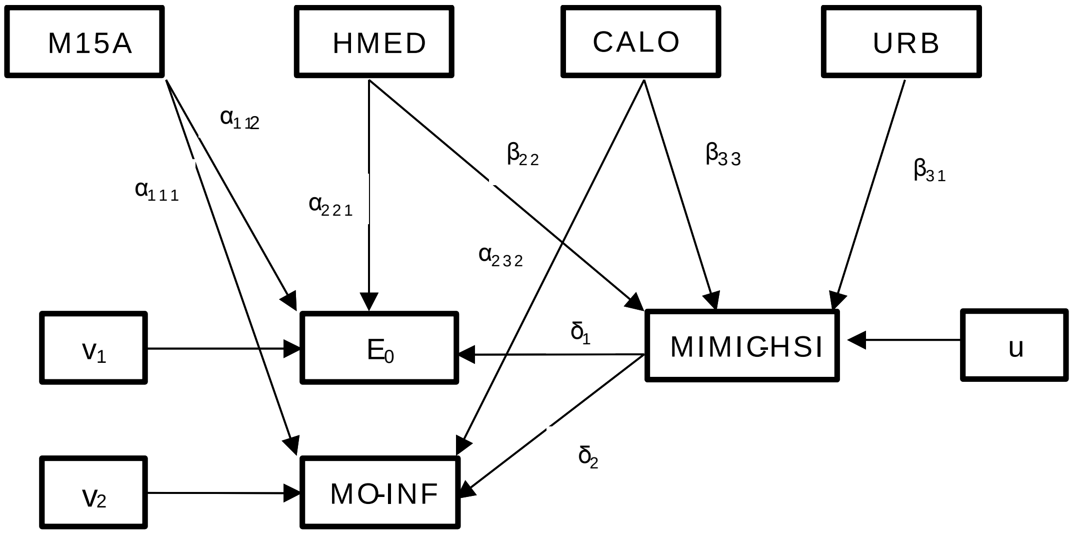

Figure 2: The MIMIC Model (Adapted from Tibouti, 1986)

Additional work by Van Vliet and Van Praag (1987), showed that three health status dimensions (self-rated health, number of psychosomatic complaints, chronic diseases and illness days) combined with age and sex provide an accurate computation of MIMIC-HSI for an individual. Another application of MIMIC-HSI at the individual level is the study of R. Leu (1992), where a MIMIC model has been used for estimation of a disease disability index (chronic bronchitis). It enables to measure on an interval scale self-reported disability caused by the disease. Those two applications of MIMIC-HSI for health status assessment of an individual**,** lead us to consider including health related quality of life information in a MIMIC model for population health status measure.

4- Comparative Analysis and Discussions

For the comparison of the DALY and the MIMIC-HSI, two criteria will be examined : validity, and reliability. The main results are summarized in table 1.

Validity

Validity of population health status measures (PHSM) is the extent to which they measure a population "true" level of health status. Two key elements determine their validity: (1) the validity of each indicator included in the model and (2) the model specifications, particularly the selection of relevant indicators [Van der Maas, 2002] and the specified relationships between indicators. Validity of a PHSM can be assessed from three types of evidence: content validity, criterion validity and construct validity. Each of this evidence is investigated for the DALY and the MIMIC-HSI with respects to the models specifications and the validity of the indicators used.

Content validity of a PHSM is the extent to which it is judged to reflect the appropriate range and depth of "true" population health status. This judgement is based on the definition of population health adopted for the model specifications and on the PHSM' expected applications. Health of a population should consider both fatal and non fatal health outcomes [Murray et al, 2002c]. And expected applications of a PHSM are the monitoring of a population health status variations over time, the comparison of average levels of different populations or subgroups and the assessment of the contribution of diseases or injuries to the overall "true" population health status. The DALY metric combines fatal and non-fatal health outcomes indicators. But the accuracy of its estimation of the "true" population health status level is affected by three characteristics. (1) The reduction of the health concept to core domains of health introduce a model-specification type error, which is not taken into account in the DALYs computation. (2) The multiplicative specification of the YLD component, inspired from the QALY (Quality-adjusted life years), is based on the assumption that disability weights (i.e. disability severity) elicited from individuals are independent of their duration. In practice, individuals assign a value to a combination of disability and duration, whether it is specified or not in the interview [Sadana et al, 2002]. Thus weights assigned to identical disabilities of different duration can not be considered invariant. Like the QALY, the assumption of mutual utility independence between disability weight and duration can not be considered valid [Duru et al, 2002]. (3) In addition, the validity of the YLD component is reduced by biases in self-reported health data used for disability weights estimation. Differences of health perceptions among individuals are responsible for those biases. They are a complex function of expectations, norms, exposure to health services, information and judgmental strategies" [Sadana et al, 2002].

The MIMIC-HSI content validity as a population health status measure is mainly affected by the fact that non fatal health outcomes indicators have not been introduced to date in the MIMIC model. Nevertheless the number of variables which can be included in the model is not limited, as long as the computer capacity is sufficient. In addition, the MIMIC model enables to take into account random errors, model specification errors and measurement errors. Indeed, the model specification of a population "true" health status as a latent variable enables to estimate the relationship between the "true" population health status level and the health level derived from self-reported data. Thus biases due to differences of health perceptions can be included in the error term as well as levels of health domains not taken into account by the model. Another positive point is that the model does not require to specify the non fatal health outcomes component as the result of a multiplication of disability duration and weight. Thus the non valid assumption of independence between disability weight (i.e. disability severity) and disability duration is not required.

Regarding the ability of the DALY and the MIMIC-HSI to meet the expected applications of a PHSM, the following limitations have been noticed. (1) First both models are static. Thus application for the monitoring of a population health status time variations, requires the assumption of the stability over time of the models parameters. In addition, weights assigned to identical disabilities should be invariant over time [Essink-Bot and Bonsel, 2002]. Therefore, time variations of health perceptions for identical disability are not estimated. Nevertheless, they can be taken into account in the error parameter of a MIMIC model while the DALY does not enable to distinguish time variations due to changes in health perceptions from "true" population health status time variations. (2) For cross-population comparative purpose, the DALY's applicability is reduced by the biases in self-reported health data [Sadana et al, 2002] while MIMIC-HSI allows these biases in the error parameter of the MIMIC model. (3) Regarding diseases and injuries evaluative purpose, the DALY metric applicability is enhanced by the introduction of disease-related variables (such as incidence) in its computation, while MIMIC-HSI computation for population health status measure has not used to date disease-related variables. (4) For comparison of health status between subgroups, the DALY metric applicability is reduced by the YLLs specification as time lost due to premature death against a normative goal. This specification assigns higher DALY's value to groups of younger people than groups of older one, like its predecessor, the QALY (Quality-Adjusted Life Years) [CES, 2003]. Thus, differences in the DALY's values between age subgroups does not solely represent differences of "true" health status but also differences of age. The MIMIC model enables to compare population health status of different subgroups by computing MIMIC-HSI subgroups cardinal values to produce a rank order and then comparing the ratios of differences between these values.

Criterion validity measures how well a metric is related to a gold standard [Coons et al, 2000]. Since that , no gold standard exists for health status measures, criterion validity can hardly be proved. Construct validity of a PHSM is the extent to which it behaves as expected [Coons et al, 2000]. It can be supported by its ability to detect population "true" health status time variations. Three criteria for evaluation of population health status measures have been outlined by Murray et al, [2002b] . (1) If the fatal health outcomes indicator decreases (everything else being the same), then a PHSM should improve. (2) If the prevalence or the incidence of a disease or injury increases (everything else being the same), then a PHSM should worsen. (3) If the weight assigned to a disability (a disease or injury sequelae) increases [i.e. the severity of the disability increases], then a PHSM should worsen. The DALY fulfils these criteria. As for MIMIC-HSI, it has to be investigated once disease-related variables are included.

Reliability

Reliability is the degree to which an instrument is free from random error. It is estimated by testing the similarity of multiple replications scores. Reliability of both indexes depends essentially on the reliability of the indicators included in the models constructs. Internal consistency reliability is the most current evidence used. For the DALY, internal consistency reliability of disability weight derived from the multi-method protocol has been estimated on nine groups of individuals (one group in an international meeting in Geneva and eight groups in various countries). The resulting ordinal ranks and cardinal values were found highly correlated [Murray et al, 2002]. This suggests that rank ordering obtained from this multi-method protocol is rather invariant between population and cultures [Murray et al, 2002]. If confirmed, this property will enhance the DALY cross-population comparability. Reliability of health indicators included in the models depends also on the degree of homogeneity of data collection methods across populations and over time.

Summary of Strengths and Weaknesses of DALY and MIMIC-HSI

The respective strengths and weaknesses of both indexes are summarized in Table 1.

Table 1: Strengths and weaknesses of the DALY and the MIMIC-HSI

	Criteria	DALYs	MIMIC-HSI
Strengths	Validity	- Non-fatal health outcomes indicators included - Disease-related variables included	- Unlimited number of variables in the model - Estimation of relationship between "true" average health level and average level derived from self-reported data. - random errors, measurement errors (e.g. biases in self-reported data) and model specification errors (e.g. health domains not considered) allowed - property of independence from unit of measurement and origin point
	Reliability	Internal consistency of disability weights derived from the multi-method protocol	-
Weaknesses	Validity	- reduction of health concept to core domains of health - biases in self-reported health data - YLLs specification - assumption of independence between disability weight and duration - static model	- non fatal health outcomes not included in the model - no disease-related variables in population health status measures applications of the MIMIC model - static model
	Reliability	To be confirmed	Not proved

The DALY applicability for public health policy is reduced by limitations found in its validity, particularly biases in self-reported health data and multiplicative specification based on a non valid assumption of independence between disability weight and duration. As regards to MIMIC-HSI, two strong weaknesses should be overcome: the lack of non fatal health outcomes indicators and the lack of disease-related variables in the model. The use of variables related to health systems functions [e.g. health services supply] in the MIMIC model could be considered as a positive point in a health policy making perspective. But none of the indexes enables to assess the dynamic relationship between health systems efficiency and population health level.

A New Conceptual Framework for Population Health Status Assessment

From the critical analysis, it appears that each measure could benefit of the other's strengths to overcome their respective weaknesses. DALY's validity could be enhanced by the specification of each disability weight as a latent variable in a MIMIC-type model. The advantage of a MIMIC-disability weight index over the disability weights used in the Global Burden of Disease Study 2000, is its ability to estimate the relation between self-reported disability weights and true disability weight (i.e. free from random errors, measurement errors and model specification errors). The importance of this estimation for the SMPH cross-population comparability is acknowledged in WHO publication on Summary Measures of Population Health [Sadana et al, 2002]. A disability weight index derived from a MIMIC model has been proposed for bronchitis and its construct has been validated [Leu ,1992]. Variables explaining differences of health perception such as age and gender [Murray et al, 2002] were included in the MIMIC model as variables representing causes of disability. As the number of variables included in the index are only limited by computer capacity [Leu,1992], other relevant variables potentially influent on health perceptions, can be added in the MIMIC model. Although computing DALY from MIMIC-disability weights index might be a promising approach in enhancing its cross-population comparability, it does not free the DALY construct from the non valid assumption of independence of disability severity and duration in its multiplicative specification.

For MIMIC-HSI, the introduction of relevant information on disease-related mortality and quality of life could enhanced its applicability for the evaluation of the contribution of different diseases or injury to the overall population health status level. Thus MIMIC-HSI could be transform into a burden of disease index, called here the MIMIC-burden of disease (MIMIC-BDI). This new index will be estimated for a specific disease or group of disease.

The MIMIC-BDI construct is based on the following six assumptions. (1) A latent variable (MIMIC-BDI) represents the "true" population disease-related health status level (i.e. the contribution of a disease to the overall population health status level). (2) Health care utilization indicators are observable health effects that can reflect the "true" disease-related population health status level. (3) There are two kind of health care utilization indicators: ambulatory health services utilization and hospital facilities utilization. (4) Ambulatory health services utilization depends on "true" disease-related population health status level, ambulatory health services supply, disability weights elicited from health care professionals, disability weights elicited from general population and health services financial accessibility. (5) Hospital

facilities utilization depends on "true" disease-related population health status level, hospital care supply, disability weights elicited from health care professionals, disability weights elicited from patients and health services financial accessibility. (6) The "true" disease related population health status level can be expressed as a linear transformation of its determinants: disease incidence, death rates and disability weights elicited from general population and patients.
The direct relationships between the variables of the model are structured in Figure 3.

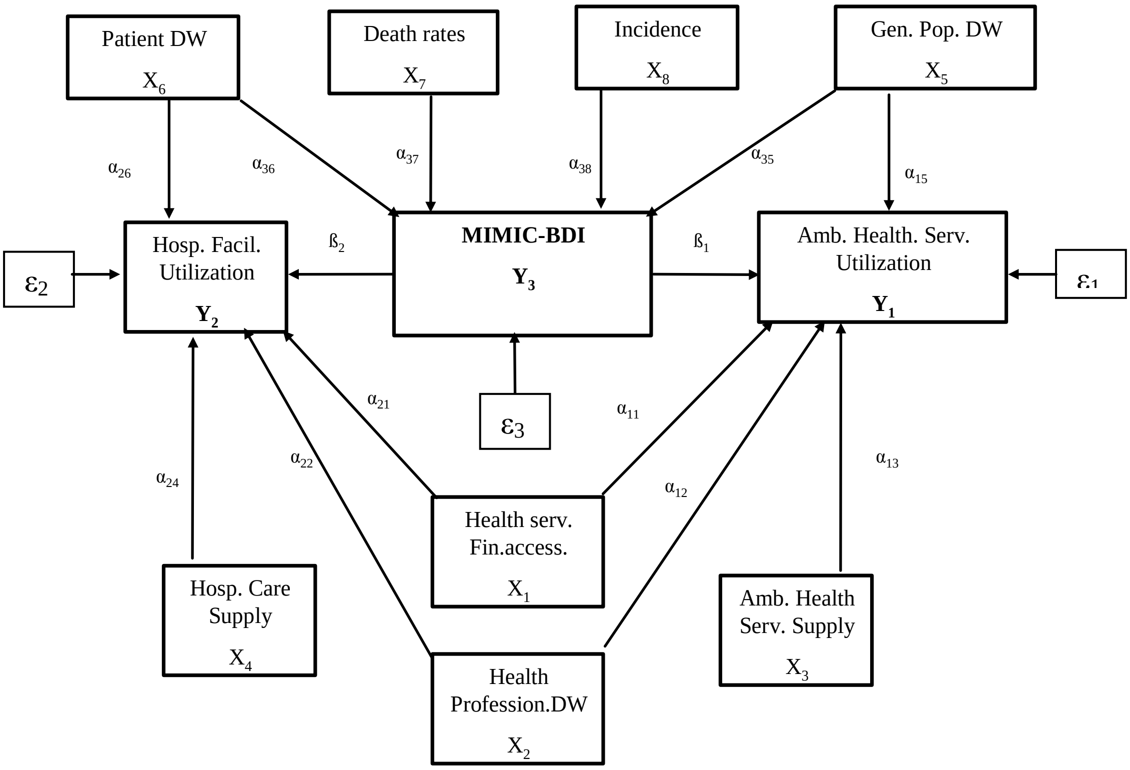

Figure 3: Proposed MIMIC model

The MIMIC-BDI model is given by

$$Y_1 = \sum_{k=0}^{8} \alpha_{1k} X_k + \beta_1 Y_3 + \varepsilon_1 \quad (8)$$

$$Y_2 = \sum_{k=0}^{8} \alpha_{2k} X_k + \beta_2 Y_3 + \varepsilon_2 \quad (9)$$

$$Y_3 = \text{MIMIC-BDI} = \sum_{k=0}^{8} \alpha_{3k} X_k + \varepsilon_3 \quad (10)$$

Where :

Y_1 is an indicator of ambulatory health services utilization (such as number of general physician visits) ;

Y_2 is an indicator of hospital facilities utilization (such as mean number of days spent in hospital);

Y_3 is the MIMIC-BDI;

X_1 is an indicator of health services financial accessibility such as the average household available income ;

X_2 is the disability weight (DW) elicited from health care professionals (i.e. disability severity reported by health care professionals) ;

X_3 is an indicator of the ambulatory health services supply (such as number of general physicians) ;

X_4 is an indicator of the hospital care supply (such as number of hospital beds per 1000 population) ;

X_5 is the disability weight elicited from general population;

X_6 is the disability weight elicited from patients;

X_7 is the death rates due to a specific disease or group of diseases;

X_8 is the disease incidence

ε_1, ε_2, ε_3 are disturbance terms, α_k and β_k are parameters to be estimated.

As specify by Van de Ven and Hooijmans (1991), X_0 is set 1 in order to introduce constant parameters α_{10} and α_{20} in the linear transformations of health indicators, Y_1 and Y_2. On the basis of our assumptions, we can specify :

(1) $\alpha_{14} = 0$, $\alpha_{16} = 0$, $\alpha_{17} = 0$, $\alpha_{18} = 0$ (i.e. ambulatory health services utilization is not directly affected by hospital care supply X_4, disability weight elicited from patients X_6, death rates X_7 and disease incidence X_8).

(2) $\alpha_{23} = 0$, $\alpha_{25} = 0$, $\alpha_{27}= 0$, $\alpha_{28} = 0$ (i.e. hospital facilities utilization is not directly affected by ambulatory health care supply X_3, disability weight elicited from general population X_5, death rates X_7 and disease incidence X_8).

(3) $\alpha_{31} = 0$, $\alpha_{32} = 0$, $\alpha_{33} = 0$, $\alpha_{34} = 0$, (i.e. MIMIC-BDI is not directly affected by the health services financial accessibility indicator X_1, disability weight elicited from health care professionals X_2, ambulatory health services supply X_3, hospital care supply X_4.

Eqs. 8, 9 and 10 can be transformed as:

$$Y_1 = \alpha_{10} + \alpha_{11} X_1 + \alpha_{12} X_2 + \alpha_{13} X_3 + \alpha_{15} X_5 + \beta_1 Y_3 + \varepsilon_1 \quad (11)$$

$$Y_2 = \alpha_{20} + \alpha_{21} X_1 + \alpha_{22} X_2 + \alpha_{24} X_4 + \alpha_{26} X_6 + \beta_2 Y_3 + \varepsilon_2 \quad (12)$$

$$\text{MIMIC-BDI} = Y_3 = \alpha_{30} + \alpha_{35} X_5 + \alpha_{36} X_6 + \alpha_{37} X_7 + \alpha_{38} X_8 + \varepsilon_3 \quad (13)$$

By substituting Y_3 into Eqs. 11 and 12, the reduced-form of the model is

$$Y_1 = \alpha_{10}+\beta_1\alpha_{30}+\alpha_{11}X_1+\alpha_{12}X_2+\alpha_{13}X_3+(\alpha_{15}+\beta_1\alpha_{35}) X_5+\beta_1\alpha_{36} X_6+\beta_1\alpha_{37} X_7+\beta_1\alpha_{38} X_8+\varepsilon_1 +\beta_1\varepsilon_3 \quad (14)$$

$$Y_2 = \alpha_{20}+\beta_2\alpha_{30}+\alpha_{21}X_1+ \alpha_{22}X_2 +\alpha_{24}X_4+\beta_2\alpha_{35} X_5+(\alpha_{26}+\beta_2\alpha_{36}) X_6+\beta_2\alpha_{37} X_7+\beta_2 \alpha_{38} X_8+\varepsilon_2 + \beta_2\varepsilon_3 \quad (15)$$

To remove the indeterminacy of the model, necessary conditions are [Van de Ven and Hooijmans, 1991]:

$\beta_1 = 1$ and $\alpha_{30} = 0$

As X_k , Y_1 and Y_2 variables are observable, parameters α_k and β_k can then be easily estimated by usual econometrics methods (such as maximum likelihood method). Then MIMIC-BDI can be computed from eq. 13.

MIMIC-BDI benefits from the respective strengths of DALY and MIMIC-HSI metrics. First the removal of the multiplicative specification between disability weights, incidence and duration, enables to avoid the assumption of independence between disability weight and duration. Second the disability weights included in the model are derived from different perspectives: general population, patient and health care professionals. Third, the MIMIC model allows models specification errors, measurement errors and random errors. Thus errors in the derivation of disability weights or in the selection of relevant health indicators are accounted. Another advantage to notice is that the number of variables included in the model is not limited (except by computer capacity). Nevertheless, the MIMIC model specified here is static and remains to be tested and validated.

An estimation of a MIMIC-BDI for diseases evaluated in the WHO global burden of disease project (GBD) is considered in a further study. For each group of disease, an ordering of the MIMIC-BDI values for countries included in the GBD project will be estimated, from WHO data of incidence, death rates, and disability weights (general population and health care professionals). Some limitations are expected in computing MIMIC-BDI. First, data for hospital and ambulatory health care supply regarding specific diseases might be missing. Thus, generic values will be adopted for all diseases. Likewise, data for the indicator of health services financial accessibility specific to groups of disease are limited and a generic value will be used. Finally disability weights elicited from patients are not available. In this case, we might consider that hospital facilities utilization is only influenced by disability weights elicited from health professionals. Once the ordering of countries MIMIC-BDI values for a group of disease is obtained, validity, reliability and interpretability of the results will be estimated. We consider investigating MIMIC-BDI applicability to the following:

(1) Comparison of health status between different population and construct of an ordering. The quality of the data used is crucial. A special attention should be given to the method used to derive disability weights particularly its ability to reduce biases due to differences of health perceptions among individuals.
(2) Comparison of health status of a particular population at different points in time. As the MIMIC model is a static model, it has to be assumed that the parameters are stable over time. This application requires data for numerous periods of time for a particular population in order to estimate most accurately as possible the parameters of the model.
(3) Evaluation of the contribution of different diseases or injuries to the overall population health status level.
(4) Cost-effectiveness analysis of health interventions. Here, its applicability is enhanced by the fact that it includes variables such as health care supply and health services financial accessibility indicators which are related to health systems functions.

Then it should be interesting to compare the countries rank orders obtained from the MIMIC-BDI and the DALY.

4 – Conclusions

This study has compared DALY and MIMIC-HSI population health status measures. Their respective strengths and weaknesses have been outlined and a possible complementarity considered. It was found that a new conceptual framework could be proposed for the estimation of a MIMIC burden of disease index, called MIMIC-BDI. MIMIC-BDI includes disease-related information such as disability weights as the DALY metric while it avoids similarly to MIMIC-HSI the multiplicative specification between disability weights, incidence and duration. Thus, the assumption of independence of severity and duration to elicit disability weights is not required. Another advantage of MIMIC-BDI is that disability weights derived from different perspectives (general population, patient, and health care professionals) can be used for its estimation. MIMIC-BDI should also benefit from two important property of the MIMIC model.

(1) Models specification errors (e.g. selection of health indicators) , measurement errors (e.g. biases in self-reported data) and random errors are allowed. (2) And the number of variables which can be included in the model is only limited by data availability and computer capacity.

Nevertheless, the MIMIC model is not dynamic and requires data such as patient disability weights which are not available at present. Although it seems quite promising for health policy applications (particularly cross-population health status comparison and health interventions cost-effectiveness analysis), it remains to be tested and validated. A further study should compare ordering of a set of countries DALYs values to the ordering obtained from MIMIC-burden of disease index. Besides, a dynamic transformation of the model should be considered to promote its applicability for population health status monitoring over time.

References

Anand S, Hanson K. Disability-adjusted life years: a critical review. Journal of Health Economics 1997; 16: 685-702

Berg RL., eds., Health Status Indexes: Proceedings of a Conference Conducted by Health Services Research, Tucson, Arizona. Chicago Hospital Research and Educational Trust, 1973.

CES, Guidelines for Health Economics Studies. French Health Economics Association, 2003. http://perso.wanadoo.fr/ces

Chatterji S, Ustün BL, Sadana R, et al. The conceptual basis for measuring and reporting on health. Discussion Paper No 45, World Health Organization / Global Program on Evidence for Health Policy, 2002. Geneva. www.who.int/

Coons SJ, Rao S, Keininger DL, et al. A comparative review of generic Quality of life Instruments. Pharmacoeconomics 2000 ; 17 (1) : 13-35

Duru G, Auray JP, Béresniak A, et al. Limitations of the Methods used for Calculating Quality-Adjusted Life-Year Values. Pharmacoeconomics 2002 ; 20 (7) : 463-473

Essink-Bot M and Bonsel GJ. How to derive disability weights. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002: 449-466

Field MJ, Gold GM, eds. Summarizing Population Health: Directions for the Development and Application of Population Metrics. Institute of Medicine, Washington D.C. National Academy Press, 1998.

Kindig D and Stoddart G. What is a population health? Am J Public Health. 2003; 93: 380-383

Leu RE, Gerfin M and Spycher S. The validity of the MIMIC health index – some empirical evidence. In P.Zweifel and H.E. Frech III (eds.), Health Economics Worldwide, Kluwer Academic Publishers, 1992: 109-142

McKenna M and Marks J. Commentary on the uses of summary measures of population health. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002: 67-74

Mathers CD, Stein C, Ma Fat D, et al. Global Burden of Disease 2000: version 2 methods and results. Discussion Paper No 50, World Health Organization / Global Program on Evidence for Health Policy, 2002.Geneva. www.who.int/

Mathers CD, Vos T, Lopez AD, et al, eds. National burden of disease studies: a practical guide. 2.0., World Health Organization / Global Program on Evidence for Health Policy, 2001.Geneva. www.who.int/evidence/nbd

Murray CJL. Quantifying the burden of disease: the technical basis for disability-adjusted life years. In Murray CJL and Lopez AD, eds. Global comparative assessments in the health sector: disease burden, expenditures and intervention packages. WHO, Geneva, 1994: 3-19

Murray CJL and Acharya AK,. Understanding DALYs. Journal of Health Economics 1997; 16: 703-730.

Murray CJL, Mathers CD, Salomon JA, et al. Health gaps : an overview and critical appraisal. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002a: 233-244

Murray CJL, Salomon JA, Mathers CD. A critical examination of summary measures of population health. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002b: 13-40

Murray CJL and Frenk J. Summary measures of population health in the context of WHO framework for health system performance assessment. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002c: 1-12
.
Murray CJL, Salomon JA, Mathers CD, et al. Summary measures of population health: conclusions and recommendations. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002d: 731-756

Sadana R, Mathers CD, Lopez AD, et al. Comparative analyses of more than 50 household surveys on health status. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002: 369-386

Richardson J. Evaluating summary measures of population health. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002: 147-160

Robinson PM, and Ferrara MC. The estimation of a Model for an Unobservable Variable with Endogenous Causes. In DJ Aigner and AS Goldberg, eds. Latent Variables in Socio-economics Models, North Holland Publ. Co., Amsterdam, 1977: 131-142

Tibouti. État de santé, parités de pouvoir d'achat et croissance économique. Ph D thesis of Aix-Marseille II University, France, 1986

Van de Ven WPMM and Hooijmans EM. The MIMIC health status index (what it is and what it does). In G.Duru and J.H.P Paelincks, eds. Econometrics of Health Care, Kluwer Academic Publishers, 1991: 19-24

Van de Ven WPMM and Van der Gaag J. Health as an unobservable: A MIMIC- model of demand for Health Care. Journal of Health Economics 1982; 1: 157-183

Van der Maas PJ. Applications of summary measures of population health. In Murray CJL, Salomon JA, Mathers CD and Lopez AD, eds. Summary measures of population health: concepts, ethics, measurement and applications. WHO, Geneva, 2002: 53-60

Van Vliet RCJA, Van Praag BMS. Health Status estimation on the basis of the MIMIC-health care models. Journal of Health economics 1987; 6: 27-42

WHO, World Health Report 2000. Health Systems : improving performance. World Health Organization, Geneva, 2000.