Healthy life expectancy in Hong Kong Special Administrative Region of China

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Abstract Sullivan's method and a regression model were used to calculate healthy life expectancy (HALE) for men and women in Hong Kong Special Administrative Region (Hong Kong SAR) of China. These methods need estimates of the prevalence and information on disability distributions of 109 diseases and HALE for 191 countries by age, sex and region of the world from the WHO's health assessment of 2000. The population of Hong Kong SAR has one of the highest healthy life expectancies in the world. Sullivan's method gives higher estimates than the classic linear regression method. Although Sullivan's method accurately calculates the influence of disease prevalence within small areas and regions, the regression method can approximate HALE for all economies for which information on life expectancy is available. This paper identifies some problems of the two methods and discusses the accuracy of estimates of HALE that rely on data from the WHO assessment.

Keywords Life expectancy; Health status indicators; Disability evaluation; Quality-adjusted life years; Sex factors; Regression analysis; Hong Kong (*source: MeSH, NLM*).

Mots clés Espérance vie; Indicateur état sanitaire; Evaluation incapacité; Rapport qualité vie-survie; Facteur sexuel; Analyse régression; Hong Kong (*source: MeSH, INSERM*).

Palabras clave Esperanza de vida; Indicadores de salud; Evaluación de la incapacidad; Calidad de acuerdo a los años de vida; Factores sexuales; Análisis de regresión; Hong Kong (*fuente: DeCS; BIREME*).

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Introduction

The assessment of population health is vital for health care planning at country and global levels (*1, 2*). WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of diseases or infirmity" (*3*). This definition provides a basis for the broad perspective needed to analyse a population's health.

Disability-adjusted life expectancy (DALE) is one of the summary measures of population health developed by the Global Burden of Disease study to enable comprehensive assessment of the global burden of disease and injury, inform global priority-setting for health research, and report on trends in population health across the world (*2, 4, 5*). To reflect the inclusion of all states of health in the computation of healthy life expectancy, the name of the indicator was altered in 2001 from DALE to healthy life expectancy (HALE) (*6*). The use of HALE as a summary measure of population health for comparative assessments of levels of health was advocated by WHO, because it is comparable directly with life expectancy and can be compared across populations (*7*).

Hong Kong — a former British colony at the mouth of the Pearl River in South China — has been a Special Administrative Region (SAR) under Chinese sovereignty since July 1997. It is made up of Hong Kong Island, the Kowloon Peninsula, the New Territories and 235 outlying islands. In 2001, Hong Kong SAR had 6.72 million inhabitants in an area of 1000 square kilometres, with a density of 6720 persons per square kilometre. As more than 80% of the land is hilly, Hong Kong is one of the most densely populated cities in the world. The long colonial occupation has resulted in huge economic, cultural and demographic differences between Hong Kong SAR and the rest of China. The health performance data of Mainland China provided in the Global Burden of Disease assessment (*5*) therefore does not reflect accurately the health situation for residents in Hong Kong SAR. This study aimed to assess overall population health in Hong Kong SAR and judge how well the health of this population compared with that of WHO's 191 Member States in terms of HALE.

Data and methods

Analyses of population health were carried out with the revised life table for the population of Hong Kong SAR for 2000, published by the Census and Statistics Department of Hong Kong SAR (*8*). Hong Kong SAR has a mandatory reporting system to record all vital events, so the coverage of vital statistics in this life table is almost complete and the quality of the data is excellent. The life table follows WHO guidelines and is comparable with that from any other WHO Member State. The prevalence distributions of disabilities in the eight geographical regions of the world, and severity weights for each disability class were given in WHO's Global Burden of

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Disease study (*3, 5*). A further study reported on general health status, physical, mental and cognitive disability distributions for 109 diseases, and injuries by age group, sex and region (*9*).

Three types of data were needed to estimate HALE for the population of Hong Kong SAR: the segment of the population surviving to each age (which can be obtained from the life table), the prevalence of each type of disability at each age and the weight assigned to each type of disability (*5, 7*). To date, city-level estimates of disability prevalence and years of life lived with adjusted disability for the population of Hong Kong SAR have not been made available by WHO, because Hong Kong SAR ceased to be a WHO member state in 1997 and thus was excluded from the *world health reports* of 2000 and 2001 (*3, 6*). In addition, data on morbidity and disability in Hong Kong SAR are not available from official statistics.

Technically, it would be possible to calculate the prevalence of disability in the population of Hong Kong SAR from estimates by the Global Burden of Disease study if the study's region-specific data on disability fairly reflected the general health status of the population of Hong Kong SAR (*3, 5*). This method was first applied to global health assessments and estimates of DALE in *The world health report 2000* (*3*). WHO obtained health status and disability data from 64 household interview surveys to estimate the prevalence of disability for 46 countries only (*7*). For the remaining 145 countries, for which WHO did not obtain data from household surveys, WHO used prior disability estimates derived from regional analyses of the burden of disease (*5, 7*). It is hard, however, to choose a region appropriate to represent the health status and distribution of morbidity in Hong Kong SAR from the estimates of the Global Burden of Disease report. According to the report, Hong Kong SAR was assigned to the region "other Asia and islands (OAI)", which includes all countries and islands in Asia and the Western Pacific, except for China, India, Japan, all former member states of the Soviet Union in Central Asia and the Middle East (*9*). The general health situation in Hong Kong SAR, however, is significantly better than the general health of the OAI. Life expectancies at birth for men and women in Hong Kong SAR in 2000 were 78.0 and 83.9 years, respectively (*8*); the corresponding figures for OAI in the Global Burden of Disease study were 60.8 and 63.4 years, respectively (*5*). The observed discrepancy is explained by the fact that many developing countries, such as Bangladesh, Cambodia, Lao People's Democratic Republic, Myanmar, Nepal, Papua New Guinea and Sri Lanka, were assigned to the same region as developed countries or areas, such as Hong Kong SAR, the Republic of Korea and Singapore. This makes it undesirable to use data about disability in OAI to produce revised estimates for Hong Kong SAR.

We used logistic regression to estimate the prevalence of disability for any countries not included in the WHO assessment, by fitting age-, sex- and disability-specific prevalence rates for the eight geographical regions with the corresponding life expectancy at birth (*5, 9*). The prevalence rates for the population of Hong Kong SAR were computed by putting the life expectancy at birth in Hong Kong SAR into the logistic regression equation. To facilitate comparison of the results of this study with HALE estimates from *The world health report 2001* (*6*), we estimated HALE for the population of Hong Kong SAR by Sullivan's method and a classical linear regression model (CLRM).

Sullivan's method

Sullivan's method is the original standard procedure used to estimate HALE and was used to calculate the value of HALE for 191 WHO Member States with life tables and severity-weighted disability estimates of prevalence (*1*, *5*). This method multiplies the total number of person-years lived between ages x and x+5 from the abridged life table (L_x) by the corresponding severity-weighted prevalence of disability (D_x) to calculate the equivalent healthy person years of life lost to disability at different ages. The number of person-years lived in good health between ages x and x+5 is then calculated by separating the person-years of life lost to disability from the total person-years lived inside the age range. The life expectancy then is calculated in the traditional manner to give the HALE. The HALE at age x is equal to the total sum of equivalent person-years of healthy life lived from age x to age ω [where ω is the age when the final survivor dies $\sum_x (1 - D_x) L_x$] divided by the number of persons survived at age x (l_x). The gap between life expectancy and HALE corresponds to the equivalent person-years of life lost through living with disability resulting from diseases and injuries (*5, 7*).

Classical linear regression model

An alternative method for estimating HALE involves developing a two-variable linear regression model from the observation of paired data from *The world health report 2001* (*6*). The value of HALE at birth for each of the 191 countries is regressed on the corresponding value of life expectancy at birth, without adjustment for disability. More specifically, the model can be expressed through the following equation.

$$HALE = \alpha + \beta\ (\mathrm{LE}) + \mu$$

The key objective of this modelling process is to use the statistical dependence of HALE at birth (dependent variable) on the total life expectancy at birth (explanatory variable) (*7*) to estimate the value of the unknown regression coefficients (α and β) on the basis of observations of HALE and total life expectancy. Random error is represented in the equation by μ.

Compression of morbidity hypothesis

Mathers et al. tested the compression of morbidity hypothesis — that fewer expected years of good health are lost due to non-fatal consequences of diseases and injuries as mortality declines (*10*) — by examining the relation between the number of life years to be lived with disability and the total life expectancy on the basis of observations for 191 WHO Member States from *The world health report 2000* (*7*). They concluded that the correlation across countries between HALE and life expectancy is very high at birth and at age 60 years. In addition, they highlighted that compression of morbidity was valid, although, with the 1999 dataset, the number of life years with disability declined, in absolute and relative terms, as life expectancy increased. The validity of their test was completely dependent on information from The *world health report 2000*. It has yet to be established whether the compression of morbidity theory would hold for HALE estimation. The *world health report 2001* suggests an overall increase in severity-weighted prevalence and a reduction in HALE estimates for most member states (*6*). We therefore tested the hypothesis of Mathers et al. by the using the latest HALE estimates from *The world health report 2001* as the input data for the regression analysis (*6*).

Results

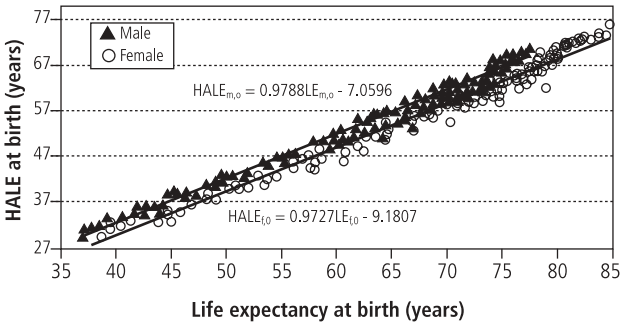
According to the latest life table compiled by the Census and Statistics Department of Hong Kong SAR, Hong Kong SAR had a very high ranking of life expectancy. In 2000, life expectancies at birth for men and women in Hong Kong SAR were 78.0 and 83.9 years, respectively (*8*); these were the highest life expectancies for men and the second highest for women in a ranking of the 191 WHO Member States. Table 1 shows the estimated prevalence of disability by age, disability class and sex for Hong Kong SAR from a fitted logistic curve. The estimates of disability prevalence for both sexes followed the usual hazard curves: they were high in the early years and then decreased before rising steadily with age. In most age groups, severity-weighted prevalence of disability was higher for men than for women. The severity-weighted prevalence rose with age and was substantially higher for men over the age of 45 years than for women.

Estimates by Sullivan's method

By using estimated age- and sex-specific, severity-weighted disability prevalence and regression coefficients, HALE at birth for the population of Hong Kong SAR in 2000 was estimated from the corresponding life tables. By integrating estimated, regional, non-fatal, health distributions into the life tables, Sullivan's method gave estimates of healthy life expectancy at birth in Hong Kong SAR in 2000 of 70.3 and 75.7 years for men and women, respectively. This indicates that 9.9% and 9.7% of the life expectancy at birth for men and women, respectively, in Hong Kong SAR would be lost due to adjusted disability. When we compared the HALE estimates with those for WHO Member States, Hong Kong SAR had the third highest healthy life expectancy for men and the second highest for women (Table 2).

Fig. 1 shows the relation across countries between total life expectancy at birth and HALE at birth for men and women in 2000. The HALE at birth was significantly correlated with the total life expectancy at birth in a linear manner; adjusted R^2 values for men and women were 0.9819 and 0.9803, respectively. New evidence from the WHO multi-country household survey study suggested an overall increase in severity-weighted prevalence rates and hence a reduction in HALE estimates at the global level (*6*). This affected estimates of slope coefficient (β), which were 0.9788 and 0.9727 for men and women, respectively, in 2000. These differences imply that more years lived would not reduce the number of life-years lived with disability and show that the compression of morbidity theory does not hold.

Fig. 1. **Relation between healthy life expectancy (HALE) and life expectancy at birth by sex for 191 countries in 2000** (ref.*6*)



Estimates by classical linear regression

The CLRM estimated HALE at birth in Hong Kong SAR in 2000 at 69.3 and 72.4 years for men and women, respectively. The equivalent person-years lost due to adjusted disability as a percentage of the total life expectancy at birth would be 11.2% for men and 13.7% for women. In comparison with the estimated HALE for 191 WHO Member States, Hong Kong SAR ranked twelfth for men and for women (Table 2).

Discussion

Estimates of HALE produced by CLRM were slightly lower than those obtained with Sullivan's method. This suggests that interpolated severity-adjusted estimates of prevalence ob-

Table 1. **Estimated prevalence (per 1000 inhabitants) of seven classes of disability[a] for men and women by age group in Hong Kong Special Administrative Region of China[b]**

Age group (years)	Disability class							
	I	II	III	IV	V	VI	VII	Weighted disability prevalence[c]
Men								
0–4	105.5	91.3	27.4	11.0	6.8	3.3	2.0	22.3
5–14	105.3	79.6	21.4	10.4	5.8	3.0	1.7	19.3
15–44	136.1	129.2	67.7	34.2	17.7	28.1	8.2	64.3
45–59	211.9	216.1	99.3	51.6	28.9	37.5	16.9	99.9
⩾60	363.2	403.5	192.5	104.4	67.2	66.7	53.0	211.8
Women								
0–4	107.0	97.7	28.8	11.7	6.7	3.3	2.0	23.2
5–14	99.9	80.2	20.6	9.2	5.2	2.7	1.6	18.3
15–44	139.5	113.5	64.6	22.2	12.9	37.8	6.2	61.1
45–59	235.1	219.8	81.0	37.6	21.3	41.6	12.6	88.4
⩾60	349.3	394.9	162.8	83.1	57.7	66.9	51.0	193.7

[a] Defined in the Global Burden of Disease study on the basis of the results of the Person Trade-off protocol at the Geneva meeting on disability weights (*4*).
[b] Input data were obtained from 1990 estimates in the Global Burden of Disease study.
[c] Based on the standard in the Global Burden of Disease study.

Table 2. **Relative ranking of healthy life expectancy (HALE) in Hong Kong Special Administrative Region (SAR) of China at birth, by sex, relative to the top 30 of 191 WHO Member States in 2000**[a]

Male			Female		
Rank	**Country**	**HALE**	**Rank**	**Country**	**HALE**
1	Japan	71.2	1	Japan	76.3
2	Switzerland	70.4		**Hong Kong SAR**[b]	**75.7**
	Hong Kong SAR[b]	**70.3**	2	San Marino	74.3
3	Sweden	70.1	3	Monaco	73.9
4	Andorra	69.8	4	Andorra	73.7
5	Iceland	69.8	5	Switzerland	73.7
6	San Marino	69.7	6	Australia	73.3
7	Greece	69.7	7	France	72.9
8	Australia	69.6	8	Italy	72.8
9	Italy	69.5	9	Sweden	72.7
10	New Zealand	69.5	10	Iceland	72.6
11	Monaco	69.4	11	Spain	72.5
12	Israel	69.3	12	Austria	72.5
	Hong Kong SAR[c]	**69.3**		**Hong Kong SAR**[c]	**72.4**
13	Denmark	68.9	13	Norway	72.3
14	Norway	68.8	14	Greece	72.3
15	Malta	68.7	15	New Zealand	*72.1*
16	Spain	68.7	16	Malta	72.1
17	France	68.5	17	Luxembourg	72
18	Canada	68.3	18	Canada	71.7
19	United Kingdom	68.3	19	Finland	71.5
20	Netherlands	68.2	20	Germany	71.5
21	Austria	68.1	21	United Kingdom	71.4
22	Ireland	67.8	22	Netherlands	71.2
23	Belgium	67.7	23	Belgium	71
24	Luxembourg	67.6	24	Ireland	70.9
25	Germany	67.4	25	Israel	70.6
26	Singapore	66.8	26	Denmark	70.1
27	Cyprus	66.4	27	Slovenia	69.3
28	Finland	66.1	28	Singapore	68.9
29	USA	65.7	29	USA	68.8
30	Cuba	65.1	30	Republic of Korea	68.8

[a] Ranking based on HALE estimates from *The world health report 2001* (*6*).
[b] Estimate based on Sullivan's method.
[c] Estimate based on classical linear regression model.

tained through logistic regression would be consistently lower if revised estimates of severity-weighted prevalence rates from the WHO multi-country household survey study were used.

Regression itself limits the accuracy of HALE estimation. For example, as Hong Kong SAR had the highest ranking of life expectancy for men in 2000, the ranking of HALE should also place Hong Kong SAR at the highest rank. However, HALE calculated by CLRM put Hong Kong SAR in thirteenth place. This suggests that the regression equation of HALE, especially for females, is not simply a linear function but may be influenced by convexity at the end of the scale, while none of the original estimates of the top 12 for both sexes sit on the line at the higher end of the scale.

Sullivan's method should work better than CLRM in estimating HALE because only Sullivan's method can calculate the influence of diseases within small areas and regions — such as laryngeal and nasopharyngeal cancer in the Pearl River delta economies, skin cancer in Oceanic countries or leukaemia in Ukraine. In addition, Sullivan's method separately accounts for mortality, severity-weighted disability data and the availability of data necessary for the calculation. Observed cross-sectional prevalence rates of disability in the population are sufficient for Sullivan's method.

The CLRM can be used to estimate the expected value of HALE in 2000 for any economies in the world that were excluded from the WHO assessment. We might also be able to broaden estimates of HALE from the country level to the state, city or even county levels, because the regression equation derived can accurately approximate the true regression function from the WHO dataset. It is not difficult to understand that estimates of HALE at the country level are inadequate for population health assessments, because the huge epidemiological heterogeneity within countries, especially large countries, means that a single indicator of the summary measures of population health is not enough to describe the actual health status. For example, the life expectancies of Hong Kong SAR, Macao SAR and China (Province of Taiwan) are very different from those for the rest of China (*11*); hence, it is not appropriate to use a single value of HALE to represent the health status of all people within the economies of China. It should be mentioned, however, that although a reasonably high correlation exists between life expectancy at birth and HALE, considerable

variation in HALE also exists for any given level of life expectancy in the WHO assessment (*3*, *6*).

The regression procedure does not take into account specific differences in epidemiological conditions in Hong Kong SAR compared with other countries or regions with similar life expectancy. Moreover, as discussed above, the application of CLRM is based on the strict assumption that higher life expectancy is associated with compression of morbidity (*10*). This assumption was rejected by this study, and higher life expectancy does not reduce the DALE or the public's need for health care service in Hong Kong SAR. In a previous study, we showed that no significant reduction was seen in the demand for hospital patient days in Hong Kong SAR between 1996 and 2000 (*12*) despite the fact that life expectancy for men increased from 76.7 to 78.0 years and for women from 82.7 to 83.9 years during this period (*8*).

If CLRM was used to calculate HALE for planning of future health care policy, the resource requirement for health care services in Hong Kong SAR would be underestimated. Whether healthy life expectancy should be used as an indicator in the planning of health care resources for policy-makers needs careful thought. ■

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Résumé

Espérance de vie en bonne santé à Hong Kong (région administrative spéciale de Chine)

La méthode de Sullivan et un modèle de régression ont été utilisés pour calculer l'espérance de vie ajustée sur la santé (HALE) pour l'homme et la femme à Hong Kong (région administrative spéciale de Chine). Ces méthodes nécessitent des estimations de la prévalence de 109 maladies et des informations sur la distribution des incapacités qu'elles entraînent ainsi que la valeur de l'espérance de vie ajustée sur la santé pour 191 pays, par âge, sexe et région, d'après l'évaluation de la santé dans le monde réalisée par l'OMS en 2000. La population de Hong Kong (région administrative spéciale de Chine) possède l'une des espérances de vie ajustées sur la santé les plus élevées du monde. La méthode de Sullivan donne des estimations plus élevées que la méthode classique de régression linéaire. Alors que la méthode de Sullivan calcule avec une bonne exactitude l'influence de la prévalence des maladies à l'intérieur de petites zones et régions, la méthode de régression permet d'obtenir une valeur approximative de l'espérance de vie ajustée sur la santé dans tous les contextes économiques pour lesquels on dispose d'informations sur l'espérance de vie. Le présent article expose quelques problèmes associés à ces deux méthodes et examine l'exactitude des estimations de l'espérance de vie ajustée sur la santé qui s'appuient sur les données de l'évaluation réalisée par l'OMS.

Resumen

Esperanza de vida sana en Hong Kong (Región Administrativa Especial de China)

Se utilizaron el método de Sullivan y un modelo de regresión para calcular la esperanza de vida ajustada en función del estado de salud (EVAS) para hombres y mujeres en Hong Kong (Región Administrativa Especial de China). Estos métodos requieren estimaciones de la prevalencia y datos sobre las distribuciones de la discapacidad para 109 enfermedades y la EVAS para 191 países por edad, sexo y región del mundo, información que se extrajo de la evaluación de la situación sanitaria en 2000 realizada por la OMS. La población de la RAE de Hong Kong tiene una de las esperanzas de vida sana más elevadas del mundo. El método de Sullivan arroja estimaciones más altas que la regresión lineal clásica. Aunque el primero permite calcular con precisión la influencia de la prevalencia de enfermedades dentro de áreas y regiones pequeñas, la regresión puede suministrar valores aproximados de la EVAS para todas las economías respecto de cuya esperanza de vida se dispone de información. En este artículo se identifican algunos problemas de los dos métodos y se analiza la exactitud de las estimaciones de la EVAS basadas en los datos aportados por la evaluación de la OMS.

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