Measuring Population Health
by a Multi-Attribute Health Status Classification System

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Abstract

This paper presents an assessment of the health status of the Singaporean population as measured by a multi-attribute health status classification system. The assessment describes the functional health status of the population on eight aspects or dimensions of health: seeing, hearing, speaking, walking, use of hands and fingers, feelings, memory and thinking, and pain. Differences in functional health status among different demographic groups are analysed. The results of the study may help to better understand population health and health care needs and to plan health care services. This research attempts to introduce the health care program evaluation research in Singapore and Asia.

Key words: Health Status

Population Health

Health Status Assessment

Multi-Attribute Health Status Classification

Health Utilities Index

I. Introduction

The patient population and the pattern of disease in the world have been changing in the last several decades. The population is getting older and more and more chronic illnesses have emerged in which reversal of the clinical state or cure is often at most a remote possibility. To meet these changes, the number of health interventions has been growing rapidly and more emphasis has been placed on health promotion and disease prevention [1]. However, health care cost as measured by the proportion of the gross national product has also been increasing rapidly. As a result, health care systems, particularly in the developed countries, have been facing tremendous cost pressure. In the meantime, patients have become more concerned with the value they get from their health care expenditure. There has been an increasing pressure and interest in evaluating the effectiveness and efficiency of health care programs and interventions.

The effectiveness of a health care program or intervention is ultimately determined by its influence upon the health of its recipients. Therefore, to evaluate and compare health interventions or treatment programs, it is necessary to develop common measures of health outcomes. Traditionally, condition-specific mortality and morbidity rates have been used for these purposes. However, with the shift of emphasis from the curing of disease to minimising the impact of illness on everyday activities in recent years, the efficacy and effectiveness of health care programs or interventions can no longer be judged by morbidity or mortality rates. Measures of the actual performance of activities have to be developed to provide a relevant and

sensitive indicator for evaluating population health, assessing health care needs and determining the allocation of resources [2-5].

Great progress in health status measurement and health care program evaluation has been made in North America and Europe in the last three decades [6,7]. However, comparatively few studies in this area have been conducted in Asia. This is probably because the set of driving forces such as high health care cost, ageing population and acknowledgement of patient autonomy and preference has not acted in the same capacity in the developing countries as in the developed countries. However, as their economies grow, developing countries are beginning to face the same problems as the developed countries. In the case of Singapore, ageing population and rising health care cost have already been issues of concern [8]. Maintaining the effectiveness and efficiency of the health care system and improving population health have become important issues on the agenda.

This paper reports an assessment of the functional status of the Singaporean population as measured by a multi-attribute health status classification system. This research represents part of a large effort to apply the health care program evaluation research in Singapore. A nation-wide random sample was taken. Population functional health status and its relationship with demographic factors are analysed. Results from this and other similar research may be useful to better understand population health and health care needs and help the planning of health care services.

II. Methods

This study is part of an attempt to apply the health utilities index (HUI) approach to health care program evaluation [5, 12] in Singapore. The HUI approach consists of three components: (i) a multi-attribute health status classification (MAHSC) system, (ii) a measurement system of preferences for health states, and (iii) a combination of health status data and preference data to yield information on the desirability of health care programs or interventions. This paper reports the application of a MAHSC system in measuring the functional health status of the Singaporean population.

2.1. Health Status Measurement

A MAHSC system is a method of describing the health status of an individual at a point in time [9]. It defines health in different dimensions or attributes, each with multiple levels of functioning varying from good to poor. An individual's health status is classified according to his or her functioning level on each of the attributes. Each unique combination of levels represents a person’s health or a (different) health state.

The first MAHSC system was developed more than 20 years ago by Bush and colleagues in the United States [10]. Following their work, a number of other MAHSC systems have been developed in different countries. Depending on its purpose, each system has different health attributes and/or different functioning levels on each attribute. Such systems have been increasingly used in clinical research, clinical practice and policy analyses [11, 12].

A MAHSC system developed at McMaster University in Canada was used in this study. This system has evolved three generations from the original Mark I

system with four attributes: physical function, role function, social-emotional function, and health problem [13] to the current Mark III system with eight attributes: seeing, hearing, speaking, walking, feelings, memory and thinking, use of hands and fingers, and pain [11]. This system was selected for this study for several reasons. First, it provides a compact but comprehensive health status measurement framework for population health assessment and program evaluation. The system is capable of describing a total of 972,000 different health states, although not all of the health states are feasible. Second, the system has been successfully applied in a number of population health surveys [11] and evaluative clinical studies [14-16]. Finally, the system has been developed to be compatible with measuring preferences of health states, which is one of the objectives for our large study. The complete MAHSC (Mark III) system is shown in Table 1.

TABLE 1 : Multi-Attribute Health Status Classification System: Mark III

Seeing

1. Able to see well enough to read ordinary newsprint and recognise a friend on the other side of the street, without glasses or contact lenses.
2. Able to see well enough to read ordinary newsprint and recognise a friend on the other side of the street, but with glasses or contact lenses.
3. Able to read newsprint with or without glasses but unable to recognise a friend on the other side of the street even with glasses or contact lenses.
4. Able to recognise a friend on the other side of the street with or without glasses, but unable to read ordinary newsprint, even with glasses or contact lenses.
5. Unable to read newsprint and unable to recognise a friend on the other side of the street, even with glasses or contact lenses.
6. Unable to see at all.

Hearing

1. Able to hear what is said in a group conversation with at least 3 people without a hearing aid.
2. Able to hear a conversation with 1 other person in a quiet room without a hearing aid, but requires a hearing aid to hear what is said in a group conversation with at least 3 other people.

3. Able to hear a conversation with 1 other person in a quiet room with a hearing aid and able to hear what is said in a group conversation with at least 3 other people, with a hearing aid.
4. Able to hear a conversation with 1 other person in a quiet room without a hearing aid, but unable to hear what is said in a group conversation with at least 3 other people even with a hearing aid.
5. Able to hear a conversation with 1 other person in a quiet room with a hearing aid, but unable to hear what is said in a group conversation with at least 3 other people, even with a hearing aid.
6. Unable to hear at all.

Speaking

1. Able to be understood completely when speaking with strangers or people who know me well.
2. Able to be understood partially when speaking with strangers but able to be understood completely when speaking with people who know me well.
3. Able to be understood partially when speaking with strangers or people who know me well.
4. Unable to be understood when speaking with strangers but able to be understood partially when speaking with people who know me well.
5. Unable to be understood when speaking with other people (or unable to speak at all).

Walking

1. Able to walk around the neighbourhood without difficulty and without walking equipment.
2. Able to walk around the neighbourhood with difficulty, but does not require walking equipment or the help of another person.
3. Able to walk around the neighbourhood with walking equipment, but without the help of another person.
4. Able to walk only short distances with walking equipment, and requires a wheelchair to get around the neighbourhood.
5. Unable to walk alone even with walking equipment. Able to walk short distances with the help of another person, and requires a wheelchair to get around the neighbourhood.
6. Cannot walk at all.

Feelings (Emotion)

1. Happy and interested in life.
2. Somewhat happy.
3. Somewhat unhappy.
4. Very unhappy.
5. So unhappy that life is not worth living.

Use of Hands and Fingers (Dexterity)

1. Full use of two hands and ten fingers.
2. Limitations in the use of hands or fingers, but does not require special tools or the help of another person.
3. Limitations in the use of hands or fingers, is independent with the use of special tools and does not require the help of another person.
4. Limitations in the use of hands or fingers, requires the help of another person for some tasks (not independent even with use of special tools).
5. Limitations in the use of hands or fingers, requires the help of another person for most tasks (not independent even with the use of special tools).

6. Limitations in the use of hands or fingers, requires the help of another person for all tasks (not independent even with the use of special tools).

Memory and Thinking (Cognition)

1. Able to remember most things, think clearly and solve day to day problems.
2. Able to remember most things, but has a little difficulty when trying to think and solve day to day problems.
3. Somewhat forgetful, but able to think clearly and solve day to day problems.
4. Somewhat forgetful and have a little difficulty when trying to think and solve day to day problems.
5. Very forgetful and have great difficulty when trying to think and solve day to day problems.
6. Unable to remember anything at all, and unable to think and solve day to day problems.

Pain

1. Free of pain and discomfort.
2. Mild to moderate pain that prevents no activities.
3. Moderate pain that prevents some activities.
4. Moderate to severe pain that prevents some activities.
5. Severe pain that prevents most activities.

To describe a person's health is to select the most appropriate level for the person on each attribute. In this way, an individual's health or a health state is described by an eight element vector (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8), where x_i is the level on attribute i (i = 1, …, 8). The measurement system is developed independently of factors such as age and gender, but it is used in the circumstances normal for the subject. For example, cognition levels for children should be assessed according to children's normal standards of memory and thinking capacities. For the speaking and hearing attributes, it is assumed that a common language or dialect spoken by both the speaker(s) and the listener(s) is used for the assessment.

2.2. Field Work

The target population of the study was the general residential population of Singaporean citizens. A random sample of individuals, one from each household, was taken from the 1992 Register of Electoral Voters. The sample was designed to select 1,000 individuals or households for the survey, comprising 45% Chinese, 35% Malay and 25% Indian. The stipulated proportions were used to partially reflect the actual population proportions of the three major racial groups, although an equal number of responses in each group is desirable to yield maximum statistical power in comparison. The sampling was carried out by a combination of random sampling and quota sampling. Individuals or households were randomly taken from the register in each constituency until the quota for each racial group was met.

A contact letter from the project investigators and a supporting letter from the Dean of the Nanyang Business School, Nanyang Technological University (NTU), were sent to each individual or household, requesting participation in the study. This was followed by telephone calls if a telephone number for the selected respondent could be found in the telephone directory. Otherwise site visits were made to elicit consent. If a subject agreed to participate, arrangements were made for a face-to-face interview. A subject was given up if contact could not be established after at least five telephone calls or two site visits spanning a period of three weeks.

Interview instruments developed at McMaster University in Canada were adapted for this study. These instruments have been successfully used in a number of similar studies [5, 11, 12]. Their use allows a comparison of functional status and health state preferences among different populations. The instruments included

written interview manuals and props to help respondents describe their own health status and compare different health states. The interview manuals contain detailed explanations and instructions for each step of the interview and emphasise the importance of phrasing each question consistently to ensure consistency of data. The adaptation of the instruments included modifications of questions to account for cultural and language differences. The adapted instruments were translated to Chinese and Malay. The translations were tested extensively for their accuracy.

Interviews were conducted by thirty final-year students at the Nanyang Business School in July to November 1996. The interviewers were recruited and trained by the project investigators over a period of three months. The training included discussions of study and interview procedures, followed by trial interviews with peer interviewers and NTU lecturers. A pilot study was conducted at the final stage of the training period. Feedback from the trial interviews and the pilot study was used to assess the progress of training as well as to improve the interview instruments. The data from the pilot study were not included in the results reported in this paper. The interviewers were organised in ten groups of three and households were randomly assigned to each group.

For the health status measurement task[1], the interviewer first explained the MAHSC system and its use to describe a person's health to the respondent. The respondent was then presented with a card with the detailed descriptions of the attribute levels as shown in Table 1 for each of the eight single attributes. The respondent was asked to read the descriptions of the functional levels and select the one that most appropriately described his/her ability on that attribute. After

[1] Other parts of the research will be reported separately.

describing his/her own health on all the eight attributes, the respondent was requested to describe the health status of each family member in the same way. Respondents were allowed to discuss his/her assessment with family members. If necessary, the questionnaire could be returned by mail at a later date in a self-addressed envelope provided by the interviewer.

III. Results

Contact letters were sent to a total of 829 households out of the 1,000 households due to a time constraint. Among them, 326 were not able to be contacted within a three-week consecutive period, 50 were considered to be ineligible due to language and other barriers, 210 refused to be interviewed and a total of 243 households were interviewed. This represents a response rate of 53.6 percent of the contacted and eligible households.

Health status measurements were obtained for a total of 981 individuals. This group of individuals closely represented the target population. The respondents consisted of 432 (44%) Chinese, 237 (24.2%) Indian, 295 (30.1%) Malay, and 17 (1.7%) others. The proportions for the three major ethnic groups are very close to the designed proportions. The sample also closely resembled the actual Singaporean population in other demographic aspects such as gender, age, marriage status, etc. For example, the sample contained 495 (50.5%) males and 486 (49.5%) females; 291 (30.2%[2]) of 20 years old or younger, 504 (50.2%) between 20 and 50, and 170 (17.6%) above 50; and 508 (51.8%) married, 462 (47.1%) singles, and 11

[2] 16 respondents refused to disclose their age and were not included in this calculation.

widowed or divorced (1.1%). These proportions are very close to the proportions of the actual population [17].

3.1. General Functional Status of the Sample

A total of 179 different health states were reported by the 981 respondents in the survey. Table 2 lists the top 19 health states that were reported by at least six respondents. About 50 percent of the respondents reported perfect health (32.93%) or level 2 of vision (wearing glasses or contact lens) and normal functioning on all the other attributes (16.11%). The other respondents reported deficiencies on one or more attributes.

Table 2. Health States Reported by Respondents

No.	Health State (V, H, S, W, D, E, C, P)	Frequency	Percentage
1	(1, 1, 1, 1, 1, 1, 1, 1)	323	32.93
2	(2, 1, 1, 1, 1, 1, 1, 1)	158	16.11
3	(2, 1, 1, 1, 1, 1, 1, 2)	43	4.38
4	(2, 1, 1, 1, 1, 2, 1, 1)	33	3.36
5	(1, 1, 1, 1, 1, 2, 1, 1)	32	3.26
6	(1, 1, 1, 1, 1, 1, 1, 2)	27	2.75
7	(1, 1, 1, 1, 1, 1, 2, 1)	20	2.04
8	(2, 1, 1, 1, 1, 1, 3, 1)	16	1.63
9	(2, 1, 1, 1, 1, 2, 1, 2)	14	1.43
10	(2, 1, 1, 1, 1, 1, 2, 2)	11	1.12
11	(1, 1, 1, 1, 1, 2, 1, 2)	11	1.12
12	(2, 1, 1, 1, 1, 2, 2, 2)	8	0.82
13	(2, 1, 1, 1, 1, 1, 3, 2)	8	0.82
14	(2, 1, 1, 1, 1, 1, 2, 1)	8	0.82
15	(1, 1, 1, 1, 1, 1, 2, 2)	8	0.82
16	(1, 1, 1, 1, 1, 2, 2, 2)	7	0.71
17	(1, 1, 1, 1, 1, 1, 3, 1)	7	0.71
18	(2, 1, 1, 1, 1, 2, 1, 3)	6	0.61
19	(1, 1, 2, 1, 1, 1, 1, 1)	6	0.61
Total		746	76.04

The results from our survey are compared similarly with results from some large national health surveys. Table 3 lists the five most common health states and their frequencies reported in the 1991 Canadian General Social Survey [18]. About 32.93 percent of respondents reported to be in perfect health in our survey, compared with 29.72% in the Canadian health survey. The second most common health state in both surveys has level 2 vision (wearing glasses or contact lens) and level 1 functioning on every other attribute, with a reported frequency of 22.05% from the Canadian health survey and 16.11% from our survey. In total, about 50 percent of the population reported being in perfect health with or without wearing glasses or contact lens. Similar percentages have also been reported in other countries [19]. However, more respondents reported to be in a health state with pain in the Singaporean sample than the Canadian national health survey.

Table 3. The Five Most Common Health States Reported in the 1991 Canadian General Social Survey

No.	Health State (V, H, S, W, D, E, C, P)	Frequency (000's)	Percentage
1	(1, 1, 1, 1, 1, 1, 1, 1)	6079.8	29.72
2	(2, 1, 1, 1, 1, 1, 1, 1)	4510.9	22.05
3	(2, 1, 1, 1, 1, 1, 3, 1)	829.7	4.06
4	(1, 1, 1, 1, 1, 2, 3, 1)	808.3	3.95
5	(1, 1, 1, 1, 1, 2, 1, 1)	787.4	3.85

For the individual attributes, we divide the eight attributes into two groups: (i) the five attributes of seeing, hearing, speaking, walking, and dexterity; and (ii) the three attributes of feelings, cognition, and pain. Group one represents a person's capacities in using the eyes, ears, mouth, legs and feet, and hands and fingers, respectively. They are the "hard" dimensions of health of which the performance level can be measured objectively. Group two represents a person's "soft"

dimensions of health of which the performance level can only be measured subjectively. The "soft" attributes are used to assess a person's emotional, cognitive and morbidity aspects of life. Table 4 displays the reported frequencies on levels of each attribute from the sample.

Respondents reported near perfect functional status on the "hard" attributes except the attribute of seeing. Only 7.95%, 4.09%, 3.47%, and 3.06% of all the respondents reported a deficiency (a level higher than level 1) on the attributes of hearing, speaking, walking and dexterity, respectively. However, high deficiency rate was reported on the attribute of seeing. Among the 980 respondents, 536 (54.7%) reported normal vision, 405 (41.3%) reported vision deficiency correctable with glasses or contact lens, 9 (0.9%) reported long-sight problems and 5 (0.5%) reported short-sight problems that were not correctable with glasses or contact lens. No respondent was blind.

Table 4. Population Functional Status by Individual Attribute

Level	1	2	3	4	5	6	Total
Seeing							
Frequency	536	405	25	9	5	0	980[3]
%	54.69	41.33	2.55	0.92	0.51	0.00	100.00
Hearing							
Frequency	939	29	4	5	1	1	979
%	95.91	2.96	0.41	0.51	0.10	0.10	100.00
Speaking							
Frequency	903	60	16	1	1	N/A	981
%	92.05	6.12	1.63	0.10	0.10		100.00
Walking							
Frequency	946	15	6	3	0	0	980
%	96.53	1.53	0.61	0.31	0.00	0.00	100.00
Dexterity							
Frequency	951	25	2	2	1	0	981
%	96.94	2.55	0.20	0.20	0.10	0.00	100.00

[3] The total number of observations for some attributes is smaller than 981 due to either missing data or undefined cases where a respondent completely lost one eye (ear) but had normal vision (hearing) from the other.

Feelings							
Frequency	731	213	32	3	1	N/A	980
%	74.59	21.73	3.27	0.31	0.10		100.00
Cognition							
Frequency	739	128	91	19	3	0	980
%	75.41	13.06	9.29	1.94	0.31	0.00	100.00
Pain							
Frequency	696	217	57	7	3	N/A	980
%	71.02	22.14	5.82	0.71	0.31		100.00

Relatively high percentage of deficiency was reported on all the three "soft" attributes. For the feelings attribute, 74.59% or 731 out of 980 respondents reported to be happy and interested in life, 21.73% or 213 respondents were only somewhat happy, 3.27% or 32 respondents were somewhat unhappy, 0.31% or 3 respondents were very unhappy, and 0.10% or one respondent was so unhappy that life was not worth living. For the cognition attribute, 75.41% or 739 out of 980 respondents were able to perform normally, 13.6% or 128 respondents had a little difficulty in coping with everyday problems, 1.94% or 19 respondents were able to think normally but somewhat forgetful, and 0.31% or 3 respondents had a little difficulty in both thinking and memory. For the pain attribute, 71.02% or 696 out of 980 respondents were free of pain and discomfort, 22.4% or 217 respondents reported mild to moderate pain that prevented no activities, 5.82% or 57 reported moderate pain that prevented some activities, 0.71% or 7 respondents reported moderate to severe pain that prevented some activities, and 0.31% or 3 respondents reported severe pain that prevented most activities.

3.2. Demographic Factors and Functional Health Status

Information was collected on the following demographic and socio-economic factors: age, race, education, occupation, gender, marital status, and household income.

Several statistical procedures were used to determine the association of these factors with a person's functional health status. They include analyses of variance (ANOVA) on the number of deficiencies and tests of homogeneity on the proportions of respondents on the levels of each attribute among different demographic groups [20]. Only the three major ethnic groups were used in statistical analyses with the racial factor because there were only 17 respondents of others races.

An ANOVA was first conducted on the number of deficiencies. The number of deficiencies is the number of attributes on which a respondent reported a functional level less than normal or higher than level 1. Table 5 displays the results of the analysis. A significant effect on the number of deficiencies, at the significance level of 1%, was detected for age, household income, and race.

Table 5. ANOVA for the Number of Deficiencies

Source of Variation	SS	DF	MS	F	p-value
Covariates	174.494	1	174.494	119.943	0.000
Age	174.494	1	174.494	119.943	0.000
Main Effects	123.823	23	5.384	3.701	0.000
Education	5.978	7	0.854	0.587	0.767
Gender	1.260	1	1.260	0.866	0.352
Income	29.097	6	4.849	3.333	0.003
Marriage	2.630	1	2.630	1.808	0.179
Occupation	10.478	6	1.746	1.200	0.304
Race	52.361	2	26.180	17.996	0.000
Explained	565.155	24	23.548	16.186	0.000
Residual	1251.132	860	1.455		
Total	1816.287	884	2.055		

A significant ageing effect is expected because of the human ageing process. Table 6 shows the percentage of respondents who reported perfect functioning (level 1) on each attribute in different age groups. It can be observed that the percentage of respondents with perfect functioning on each attribute decreases as age increases.

Some details of the results appear to be worthy of emphasis. The percentage of perfect functioning decreased at different rates and in different patterns for different attributes. This implies that the human ageing process acts differently on different attributes. This information is very important for the understanding of the health care needs of a population and the planning of health care services. In general, it seems that the functional health status on the "soft" attributes deteriorates faster than the functional health status on the "hard" attributes except vision. For the vision attribute, the percentage of perfect eye sight had two dramatic decreases: one at the schooling stage (8 to 24) and one at the late middle-age stage to early elderly stage (45 to 64). The functional deterioration on the other four "hard" attributes occurred mostly at the elderly stage (> 64).

Table 6. Percentage of Perfect Functioning for Various Age Groups

Age	Vision	Pain	Emo.	Cog.	Speak	Hear	Walk	Dext.
0 - 7	99.0	90.0	95.0	94.0	91.0	100.0	99.0	99.0
8 - 17	67.8	90.4	89.0	84.9	92.5	99.3	99.3	99.3
18 - 24	48.9	80.0	73.3	78.9	97.8	98.9	98.9	100.0
25 - 34	58.9	79.2	75.9	78.7	94.3	97.4	99.0	96.9
35 - 44	61.6	67.8	70.0	72.3	91.5	94.9	98.9	96.6
45 - 54	31.3	51.9	64.9	67.2	93.9	94.7	97.0	93.9
55 - 64	23.4	48.7	63.6	59.7	90.9	96.1	87.0	93.5
> 64	20.4	25.9	51.9	49.1	77.8	73.6	75.9	94.4

For the three major ethnic groups, Malay respondents reported a significantly lower average number of deficiencies (0.97) than the Chinese respondents (1.63) and the Indians respondents (1.65). This does not imply that one racial group is healthier than another because the number of deficiencies is not a measure of overall health. However, it is worthwhile to examine the functional status on each attribute for the three ethnic

groups. Table 7 shows the reported frequencies on the levels of each attribute by the three major ethnic groups.

A test of homogeneity was performed for each attribute, in which a level was combined to the next (higher) level if the expected frequency was less than 5. The reported proportions are significantly different, at the significance level of 1%, for the attributes of vision ($p < 0.0001$), feelings ($p < 0.0001$), cognition ($p = 0.0003$), and pain ($p < 0.0001$). For the vision attribute, the difference was due to the number of people wearing glasses or contact lens. The Chinese group had the highest proportion of respondents wearing glasses or contact lens, followed by the Indians and then the Malays. For the three "soft" attributes, Malay respondents reported consistently the highest percentage on level 1 among the three groups. Since the assessments on the three "soft" attributes were subjective, the detected differences might imply some difference in the perception of health among the three groups. Further research is needed to investigate this issue.

Table 7. Attribute Functional Status for the Three Ethnic Groups

Level	1	2	3	4	5	6	Total
Seeing							
Chinese	197(45.6)	221(51.2)	12(2.8)	2(.4)	0(.0)	0(.0)	432
Malay	198(67.1)	83(28.1)	9(3.1)	3(1.0)	2(.7)	0(.0)	295
Indian	133(56.1)	94(39.6)	4(1.7)	3(1.3)	3(1.3)	0(.0)	237
Hearing							
Chinese	409(94.7)	18(4.2)	3(.7)	2(.4)	0(.0)	0(.0)	432
Malay	285(96.6)	8(2.8)	0(.0)	1(.3)	1(.3)	0(.0)	295
Indian	230(97.0)	3(1.3)	1(.4)	2(.9)	0(.0)	1(.4)	237
Speaking							
Chinese	392(90.8)	32(7.4)	6(1.4)	1(.2)	1(.2)	N/A	432
Malay	275(93.2)	16(5.4)	4(1.4)	0(.0)	0(.0)		295
Indian	219(92.4)	12(5.1)	6(2.5)	0(.0)	0(.0)		237
Walking							
Chinese	414(95.8)	13(3.0)	3(.7)	2(.5)	0(.0)	0(.0)	432
Malay	290(98.3)	3(1.1)	1(.3)	1(.3)	0(.0)	0(.0)	295
Indian	226(95.4)	9(3.8)	2(.8)	0(.0)	0(.0)	0(.0)	237
Dexterity							

Chinese	423(97.9)	8(1.9)	0(.0)	0(.0)	1(.2)	0(.0)	432
Malay	288(97.6)	5(1.7)	0(.0)	2(.7)	0(.0)	0(.0)	295
Indian	223(94.1)	12(5.1)	2(.8)	0(.0)	0(.0)	0(.0)	237
Feelings							
Chinese	306(70.8)	110(25.5)	15(3.5)	0(.0)	1(.2)	N/A	432
Malay	256(86.8)	33(11.2)	4(1.3)	2(.7)	0(.0)		295
Indian	157(66.2)	67(28.3)	12(5.1)	1(.4)	0(.0)		237
Cognition							
Chinese	305(70.6)	62(14.4)	53(12.3)	10(2.3)	2(.4)	0(.0)	432
Malay	249(84.4)	27(9.2)	18(6.1)	1(.3)	0(.0)	0(.0)	295
Indian	172(72.6)	37(15.6)	19(8.0)	8(3.4)	1(.4)	0(.0)	237
Pain							
Chinese	304(70.4)	104(24.1)	22(5.1)	2(.4)	0(.0)	N/A	432
Malay	234(79.4)	52(17.6)	6(2.0)	3(1.0)	0(.0)		295
Indian	147(62.0)	56(23.6)	29(12.2)	2(.9)	3(1.3)		237

For the household income factor, Table 8 displays the reported percentage of perfect functioning on each attribute for different household income groups. A test of homogeneity was also performed on the proportions reported on the levels of each attribute. Significant differences, at the significance level of 1%, were detected for the attributes of vision ($p = 0.0001$), speaking ($p = 0.0004$), feelings ($p = 0.001$), cognition ($p = 0.008$), and pain ($p = 0.003$). In general, higher household income groups reported higher rates of vision deficiency. The reason for this phenomenon is not clear. It is felt that income and vision might be confounded with other factors such as education. For the other attributes, the lowest household income group ($< \$30,000$) reported the highest rate of deficiencies in speaking, cognition, and pain. We are not able to assess the causal relationship between physical health and income. In other words, it is not clear whether income improves a person's physical health or poor physical health is a barrier to high income. Nevertheless, a person's mental health does not show the same pattern. For the feelings attribute, no pattern of association was observed between income and happiness level. Rich people were not necessarily happier or less happy than others.

Table 8. Percentage of Perfect Functioning for Various Household Income Groups								
Income	Vision	Hear	Speak	Walk	Dex.	Emo.	Cog.	Pain
< 30K	61.7	95.5	87.3	96.6	96.9	73.9	68.3	64.9
30K-60K	56.6	95.8	94.8	97.6	97.2	74.8	79.7	78.0
60K-90K	50.3	95.3	91.9	99.3	98.0	77.2	77.2	70.5
90K-120K	44.6	98.2	100.0	91.1	98.2	83.9	78.6	73.2
120K-150K	43.6	97.4	100.0	100.0	100.0	71.8	87.2	87.2
150K-180K	22.2	88.9	88.9	88.9	100.0	88.9	77.8	77.8
> 180K	29.7	100.0	91.9	83.8	89.2	37.8	75.7	54.1

For the other demographic factors, tests of homogeneity detected no significant gender effect for any of the eight attributes. The marriage factor is confounded with the age factor because unmarried people were younger. Occupation had a significant effect only on vision ($p = 0.0011$), for which professionals reported a higher percentage of vision deficiency (wearing glasses or contact lens) than others. For the education factor, tests of homogeneity excluding pre-school children detected a significant effect on vision ($p < 0.0001$), speaking ($p = 0.004$), cognition ($p < 0.006$) and pain ($p = 0.01$). Table 9 displays the reported percentage of perfect functioning for different educational groups. In general, respondents with a university education reported higher percentage of wearing glasses or contact lens. However, respondents with low education reported more serious vision problems that were not correctable with glasses or contact lens. Respondents with little or no formal schooling also reported higher deficiency rate in speaking and cognition and higher level of pain.

Table 9. Percentage of Perfect Functioning for Various Educational Groups								
Education	Vision	Hear	Speak	Walk	Dex.	Emo.	Cog.	Pain
No/Lower Pri.	53.8	93.8	87.4	95.3	95.2	75.7	66.8	65.9
Primary	39.4	93.6	91.5	92.6	94.7	63.8	69.1	59.6
Lower Sec.	62.3	95.6	95.6	99.1	99.1	76.7	77.2	66.7
Secondary	49.8	94.0	89.2	94.4	96.9	69.2	71.3	70.3
Post Sec.	52.8	98.1	96.2	97.2	99.1	72.6	75.5	75.5
Diploma	46.7	100.0	98.3	98.3	93.3	76.7	78.4	75.0

Degree	31.8	97.8	96.6	100.0	97.7	69.3	85.2	73.9

4. Conclusion and Discussion

This study used a MAHSC system developed in Canada to assess the functional status of the Singaporean population. Little difficulty was encountered in adapting the system to Singapore except of language barriers. Respondents had little difficulty in choosing an appropriate functional level on each attribute. An assessment of the health status of the Singaporean population was obtained by a random sample. The results may help to better understand health care needs and plan health care services for the population.

According to the sampling results from this study, an ordinary Singaporean had a 32.93% chance of being in perfect health, a 16.11% chance of being in perfect health except for a need to wear glasses or contact lens, and a 50.96% chance of having some other deficiency on one or more attributes. These percentages are similar to results obtained from national health surveys in Canada and the United States. The respondents in our sample reported deficiencies on the eight attributes in the order of vision (45.31%), pain (28.98%), feelings (25.41%), cognition (24.59%), speaking (7.95%), hearing (4.09%), walking (3.47%) and dexterity (3.06%).

Statistical procedures were used to assess the relationship of demographic factors and a person's functional health status. Age was found to be the most important factor that affected an individual's health status. In particular, patterns in which a person's functional health status on each attribute was affected by age were

obtained. This type of information would be very important in planning health care services in meeting the demand of different age groups in a population.

Differences on other demographic factors were also identified. In general, there was some evidence that serious problems on the "hard" attributes of vision, hearing, speaking, walking and cognition were associated with low household income and educational level. Respondents with low household income and/or education also reported more problems in memory and thinking and pain.

There are some limitations of this study that should be noted. First, the observations reported in this paper were based on a random sample of less than 1,000 respondents. Although the sample was verified to be representative of the target population, the sample size is small particularly when the results are compared with results from other national health surveys. Second, the statistical analyses in this study are limited to identifying differences among different demographic groups. Since each factor was considered separately, it does not provide a complete analysis of the influence of different demographic factors on a person's functional status. A complete analysis is difficult because the level on each attribute is categorical. Finally, the study does not provide an analysis on the causal relationship between the demographic factors and a person's health status. For example, respondents with no or little education and low household income reported higher deficiency in the physical aspects of health as well as cognition and pain. But it is not clear if poor health is a cause of low social-economic level or vice versa. These issues are worth future research.

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