Multiple Chronic Diseases and Their Linkages with Functional health and Subjective Wellbeing among adults in the low-middle income countries: An Analysis of SAGE Wave1 Data, 2007/10

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Abstract

This paper examines the prevalence and determinants of multiple chronic diseases and their association with the self-rated health, functional health and quality of life among adults in six SAGE countries: China, India, Russia, South Africa Mexico and Ghana. We use ADL and IADL activities as measures of functional health and WHOQoL index as a measure of quality of life. Poisson regression models are estimated to understand the social determinants of multiple chronic diseases. Logit models and OLS are estimated to examine the association between multiple chronic morbidities and self-rated health, functional health and quality of life. Russia had the highest prevalence of multi-morbidity (32.8%, 95%CI=25.5-41.1) followed by South Africa (22%, 95%CI=17.7-26.9); the other four countries had prevalence of multi-morbidity around 21%. Measures of socioeconomic status: education and wealth were found negatively associated with the number of chronic diseases. Higher number of chronic conditions was associated with the poorer self rated health, functional health and WHOQoL.

Introduction

The present century is witnessing fundamental changes in its health and disease patterns due to rapid population ageing and epidemiological transition that ensues change from the predominance of parasitic and infectious diseases to chronic non communicable diseases among adult population (Omran, 1971; Joubert & Bradshaw, 2006). The onset of a chronic disease often leads to the simultaneous occurrence of various other health problems; therefore, with increasing longevity, multiple morbidities (defined as co-existence of two or more chronic diseases) become progressively common (Prados-Torres et al, 2012). Evidences from both developed and developing countries show that older adults are at higher risk for multiple chronic diseases(Gijsen et al., 2001; Khanam et al., 2011; Salisbury, Johnson, Purdy, Valderas, & Montgomery, 2011; Salive, 2013; van den Akker, Buntinx, Metsemakers, Roos, & Knottnerus, 1998; Walker, 2007).

Multiple morbidities have been proven to be associated with adverse health outcomes, such as, reduced physical functions (Fried et al., 1999; Kadam & Croft, 2007) and quality of life (Fortin et al., 2004), poor self rated health (Galenkamp et al., 2011; Hoeymans et al., 1999), increased use of inpatient and ambulatory health care (Wolff et al, 2002; Salisbury et al., 2007) and in worst cases to mortality (Gijsen et al., 2001). Verbrugge and colleagues (1989) were the first to demonstrate the exponential increase in disability with increasing numbers of chronic diseases. Also, the prevalence of multiple morbidities increases the complexities of clinical decision and patient management and is consequently associated with higher medical care costs (Barnett et al., 2012; Parekh & Barton, 2010). Therefore, people living with chronic and multiple chronic conditions often face higher out-of-pocket expenditure because of the need for longterm medical care. Overall, the rising prevalence of multiple morbidities and co-morbidities are known to raise the health care cost, add to the economic vulnerability of older adults and result in adverse effect

on their physical and mental wellbeing further exacerbated by socioeconomic deprivation and poor medical care facilities (Lehnert et al., 2011; Marengoni et al., 2011; Tu, 2004).

Given the pace of epidemiological transition and multiple effects of chronic diseases, various studies have evaluated the association of socioeconomic status (SES) with multiple morbidity and identified low level of education and poor economic status as risk factors (Khanam et al, 2011; Uijen & Van de, 2008; Schafer et al, 2012). Chandola et al. (2007) showed that physical health deteriorated more rapidly with age among persons from the lowest occupational grade. Schäfer et. al., (2012) analyzed the association for German population and concluded that lower SES lead to a greater extent of multi-morbidity. The ample literature on multi-morbidity is, however, largely riveted to the developed world with a focus on elderly population considering it as the problem of aged population. In the year 2012, Agborsangaya et. al. extended the studies of multi morbidity to adult population and revealed that 70% of the individuals with multi-morbidity belonged to less than 65 years of age group. There is still a virtual vacuum of studies focused on developing countries where the situation is more challenging with considerable burden of chronic conditions among adults younger than 60 years. At the same time, both demographic as well as epidemiological transition in the middle and low income countries are occurring at a much faster rate in a background of limited health care infrastructure. Second, these parallel transitions precede the progress in development and accumulation of wealth. The infectious and parasitic diseases are still a major concern but the increase in the prevalence of chronic diseases should not be overlooked. In general, there is limited awareness among these countries about the magnitude and consequences of non communicable diseases along with the limited capacity of the government to respond in a cost-effective manner with the existing health care system (Nugent, 2008). Therefore, this study based on adult population (aged 18 and above) of six low and middle income countries is an attempt to address these gaps.

The six countries, namely, India, China, Ghana, Russia, South Africa and Mexico are at different stages of the demographic and epidemiological transitions. These nations are increasingly experiencing a rise in elderly population (except Russia) which has serious implications for the burden of disease as this age group is the most susceptible group for various morbidities (Bloom et al., 2011b; Dey et al., 2012; Williams & Krakauer, 2011; National Sample Survey Organisation, 2006). China is on the track to meet its MDGs target but has experienced a notable shift towards the epidemic of chronic and non-communicable diseases (NCDs) (Tang et al., 2013). India, on the contrary, is still struggling with infectious and parasitic diseases with a considerable increase in the burden of chronic diseases (Bloom et al, 2013). Mexico has experienced a tremendous rise of 52% (from 23% to 75%) in the proportion of deaths from NCDs over a span of 50 years (Gonzalez et al, 2006). The government of Ghana though have recognized the growing burden of chronic disease since early 1990s; but it is yet to have a chronic disease policy or an integrated plan to deal with the issue (Bosu, 2012). The demographic changes in Russia in terms of increase in adult mortality and decline in life expectancy are mainly due to mortality from preventable causes including chronic diseases; still

there is a lack of comprehensive programs for the their prevention (Chenet et al, 1998; Leon & Shkolnikov, 1998; Notzon et al., 1998; Cockerham. 2000). South Africa is in the midst of a health transition characterized by a quadruple burden of communicable, non-communicable, perinatal and maternal, and injury-related disorders (Joubert & Bradshaw, 2006). The growing burden of NCDs demands concerted action from the government. Therefore, from this backdrop, the main objectives of this research work are: a) to examine the prevalence and determinants of multiple morbidities across the six SAGE countries; and b) to examine the association between multiple morbidities and other health conditions namely self-rated health, ADL, IADL and quality of life (WHOQoL) across the six SAGE countries.

Data Sources:

This study used the data from WHO-SAGE survey WAVE-1 for the analysis. SAGE is a longitudinal ageing study with nationally representative samples of adults from six countries: China, Ghana, India, Mexico, the Russian Federation and South Africa. Detailed description of study and sample design is provided in Kowal et al. (2012) (Kowal, Chatterji, Naidoo, Biritwum, & Wu, 2012).

Methods

Chronic conditions and multi-morbidity

In this study, Multi-morbidity is defined as the simultaneous presence of two or more chronic condition at the time of data collection. We have included eight chronic health conditions namely: arthritis, stroke, angina pectoris, diabetes mellitus, asthma, hypertension, chronic lung disease and visual acuity. Among these, for arthritis, angina pectoris, asthma, lung disease, SAGE survey provides two types of measures: first, is self reports of the diagnosis of individual diseases and second is the symptom based assessment of aforementioned diseases. The specific question asked in SAGE for self reports is: “Have you ever been diagnosed with/told that you have disease name? Thus, we have considered an individual as suffering from these diseases if he is found positive in the symptom based assessment. For, stroke and diabetes mellitus we have relied on the self reports of diagnosis and for hypertension and visual acuity, we have used objective assessment.

The measurement of hypertension is described as follows: In WHO-SAGE India 2007, three consecutive readings of blood pressure (systolic and diastolic both) have been taken. We have taken the mean of measured readings for each respondent to form a measure of blood pressure for both the indicators (systolic and diastolic). Further we have, classified hypertension according to the 1999 update of WHO/ISH guidelines for the management of hypertension. A summary of this update has been published in the Journal of Hypertension (ref: Journal of Hypertension. 2003 Nov; 21(11):1983-1992). Based on the abovementioned guideline, in this study, we have considered the limit of high systolic blood pressure to be 140mm/hg or above and

of diastolic blood pressure to be 90mm/hg or above. An individual is considered to be hypertensive if he/she is measured to have either systolic or diastolic hypertension.

Subjective health outcomes

Self rated health

Self rated health was asked on a five point scale: very good, good, moderate, bad, and very bad. For the convenience of analysis, we combined bad and very bad health categories as 'bad health' and rest into other (good health) to derive a dichotomized health variable. 'Bad health' is the outcome of interest in the analysis.

Functional health (ADL)

Limitations in the activities of daily living (ADL) are used to assess the functional limitation. SAGE-Survey collected data on ADLs based on self- reports about particular activities in the last 30 days on a five-point scale ranging from none to extreme difficulty. In this study, severe and extreme difficulties were combined to represent limitation in a particular activity. The ADLs include sitting, walking, standing-up, standing, climbing, crouching, picking up, eating, dressing, using toilet, moving around in home, transferring and concentrating for about 10 minutes.

Quality of Life

In SAGE QoL was assessed by asking respondents to rate their satisfaction with different domains of their lives (namely energy, money to meet needs, satisfaction with health, respondent himself, ability to perform activities of daily living, personal relationships, conditions of living place, life as a whole, and a five point scale of overall rating of quality of life) as well as rating their overall life satisfaction. Respondents were asked to respond on a five point scale ranging from very satisfied to very dissatisfied. A composite score was created by summing the responses across the different questions and rescaling the responses from 0-100 where a higher score indicated better quality of life.

Statistical Methods

The statistical analysis is carried out in two parts: first we have examined the correlates of multi-morbidity (2-plus chronic disease) and one-plus chronic disease. Secondly, we have examined the association of multiple chronic conditions with the four of subjective health outcomes namely: 1-plus ADL limitations, depression, self rated poor health and WHOQoL index.

Of the four measures of subjective health, 1-plus ADL limitations, depression, self rated poor health are binary outcome variables, therefore we have used the logit models to examine the association of chronic diseases with these indicators. The WHOQoL index is metric variable; therefore, we have used linear regressions. Further, all the regression are run on the pooled data from the six countries; therefore, the regression are estimated in the multilevel framework. Specifically, we have used *random intercept multilevel (three level) regressions*, where, country

formed the highest level, state/province of residence formed the second level and individuals were at the first level. The multilevel analysis is performed using MLwin version 2.29.

Results

This study analyzed the data on 42,489 individuals from WHO-SAGE wave-1 conducted in six middle-low income countries namely India, China, Ghana, Russia, South Africa and Mexico. Table1 presents the percentage distribution of the study population by socioeconomic and demographic characteristics from the six countries. Among the countries, Russia has the highest percentage of population aged 70 years and above (12.5%) while it is less than 10% for other countries. There are wide differentials among countries in the proportion of rural population ranging from 19% in Russia to 75% in India. The percentage of population with no schooling is highest in India (36.2) followed by Ghana (32.7) and lowest for Russia (0.3%). Similarly, the percentage of population with 10-plus years of schooling is highest for Russia (87%); whereas it is less than 30% for Ghana (29.4%), Mexico (25.7%) and India (26.8%). The study revealed considerable variations in the population distribution by wealth quintiles across the six countries. India and South Africa, however, reflected a fairly equitable distribution of adult population by wealth quintiles. The Chinese population depicted the largest heterogeneity in terms of household wealth as 10% of the adult population belonged to the household from the lowest wealth quintiles while 33% hail from the highest wealth quintiles.

[Table1 around here]

Table2 shows prevalence of any chronic disease, multi-morbidity (2-plus chronic diseases), 1-plus ADL limitation, depression, self rated poor health and mean WHOQoL index (higher value represents better quality of life) based on the pooled sample of the six SAGE countries. Overall, the prevalence of morbidity-defined as the presence of at least one of the eight chronic diseases-was 53.3% (95%CI= 51.8-54.7) and the prevalence of multi-morbidity-defined as the presence of atleast 2-plus chronic conditions -was 21% (95%CI=20.0-21.9). Among the six countries, Russia had the highest prevalence of multi-morbidity (32.8%, 95%CI=25.5-41.1) followed by South Africa (22%, 95%CI=17.7-26.9); the other four countries had prevalence of multi-morbidity around 21%. The prevalence of atleast one chronic disease was highest in South Africa (69.1%, 95%CI=61.9-75.5) followed by Ghana (61.8%, 95%CI=58.4-65.1) and lowest in India (50.6%, 95%CI=48.9-52.4). The consistent increase in the prevalence of both any morbidity (one disease) and multi-morbidity (two-plus disease) depicted the positive association with age where in 87% (95%CI= 84.7-88.4) of the population in the oldest age group (70-plus) had at least one chronic disease and 59% (95%CI=56.1-60.8) of them showed multi-morbidity. The measures of socioeconomic status - years of schooling and wealth quintiles- were negatively associated with the prevalence of morbidity and multi-morbidity with consistent decline in the prevalence by increasing levels of socioeconomic status. For example, prevalence of multi-morbidity and any one morbidity was 34% (95%CI=31.9-35.9) and 65% (95%CI=62.9-67.4) respectively among

adults with no schooling compared with 15% (95%CI =13.2-17.5) and 44% (95%CI =40.9-46.7) prevalence among adults with 10-plus years schooling (table2).

[Table2 around Here]

Further, overall prevalence of measures of subjective health namely 1-plus ADL limitation, depression, self rated poor health and mean WHOQoL from the pooled data of six countries was 14% (95%CI=13.2-14.8), 5.7% (95%CI=5.0-6.4), 11.6% (95%CI=10.9-12.4) and 54.4 (95%CI=53.9-4.9) respectively. The prevalence of all the measures of subjective health appeared to be positively associated with age, that is, the prevalence was higher in the higher age groups. Contrarily, socioeconomic status was negatively associated with ADL, depression and self rated poor health and positively associated with mean WHOQoL index. For example, the prevalence of: any ADL limitation was 34% (95%CI=31.4-35.9) in no schooling group *versus* 6.3% (95%CI=5.5-7.2) in 10+ years of schooling group; depression was 12% (95%CI=10.6-13.5) in no schooling group *versus* 3.7% (95%CI=2.9-4.6) in 10+ years schooling group; self rated poor health was 18.6% (95%CI=17.2-20.1) in no schooling group *versus* 5.2% (95%CI=4.4-6.2) in the 10+ years of schooling group and Mean WHOQoL index was 51 (95%CI=50.1-51.9) for no-schooling group *versus* 57.5 (95%CI=56.8-58.3) for 10+ years of schooling group. Similar patterns were observed for household wealth quintiles and such patterns point to the positive SES gradients of health. Results also depicted considerable cross country variations in the prevalence of 1+ADL, depression, self-rated poor health and Mean WHOQoL.

The results in table2 also presents the prevalence of 1-plus ADL limitation, depression and self rated health along with mean WHOQoL index among adults with different number of chronic conditions. The table shows that with increasing number of chronic conditions, measures of subjective health become worse. For instance, percentage of adult population with 1+ADL increased from seven percent (no disease) to 59% (atleast four diseases); depression increased by nine times (three percent for no disease vs 27% for four diseases); self reported poor health increased from six percent to 49% and the mean WHOQoL declined from 57 to 43.

We further examined the subjective health among those with one disease and multi-morbidity (2-plus diseases) across selected socioeconomic and demographic groups. The results summarized in Table3 reveal that compared with adults having one chronic disease, multi-morbid adults had remarkably high prevalence of 1-plus ADL limitation (31.8%, 95%CI=29.7-33.9 *vs*. 12.1%, 95%CI=11.1-13.2), depression (12.4%, 95%CI=11.0-13.9 *vs.* 4.9%, 95%CI=4.0-6.0), self rated poor health (26.1%, 95%CI=24.3-28.0 *vs.* 10.2%, 95%CI=9.0-11.6) and lower mean WHOQoL index (49.1, 95%CI=48.4-49.9 *vs.* 54.2, 95%CI=53.6-54.7). Results show wide cross-country variations in the prevalence of measures of subjective wellbeing among adults with one chronic disease and with two-plus disease (multi-morbid) with poorer subjective health outcomes for multi-morbid adults. The maximum variation was observed for 1+ADL and depression with India having the highest prevalence of both 1-plus ADL limitation and depression (53%,

95%CI=49.5-56.1 and 24%, 95%CI=21.3-26.5 respectively among multi-morbid and 26%, 95%CI=23.4-28.5 and 11%, 95%CI=9.2-14.1 among those with one disease).

[Table3 around here]

Overall, the prevalence of multi-morbidity resulted in poorer subjective health outcomes across all the socioeconomic and demographic groups. The measures of SES revealed positive gradients for all the subjective health outcomes among both the multi-morbid adults and adults with one disease. However, the strength of the gradient varied between both the groups and across the indicators (table3).

Correlates of chronic morbidity and multiple chronic morbidity

Table4 presents the results of multi-level random intercept binary regressions to examine the correlates of 1-plus chronic diseases, 2-plus chronic diseases and 3-plus chronic diseases respectively. The results show that age is significantly and negatively associated with the all the three outcomes. Females were more likely to suffer from 2-plus and 3-plus chronic diseases (OR=1.06; p-value<0.1 and OR=1.12, p-value<0.05 respectively). Rural residence is significantly positively associated for atleast one chronic disease; but, it is statistically significant and negatively associated with prevalence of 2-plus and 3-plus chronic diseases. The SES measured by years of schooling and household wealth quintiles show negative gradients with prevalence of all three outcomes. That is, the likelihood of one, 2-plus and 3-plus chronic diseases declined with the increasing levels of socioeconomic status. Among the health risk factors, obesity, high risk waist-hip ratio and low physical activity (inactivity) is associated with the higher prevalence of single and multiple chronic diseases.

Association of multi-morbidity with the subjective health outcomes

In this section, we describe the relationship between multiple morbidity and subjective health outcomes: 1-plus ADL limitation, depression, self-rated poor health and WHOQoL index. The analysis is performed in two steps. First, we examined the effects of absolute number of diseases on selected subjective health outcomes after adjusting for the social, demographic and health risk factors. In the next step, we examined the independent effects of each disease and each pair of diseases on each of the subjective health outcomes. The regressions are estimated in the multilevel framework.

The effects of increasing level of multi-morbidity (number of chronic diseases) on the subjective health outcomes (ADL, depression, self rated health and WHOQoL) are shown in table5. The table5 presents both adjusted (for control variables) and unadjusted estimates for each of health outcome. The results show that higher number of chronic diseases has a statistically significant effect on the subjective health outcomes which declines manifold with the increasing number of chronic diseases. Moreover, for each of the ADL limitations, depression and self rated poor health; the adjusted odds appear to be similar. Those with three chronic diseases are more than 4

times as likely to have 1-plus ADL, depression and poor self rated health as ones with no diseases. The WHOQoL index declines by 6 points for individuals with 3 chronic diseases compared with the individuals with no diseases. Compared with adults with no disease, those with 4 or more diseases are almost 7 times more likely to have 1-plus ADL limitations, depression and poor self rated health.

[Table5 around here]

Table6 presents the regression results showing association of diseases and disease pairs on each of the chronic diseases. The model1 in table6 shows effects of individual chronic diseases on subjective health outcomes after adjusting for the effects of other diseases and the control variables. The model 2 presents main effects as well as the interactions of the pairs of the chronic diseases. Results from model1 show that all the diseases except hypertension had statistically significant negative effects on the subjective health outcomes. For example, adults with arthritis are more than two times more likely to have 1-plus ADL and depression and 1.8 times more likely to report poor health. The effect on WHOQoL index is also negative where, WHOQoL index declined by 3 points among persons with arthritis. Other diseases like angina, lung diseases, low vision, diabetes and stroke showed similar negative effects on health outcomes.

[Table6 around here]

Results from the model2 shows that the main effects on the different subjective health outcomes for all the diseases except hypertension were significant and negative. That is, the subjective health is worse in the presence of chronic diseases. The main effects indicate the effect of each disease on a person suffering from none of the other conditions. The interaction estimates for pairs of diseases present a mixed picture as only few of the interactions emerged to be statistically significant and some of the interactions of disease pairs were positive, while, some were negative. A positive interaction (odds ratio greater than one in logit models of ADL limitations, depression and poor self rated health and negative coefficients in linear regressions for WHOQoL index) show that the combined effect of two diseases disease is more than the additive effect of each one of them individually; while a negative interaction (odds ratio less than one in logit models of ADL limitations, depression and poor self rated health and positive coefficients in linear regressions for WHOQoL index) indicates that the effect of the two diseases is less than the additive effect of each of them individually. The positive interactions show synergistic effects of the pair of diseases and the negative interactions show antagonistic effects. Regression results for one ADL limitations show that the interactions of hypertension-angina, hypertension-diabetes, arthritis-angina, arthritis-lung diseases, arthritis-asthma, arthritis-low vision, angina-lung diseases, angina-asthma and low vision-diabetes showed statistically significant interactions; of which the interaction of hypertension-diabetes was synergistic. For depression, the interactions of hypertension-angina, arthritis-angina, arthritis-lung diseases, angina-diabetes, lung diseases-asthma and low vision diabetes were statistically significant; but no synergistic interactions emerged. For, self rated poor health, hypertension-asthma, arthritis-

angina, arthritis-lung diseases, arthritis-asthma, angina-lung disease, angina-low vision, lung diseases-diabetes, asthma-diabetes and low vision-diabetes were statistically significant; out of these significant interactions only hypertension- asthma was synergistically associated with poor self rated health. Similarly for the WHOQoL index, hypertension-asthma, arthritis-angina, arthritis-lung disease, arthritis-asthma, arthritis-diabetes, angina-lung diseases, low vision-diabetes were and significant and hypertension-asthma showed synergistic interaction.

Discussion

In this study, we explored the prevalence and correlates of multi morbidity among adult population across six developing countries and its association with functional health and well being. In the first stage of analysis, the study measured the prevalence of multi-morbidity, 1+ morbidity, 1+ADL, depression, self rated poor health and mean WHOQoL score on the pooled sample of six countries. We assessed the change in measures of functional health and well being in the presence of one disease and 2+ morbidities. In the second stage, we estimated correlates of atleast one morbidity and multi-morbidity. In the last stage, we evaluated the effect of increasing number of diseases, individual diseases, namely arthritis, stroke, angina pectoris, diabetes mellitus, asthma, hypertension, chronic lung disease and visual acuity as well as the interaction effect of these diseases on functional limitation, depression, self rated health and quality of life using *random intercept multilevel (three level) regressions*.

Results reveal that more than half of the adults had at least one disease and around one fifth had two or more (multi-morbidity) diseases out of the eight chronic diseases. Among the six countries, Russia has the highest prevalence of multi morbidity which is one of the reasons for high adult mortality in the country (Cockerham, 2000). India has the highest prevalence of 1+ADL limitation and depression among its adult population. The study reflected a positive association of age with multi morbidity and measures of subjective well being; the increase in the number of chronic diseases is further positively associated with adverse functional health and poor quality of life. The issues of disabilities become prominent in old age than longevity (Fried et.al, 1999; Cutler, 2003) because people with functional limitation need constant care and support and are at an increased risk of being hospitalized (Melzer et.al, 1999).

The results reveal negative association of socioeconomic factors with the prevalence of chronic diseases which remains true for multiple morbidities, which is consistent with the findings of previous research work (Marengoni et.al, 2011; Schafer et.al, 2012; Agborsangaya et.al, 2012; Fried et.al, 1999). The prevalence of 1+ ADL limitation, depression and poor self rated health declines and WHOQol score increases with the improvement in the level of education and wealth status. The study presented an interesting finding as adults with multiple morbidities have poorer functional health and subjective well being as compared to adults with one chronic disease irrespective of their socioeconomic status.

The study further investigated the correlates of one chronic diseases, 2-plus chronic diseases and 3-plus chronic diseases. We replicate the results of Kirchberger et.al, 2012; Marengoni et.al, 2011; Schram et.al, 2008 and Agborsangaya et.al, 2012 to conclude that multi morbidity is significantly higher among older people, women and individuals of low socioeconomic status (measured in terms of years of schooling and household economic status). We further identified obesity, high risk waist-hip ratio and low physical activity as the risk factors for single and multiple chronic diseases.

This study makes an important contribution in the field of epidemiology by extending the analysis to examine the effect of multiple chronic diseases on functional health and quality of life among adult population, along with assessing the interaction effect of the eight selected chronic diseases. The study revealed that increase in number of chronic diseases leads to manifold increase in the functional impairments, depression and self rated poor health. The quality of life declines rapidly with increasing number of morbidities. Further, when we analyzed the interaction estimates according to the pair of eight chronic diseases, we found a very assorted picture. The interaction effect explains whether the effect of two diseases is more than or less than the additive effect of each disease individually. Only a few of the interactions were significant; some of them had synergistic effect, while others have antagonistic effect. Among all the pair of diseases, the interactions of hypertension with any of the chronic diseases have depicted significant association. The interaction effect of hypertension-diabetes is more than their additive effect on 1-plus ADL limitation. The pair of hypertension-asthma was synergistically associated with self rated poor health and WHOQoL index. The study did not find any significant synergistic interactions for depression.

The identification of these interaction effects of chronic diseases is essential for prevention and for planning optimum resource allocation. Chronic diseases tend to have multiple effects on an individual *viz-a-viz* from poor functional health and well being to increasing the vulnerability for various other morbidities as well as exerting a burden on financial resources. These findings can help in the aversion of chronic diseases and minimize the likelihood of second disease when a specific disease is already present. This study adds significantly to the literature in terms of revealing the vulnerability of adult population to multiple morbidities as well as the adverse effect of presence of one chronic disease and multiple morbidities on an individual. In developing countries, the health care financing and allocation of health care resources is a major challenge. The burden of chronic diseases is preventable and can be controlled if due attention is given to them and interventions are made on time.

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Table1: Characteristics of sample population from WHO-SAGE Wave1 Data

	India	China	Ghana	Mexico	Russia	South Africa	All Countries	Male (pooled)	Female (pooled)
N	11,230	14,813	5,110	2,756	4,355	4,225	42,489	18,327	24,144
Age Group									
18-49 (%)	75.2	74.2	75.4	73.6	58.7	75.9	70.7	71.8	69.5
50-59 (%)	12	11.6	9.8	12.7	18.7	12	14.6	14.5	14.7
60-69 (%)	7.7	8.2	6.8	6.8	10.2	7.4	8.4	8.2	8.6
70+ (%)	5.1	6	8.1	7	12.5	4.7	6.4	5.6	7.2
Sex									
Male (%)	50.9	50.9	50	48	45	47.2	50.7	-	-
Female (%)	49.1	49.1	50	52	55	52.8	49.3	-	-
Residence									
Urban (%)	25.5	48.5	45.8	77.8	81.5	69.3	44.6	44.0	45.2
Rural (%)	74.5	51.5	54.2	22.2	18.5	30.7	55.4	56.0	54.8
Marital status									
Never Married (%)	9.4	5.7	8.4	21.3	12.8	31	8.4	10.5	6.3
Currently Married /Cohabiting (%)	81.9	89	72.6	69.6	61.1	52.8	83.3	85.3	81.3
Widowed/Divorced /Separated (%)	8.7	5.3	19	9.1	26	16.1	8.3	4.2	12.4
years of schooling									
No schooling (%)	36.2	8.4	32.7	5.9	0.3	7.8	18.3	11.3	25.6
1-5 years (%)	17.6	16	9.6	20.2	2.4	15.1	16.2	15.6	16.9
6-9 years (%)	19.4	46.2	18.9	48.3	10.3	26.9	33.5	35.6	31.5
10+ years (%)	26.8	29.4	38.8	25.7	87	50.2	31.9	37.6	26.1
Wealth quintile									
Lowest (%)	20.6	9.8	15.3	16.5	12.7	18.9	14.3	14.5	14.1
Second (%)	21.2	15.9	17.9	23.3	12.8	19.5	17.9	17.7	18.0
Middle (%)	19.9	18.3	19.1	20.1	16.5	20.5	19.0	20.1	17.9
Fourth (%)	18.0	23.4	22.6	15.4	23.5	19.4	21.3	20.7	21.8
Highest(%)	20.2	32.6	25.2	24.6	34.5	21.8	27.6	27.0	28.2

All the percentages are weighted by sampling weights.

Table2: Mean number of diseases, Morbidity and Multi-morbidity prevalence (%) and measures of subjective wellbeing by background characteristics, WHO-SAGE Wave1

Background Variables	Mean Number of diseases	Multi-morbidity (%)	1+ morbidity (%)	1+ADL (%)	Depression (%)	Self rated poor health (%)	Mean WHOQoL
Age Group							
18-49	0.6 (0.6-0.6)	11.9 (10.9-13.0)	42.9 (41.0-44.7)	9.1 (8.2-10.0)	4.9 (4.2-5.7)	7.4 (6.5-8.5)	55.4 (54.9-55.9)
50-59	1.2 (1.2-1.2)	32.9 (31.3-34.6)	72.4 (70.6-74.1)	16.8 (15.5-18.3)	6.4 (5.1-7.9)	16.2 (15.0-17.5)	53.3 (52.8-53.8)
60-69	1.6 (1.6-1.6)	47.9 (46.3-49.6)	82.2 (80.9-83.5)	27.7 (25.9-29.6)	8.2 (7.2-9.3)	22.3 (20.6-24.1)	51.5 (50.8-52.3)
70+	1.9 (1.8-2.0)	58.5 (56.1-60.8)	86.6 (84.7-88.4)	44 (41.7-46.4)	9.6 (8.4-10.9)	33.6 (31.6-35.6)	49.2 (48.4-50.0)
Sex							
Male	0.8 (0.8-0.8)	18.4 (17.1-19.7)	52.5 (50.4-54.6)	10.1 (9.1-11.2)	4.7 (4.0-5.6)	10.1 (9.1-11.3)	55.1 (54.6-55.7)
Female	0.9 (0.9-0.9)	23.6 (22.4-24.9)	54.1 (52.3-55.9)	18 (16.8-19.2)	6.7 (5.9-7.5)	13.1 (12.2-14.1)	53.7 (53.1-54.2)
Residence							
Urban	0.8 (0.7-0.8)	19.3 (17.6-21.2)	49.9 (47.5-52.3)	10 (8.7-11.4)	5 (3.9-6.4)	8.4 (7.5-9.4)	55.5 (54.7-56.2)
Rural	0.9 (0.9-0.9)	22.2 (21.2-23.3)	56 (54.2-57.7)	17.2 (16.2-18.3)	6.2 (5.6-7.0)	14.2 (13.1-15.3)	53.5 (53.0-54.1)
Years of schooling							
No schooling	1.2 (1.1-1.2)	33.9 (31.9-35.9)	65.2 (62.9-67.4)	33.6 (31.4-35.9)	12 (10.6-13.5)	18.6 (17.2-20.1)	51 (50.1-51.9)
1-5 years	1 (1.0-1.1)	26.7 (24.5-29.1)	62.4 (59.7-65.0)	18.7 (16.5-21.1)	5.8 (4.7-7.2)	18.6 (16.2-21.2)	51.7 (50.9-52.5)
6-9 years	0.8 (0.7-0.8)	16.8 (15.4-18.3)	51.5 (49.0-53.9)	8.7 (7.6-9.9)	4.3 (3.5-5.4)	10.6 (9.2-12.2)	54.3 (53.7-54.9)
10+ years	0.7 (0.6-0.7)	15.2 (13.2-17.5)	43.7 (40.9-46.7)	6.3 (5.5-7.2)	3.7 (2.9-4.6)	5.2 (4.4-6.2)	57.5 (56.8-58.3)
Income quintile							
Lowest	1 (1.0-1.1)	27.5 (25.2-30.0)	59 (56.4-61.6)	24.2 (21.7-26.9)	8.5 (7.0-10.2)	19.4 (17.3-21.6)	48 (47.2-48.8)
Second	0.9 (0.8-1.0)	22.7 (20.8-24.7)	56.4 (53.3-59.4)	18.5 (16.5-20.6)	6.7 (5.6-8.0)	15 (13.3-16.8)	52.1 (51.4-52.8)
Middle	0.9 (0.8-0.9)	21.2 (19.1-23.4)	54.7 (50.8-58.5)	14.3 (12.8-16.0)	6.5 (5.4-7.8)	13.9 (12.3-15.6)	53.7 (53.0-54.5)
Fourth	0.9 (0.8-0.9)	20.9 (18.9-23.0)	55.6 (52.2-59.0)	11.1 (9.8-12.6)	5.2 (4.0-6.7)	10.2 (8.7-12.0)	55.6 (54.8-56.4)
Highest	0.7 (0.6-0.7)	16.2 (14.4-18.2)	45.5 (42.6-48.4)	7.6 (6.6-8.7)	3.5 (2.8-4.3)	4.9 (4.0-6.0)	58.7 (58.0-59.4)
Country							
India	0.8 (0.8-0.9)	20.8 (19.4-22.3)	50.6 (48.9-52.4)	26.2 (24.6-27.9)	11.6 (10.1-13.2)	10.9 (9.8-12.1)	53.7 (53.1-54.4)
China	0.8 (0.8-0.9)	19.7 (18.4-21.0)	54 (51.7-56.3)	5.6 (4.9-6.2)	1.6 (1.2-2.2)	12.5 (11.4-13.6)	54.9 (54.2-55.6)
Ghana	0.9 (0.8-1.0)	21.6 (19.0-24.6)	61.8 (58.4-65.1)	16.7 (14.7-18.9)	5.2 (4.0-6.7)	8.9 (7.4-10.8)	52.3 (51.4-53.1)

Mexico	0.8 (0.7-1.0)	21.2 (17.5-25.4)	52.4 (45.0-59.8)	19 (14.6-24.4)	9.3 (6.5-13.1)	6.9 (4.6-10.2)	55.3 (53.8-56.9)
Russia	1.2 (1.0-1.4)	32.8 (25.5-41.1)	57.9 (49.7-65.7)	11.6 (9.4-14.1)	4.9 (3.6-6.7)	11.3 (8.6-14.7)	53.5 (52.2-54.9)
South Africa	1 (0.9-1.1)	22 (17.7-26.9)	69.1 (61.9-75.5)	19.4 (14.9-24.9)	5 (2.5-9.9)	9.7 (7.0-13.3)	53.8 (51.7-55.8)
Number of diseases							
0				7.2 (6.3-8.2)	3.2 (2.6-4.0)	6 (5.0-7.1)	56.90215 (56.3-57.5)
1				12.1 (11.1-13.2)	4.9 (4.0-6.0)	10.2 (9.0-11.6)	54.17647 (53.6-54.7)
2				25.2 (22.8-27.7)	9.7 (8.2-11.6)	19.1 (17.1-21.1)	51.03618 (50.2-51.9)
3				37.7 (34.1-41.4)	12.7 (10.4-15.5)	35 (31.6-38.6)	46.71486 (45.6-47.8)
4+				58.6 (53.2-63.9)	27 (22.3-32.3)	49.4 (44.6-54.2)	42.97506 (41.6-44.3)
Total	**0.8 (0.8-0.9)**	**20.9 (20.0-21.9)**	**53.3 (51.8-54.7)**	**14 (13.2-14.8)**	**5.7 (5.0-6.4)**	**11.6 (10.9-12.4)**	**54.4 (53.9-54.9)**

Notes: % estimates are weighted by the pooled country weight and figures in the parentheses are the 95% confidence intervals.

Table3: Prevalence of 1+ADL limitations, Depression, Self rated poor health and Mean WHOQoL index among adults with one diseases and 2 or more diseases, WHO-SAGE Wave1

	1 disease				**2+ morbidity**			
	1+ ADL (%)	**Depression (%)**	**Self rated poor health (%)**	**Mean WHOQoL**	**1+ ADL (%)**	**Depression (%)**	**Self rated poor health (%)**	**Mean WHOQoL**
Age Group								
18-49	8.3 (7.0-9.7)	4.6 (3.6-5.8)	7.3 (5.7-9.4)	54.8 (54.1-55.5)	24.9 (21.1-29.0)	14.6 (11.8-17.9)	17.5 (13.8-21.9)	50.2 (48.9-51.4)
50-59	14.2 (12.6-15.9)	4.5 (3.2-6.4)	13.6 (12.1-15.2)	54 (53.3-54.6)	25.5 (23.1-28.1)	11.1 (9.2-13.3)	25.4 (23.1-27.8)	49.9 (49.1-50.6)
60-69	21.3 (19.1-23.6)	5.8 (4.6-7.4)	16 (14.2-18.0)	52.8 (52.0-53.6)	37.3 (34.4-40.2)	10.9 (9.5-12.4)	31.7 (28.9-34.6)	48.3 (47.5-49.2)
70+	37.5 (33.9-41.2)	9.1 (7.1-11.8)	26 (23.1-29.1)	49.6 (48.6-50.6)	49.6 (46.8-52.4)	10.4 (8.9-12.0)	40.8 (38.1-43.4)	46.7 (45.8-47.7)
Sex								
Male	8.4 (7.2-9.9)	3.6 (2.6-5.2)	8.2 (6.8-10.0)	55 (54.3-55.7)	26.3 (22.9-29.9)	11.7 (9.6-14.3)	24.3 (21.4-27.3)	49.7 (48.8-50.6)
Female	16.3 (14.8-18.1)	6.4 (5.3-7.6)	12.6 (10.6-14.8)	53.2 (52.4-54.0)	36.2 (34.1-38.5)	12.8 (11.2-14.5)	27.7 (25.7-29.7)	48.7 (47.7-49.6)
Residence								
Urban	8.5 (7.0-10.2)	4.7 (3.2-6.8)	6.4 (4.9-8.3)	55.2 (54.2-56.2)	26 (22.4-30.1)	11.4 (9.1-14.2)	23 (20.0-26.4)	49.9 (48.6-51.3)
Rural	14.8 (13.4-16.2)	5.1 (4.2-6.2)	13.1 (11.4-15.0)	53.4 (52.8-54.1)	35.8 (33.6-38.1)	13 (11.4-14.7)	28.3 (26.2-30.5)	48.6 (47.7-49.4)
years of schooling								

No schooling	31.3 (28.1-34.7)	11 (8.9-13.5)	15.2 (13.4-17.3)	51 (50.2-51.9)	48.5 (45.4-51.6)	16.8 (14.8-18.9)	30.7 (28.5-33.0)	46.7 (45.9-47.6)
1-5 years	15 (12.1-18.3)	4.4 (3.0-6.3)	15 (11.0-20.1)	52.9 (51.7-54.0)	35.8 (31.8-40.1)	11.4 (8.7-14.8)	32.4 (29.0-35.9)	48.7 (47.4-50.0)
6-9 years	7 (5.6-8.6)	3.7 (2.5-5.4)	9.1 (7.1-11.6)	54.2 (53.1-55.3)	22 (17.8-26.8)	9.2 (6.8-12.4)	27 (22.4-32.2)	49.2 (48.0-50.4)
10+ years	5 (3.9-6.5)	3.1 (2.0-4.7)	5.3 (3.8-7.3)	56.8 (55.9-57.8)	18.2 (14.8-22.3)	11.1 (8.2-14.9)	13.8 (11.3-16.8)	52.5 (50.9-54.1)
Wealth quintile								
Lowest	22.7 (19.2-26.5)	7.1 (4.9-10.2)	16.8 (14.0-20.1)	48.4 (47.1-49.6)	41.5 (37.5-45.6)	15.1 (12.4-18.3)	36.1 (32.3-40.2)	43.4 (42.2-44.7)
Second	16.1 (13.4-19.3)	6.1 (4.6-8.0)	11.8 (8.9-15.3)	52.3 (51.2-53.4)	35.4 (31.4-39.5)	13.1 (10.8-15.9)	29.3 (25.6-33.4)	47.7 (46.6-48.8)
Middle	10.8 (8.9-13.0)	5.1 (3.6-7.2)	12.2 (9.6-15.5)	54 (52.9-55.1)	35.6 (31.4-40.0)	14.1 (11.0-18.0)	30.2 (26.6-34.0)	48.6 (47.3-50.0)
Fourth	9 (7.4-10.9)	5 (3.1-8.2)	9.9 (7.4-13.2)	54.7 (53.6-55.9)	25.5 (21.7-29.7)	10 (7.4-13.3)	21.2 (18.3-24.4)	51.5 (50.2-52.9)
Highest	7 (5.7-8.5)	2.6 (1.8-3.8)	4.2 (2.9-5.9)	58.5 (57.6-59.4)	22.8 (18.5-27.8)	10.1 (7.4-13.5)	15.8 (11.2-21.7)	53.4 (51.5-55.2)
Country								
India	25.9 (23.4-28.5)	11.4 (9.2-14.1)	9.6 (8.2-11.1)	53.8 (53.1-54.6)	52.8 (49.5-56.1)	23.8 (21.3-26.5)	23.8 (21.3-26.4)	48.1 (47.2-49.0)
China	3.9 (3.2-4.7)	1 (0.5-1.9)	11.2 (9.4-13.4)	54.6 (53.7-55.4)	17.1 (14.7-19.9)	4.7 (3.3-6.7)	29.2 (26.3-32.2)	49.9 (48.6-51.1)
Ghana	15.3 (12.5-18.6)	4.1 (2.7-6.2)	6.8 (4.8-9.5)	53.5 (52.2-54.8)	30.8 (26.0-36.1)	10.7 (7.8-14.7)	16.9 (13.4-21.1)	46.3 (44.5-48.0)
Mexico	23.3 (14.6-35.1)	9.8 (5.8-15.8)	6.7 (3.5-12.6)	52.7 (49.4-55.9)	35.6 (27.5-44.6)	17.1 (10.3-27.0)	19.1 (12.0-29.0)	50.7 (48.1-53.4)
Russia	8.1 (4.9-13.1)	3.8 (1.9-7.5)	8.1 (4.6-14.0)	52.5 (50.5-54.5)	26.9 (21.3-33.4)	8.8 (6.1-12.5)	23 (18.4-28.3)	49.3 (47.1-51.5)
South Africa	10.2 (6.8-14.9)	3 (1.4-6.4)	5.3 (2.8-9.6)	55.1 (53.0-57.2)	46.9 (37.1-57.0)	6.9 (4.3-10.8)	20.2 (14.4-27.5)	45.3 (40.3-50.4)
Total	**12.1 (11.1-13.2)**	**4.9 (4.0-6.0)**	**10.2 (9.0-11.6)**	**54.2 (53.6-54.7)**	**31.8 (29.7-33.9)**	**12.4 (11.0-13.9)**	**26.1 (24.3-28.0)**	**49.1 (48.4-49.9)**

Figure1: Percentage distribution of sample population by number of chronic diseases across countries (Panel A) and across broad age groups (Panel B), WHO-SAGE Wave1 2007

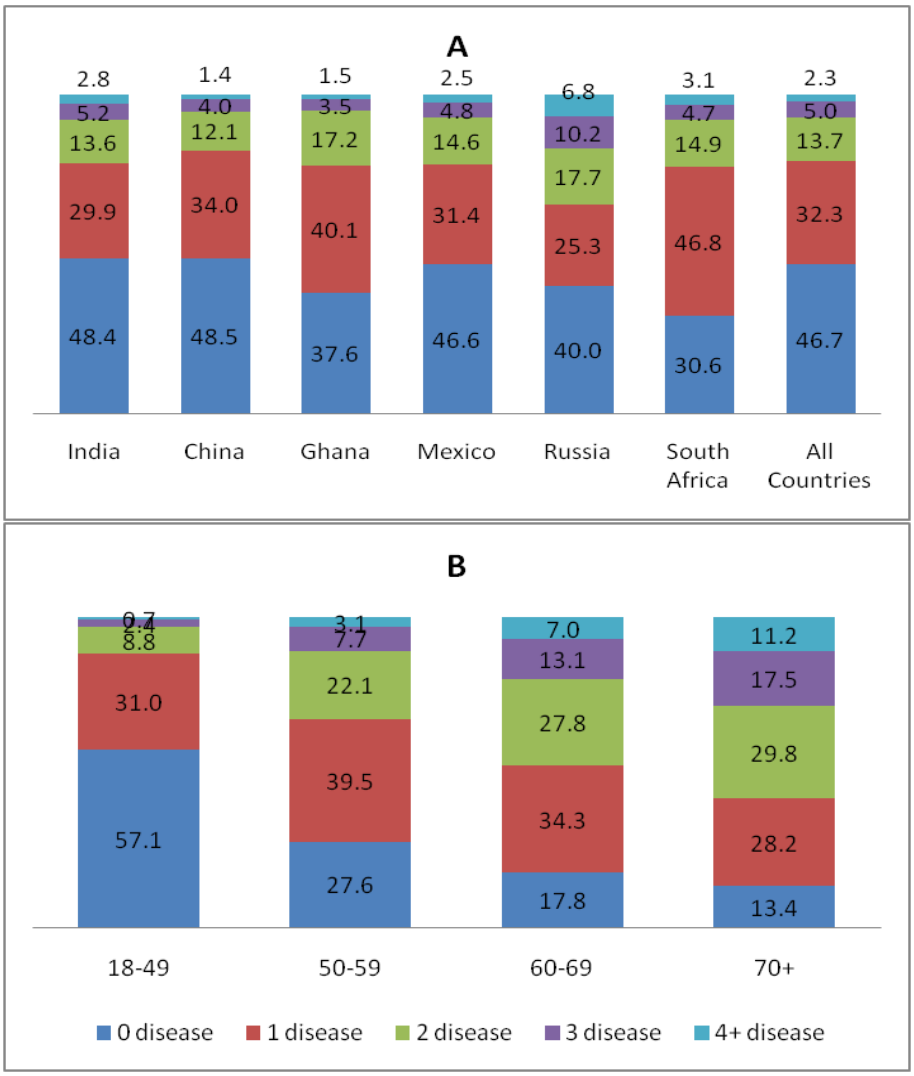

Table4: Correlates of at least one morbidity and multimorbidity (2+morbidity & 3+multimorbidity)

Predictors	1+ Disease	2+ disease	3+ disease
	OR	OR	OR
Age			
18-49			
50-59	3.25***(3.04-3.47)	3.12***(2.88-3.37)	3.18***(2.75-3.66)
60-69	5.33***(4.91-5.76)	5.24***(4.83-5.7)	5.91***(5.1-6.82)
70+	7.55***(6.81-8.29)	7.53***(6.9-8.26)	8.4***(7.17-9.75)
Sex			
Male			
Female	0.99(0.91-1.07)	1.06*(0.99-1.14)	1.12**(1.02-1.21)
Residence			
Urban			
Rural	1.05*(0.98-1.11)	0.96*(0.91-1.01)	0.85***(0.79-0.9)
Marital Status			
Never Married			
Currently	1.51***(1.33-1.7)	1.31***(1.14-1.47)	1.49***(1.26-1.75)
Widowed/Divirced	1.78***(1.56-2.03)	1.45***(1.26-1.64)	1.62***(1.36-1.9)
Years of schooling			
No Schooling			
1-5 years	0.93**(0.86-1.01)	0.93**(0.87-1)	1.02(0.93-1.11)
6-9 years	0.76***(0.7-0.82)	0.81***(0.76-0.87)	0.86**(0.78-0.95)
10+ years	0.61***(0.55-0.66)	0.64***(0.6-0.69)	0.66***(0.59-0.74)
Wealth Quintile			
Lowest			
Lower	1.04(0.95-1.13)	0.97(0.9-1.04)	0.89**(0.81-0.98)
Middle	1.07*(0.98-1.17)	0.96(0.89-1.03)	0.93*(0.84-1.02)
Higher	0.96(0.87-1.04)	0.89***(0.82-0.95)	0.85***(0.77-0.94)
Highest	0.92**(0.84-1.01)	0.82***(0.76-0.89)	0.73***(0.66-0.81)
Waist-hip ratio			
High risk	1.25***(1.16-1.34)	1.25***(1.17-1.32)	1.2***(1.11-1.28)
Otherwise			
Body Mass Index			
Obese	1.75***(1.58-1.94)	1.59***(1.48-1.71)	1.65***(1.51-1.8)
Otherwise			
Physical Activity			
Active			
Inactive	1.09**(1.02-1.16)	1.13***(1.07-1.19)	1.24***(1.17-1.32)
Daily Tobacco			
No			
Yes	1.01(0.94-1.08)	0.99(0.93-1.06)	1.01(0.93-1.09)
Alcohol Consumption			
No			
Yes	1.13**(1.03-1.23)	1.04(0.96-1.12)	0.95(0.85-1.07)
cons	0.74**(0.52-1)	0.14***(0.1-0.21)	0.03***(0.02-0.05)
Random Part			
Country level variance	0.13(0.01-0.52)	0.2(0.04-0.7)	0.52(0.1-1.89)
Province level variance	0.18(0.12-0.28)	0.18(0.11-0.26)	0.14(0.09-0.22)

Table5: Multilevel Logit Model to examine the effects of count of disease on the measures of subjective health, SAGE wave 1

Number of chronic diseases	ADL		Depression		SRH		WHOQoL	
	Unadjusted OR	Adjusted OR	Unadjusted OR	Adjusted OR	Unadjusted OR	Adjusted OR	Unadjusted beta	Adjusted beta
No disease								
1 disease	2.07*** (1.93-2.22)	1.51*** (1.38-1.65)	1.77*** (1.57-2.01)	1.62*** (1.42-1.84)	1.9*** (1.74-2.08)	1.5*** (1.35-1.65)	-4.26*** (-4.58--3.94)	-1.28*** (-1.59--0.98)
2 disease	4.08*** (3.78-4.39)	2.47*** (2.26-2.72)	2.8*** (2.48-3.18)	2.44*** (2.14-2.82)	3.38*** (3.09-3.69)	2.25*** (2.03-2.5)	-7.38*** (-7.73--7.03)	-3.11*** (-3.46--2.77)
3 disease	7.28*** (6.66-7.92)	3.81*** (3.42-4.26)	4.74*** (4.12-5.46)	4.05*** (3.47-4.75)	6.33*** (5.71-6.98)	4.03*** (3.59-4.5)	-10.74*** (-11.19--10.28)	-5.79*** (-6.23--5.35)
4+ disease	15.18*** (13.58-16.83)	7.21*** (6.33-8.17)	8.75*** (7.53-10.12)	7.33*** (6.24-8.61)	12.3*** (10.99-13.71)	7.38*** (6.43-8.38)	-14.6*** (-15.16--14.03)	-8.93*** (-9.48--8.38)
Country	0.69 (0.17-2.36)	1.24 (0.3-4.24)	0.73 (0.16-2.52)	0.73 (0.16-2.52)	0.16 (0.03-0.55)	0.3 (0.07-0.97)	7.41 (-1.93-16.76)	5.99 (-1.24-13.22)
Province/state	0.24 (0.16-0.35)	0.3 (0.21-0.44)	0.43 (0.28-0.64)	0.43 (0.28-0.64)	0.17 (0.11-0.24)	0.21 (0.14-0.3)	8.57 (5.68-11.46)	3.99 (2.49-5.49)
Individual	na	na	na	na	na	na	163.83 (161.6-166.0)	120.68 (118.9-122.4)

Notes: * p<.1, ** p<.05, *** p<.01; Figures in the parentheses are 95% credible intervals; Adjusted ORs are controlled for the effects of background characteristics and health risk factors. na= not applicable. Estimates are obtained through MCMC algorithm available in the MLWin.

Table6: Multi level regression estimates showing the effects of combinations of chronic diseases on measures of subjective health (1+ADL limitation, Depression, SRH and WHOQoL index), SAGE wave 1

	ADL		Depression		SRH		WHOQoL	
	OR (95% CI)		OR (95% CI)		OR (95% CI)		Beta coefficient (95% CI)	
	Model1	Model2	Model1	Model2	Model1	Model2	Model1	Model2
Main Effects								
Arthritis	2.15*** (1.99-2.32)	2.75*** (2.43-3.12)	2.06*** (1.85-2.28)	2.54*** (2.13-3.03)	1.84*** (1.7-1.99)	2.28*** (1.98-2.61)	-2.96*** (-3.28--2.64)	-3.69*** (-4.24--3.13)
Angina	2.15*** (1.96-2.34)	2.74*** (2.35-3.2)	1.98*** (1.76-2.21)	2.89*** (2.32-3.56)	2.15*** (1.97-2.35)	2.66*** (2.25-3.11)	-3.49*** (-3.87--3.09)	-3.79*** (-4.47--3.11)
Lung Disease	2.02*** (1.8-2.25)	2.48*** (2.03-3.04)	2.14*** (1.86-2.44)	2.28*** (1.73-2.98)	2*** (1.79-2.22)	2.8*** (2.23-3.42)	-2.74*** (-3.21--2.26)	-3.36*** (-4.25--2.48)
Asthma	1.5*** (1.31-1.72)	1.84*** (1.4-2.39)	1.71*** (1.45-2)	2.24*** (1.58-3.07)	1.57*** (1.35-1.79)	1.72*** (1.25-2.29)	-2.61*** (-3.2--2.02)	-3.18*** (-4.35--1.99)
Hypertension	1.04 (0.97-1.11)	1.05 (0.95-1.16)	0.98 (0.88-1.08)	1.09 (0.93-1.26)	1.05 (0.98-1.13)	1.02 (0.92-1.15)	0.01 (-0.25-0.26)	0.02 (-0.32-0.38)
Low vision	1.28*** (1.19-1.36)	1.33*** (1.19-1.47)	1.23*** (1.11-1.35)	1.25** (1.07-1.45)	1.19*** (1.11-1.28)	1.26*** (1.11-1.43)	-0.89*** (-1.15--0.62)	-0.94*** (-1.35--0.53)
Diabetes	1.31*** (1.16-1.47)	1.38** (1.07-1.76)	1.16** (0.97-1.35)	1.51** (1.08-2.06)	1.83*** (1.61-2.07)	2.29*** (1.79-2.88)	-2.26*** (-2.77--1.74)	-3.4*** (-4.36--2.42)
Stroke	2.4*** (1.99-2.86)	2.36*** (1.97-2.81)	2.21*** (1.75-2.73)	2.17*** (1.73-2.7)	2.22*** (1.86-2.62)	2.18*** (1.83-2.57)	-4.28*** (-5.08--3.5)	-4.25*** (-5.04--3.47)
Twoway Interactions								
Hypertension×Arthritis		0.96 (0.83-1.11)		1.02 (0.83-1.23)		0.92 (0.79-1.06)		0.28 (-0.36-0.92)
Hypertension×Angina		0.84** (0.7-0.99)		0.63*** (0.5-0.79)		1.03 (0.87-1.22)		0.04 (-0.71-0.78)

Hypertension×Lung disease		0.93 (0.75-1.17)		1.05 (0.8-1.36)		0.93 (0.76-1.15)		-0.1 (-1.05-0.84)
Hypertension×Asthma		1.02 (0.77-1.32)		1.01 (0.72-1.37)		1.53*** (1.16-1.99)		-1.07** (-2.28-0.16)
Hypertension×low vision		1.06 (0.93-1.21)		1.01 (0.84-1.22)		1.03 (0.89-1.19)		0.02 (-0.49-0.55)
Hypertension×diabetes		1.25** (0.98-1.57)		1.11 (0.79-1.53)		1.12 (0.87-1.41)		-0.37 (-1.4-0.64)
Arthritis×angina		0.78*** (0.65-0.92)		0.64*** (0.51-0.81)		0.79** (0.67-0.93)		0.69** (-0.09-1.5)
Arthritis×Lung disease		0.73** (0.57-0.9)		0.84* (0.64-1.08)		0.82** (0.66-1.03)		1.17** (0.11-2.2)
Arthritis×Asthma		0.8* (0.59-1.05)		0.83 (0.59-1.14)		0.73** (0.54-0.95)		1.34** (0.05-2.64)
Arthritis×Low vision		0.82** (0.7-0.94)		0.99 (0.81-1.22)		0.95 (0.82-1.11)		0.14 (-0.5-0.78)
Arthritis×Diabetes		0.95 (0.73-1.21)		0.88 (0.61-1.23)		0.87 (0.67-1.1)		1.56** (0.39-2.73)
Anginax×Lung disease		0.86* (0.69-1.06)		1.17 (0.88-1.52)		0.78** (0.63-0.95)		0.72* (-0.32-1.75)
Anginax×Asthma		0.81* (0.6-1.06)		0.85 (0.61-1.13)		0.86 (0.65-1.1)		0.71 (-0.56-1.99)
Anginax× Low vision		0.99 (0.83-1.16)		1.05 (0.84-1.28)		0.9* (0.75-1.05)		-0.43 (-1.19-0.33)
Anginax×Diabetes		0.92 (0.69-1.22)		0.79* (0.54-1.11)		0.96 (0.73-1.24)		-0.03 (-1.3-1.23)
Lung disease ×Asthma		0.86 (0.65-1.12)		0.76** (0.54-1.02)		0.9 (0.68-1.17)		0.54 (-0.69-1.77)
Lung diseasex×Low vision		1.1 (0.88-1.35)		0.99 (0.76-1.28)		0.92 (0.75-1.12)		-0.3 (-1.26-0.64)
Lung diseasex×Diabtes		1.05 (0.74-1.48)		1 (0.66-1.45)		0.67** (0.47-0.91)		0.39 (-1.23-1.97)
Asthmax×Low vision		1.04 (0.78-1.36)		1.06 (0.77-1.45)		1 (0.76-1.31)		-0.08 (-1.25-1.15)
Asthmax×Diabetes		1.31 (0.81-2.02)		1.32 (0.77-2.07)		0.65** (0.41-0.99)		1.26 (-0.79-3.32)
Low vision×Diabetes		0.74** (0.57-0.92)		0.7** (0.5-0.95)		0.85* (0.66-1.06)		1.73*** (0.71-2.73)
Random Part								
Country	1.04 (0.24-3.56)	0.97 (0.21-3.31)	0.8 (0.17-2.89)	0.85 (0.18-3.02)	0.26 (0.05-0.91)	0.25 (0.05-0.84)	9.71 (2.18-34.24)	10.38 (2.35-35.84)
Province	0.3 (0.2-0.43)	0.3 (0.2-0.43)	0.41 (0.25-0.63)	0.39 (0.24-0.62)	0.21 (0.14-0.31)	0.21 (0.14-0.31)	3.66 (2.47-5.27)	3.67 (2.49-5.34)
Individual	na	na	na	na	na	na	116.5 (114.7-118.4)	116.4 (114.5-118.2)

Notes: * p<.1, ** p<.05, *** p<.01; Figures in the parentheses are 95% credible intervals; Adjusted ORs are controlled for the effects of background characteristics and health risk factors. na= not applicable. Estimates are obtained through MCMC algorithm available in the MLWin.