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Determinants and Functional Impact of Nutritional Status Among Older Persons in Rural Bangladesh

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Abstract
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Background: Malnutrition is a major problem in Bangladesh. One third of the population in Bangladesh is malnourished, but figures for older persons specifically are scant.

Aims: This thesis describes the nutritional status of individuals aged 60+ years, living in a rural community in Bangladesh, with particular focus on the impact of demographic, health and social factors on nutritional status. A main aim is to examine the magnitude of malnutrition in this population. Second, the thesis focuses on the impact of demographic, health and social factors on nutritional status. Third, this thesis also aims to investigate the influence of nutritional status on functional abilities.

Methods: A cross-sectional study of people aged 60+ years was conducted in Matlab, a rural area in Bangladesh during 2003-2004. Data were obtained through home interviews, clinical examination and cognitive tests. Nutritional status was assessed using a modified form of the Mini Nutritional Assessment. Physical function was measured by self-reported and performance-based instruments. Cognitive function was assessed using general and specific cognitive tasks. A total of 850 individuals were randomly selected for the purpose of the study, of which 625 participated in the home interviews and 473 underwent clinical examinations and cognitive tests. Information on complete nutritional status was available for 457 individuals.

Results: About 26% of older people living in a rural community in Bangladesh were malnourished and 62% were at risk of malnutrition (Studies I-IV). Self-reported health problems (Study I), physician's diagnoses (Study II), food expenditure (Study I), literacy (Studies I, II), personal income (Study II), female gender (Studies I, II) and financial support (Study II) were significantly associated with nutritional status. Health indicators accounted for the largest variations in nutritional status compared to demographic and socio-economic indicators (Studies I, II). Nutritional status was directly associated with self-reported and performance-based physical functions (Study III), as well as general and specific cognitive functions (Study IV).

Conclusion: In low income countries, nutritional status of older persons needs to be addressed both from a health and a socio-economic perspective. Good nutritional status is essential for older persons to be functionally active, both physically and cognitively.

Keywords: Nutritional status, Mini Nutritional Assessment, older persons, community living, poverty, physical function, cognitive function, low-income country, Bangladesh.

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To my parents

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I Kabir, Z.N., Ferdous, T., Cederholm, T., Khanam, M.A., Streatfield, K., Wahlin, Å. (2006) Mini Nutritional Assessment of rural elderly people in Bangladesh: the impact of demographic, socio-economic and health factors. *Public Health Nutrition*, 9 (8): 968-974.

II Ferdous, T., Kabir, Z.N., Wahlin, Å., Streatfield, K., Cederholm, T. (In press) The multidimensional background of malnutrition among rural older individuals in Bangladesh – a challenge for the Millennium Development Goal. *Public Health Nutrition*, doi:10.1017/S1368980009005096.

III Ferdous, T., Cederholm, T., Razzaque, A., Wahlin, Å., Kabir, Z.N. (2009) Nutritional status and self-reported and performance-based evaluation of physical function of elderly persons in rural Bangladesh. *Scandinavian Journal of Public Health,* 37(5): 518-524.

IV Ferdous, T., Cederholm, T., Kabir, Z.N., Hamadani, J.D., Wahlin, Å. Nutritional status and cognitive function in community living rural Bangladeshi older adults: Data from the Poverty and Health in Ageing project. *Manuscript submitted for publication.*

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Contents

Abbreviations

ADL	Activities of Daily Living
BAMSE	Bangla Adaptation of Mini-Mental State Examination
BBS	Bangladesh Bureau of Statistics
BMI	Body Mass Index
DSS	Demographic Surveillance System
ESPEN	European Society for Clinical Nutrition and Metabolism
FAO	Food and Agricultural Organization
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
ICF	International Classification of Functioning, Disability and Health
ICIDH	International Classification of Impairments, Disabilities and Handicaps
IPHN	Institute of Public Health Nutrition
MDG	Millennium Development Goal
MMSE	Mini Mental State Examination
MNA	Mini Nutritional Assessment
MUAC	Mid Upper Arm Circumference
MUST	Malnutrition Universal Screening Tool
NRS-2002	Nutritional Risk Screening-2002
PHA	Poverty and Health in Ageing
PRB	Population Reference Bureau
SPSS	Statistical Package for the Social Sciences
SRQ 20	Self-Reporting Questionnaire 20 items
UNDP	United Nations Development Programme
WFB	World Fact Book
WHO	World Health Organization
WFP	World Food Programme
WHOSIS	World Health Organization Statistical Information System

Introduction

Definition of malnutrition

There is no universally accepted definition of malnutrition [1]. The World Health Organization (WHO) defines malnutrition as "the cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions"(p.10) [2]. Hickson [3] defined malnutrition as the "state of being poorly nourished" (p.4), which can be caused by lack of one or more nutrients (e.g., proteins, vitamins, fats) known as undernutrition, or an excess of nutrients identified as overnutrition. The European Society for Clinical Nutrition and Metabolism (ESPEN) defines malnutrition as "a state of nutrition in which a deficiency or excess (or imbalance) of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (body shape, size and composition) and function, and clinical outcome" (p.182) [4]. Malnutrition can be explained by an imbalance between nutrient intake and nutrient requirements over time [5]. The balance can be either positive leading to over- or negative, i.e. undernutrition. In this thesis, malnutrition will refer to the state of undernutrition.

Prevalence of malnutrition among older persons

The prevalence of malnutrition varies with the population studied and the criteria used to define malnutrition. It is estimated that 25-60% of hospital admitted older persons in high-income western countries are either malnourished or at risk of malnutrition [6, 7]. The prevalence varies between 38-62% in institutionalized older persons [8, 9], 15-36% living in service flats or community residential homes [10-12] and 4-14% in community living older persons [13-15].

Corresponding data from Asia varies in a similar fashion. The prevalence of malnutrition and at risk of malnutrition among frail older persons in Japan, are between 19% and 58%, respectively [16]. Self-assessment data on individuals' nutritional status indicated that, 22-59% of older individuals in Taiwan were either malnourished or at risk of malnutrition [17]. Two thirds of Indian older adults had a body mass index (BMI) <18.5 kg/m^2 [18]. In Malaysia, 68% of older adults are classified as having mild to moderate malnu-

trition according to the Subjective Global Assessment [19]. In Singapore, 30% of community-dwelling older persons are at nutritional risk [20]. In a Chinese study the prevalence of malnutrition was 8%, whereas 36% of the community living older Chinese were reported to be at risk of malnutrition [21].

Malnutrition is especially prevalent in low-income countries. It is estimated that one third of the population, including infants, children, adolescent, adults, and older persons suffer from malnutrition [22]. The prevalence varies between 23-39% in Tanzania [23]. A recent study [24] reports that almost half of older Africans in sub-Saharan Africa are malnourished. Interestingly, these findings in community living older adults are comparable with findings from older people in hospitals or sheltered housing in high-income countries.

Assessment of nutritional status

Malnutrition is a common but frequently under-diagnosed condition among older persons [25]. Almost 60% of malnourished cases in hospital are found to be under-diagnosed [26] i.e. their state of undernutrition is not detected. Given the fact that there is no gold standard to evaluate nutritional status, it is difficult to determine the exact prevalence of undernutrition. Also due to the lack of agreement on how to define undernutrition [1], there are a number of different methods and screening tools available to evaluate nutritional status of older individuals. Most of these assessment and screening methods include anthropometric variables, weight history, estimation of food intake [27], and in some cases analyses of biochemical markers [28].

Weight, height, and the calculation of BMI are the most commonly used anthropometric variables to assess malnutrition among older persons in nutritional research studies [7, 29-31]. However, BMI has several limitations in terms of usefulness in older populations. Both weight and height decrease with increasing age, but the reductions are not always parallel [32]. Longitudinal studies have shown an age related decline in body mass and body fat after age 70 years [33]. Sarcopenia, i.e. loss of lean body mass, occurs especially with aging [34], and is more pronounced than the loss of total body mass [35]. BMI is insensitive to the difference between fat and lean body mass [36], and therefore the use of BMI to identify malnutrition has been questioned. Another important issue is the different cut-off values to define underweight. The National Institute of Health in USA as well as WHO define underweight as a BMI less than 18.5 kg/m^2 [37]. A similar cut-off is suggested by the ESPEN to identify severe nutritional risk [4]. In their study, Guigoz and co-authors used <19 kg/m^2 as the lowest BMI cutoff both for men and women [38].

In addition to BMI, mid-upper arm circumference (MUAC) and calf circumference are sometimes used as an anthropometric variables to assess nutritional status of older adults [17, 29, 39, 40]. MUAC most likely needs different cutoffs for men and for women [17], as well as for Europeans and non-Europeans [38, 41].

Among the biochemical markers, serum albumin is one of the most commonly used indicators of nutritional status [28, 42, 43]. However, the use of serum albumin as such has been questioned. A recent study demonstrate albumin as a prognostic marker of morbidity and mortality rather than a marker of nutritional status [44]. Most often a low serum albumin represents ongoing inflammation. During periods of inadequate nutrient intake, a decreased rate of albumin degradation and mobilization of albumin from the extra vascular space contribute to the maintenance of a normal serum albumin concentration [45]. For these reasons, albumin may not be a sensitive screening test for early stages of nutritional deterioration.

In 2003, the ESPEN published guidelines for nutrition screening [46]. The guidelines recommend the Malnutrition Universal Screening Tool (MUST) for community use, the Nutritional Risk Screening-2002 (NRS-2002) for hospitals, and the Mini Nutritional Assessment (MNA) for older persons.

The Mini Nutritional Assessment (MNA)

Originally, MNA was developed by Guigoz and colleagues [38] to assess nutritional status among older individuals. The purpose of MNA is to identify malnutrition and risk of developing malnutrition among older adults in clinics, nursing homes, and hospital settings. MNA was originally developed for older persons in Europe and in the USA [41]. However, the use of MNA is not limited to Europe and the USA; MNA has been widely used in different countries and in different settings such as in community, home care, primary health care, general practitioner practice, out patient settings, in hospitals and institutions [14, 41, 47]. A complete description of the MNA instrument is available in the Methods section.

Determinants of malnutrition in aging

Numerous factors can lead to malnutrition among older persons, including physical, medical, psychiatric, social, and economic factors. In most of the cases, these factors are associated with each other. The most important determinants of malnutrition are poor diet and illness. Poor diet and illness are related to access to food and influenced by socio-economic status [48]. Ac-

cording to the WHO, malnutrition can occur as a result of chronic insufficient food intake because of unavailability or lack of affordability, or as a result of improper absorption of nutrients due to illness [49]. Hickson [3] divided the causes of malnutrition into the three following categories: *Medical factors* such as respiratory disorders, gastrointestinal disorders, poor appetite, loss of smell and taste; *social factors* such as poverty, loneliness, lack of knowledge about food; *psychiatric factors* such as depression, dementia, and anxiety.

Older persons often suffer from a wide range of diseases. In North India, a cross-sectional study reports 89% of the older participants to be ill [50]. In Malaysia, 60% of older adults had one or two chronic diseases [51]. A large number of older persons in Botswana in southern Africa, are also reported to have one or more chronic diseases [52]. In Bangladesh, the prevalence of both chronic (76%) and acute illnesses (51%) in old age is high [53]. Since the prevalence of diseases generally increase with increasing age, the risk of developing disease-related malnutrition is also high in this group of people [54]. Findings from previous research show that malnutrition is more pronounced among older patients who have multiple diseases [55, 56]. Reduction in food intake lead to malnutrition in people suffering from anorexia, inflammatory disorders, depression or changes in taste [54].

Poverty is a strong predictor of poor health [57], and malnutrition is more prevalent among older persons who live in poverty [58, 59]. In a study from Peru, people with low socio-economic status were found to suffer from more nutritional deficiencies [60]. In Bangladesh, low socio-economic status is found to be an important predictor of low BMI among adults [61, 62].

Depression is a major cause of weight loss and one of the risk factors of malnutrition in older persons [63-65]. Recently, Johansson and co-authors [14] reported depression as one of the predictors for developing malnutrition among home living Swedish older persons. Similar findings are also reported by Cabrera and colleagues [66] who studied a group of community living older people in southern Brazil. Social isolation, eating alone, and not having enough social interaction influence food intake [67, 68]. Often when people lose their spouse, they become socially isolated and suffer consequences of loneliness which in turn influence their nutritional status [58].

Consequences of malnutrition in aging

The consequences of malnutrition are diverse, severe and long-lasting [48]. Malnutrition is associated with physiological, psychological, and immunological consequences [54] and has a strong impact on mortality, morbidity

[48, 54], and quality of life [13]. In addition, malnutrition increases vulnerability for infection, pressure sores, delayed wound healing, and reduces rates of drug metabolism [48, 58, 69].

Physical function

Physical function is an extensive area that can refer to the function of a specific organ or organ system, to mobility, strength, range of motion, or ability to carry out everyday activities [70]. Most of the scientific literature in this area has focused on the concept of limitations, i.e., disability, in physical function [71-74]. In 1980, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) was published by the WHO as a manual of classification relating to the consequences of disease [75]. The ICIDH identifies three concepts, or levels, of physical difficulties – impairment (organ level), disability (person level) and handicap (societal level). However, these classifications were criticized because the concepts were too broad and the definitions not sufficient to distinguish between the various concepts [76, 77]. As a result, the International Classification of Functioning, Disability and Health, known as ICF was introduced by the WHO in 2001 [78] which is a revision based on the ICIDH concepts. In ICF, impairment is defined as "problems in body function or structure such as a significant deviation or loss" (p.47). Disability, on the other hand, is a complex phenomenon which reflects an interaction between a person's health conditions and the social and environmental context in which he or she lives. Although disability serves as an umbrella term for impairments, restrictions in activities, or limited participation, an individual could have an impairment without having any disability [78]. Disability occurs when there is a gap between a person's capability and the environmental demand [79].

Malnutrition induces impairments in physical performance such as reduced physical activity or work capacity [48, 80]. Low BMI is reported to be one of the risk factors for impaired physical function in community living older individuals [81]. Results from the Australian Longitudinal Study of Ageing report that loss of body weight significantly increases the risk of functional limitations in older Australians [82]. Using cross-sectional data, Olin and co-authors [83] conclude that malnourished participants have lower functional ability than well-nourished participants.

Assessment of physical function

Physical function can be assessed by both self-reported and performance-based instruments. Activities of Daily Living (ADL) are one of the most commonly used self-reporting instruments to assess physical function in community settings [74, 84, 85]. ADL includes participants' ability to dress, transfer, eat, use the toilet, and bathe. Participants are asked if they can per-

form these activities without difficulties or if they need personal assistance. Performance-based measures, on the other hand, are more complex and information can only be obtained by direct participation. In performance tests, participants are asked to perform certain activities such as to lift up an object, to move their wrist or to walk a certain distance. Performance-based measures assess specific functions of the body such as muscle strength, range of motion, ability to grasp, flexibility and hand function [86], whereas self-reported instruments like ADL measures the basic physical function such as gross body movements and self-care [87].

Cognitive function

The term "Cognition" comes from the Latin word "co-gnoscere" meaning to become acquainted with or to come to know. Cognition reflects the process of knowing and, more precisely, the process of being aware, knowing, thinking, learning and judging [88]. According to Salthouse [89] cognitive ability refers to "the individual's intellectual level as measured by conventional tests of intelligence and cognitive functioning" (p.310). It would be impossible to provide a full picture of human cognition in this limited space, but at an abstract level the multitude of functions covered by the umbrella term cognition may be conceptually subdivided in a relatively straightforward manner, like, into short-term or working memory, and long-term memory. Working memory deals with temporarily storing and managing information, whereas long-term memory stores information for later use [90]. Tulving [91] has separated long-term memory into two major categories, declarative and non-declarative memory, and the typical subdivision of declarative memory is semantic and episodic memory. At an overall level, cognitive abilities can be divided into fluid and crystallized abilities, where fluid abilities deal with novel information and crystallized abilities build mostly on knowledge that is already acquired. For some types of cognitive functions such as episodic memory, working memory and fluid abilities, the decline typically starts after the age of 25 years and continues into late life. Conversely, crystallized abilities, such as semantic memory, remain relatively stable until late adulthood [92]. However, the trend varies from person to person, i.e. the patterns of cognitive decline and the individual variation in cognitive performance depends on demographic factors, lifestyle, disease related factors [93] and nutritional status [94]. It is important to keep in mind that although assessment of cognitive abilities may have high validity and reliability, the multitude of predictors hampers the possibility to directly generalize results to all sorts of contexts or even to everyday functioning.

Nutritional status is an important factor that influences cognitive function at different periods of life [48, 69]. Low BMI and weight loss are found to be associated with impaired cognitive performance in older participants living

in sheltered accommodation [95]. Epidemiological studies have shown significant associations between quality of diet and prevalence of cognitive impairment [96, 97]. Specific deficiencies of certain micronutrients such as vitamin B, C, E and folate [98-102] as well as omega-3 fatty acids, i.e. fish oil [103] may also increase the risk of cognitive deficits. Starvation or partial food deprivation can have a negative effect on cognitive function as well [69] probably due to micronutrient deficiencies during starvation.

Assessment of cognitive function

A variety of cognitive screening instruments are available to evaluate various aspects of cognition in older adults. Among them, the Mini Mental State Examination (MMSE) [104] is a widely-accepted screening tool to test cognitive performance. MMSE is a 30-point questionnaire test which includes simple questions and problems in a number of areas such as orientation to time and place, memory, arithmetic, language use and comprehension, spatial ability etc. [104]. However, for some items in the MMSE literacy is needed. MMSE has been translated into different languages and used in different populations [105-109].

Global aging

The proportion of the aged population is growing faster than any other age group. It is projected that until around 2030, the population aged 60 years and over will grow almost four times faster than the total population[110]. This demographic transition is the result of a process where first mortality is reduced and then fertility declines. Although the process primarily began in high-income countries, it has recently been observed also in low-income countries [110].

The terms old, elderly, aged or ageing may be difficult to explain since there are no universal definitions. On the contrary, these terms are individual-, culture-, country- and gender-specific. Particularly in low-income countries, old age is associated with chronic illness and disability, living with poverty and little or no access to adequate health care services [111]. The United Nations uses 60 years as the cut-off to describe “older” people. This age is commonly used as a chronological definition of “old” or “aged” [112]. The term “oldest-old” refers to people aged 80 years and over [111]. In this thesis, older person refers to individuals aged 60 years or more.

It is commonly believed that the world’s largest proportion of older people live in high-income countries today. However, sixty percent (279 million) of the world’s older population currently live in low-income countries, and this figure will increase to 71% (690 million) by 2030 [113]. In terms of regions,

over half of the world's older population is living in Asia and it is projected that the figure will increase over the next two decades [112].

Bangladesh has currently a population of almost 147 million people [114]. Six percent are aged 60 years and over [115, 116]. As a comparison, 23% of the population in Sweden is 60 years and older [116]. In Bangladesh, it is projected that in the next twenty years this figure will be almost double and will constitute more than 10% of the total population in the country [116]. Development of the age distribution in the population of Bangladesh across time is shown in *Figure 1*.

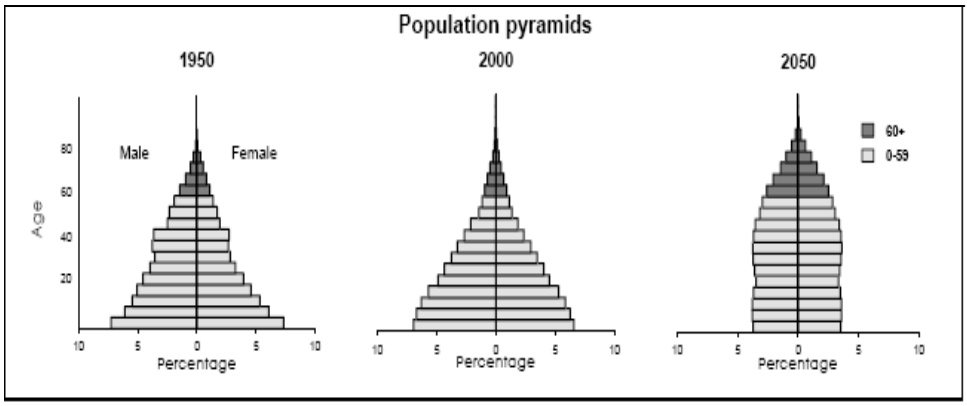


Figure 1. Population age distribution in Bangladesh in years 1950, 2000 and 2050 *(Source: UN)[110]*.

The Bangladesh context

Demographic and socio-economic information

Bangladesh is located in South Asia and covers an area of 147,000 square kilometers. It is almost entirely surrounded by India, except for a short southeastern frontier with Myanmar (formerly known as Burma), and a southern coastline on the Bay of Bengal [117, 118]. For administrative purposes, the country is divided into 6 divisions, 64 districts, and 508 subdistricts. Muslims make up almost 90% of the population of Bangladesh, Hindus account for about 9%, and other religions constitute the remaining 1%. Bangla is the official language of the country [118]. Bangladesh is one of the most densely populated countries in the world. With a population of 147 million [114], the population density is about 979 persons per square kilometer [118]. As a comparison, the corresponding figure in Sweden is 20

persons per square kilometer [116]. Life expectancy in Bangladesh is currently 62 years for men and 64 years for women [114]. Agriculture is the single largest producing sector of the economy and rice, wheat, jute, sugarcane, tobacco, oilseeds, and potatoes are the principal crops [118]. Adult literacy rate is about 48%. Bangladesh is still struggling to emerge from poverty. About 85% of the population in Bangladesh lives on US$2 a day and 42% on US$1 a day [119] and more than 60% of Bangladeshis have no access to modern health services other than immunization and family planning [120].

Nutrition situation in Bangladesh

Food consumption patterns

The patterns of food consumption very much depend on food production, food accessibility, socio-economic status [121, 122], household food security, and seasonality [123]. The common food items are rice, wheat, pulses, potatoes, vegetables and fish [122, 124, 125]. Fish consumption is more frequent during the monsoon season [122], probably due to greater availability and low prices. Milk, milk products, and meat are occasionally consumed. Although a large variety of fruits and vegetables can be found throughout the year, the consumption of fruits and vegetables are seasonal, and increase mostly during the time of winter harvest [121, 122, 124]. A recent report form a nationwide survey indicates that though food expenditure represents 62% of the total household expenditure, one of four households in Bangladesh is food insecure [126].

Within the typical dietary patterns of the Bangladeshi population, the key food group with respect to micronutrient consumption is vegetables, providing nearly 95% of vitamin A intake, 75 % of vitamin C intake, and 25 % of iron intake. Rice provides about 80-85% of the total energy while protein and fat contribute approximately 15% in general [122]. The consumption of different food items varies largely between urban and rural areas [122, 125, 127]. Likewise food habits differ between regional and household levels; still the methods of food preparation will in most cases result in significant nutrient losses. Washing rice before cooking, boiling rice and then straining the water, and the way of washing and cooking vegetables result in loss of different nutrients, especially vitamin C, B-complex and minerals [124]. Furthermore, evidence indicates that males are given preference in intra-household distribution of certain food such as milk, eggs, fish, and meat whereas vegetables and cereals are more equally distributed [128].

Information on nutritional status

Malnutrition is one of the major health related problems in Bangladesh, and the prevalence of malnutrition is among the highest in the world [122]. Approximately one third of the population in Bangladesh is undernourished [119]. Around two million children aged six months to five years are affected by acute malnutrition (wasting), out of which half a million suffer from severe acute malnutrition (severe wasting) [126]. Approximately thirty percent of the women are underweight according to BMI cutoff of <18.5 kg/m^2. The prevalence of undernutrition is higher among women aged 15-19 and women aged 45-49 years compared to other age groups [129, 130]. Malnutrition is more prevalent in rural areas than in urban areas [122, 130]. Micronutrient deficiencies, particularly vitamin A, D, iron, iodine, and zinc deficiencies are also high in Bangladesh. The prevalence of night blindness among rural pre-school children is 0.6% [131]. More than half of the pregnant women have a low vitamin A status [132]. Deficiency in vitamin D is prevalent among 16% of adolescent girls [133]. Almost three quarters of non-pregnant and half of the pregnant women [134, 135] in rural Bangladesh are anaemic, and 73% of children under five years are reported to suffer from iron deficiency anaemia [131]. Research also indicates that season has a significant effect on both food security and nutritional status in the country, and compared to the dry season the prevalence of food insecurity, child malnutrition and inadequate growth are higher in the monsoon season from July to October [123].

Health and nutritional status of older people

The current Bangladeshi scenario is characterized by gradual aging of the population. Older people currently represent only one in 20 of the population in the country. By the end of this century, however, it is projected that this group will constitute almost 26% of the total population in Bangladesh. The older population will most likely create a great burden on the health system, especially due to chronic illnesses [136]. Despite this, the aging issue is not a primary concern for policy makers and planners in Bangladesh. At the primary or at other levels, the needs of older person's healthcare are rarely addressed [137]. There are no separate healthcare facilities for older adults, and so far no comprehensive health policy exists for this group of people [138]. Thus, existing health services in the country are not enough to meet the healthcare needs for older people [139]. Unlike in many high-income countries, receiving social supports or benefits is not commonplace in Bangladesh. Only a few older persons receive pension or social benefits [138]. Lifelong pensions are only offered for government employees but not for private sector employees. Thus, poverty is one of the greatest threats for the well-being of older persons [139]. The vulnerability of older people is also re-

flected by their ill health [53, 137], poor nutritional status [31], and impaired functional ability [85].

Although several attempts have been made to assess social, health and nutritional status of the aging population in some South Asian countries [18, 140, 141], health and nutritional status of the aging population in Bangladesh is yet characterized by a lack of information. To date, not much research has been conducted in older population, particularly with respect to their nutritional status. Considering the fact that by the end of current century the number of older people will increase 10-fold [136], the importance of knowing more about older persons, identifying their physiological changes and understanding their nutritional needs is obvious. Moreover, in a society like Bangladesh where other support systems are not well-developed and where the family provides the main support and social security for older persons [137], the rapid demographical change of the population will bring challenges for the family as well as for the society. As mentioned earlier, the high prevalence of malnutrition among children, adults and women in reproductive age is one of the major challenges in the public health sector in Bangladesh. However, it is not known if the prevalence of malnutrition is similar later in life.

Integration of older persons in development efforts

At the beginning of this century, the Millennium Development Goals (MDGs) [142] were introduced by the United Nations. The aim of the MDGs is to reduce poverty and hunger, to improve health, advance education, social aspects and environmental development, in particular for low-income countries. Thus, the MDGs play an important role for policy makers and planners. However, no specific statement is made for the aging population in the given goals, targets and indicators. This exclusion of older people may contribute to the failure to reach the MDGs by 2015, unless corrective actions are taken.

Malnutrition continue to be a significant public health problem throughout the low-income countries, particularly in southern Asia and sub-Saharan Africa [2, 24, 131]. The alarming prevalence of malnutrition is not only a challenge for southern Asia or sub-Saharan Africa but also a challenge across individual countries, individual societies as well as individual families. In order to undertake this challenge, Peter Svedberg [143] recommends '*the five Ws*' (p.5). *What* undernutrition is; *who* the undernourished are; *where* the undernourished are located in terms of geographical area; *when* they are undernourished; and *why* they are undernourished [143]. This thesis will try to take an effort to answer some of Svedberg's questions.

Aims

Overall aims:

- To describe the magnitude of malnutrition that prevails in older adults in rural Bangladesh.
- To investigate the potential determinants of malnutrition among older people in rural Bangladesh.
- To investigate the impact of nutritional status on physical and cognitive functions in an aged population living in a rural community in Bangladesh.

Specific aims:

- To determine the prevalence of malnutrition that prevails among an older population in rural Bangladesh stratified by age, sex and socio-economic status (Study I).
- To investigate the impact of disease and non-disease related factors on nutritional status, and the extent to which they make independent contributions to the explanation of nutritional status among older persons in rural Bangladesh (Study I and Study II).
- To investigate the impact of nutritional status on physical function as assessed by performance-based as well as by self-reported measures in an aging population in a rural area of Bangladesh (Study III).
- To investigate the impact of nutritional status on general and specific cognitive functioning in a group of older people, aged 60 years and over, living in a rural area in Bangladesh (Study IV).

Materials and methods

The Poverty and Health in Ageing project

Data for this thesis are drawn from the project 'Poverty and Health in Ageing' (PHA) in Bangladesh. The PHA project is a collaborative project between Karolinska Institutet, Stockholm, Sweden; and International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). This study also includes collaboration with Uppsala University, Uppsala, Sweden. PHA is a multidisciplinary cross-sectional study of health and functioning in late adulthood. The main aim of the PHA project is to explore how biological, environmental and social factors are interrelated, and how they affect aging. PHA also aims at describing morbidity patterns and functional status as well as identifying determinants of good/ill health in older population. The project focuses on four main areas related to old age health: medical health, functional status, health-related quality of life and social functioning. For each participant, data were collected in three ways: home interview, clinical examination and cognitive testing.

Description of the study area

The study was conducted in the rural area of Matlab located about 55 km South-East of Dhaka City in Bangladesh (*Figure 2*). Matlab is a sub-district of the Chandpur district with an area of approximately 409 sq km. The total population in Matlab is about 445,000 (male 49%, female 51%). The main religion is Islam (90%), followed by Hinduism (9%) and others (1%). Average literacy rate is 36% (male 42% and female 31%). Main occupations in the Matlab population are farming (41%) and agricultural labour (19%). According to health care facilities, Matlab has one government health complex, six union satellite clinics, 19 family welfare centres and one health centre of ICDDR,B [144].

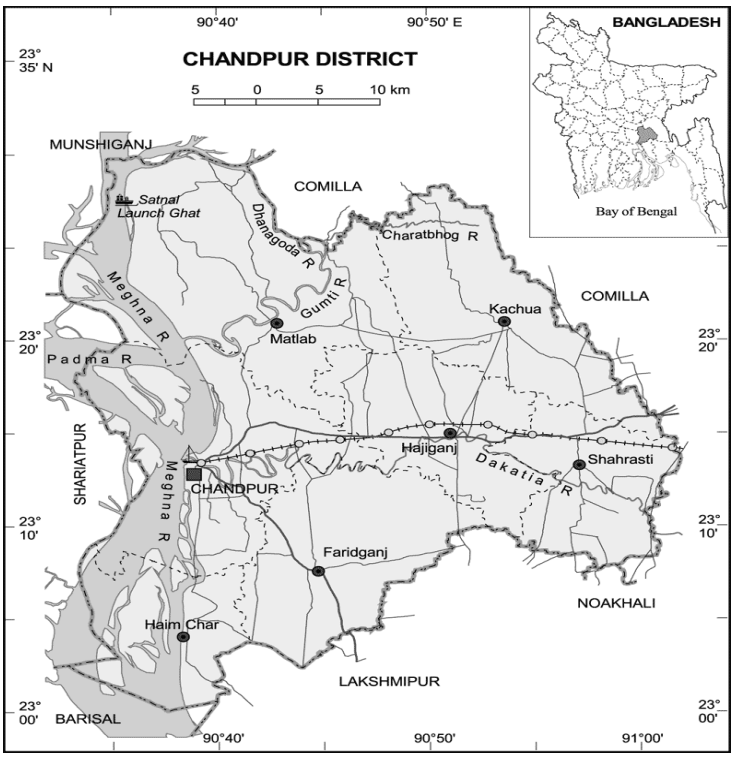


Figure 2. Map of the Chandpur district [145]

In Matlab, ICDDR,B has been maintaining a Demographic Surveillance System (DSS) since 1966. DSS has kept a register of all vital events such as birth, death, marriage and migration, for a population of about 40,000 households and more than 200,000 individuals in the Matlab sub-district [53]. For administrative purposes, Matlab DSS area is divided into 7 blocks (see *Figure 3*). ICDDR,B provides health services in four of these blocks (A, B, C and D). Among the blocks where ICDDR,B provides services, two (block-A and block-B) were purposively selected for the PHA project. The total population in blocks A and B is approximately 65,000. Among them about 8% are aged 60 years and older [146].

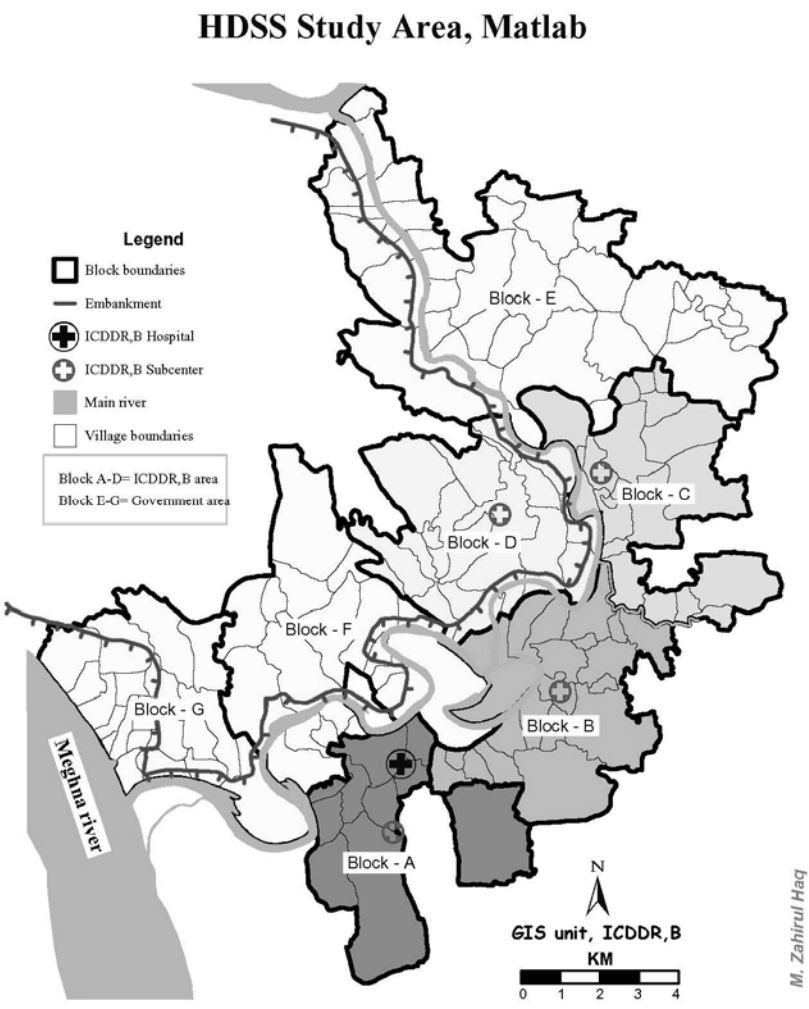


Figure 3. Map of the study area, Matlab [147].

Study participants (Study I – Study IV)

A total of 850 community-dwelling older individuals, aged 60 years and over, were randomly selected from block-A and block-B using DSS data register. Data collection took place during August 2003 to January 2004. The participants were first interviewed by trained interviewers at their home using a pre-tested structured questionnaire. They were then invited to a nearby

health centre for clinical examinations and cognitive tests. Clinical examination was conducted by trained physicians and cognitive tests were performed by specially trained psychologists. Among the 850 randomly selected participants, 63 died between sample selection and the start of data collection, 38 declined to participate, 11 migrated, 93 could not be reached, 18 were registered twice and, 2 persons were found to be below 60 years of age. A total of 625 individuals participated in the home interviews of which 473 underwent clinical examination and cognitive tests at a medical sub-centre. Thus, 152 individuals did not participate in the clinical examination and cognitive tests. The drop-out analyses indicated that the non-participants were older, mainly women, and had poor socio-economic status (Study I). Information on complete nutritional status was available for 457 individuals. Below see *Figure 4* for details on selection of study participants.

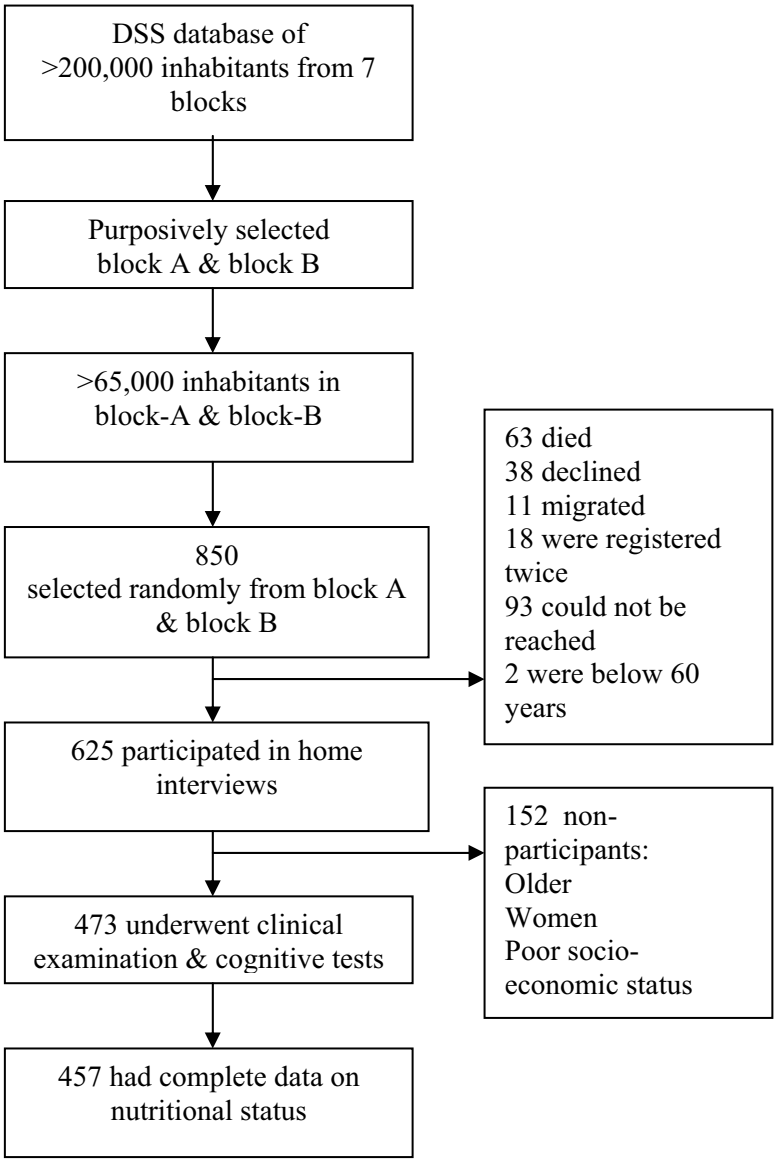


Figure 4. Selection of study participants.

Information on the data collection

Demographic and socio-economic information (Study I – Study IV)

Age and *sex* were included in all four studies as demographic variables and information was collected from the DSS database.

Literacy (Study I – Study IV), *monthly income* (Study II and Study III), *years of schooling* (Study I), *per capita daily household expenditure on food* (Study I and Study II), *financial support* (Study II), *marital status* (Study II and Study III), and *social network* (Study II) were included to denote socio-economic status of the participants.

Information on *literacy* was gathered from the DSS database and was coded as illiterate and literate. Those who could read and write Bangla were defined as literates and those who could not as illiterate. Information on *monthly income, financial support,* and *years of schooling* was collected during home interviews. *Per capita daily household expenditure on food* was calculated using daily household expenditure on food as numerator and number of household members as the denominator. *Marital status* was coded as 'married' or 'single'. Participants who never married, were divorced or widowed were all categorised as single.

The *Social network* variable was created based on the information on 'number of children living in the same household' and 'number of children living in the same *bari*'. A *bari* is a number of households, normally comprising members of the same family or close kin, sharing a common courtyard [148]. *Social network* was coded as follows:

Very good social network = One or more children living in the same household, and one or more children in other households in the same *bari*;
Good social network = ≥ 1 children in the same household (none in other households in the same *bari*);
Poor social network = ≥ 1 children in other households in same *bari*, but no children in same household; and
Very poor social network = No children living either in the same household or in the same *bari*.

Nutritional status (Study I – Study IV)

Nutritional status was assessed using the Mini Nutritional Assessment (MNA). MNA is a simple, easy-to-use but comprehensive assessment tool for older persons. MNA includes anthropometric assessment including weight, height, weight loss, and arm and calf circumferences; general as-

sessment that includes lifestyle, medication, mobility, and presence of signs of depression or dementia. In addition, MNA includes a short dietary history of number of meals consumed, fruit intake, and autonomy of feeding, as well as the self perception of health and nutrition. The complete MNA includes 18 items and the score distribution is between 0 (zero) and 30. A score less than 17 points indicates malnutrition; scores between 17 and 23.5 indicate 'at risk of malnutrition', and a score ≥24 indicates a well-nourished state [38].

As mentioned earlier, MNA has been designed, validated [38] and mostly used in high income countries [14, 83, 149]. Thus, some of the items in the original version of MNA were not relevant in the context of Bangladesh. Hence, a modified version of MNA was used in this thesis. To construct the modified MNA, retrospective data from surveys and clinical examinations were used. Considering the fact that nursing homes for frail older people do not exist in Bangladesh, this item was taken away from the MNA questionnaires. A second item, calf circumference was also excluded due to lack of information. The total possible MNA score in the modified version was thus 28. The cut-offs for undernutrition, at risk of malnutrition and well-nourished state were re-adjusted accordingly. The score cut-offs were chosen as:

Well nourished: ≥22 points;
At risk of malnutrition: 15-21.5 points; and
Undernutrition: < 15 points.

In the modified MNA, the item on neuropsychological problems were assessed using the percentile distribution of Bangla Adaptation of Mini-Mental State Examination score (BAMSE, see below) [109], where a score below the 5th percentile (<14 of a total score of 30) was considered as indicative of severe dementia, scores between the 5th and the 15th percentile (14-17) were considered indicative of mild dementia, and scores above 15th percentile (≥18) were considered as indicative of no cognitive problems. In addition, the BMI cut-offs were modified. In the original MNA, BMI <19 is indicated as low. This thesis used the cut-off <18.5, suggested by the WHO [37], to identify underweight. Importantly, this cut-off has been used in many similar studies in Asia [16, 29, 150]. Table 1 provides a comparison of the original and modified version of MNA.

Table 1. *Item-wise comparison of the original and modified Mini Nutritional Assessment (MNA).*

Items	***Scores in the original MNA***	***Scores in the modified MNA***
I. Anthropometric assessment		
Body Mass Index	0=<19; 1=≥19 to <21; 2=≥21 to <23; 3=≥23	0=<18.5; 1=≥18.5 to <20; 2=≥20 to <22; 3=≥22
Mid-Upper Arm Circumference	0.0=<21; 0.5=≥21 to ≤22; 1.0=>22	0.0=<21; 0.5=≥21 to ≤22; 1=>22
Calf Circumference	0=<31; 1=≥31	Information not available
Weight loss during last 3 months	0=weight loss >3kg; 1=does not know; 2=weight loss between 1 and 3 kg; 3=no weight loss	0=yes, lost much; 1=does not know; 2= yes, lost some; 3=no weight loss
II. Global evaluation		
Does the patient live independently in contrast to a nursing home?	0=No; 1=Yes	As nursing homes for elderly people do not exist in Bangladesh, we did not use this information.
Does the patient take more than 3 pre-scription drugs (per day)?	0=Yes; 1=No	0=Yes; 1=No

Items	*Scores in the original MNA*	*Scores in the modified MNA*
In the past 3 months, has the patient suffered from psychological stress or acute disease?	0=Yes; 1=No	In the past 3 months, has the patient suffered from any major illness for which the patient had to consult a doctor? 0=Yes; 1=No
Mobility	0=bed or chair bound; 1=able to get out of bed or chair but does not go out; 2=goes out	0=bed or chair bound; 1=able to get out of bed or chair but does not go out; 2=goes out
Neuropsychological problems	0=severe dementia or depression; 1=mild dementia; 2=no psychological problems	0=severe dementia; 1=mild dementia; 2=no cognitive problems
Pressure sores or skin ulcers	0=Yes; 1=No	0=Yes; 1=No
III. Dietetic Assessment		
How many full meals does the patient eat daily?	0=1 meal; 1=2 meals; 2=3 meals	0=1 meal; 1=2 meals; 2=3 meals

Items	*Scores in the original MNA*	*Scores in the modified MNA*	
Does s/he consume: • At least one serving of dairy product (milk, cheese, yogurt) per day? • Two or more servings of beans or eggs per week? • Meat, fish or poultry everyday?	0=if 0 or 1 yes; 0.5=if 2 yes; 1.0= if 3 yes	Does s/he consume: • At least one serving of dairy product (milk) per day? • Two or more servings of lentils or eggs per week? • Meat, fish or poultry everyday?	0=if 0 or 1 yes; 0.5=if 2 yes; 1.0= if 3 yes
Does s/he consume two or more servings of fruits or vegetables per day?	0=No; 1=Yes	0=No; 1=Yes	
Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?	0=severe loss of appetite; 1=moderate loss of appetite; 2=no loss of appetite	0=severe loss of appetite; 1=moderate loss of appetite; 2=no loss of appetite	

Items	*Scores in the original MNA*	*Scores in the modified MNA*	
How many cups/glasses of beverages (water, juice, coffee, tea, milk, wine, beer) does the patient consume per day?	0.0=less than 3 glasses; 0.5=3 to 5 glasses; 1.0=more than 5 glasses	How many glasses of water does the patient consume per day?	0.0=less than 3 glasses; 0.5=3 to 5 glasses; 1.0=more than 5 glasses
Mode of feeding	0=feeding requires assistance; 1=self-fed with some difficulties; 2=self- fed without any problem	0=feeding requires assistance; 1=self-fed with some difficulties; 2=self-fed without any problem	
IV. Subjective assessment			
Does the patient consider himself/herself to have any nutritional problems?	0=major malnutrition; 1=does not know/ moderate malnutrition; 2=no nutritional problem	0=major malnutrition; 1=does not know/ moderate malnutrition; 2=no nutritional problem	
In comparison with other people of the same age, how would the patient consider his/her health status?	0.0=not as good; 0.5=does not know; 1.0=as good; 2=better	0.0=not as good; 0.5=does not know; 1.0=as good; 2=better	
Total score	**Maximum 30**	**Maximum 28**	
Scores	≥24 points= well nourished; 17 to 23.5 points= at risk of malnutrition; < 17 points= undernutrition	≥22 points= well nourished; 15 to 21.5 points= at risk of malnutrition; <15 points= undernutrition	

Health status (Study I – Study IV)

In order to assess the individuals' health status both self-reported morbidity (Study I and Study III) and medical diagnosis based on clinical examinations (Study II and Study IV) were considered. Information on self reported morbidity was collected during the home interviews and was categorised into five groups.

Respiratory problems: Uncomfortable feeling in the chest, cough, asthma and problem with breathing
Stomach problems: Stomach ache
Sensory problems: Vision or hearing problems
Pain: Back or joint pain, and recurrent headache
Sleep problem.

Physicians performed the clinical examinations. Based on the individual's medical history, physical examination and blood test analyses, medical diagnoses of each participant were decided by the first physician. A second physician also made a diagnosis based on the recorded information. In case of disagreements in terms of diagnosis, a third physician was consulted. Medical diagnoses were, for the purpose of this study, gathered into the following categories. A complete list of diagnoses can be found in paper II.

Acute infections: Respiratory tract infection, symptoms of helminthiasis, i.e. a disease in which the body is infested by worms such as pinworm, roundworm or tapeworm, leucorrhoea, i.e. vaginal discharge;
Chronic illnesses: Arthritis, obstructive pulmonary symptoms, heart failure;
Gastrointestinal disorders: Stomach pain, abdominal bloating, fecal blood discharge;
Sensory impairment: Hearing impairment or impaired vision.

In Studies II and IV, an attempt was made to grade the severity of disease by constructing a score, i.e. a product from the occurrence of disease and the serum albumin level, according to the following description. Having at least one diagnosis within a given disease category (acute infections, chronic diseases, or gastrointestinal disorders) gave the score of 1, whereas the lack of diagnoses within the disease category resulted in 0 (zero). These scores for each of the three disease categories was then added to construct a new score variable called the 'number of disease categories'; ranging from 0 (no disease at all) to 3 (at least 1 diagnosis in all three disease categories). Serum albumin concentration was used as an indicator of disease activity and was analysed in the blood samples that were collected during the clinical examination. Cut-off values were based on the percentile distribution, i.e. the 25th percentile (35 g/l) was considered the cut-off for a normal serum albumin level [151], between the 10th and 25th percentile (33-34 g/l) as an indicator

of low levels and below the 10th percentile (<33 g/l) as very low levels of serum albumin. The levels of serum albumin were then coded as: normal = 1; low = 2; and very low = 3. Finally, a *disease severity score* was calculated based on the numbers of disease categories (0 to 3), multiplied by the level of serum albumin (normal=1, low=2 and very low=3). The resulting possible scores of disease severity were between 0 and 9 with increasing numbers indicating higher burden of disease.

Depressive symptoms (Study II and Study IV) were measured using the Self-Reporting Questionnaire 20 items (SRQ 20) [152]. The SRQ 20 was performed during the home interviews. The 20 answers were coded as yes (1) or no (0). For the purpose of this thesis a symptom summary score, between 0 and 20 points, was calculated and higher scores indicate a more depressive mood.

Functional status (Study III and Study IV)

In order to assess functional status both physical and cognitive functions were measured. *Figure 5* displays the various domains that were addressed and the assessment tools that were used to measure functional status.

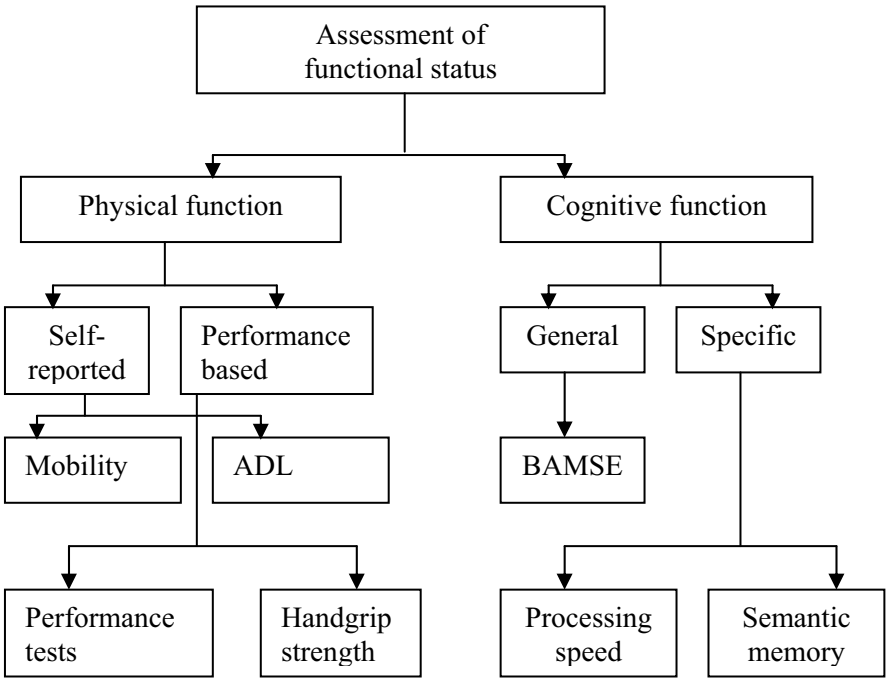


Figure 5. Assessment of functional status.

Physical function (Study III)

Four different measures were used to assess physical function in this thesis. These were mobility, activities of daily living (ADL), performance tests, and handgrip strength. Among them mobility and ADL were self-reported, and performance tests and handgrip strength were performance-based measures. Information on mobility, ADL and performance tests was collected during the home interviews. Handgrip strength was assessed during the clinical examinations.

Information on mobility included three questions on self-reported ability to walk indoors, walk outdoors, and to stand up without any help. Each mobility question had four alternative responses: *yes, without any problem; yes, with help of sticks; yes, with help of someone*; and *bedridden*. The three latter alternatives were classified as having limitations in mobility. A mobility index (0-3 points) was also constructed based on the responses to the three questions on self-reported abilities where higher scores indicated better mobility.

ADL of each participant was assessed according to five items - ability to get in and out of bed, use the toilet, take a bath, eat, and dress. Each of the self-reported ADL questions had three alternatives: *yes; yes, but need help;* and *no*. Participants who reported dependence in any of the five tasks were classified as having limitations in ADL. Furthermore, an ADL index (0-5 points) was constructed based on the responses to the five self-reported questions where higher scores indicate better function.

The performance tests comprised six items. Participants were asked to pick up a pen from the floor, lift a one-kilogram packet of salt, move their wrist, touch their opposite earlobes (e.g. left earlobe with right hand with arm behind the head), and to get up from the bed without using their hands. After each of the tasks, the interviewers recorded whether the participants could perform the task easily, perform it with difficulty, or if they could not perform at all. If a participant could not perform a task easily, s/he was identified as having performance limitations in the task. A performance test index (0-6 points) was constructed based on performance of the six tasks, higher scores indicating better performance.

Handgrip strength of the participants was measured in kilogram using a handgrip dynamometer (DynEx©, USA) and the recordings were performed with the participants in sitting position. Both hands were measured alternatively three times and the best score of each hand was recorded.

Cognitive function (Study IV)

Both general and specific cognitive performance was used to assess cognitive function. In order to assess specific cognitive function two types of tests were used - assessment of processing speed and assessment of semantic memory function. The cognitive tests were conducted by trained psychologists.

In order to assess general cognitive function this thesis used the Bangla Adaptation of Mini-Mental State Examination (BAMSE), a modified version of MMSE and adapted by Kabir & Herlitz [109]. BAMSE is an instrument which is constructed to assess cognitive function of older individuals irrespective of their literacy levels. The instrument consists of 12 questions and covers various functions including orientation of time and place, object registration, calculation, memory such as, attention backwards, recall, naming, repetition and language; three-step task, sentence construction, and copying a figure. The total score in BAMSE is 30 and higher scores indicate better cognitive performance.

Processing speed was assessed using two tasks - Complete boxes and Cross balls. During the cognitive test, participants were given a number of pictures of incomplete boxes (*Figure 6*) on a sheet of paper and were asked to draw a line to complete the boxes as fast as possible. The total number of completed boxes in 60 seconds was registered. In addition, participants were given a number of figures (*Figure 7*) on a sheet of paper including balls, triangles, squares, half circles, rectangles etc., and were asked to cross out the black balls among those figures as fast as possible in 30 seconds. Here also the total number of crossed balls was used as the outcome. Next, these two variables (Complete boxes and Cross balls) were added and the summary score was used as a measure of processing speed in the analyses.

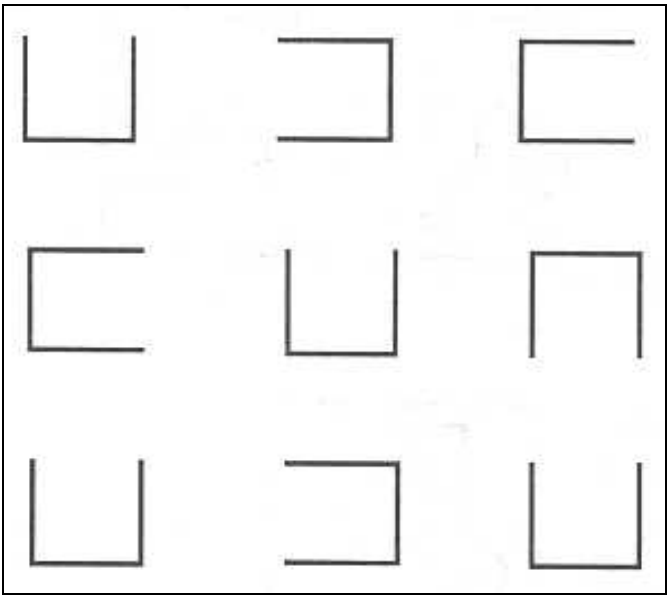


Figure 6. Pictures of ‘Complete boxes’ used during the tests of processing speed.

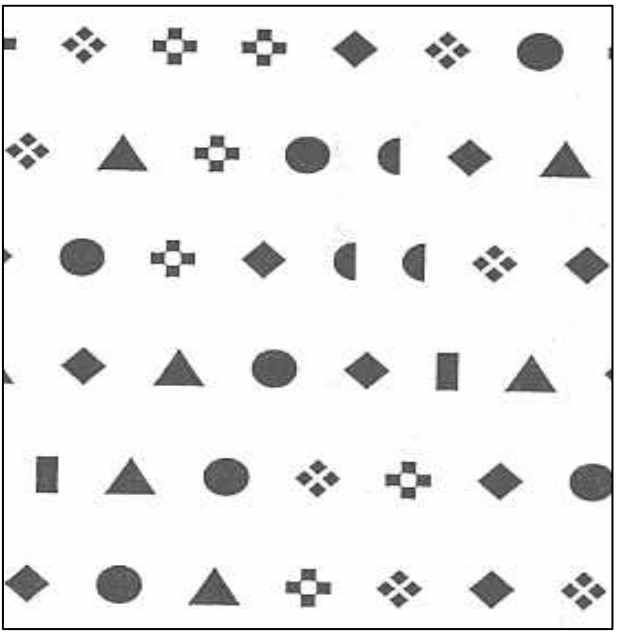


Figure 7. Pictures of ‘Cross balls’ used during the tests of processing speed.

In order to assess semantic memory function a word synonym test was used. A total of twenty everyday used words such as for example plate and water was selected for this purpose. During the test, participants were asked about the synonym of a selected word. Each participant was asked a specific word and for each word the task was to select the synonym to the specific word from three other words read out to them. The total number (0-20) of correctly identified synonyms was used as the outcome.

Statistical analyses

All statistical analyses were performed using the software SPSS. Descriptive analyses were performed to report the distribution of the data, and chi-square and independent t-tests were done to compare group differences. Correlation analyses were performed in order to identify the associations between predictors and outcome variables. Hierarchical linear regression analyses were conducted to evaluate the relationship between predictors and nutritional status in Study I and Study II, and to examine the impact of nutritional status on functional status in Study III and Study IV.

Dependent and independent variables

Nutritional status (Study I and Study II), physical function (Study III) and cognitive function (Study IV) were used as dependent variables.
Demographic (Studies I-IV), socio-economic (Studies I-IV), health (Studies I-IV) and nutritional status (Studies III and IV) were used as independent variables.

The dependent and the explanatory variables and the statistical analyses used in the Studies included in this thesis are summarised in Table 2.

Table 2. *Summary of the variables used in each study included in this thesis.*

Study	Source of information	Independent variables	Dependent variables	Statistical analyses
I	Survey[1] and clinical[2] data	Age, sex, literacy, years of schooling, per capita daily household expenditure on food, self-reported health problems	Nutritional status	Descriptive analyses, Chi-square tests, hierarchical linear regression
II	Survey[1], clinical[2] and laboratory[3] data	Age, sex, literacy, monthly income, per capita daily household food expenditure, marital status, financial support, social network, clinical diagnoses of diseases, depressive symptoms, cognitive function, serum albumin, disease severity scores	Nutritional status	Descriptive analyses, Chi-square tests, independent t-test, hierarchical linear regression
III	Survey[1] and clinical[2] data	Age, sex, literacy, monthly income, marital status, self reported health problems, nutritional status	Mobility, ADL, performance-tests, handgrip strength	Descriptive analyses, Chi-square tests, independent t-test, hierarchical linear regression
IV	Survey[1], clinical[2], and cognitive[4] data	Age, sex, literacy, impaired vision, impaired hearing, severity of disease scores, depressive symptoms, nutritional status	General cognitive function, processing speed, semantic memory function	Descriptive analyses, Chi-square tests, independent t-test, correlations coefficient, hierarchical linear regression

[1] Home interviews; [2] Clinical examinations conducted by physicians; [3]Laboratory analyses of blood samples; [4] Cognitive tests conducted by trained psychologists.

Ethical considerations

All participants were informed about the objectives of the study and informed consent was obtained before home interviews, clinical examinations and cognitive tests were conducted. Participants were also informed about their right to discontinue his/her participation from the study at any point of data collection. All information from the study was used only for research purpose and confidentiality of the data was maintained throughout the project. The study was approved by ethics committees both at ICDDR,B in Dhaka, and the Karolinska Institutet in Stockholm (Dnr 264/03).

Results

Demographic and socio-economic background (Study I – Study IV)

More than half of the respondents were women. Mean age was 69 years for both men and women. Close to two thirds of the participants were illiterate (61%), and more than two thirds did not have any personal income. More than half of the participants were married. Almost all of the participants received regular financial support mainly from their adult children and other family members. Seventy percent of the participants had either very good or good social network (Table 3).

Table 3. *Demographic and socio-economic information of older adults living in a rural area in Bangladesh.*

	Men N=208 (45%)	**Women N=249 (55%)**	**Total N=457**
Age in years, mean (SD)	69 (6.5)	69 (7.1)	69 (6.8)
Literacy (%)	59	21***	39
Personal income (%)	65	11***	36
Married (%)	93	30***	58
Received financial support (%)	74	92***	84
Very good & good social network (%)	73	68	70

***p<0.001

Nutritional status (Study I – Study IV)

According to MNA, a quarter of the participants scored less than 15 points, indicative of undernutrition. Having a score between 15 and 21.5, the majority (62%) of the participants were found to be at risk of malnutrition. Only 12% of the participants had ≥22 points, indicating that they were well nourished. No significant sex differences were found in nutritional status assessed by MNA (*Figure 8*).

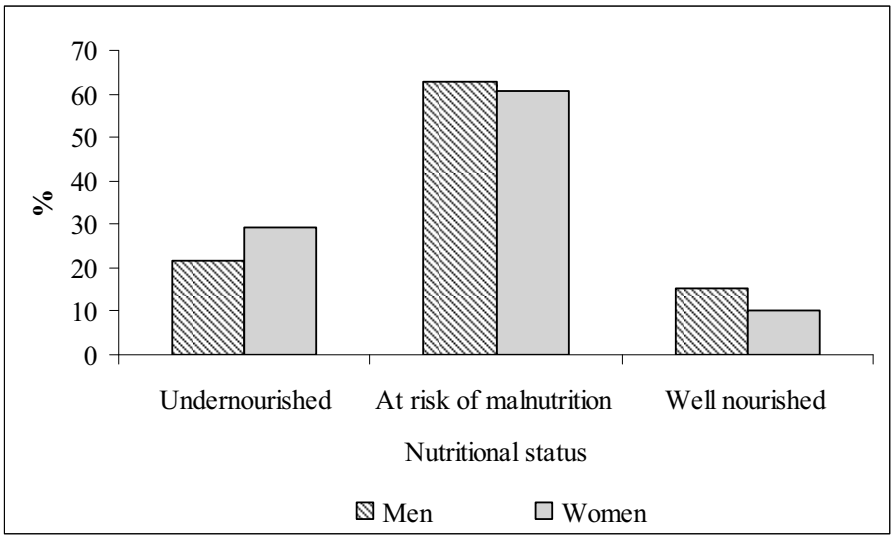


Figure 8. Nutritional status of older participants living in a rural area in Bangladesh.

Half of the participants had a BMI <18.5 kg/m^2. 16% had a BMI ≥22 kg/m^2 and only one person had a BMI >30 kg/m^2. No significant sex differences were found in the mean distribution of BMI. However, compared to the well nourished group (22.4±2.7), the mean BMI was significantly lower in both malnourished (16.9±1.8) and at risk of malnutrition (19.3±2.9) groups.

Demographic and socio-economic determinants of nutritional status (Study I and Study II)

Hierarchical linear regression analyses indicated that being a woman was significantly associated with poor nutritional status. Conversely, being literate, having income, higher per capita daily household expenditures on food and receiving regular financial support were all significantly associated with better nutritional status. Only significant results from Study I and II are presented in Table 4.

Table 4. *Hierarchical linear regression analyses examining demographic and socio-economic indicators as predictors of nutritional status.*

Predictors	***β***	**p value**
Sex (men=1, women=2)	-0.12	<0.05
Literacy (illiterate=1, literate=2)	0.15	<0.01
Income (no income=0, some income=1)	0.14	<0.01
Per capita daily household food expenditure in taka*	0.11	<0.05
Financial support (no regular support=0, regular support=1)	0.11	<0.05

*Taka 57 = $US 1 during the study period (year 2005).

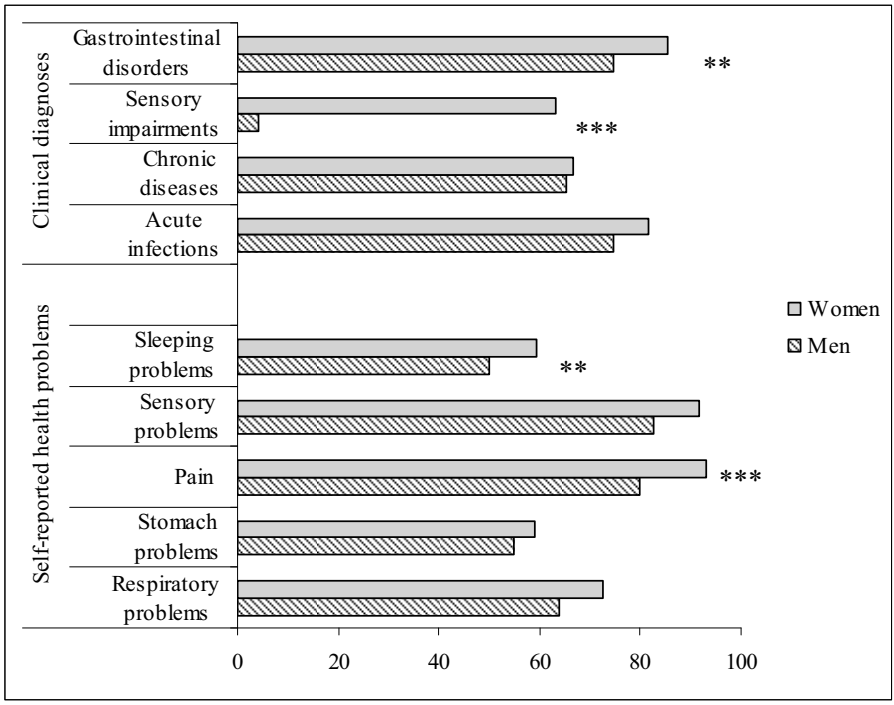
Health status (Study I and Study II)

In order to describe the health status of the participants, both self-reported health problems and clinical diagnoses were considered (*Figure 9*).

Based on self-reported data, the prevalence of pain and sensory problems were equally high in male and female participants (87%). More than two thirds reported respiratory problems. Stomach and sleeping problems were reported by half of the participants. Although more women than men reported suffering from health problems, significant sex differences were detected for pain and sleeping problems only (*Figure 9*).

Clinical examination of each participant confirmed that almost all participants suffered from a mix of medical diagnoses. The most prevalent diseases were in the categories of gastrointestinal disorders (81%) and acute infections (78%). Among the gastrointestinal disorders, the majority of the participants were suffering from upper alimentary tract disorders e.g. stomach pain. The most common acute infection was symptoms of helminthiasis, i.e. a disease in which the body is infested by worms such as pinworm, roundworm or tapeworm. More than half of the participants had at least one chronic illness, mainly arthritis, and 36% had sensory impairment where impaired vision, e.g., cataract, was the most common condition (*Figure 9*).

In addition, female participants had significantly more depressive symptoms than men, and the mean BAMSE score was significantly lower in females than in males.



** p<0.01; ***p<0.001.

Figure 9. Disease profile of older participants according to self-reported health problems and physician's diagnoses based on clinical data.

Effects of health problems and burden of disease on nutritional status (Study I and Study II)

For self-reported health problems, results show that except for pain, all other health problems i.e. respiratory problems, stomach problems, sensory, and sleeping problems were significantly associated with poor nutritional status. Results from medical diagnoses indicate that acute infections, gastrointestinal disorders were significantly associated with poor nutritional status.

Besides, severity of diseases was considered in order to identify the potential effects of the combined disease burden on nutritional status. The results indicate that higher burden of disease was significantly associated with poorer nutritional status.

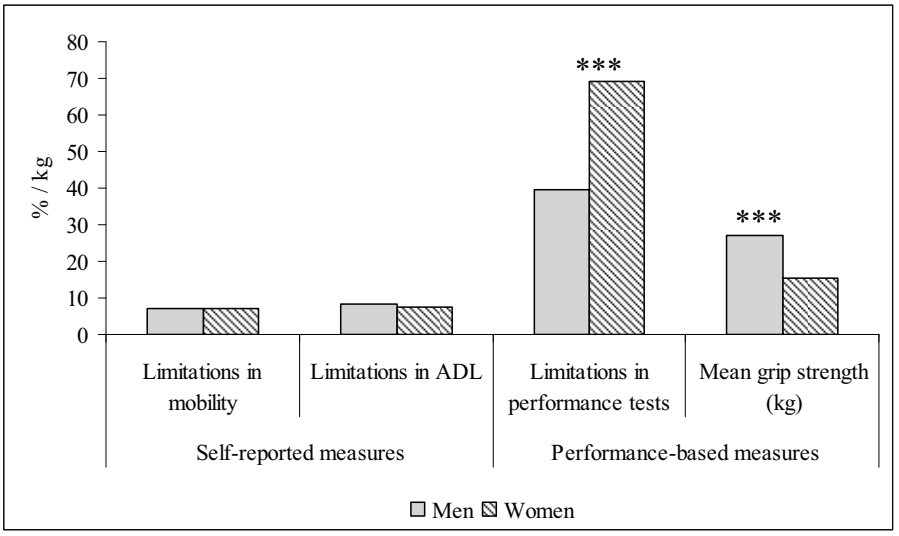
In addition, higher depressive symptoms were inversely and higher BAMSE scores were positively associated with nutritional status of older persons. Only significant results from Studies I and II are presented in Table 5.

Table 5. *Hierarchical liner regression analyses examining self-reported health problems and physician's diagnoses as predictors of nutritional status.*

Predictors	*β*	p value
Self-reported health problems		
Respiratory problems (no=0; yes=1)	-0.11	<0.05
Stomach problems (no=0; yes=1)	-0.12	<0.05
Sensory problems (no=0; yes=1)	-0.17	<0.001
Sleeping problems (no=0; yes=1)	-0.14	<0.01
Disease categories based on physician's diagnoses		
Acute infections (no=0; yes=1)	-0.17	<0.001
Gastrointestinal disorder (no=0; yes=1)	-0.13	<0.01
Severity of disease score (0-9)	-0.29	<0.001
Other health problems		
SRQ20 depressive symptoms scores (0-20)	-0.32	<0.001
Total BAMSE scores (0-30)	0.16	<0.01

Physical function (Study III)

The prevalence of limitations in the two self-reported measures of physical functions, i.e. mobility and ADL, was almost similar. Seven percent reported limitations in mobility and 8% reported limitations in ADL. No significant sex differences were observed in the self-reported data on physical function. On the other hand, more than half of the participants had difficulties in performing one or more task in the performance-based tests. A significantly higher proportion of women than men had difficulties in performing most of the tasks. Mean handgrip strength was lower in women (15.6±5.7) than in men (26.9±7.4) (*Figure 10*).

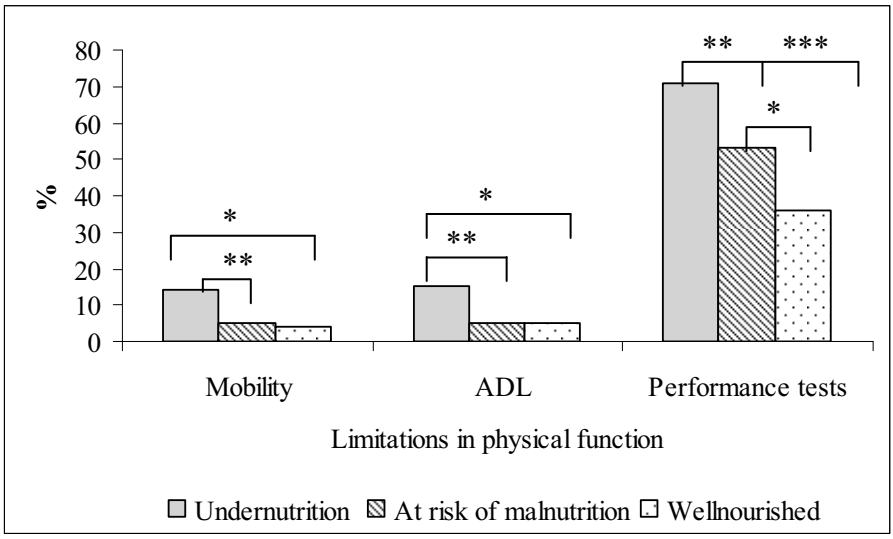


***p<0.001

Figure 10. Prevalence of limitations in self-reported and performance-based measures of physical function in older participants.

Impact of nutritional status on physical function (Study III)

Figure 11 displays the prevalence of limitations in physical function stratified by nutritional status. Significantly higher percentages of the undernourished participants reported limitations in mobility and ADL, and did worse in the performance tests compared to both well-nourished participants and participants who were at risk of malnutrition.



*p<0.05; **p<0.01; ***p<0.001

Figure 11. Limitations in self-reported and performance-based measures of physical function of the participants according to their nutritional status.

Mean handgrip strength, in both men and women, was significantly reduced in the undernourished group compared to well-nourished and at risk of malnutrition groups (*Figure 12*).

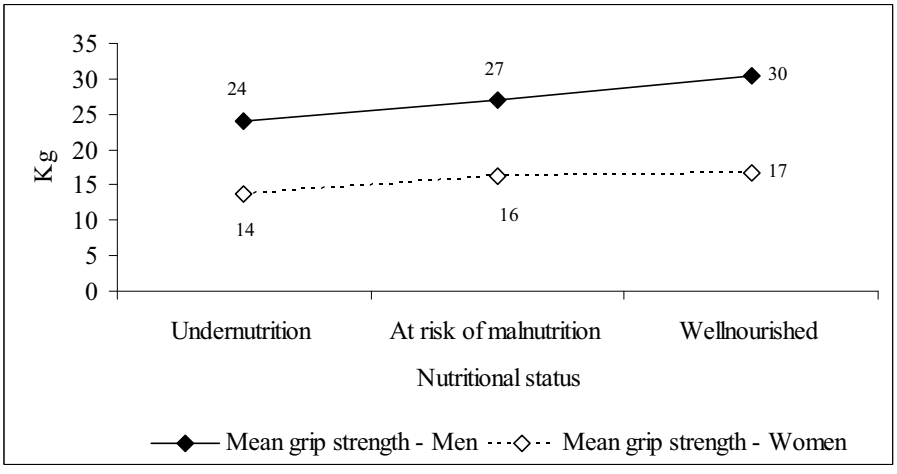


Figure 12. Mean handgrip strength of older participants according to their nutritional status.

Hierarchical linear regression analyses were conducted to identify the possible impact of nutritional status on self-reported and performance-based physical functions. Results indicate that a limitation in physical function was significantly associated with increasing age. Moreover, being a woman and higher number of self-reported health problems were significantly associated with limitations in performance-based measures but not with self-reported measures of physical function. After controlling for all possible predictors, good nutritional status was associated with better performance in both self-reported and performance-based physical function. Only significant results from the hierarchical linear regression analyses are presented in Table 6.

Table 6. *Results from hierarchical liner regression analyses with demographic, health and nutritional status as predictors of physical function.*

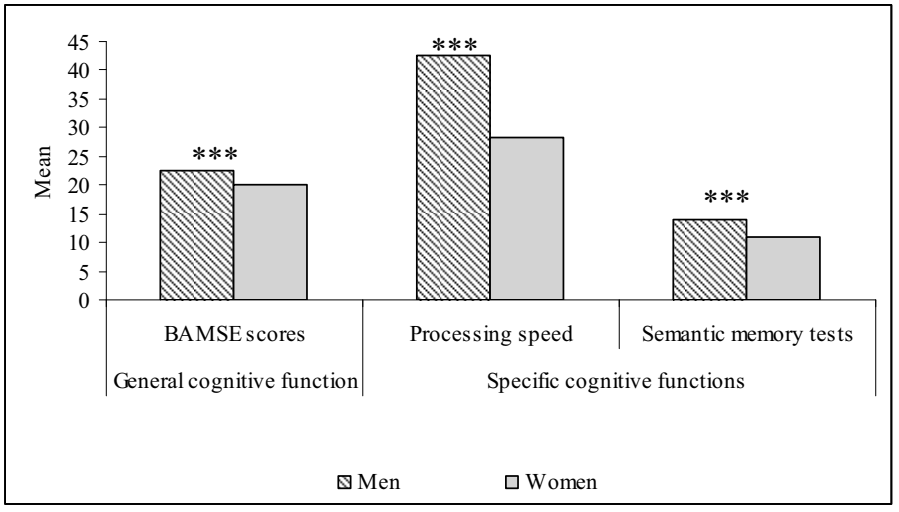
Predictors	**Self-reported physical function**				**Performance-based physical function**			
	Mobility		*ADL*		*Performance-tests*		*Handgrip strength*	
	β	p value	β	p value	β	p value	β	p value
Age	-.25	<0.001	-.20	<0.001	-.19	<0.001	-.12	<0.001
Sex (men=1, women=2)	-.04	ns	.01	ns	-.26	<0.001	-.64	<0.001
Number of health problems*	-.07	ns	-.05	ns	-.27	<0.001	-.18	<0.05
Nutritional status#	.18	<0.001	.15	<0.01	.13	<0.01	.15	<0.001

*Self-reported health problems, # Total MNA scores 0-28. ns: not significant

Cognitive function (Study IV)

Both general and specific cognitive tasks were considered in order to assess the cognitive function of the participants. Results indicate that the mean score in general cognitive function was significantly higher in men than in

women. Similarly, the specific cognitive tasks also favoured men, which indicate that women performed slower than men in the processing speed tasks and did worse in the test of semantic memory function *(Figure 13)*.



***p<0.001

Figure 13. General and specific cognitive performance by older rural Bangladeshi participants.

Impact of nutritional status on cognitive function (Study IV)

Figure 14 presents the mean scores of processing speed, semantic memory and general cognitive function (BAMSE) of the participants stratified by nutritional status. Undernourished participants were significantly slower in information processing speed compared to well-nourished participants and participants who were at risk of malnutrition. A similar pattern was also observed in the tasks of semantic memory and in general cognitive function where undernourished participants performed significantly worse compared to well-nourished participants and participants who were at risk of malnutrition.

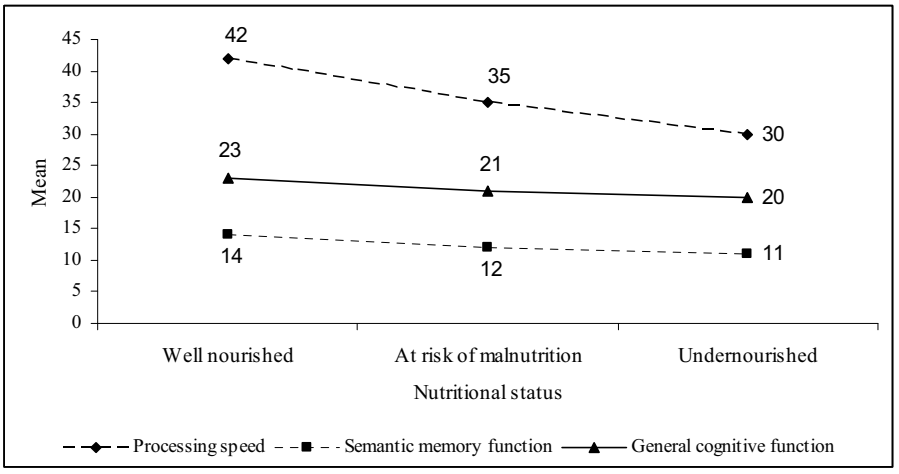


Figure 14. Processing speed, semantic memory function and general cognitive performance of older participants according to their nutritional status.

In order to identify the impact of nutritional status on cognitive function, hierarchical linear regression analyses were conducted. Table 7 presents results from the regression analyses. Results indicate that impaired vision, increasing age, illiteracy, and being a woman were all significantly associated with lower scores in processing speed and lower performance in general cognitive function. Semantic memory function was positively associated with literacy and negatively associated with female gender and impaired vision. Higher severity of disease scores were significantly associated with worse performance in specific cognitive functions (processing speed and semantic memory) but no significant associations were observed with disease severity and general cognitive function. Depressive symptoms did not show significant associations with any of the cognitive tasks. Finally, after controlling for all possible demographic and health indicators, good nutritional status was significantly associated with better general cognitive function (BAMSE), and performance in the test of processing speed. No such association was detected for semantic memory function.

Table 7. *Results from hierarchical linear regression analyses with nutritional status as predictor of cognitive function.*

Predictor	General cognitive function		Processing speed		Semantic memory	
	β	p value	β	p value	β	p value
Impaired vision (no=0; yes=1)	-.15	<0.01	-.26	<0.001	-.27	<0.001
Age	-.18	<0.001	-.25	<0.001	-.09	ns
Literacy (1=illiterate, 2=literate)	.34	<0.001	.41	<0.001	.40	<0.001
Sex (men=1, women=2)	-.24	<0.001	-.36	<0.001	-.37	<0.001
Severity of Disease (0-9)	-.04	ns	-.11	<0.01	-.14	<0.01
Depressive Symptoms (0-20)	.03	ns	-.04	ns	.01	ns
Nutritional status (MNA 0-28p)	.18	<0.001	.09	<0.05	.09	0.053

ns: not significant.

Discussion

This thesis aimed to address the gap in knowledge about the nutritional status of older adults in rural Bangladesh. The results indicate that the prevalence of malnutrition among older persons is high, and that malnutrition is associated with both ill health and impaired socio-economic conditions. The impact of nutritional status on functional status was also focused, and results show that malnutrition has a negative impact on both physical and cognitive functions.

Prevalence of malnutrition

In high income countries the prevalence of both malnutrition and at risk of malnutrition among older persons is found to be in the range 15% to 60% [6, 11]. Thomas and co-authors [7] report that about 30% of their older participants were malnourished and 63% were at risk of being malnourished; thus more than 90% of their participants were either malnourished or at risk of malnutrition. It is important to note that the population covered in the cited studies were living in service flats, in acute geriatric inpatient wards or in sub-acute care where they had access to special health and nutritional care. On the contrary, the older persons at focus in this thesis were living in their own homes in a rural community and the results reveal that almost 90% of them were either malnourished or at risk of malnutrition. It is already well documented that, in Bangladesh, the prevalence of malnutrition is high in both children and younger adults [62, 119, 130]. This thesis reports that the prevalence of malnutrition in Bangladesh is high also in old age, among community living older persons.

Determinants of malnutrition

Ill health

Evidence from other research in Bangladesh report that the prevalence of different diseases is high among older persons [53, 137]. This thesis supports such findings. The prevalence of self-reported health problems was high among the participants studied in this thesis (Study I), and most reported

multiple health problems (Study II). Clinical examinations (Study II) also indicated that almost all participants had a mix of clinical diagnoses including acute infections and chronic illnesses, gastrointestinal disorders as well as sensory problems. The negative effects of health problems on the nutritional status were evident (Studies I and II). In Bangladesh, infectious diseases remain a major concern in health care [153]. A number of studies indicate that the prevalence of helmenthic infections are highly prevalent in Bangladesh [154-156]. The most common infection among the current study participants was helminthiasis (Study II). Research indicates that in many low-income countries the contribution of infectious diseases, particularly parasitic infections e.g. hookworms to malnutrition is significant [157]. Results from this thesis support such evidence by showing that infectious diseases contribute significantly to malnutrition in rural Bangladeshi older persons (Study II).

Several studies indicate that both acute and chronic illnesses are associated with malnutrition [12, 55, 157, 158]. Depression is also reported as one of the risk factors for developing malnutrition [14]. The current findings indicate that acute infections, chronic illnesses or any specific disease or condition such as stomach pain or vision impairment or depressive symptoms does not on its own constitute the main issues to explain poor nutritional status among rural Bangladeshi older persons (Study II). The combined burden of disease, as reflected by the 'severity of disease scores', was more strongly related to malnutrition than the single disease entities.

Poverty

"Malnutrition is rooted in poverty"- this statement by the WHO [22] is a reality in most low-income countries and indeed in Bangladesh. The majority (85%) of the population in Bangladesh live below the poverty limit (income $2 a day) [119]. A poor socio-economic status is often reported as one of the major predictors of impaired nutritional status, indicated by low BMI, among Bangladeshi women and younger adults [61, 62]. Poverty certainly is one of the basic causes of inadequate diets in Bangladesh. Poor people often have insufficient access to food that is rich in nutrients, or they have no choice but to eat food which is poor in nutrients. In the current thesis, poverty is indicated by household expenditure on food (Study I), income and receiving financial support (Study II) and all these factors showed significant associations with nutritional status. Economic scarcity prevents the individual to satisfy his/her hunger and to get sufficient nutrients [159]. This is probably the reality also for the group of people studied here.

Social network

Social networks often play an important role in explaining the nutritional status of older people in high-income countries [58, 59, 160]. In high-income countries older people often live with their spouse. When one of them dies, the partner is left to live alone [161], and sometimes the left-alone individual is not able to care for themselves. In such a context, an extensive social network can improve dietary intake. Often people enjoy eating meals with family and friends, rather than eating alone [162]. In Bangladesh, the family structure is different. Most of older persons in Bangladesh live with their children. If they do not live in the same household, they often share the same compound (*bari*) as their children [148, 163]. Although this thesis reports that the majority of the participants had either a good or a very good social network, the lack of association between social network and nutritional status is notable (Study II). To explain this finding one should consider the food consumption patterns among the participants where both quality and quantity of food is poor (Study I). In this context, it can be speculated that even an extensive social network cannot ensure better nutritional status if the people of that network share the same low quality of food.

Impact of nutritional status on function

The current findings indicate that malnutrition has a negative impact on functional status, both physical (Study III) and cognitive (Study IV). Several studies have shown that poor nutritional status is associated with impaired physical function, frailty, and disability in older persons [72, 83, 164, 165]. Inadequate dietary intake is one of the risk factors to develop sarcopenia, i.e. loss of muscle mass and muscle strength. Sarcopenia limits physical functions among older individuals [166]. An important feature of this thesis is the inclusion of both self-reported and performance-based measures of physical functions (Study III), embracing approaches to physical functions from very basic (mobility, ADL) to more complex functions (performance tests). The results suggest that a good nutritional status is important for older adults to remain physically active, and is essential both for their basic and advanced physical functions.

In line with previous results [83, 167, 168], this thesis reports the important role of proper nutrition for cognitive function (Study IV). In order to examine the relation between nutrition and cognition in an aging population, both general and specific cognitive tasks were used (Study IV). Compared to the well-nourished participants, the malnourished participants performed significantly worse both in general and in specific cognitive functions. In terms of the specific cognitive functions, nutritional status showed significant effects

on processing speed, but not on semantic memory functions. Research has shown that fluid abilities such as processing speed are more affected than crystallized abilities such as semantic memory by somatic health factors [93]. It seems that nutritional status follows the same general pattern as a predictor of cognitive performance. Importantly, cognitive test performance scores cannot automatically be translated into poor everyday functioning. The level of everyday cognitive functioning is not only dependent on a variety of important individual characteristics, but also on the demands of everyday life [169].

Poor nutritional status is associated with limitations in physical functions. Research indicates that persons with limitations in physical function have difficulties to lift up frying pans, peel potatoes, chop meat or to lift a glass of water to their mouth [170]. Most of older participants of this thesis have either a good or a very good social network (Study II). Therefore, such activities (cooking etc.) are likely to be taken care of by the family members. Still, dependency make people feel less complete and often dependent older adults feel that they are bothering others [171]. Thus, the possibility that limitations in physical functions may have influenced the participants, especially the female participant's nutritional situation should not be overlooked.

This thesis uses cognitive functions both as a potential determinant (Study II) and as an outcome (Study IV) of nutritional status. The positive outcome of cognitive function both as a predictor and an outcome indicate the possibility of a bi-directional causal link between nutritional status and cognition. However, using cross-sectional data it is hard to tell which direction is stronger. A handful of clinical trials have shown that nutritional supplementations may improve cognitive outcome [172, 173]. More longitudinal data as well as intervention studies are needed to draw any firm conclusions on whether good nutrition or nutritional supplementations improve cognitive function.

The gender aspects

The gender differences are notable in all aspects throughout this thesis. Differences are visible for demographic (marital status), socio-economic (income, literacy), health and nutritional status (Study I & II). Differences are also evident in terms of functional abilities, both physical (Study III) and cognitive functions (Study IV). Some of the differences are expected. Since women have less muscle mass and lower levels of muscle strength it is difficult for them to perform tests which require high levels of strength. Osteoarthritis may be more common in women because women have a lower

peak bone mass than men [174]. However, for other aspects, it is important to understand the context of these differences.

The health status of women in low-income countries needs to be considered from a life course perspective, where various events increase their vulnerability to poor health in old age [175]. Low socio-economic conditions [176], early age in marriage, food taboos, multiple pregnancies, lack of attention to health [177], workload [176, 178], cultural beliefs [175], gender discriminations in terms of intra-household food distribution [128], and less health seeking behavior [179, 180] influence women's health and nutritional status negatively. In explaining the nutritional situation, Ramalingaswami and colleagues [181] mentioned "the exceptionally high rates of malnutrition in South Asia are rooted deep in the soil of inequality between men and women"(p 16).

The poor nutritional status of the female participants compared to males in this thesis can to some extent be explained by their worse socio-economic and health status than their male counterparts. Poverty is one of the predictors of poor nutritional status, and could be one explanatory factor behind the worse outcome in the women. In general, women also had worse health conditions than the men. A higher proportion of illiterate female participants as compared to males may be another contributing factor. Moreover, Bangladeshi women seek less healthcare services than men [180]. The poor health of older women not only influences their nutritional status but also influences their functional abilities negatively. Living in a society, especially in rural areas, where socio-cultural norms limit women's mobility, may hinder women to be exposed to the outer world [182]. Whether this could be another contributing factor to the worse outcome among women is so far mainly speculative.

Methodological considerations

In Bangladesh, like in many other low-income countries, the nutritional status of older persons is not well recognized. One reason is that only limited research has been conducted on old age group. Another reason is the general lack of simple and easy-to-handle nutritional assessment tools that also include important age-related physiological factors [183]. Indeed, there are several validated screening tools that have been used to assess nutritional status in older persons. Yet there is no gold standard. Hence, there is a large variation of reported prevalence of malnutrition across settings [184, 185]. An essential issue is whether the instruments are culturally adapted and relevant for a low-income setting. This relates for example to anthropometric measurements such as BMI and MUAC.

For these studies the MNA was used for nutritional assessment. Not because it is perfect for a low-income setting, but mostly because of the simplicity of the instrument. It is also a well-recognized and validated tool. MNA has been used in other Asian countries such as Taiwan [186], Japan [16], and China [21]. Although MNA is found to be a useful tool to identify nutritional status of older individuals, it has been suggested by several authors that the instrument needs to be modified for it to be a more useful screening tool in the Asian setting [16, 187]. Several such attempts have already been made in terms of anthropometric measurements and diet related questions in the MNA [17, 188] and this thesis is one of such contributions. A world-wide effort is currently under way to improve the feasibility of the MNA instrument [189].

By using both self-reported data (Study I) and physician's diagnoses based on clinical examinations (Study II), this thesis gives an opportunity to evaluate the reliability of morbidity data. One may question the prevalence figures and the differences among the diagnosis categories across self-reported health problems and physician's diagnoses. The variability probably reflects that both self-reported and clinical diagnosis categories were differently defined and may not necessarily reflect identical diagnoses.

When physical function was evaluated it became obvious that the prevalence of limitations in performance-based measures was much higher than the corresponding prevalence in self-reported measures (Study III). This variation may be explained by individuals' interpretations of self-reported activity, by gender, and social and cultural roles [190]. Thus, the self-reported measures may not add more appropriate information about individual's actual physical capacity [190].

Strengths and weaknesses of the thesis

One limitation of this thesis is that it includes only studies with cross-sectional study designs. Although a number of factors were found to be associated with poor nutritional status, it is not possible to state with certainty that any of them is a risk factor for malnutrition. Also, despite significant associations between disease and malnutrition, it is not clear whether ill health is the cause of malnutrition or if malnourished people are more vulnerable to ill health. The causality most likely works in both directions. Similarly, it can not be safely concluded that improving economic factors will ensure better nutritional status of older participants. The thesis also reports significant negative associations between nutritional status and functional abilities, both physical and cognitive functions. In order to understand whether malnutrition is the cause or the consequence of impaired physical

and cognitive functions, longitudinal data including nutritional intervention studies are needed. Considering that aging research in Bangladesh is still in its infancy, the cross-sectional data of these works may be viewed as positive contributions to the geriatric scene of Bangladesh.

The modifications of the MNA in the current studies limits comparisons with findings obtained with the original MNA. Although in the modified MNA the cut-off scores for undernutrition, at risk of malnutrition, and well-nourished were adjusted, the instrument could have been more comparable to the original MNA if the same total scores had been preserved and the items problematic for the context modified rather than excluded. Yet, this thesis still constitutes an attempt to use MNA in an Asian country, i.e. in a different context and setting than high-income western countries where the instrument was originally developed.

The drop-out analyses (Study I) indicates that the non-participants were older, had lower socio-economic status and were proportionally more often women. It may be assumed that the nutritional status of the non-participants probably was poor, since all these named factors also were significantly associated with lower MNA scores (Studies I & II). Thus, the present thesis is likely to underestimate the prevalence of undernutrition among the rural older population in Bangladesh. Similarly, had we had the data of the non-participants and thus being able to include more participants with low nutritional status we might have detected stronger associations between nutritional status and functional ability including both physical and cognitive functions. From that point of view, the thesis may underestimate also the true effects of nutritional status on physical and cognitive functions. In addition, the findings may not be generalizable to entire Bangladesh since the cohort includes only older persons living in one specific rural area in Bangladesh. Most of the rural areas in Bangladesh are homogenous with respect to the living conditions, socio-economic status, and availability of health care facilities. There is also a large diversity among the urban population in these aspects [85], and there are great variations in living conditions between rural and urban Bangladeshi population.

Future studies

In this thesis data only from rural older persons are presented. Hence, it is important to identify the nutritional status of older urban persons, its determinants and how it influences their functional status.

As indicated previously, ICDDR,B has been maintaining the DSS database since 1966. In future studies it will be important to study the nutritional

status of this group of people in their younger adulthood phase. Since most public health research focus on nutritional status in childhood and young adulthood, it would be interesting to find out when the group of older people became malnourished, which may also in the end give an opportunity for older persons to be included in the development programs.

In the future, another challenge is to relate the findings from this thesis with mortality data from the participants and to ascertain the relevance of the results by relating prospective survival data with the baseline characteristics.

Summary

This thesis aimed to address the gap in knowledge about the nutritional status of community living older adults in rural Bangladesh. Based on the findings, the current thesis reports that:

- Almost 90% of the older persons living at home in rural Bangladesh is either malnourished or at risk of malnutrition (Studies I – IV).
- Both health and socio-economic factors are independently associated with malnutrition, and both of these factors are important to explain nutritional status among Bangladeshi older adults (Studies I & II).
- Good nutritional status is essential for older persons to be functionally active, both physically (Study III) and cognitively (Study IV).
- Nutritional status is important for both basic and advanced physical functions (Study III), and general and specific cognitive abilities (Study IV).

The flow chart in *Figure 15* tries to summarize the findings from this thesis. The figure shows that both socio-economic and health status influence nutritional status. The lower part of the figure shows that nutritional status also influences physical and cognitive functions. It is worth mentioning that in most cases the arrows go in both directions, whereas the arrows in the figure only show relationships dealt with in this thesis.

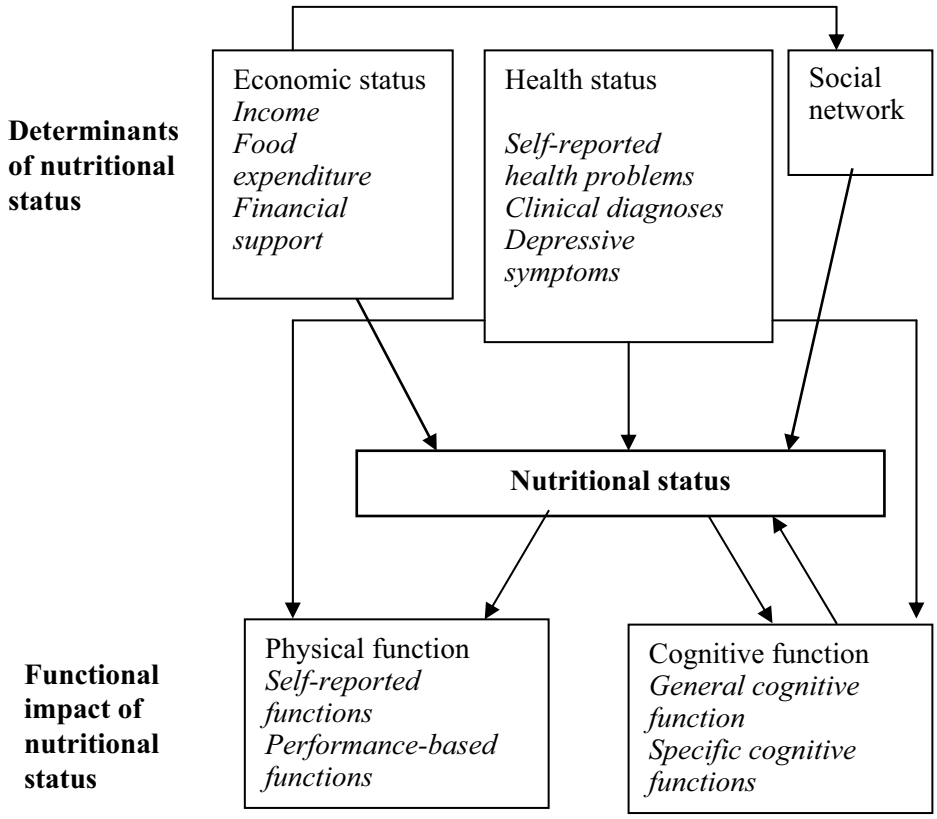


Figure 15. Visual illustration of determinants and functional impact on nutritional status among older Bangladeshi persons based on the findings in this thesis.

Concluding remarks

One of the major findings of this thesis is the multiple contributions of various health problems on nutritional status. Self-reported health problems (Study I) and physician's diagnoses (Study II) accounted for the larger variations in nutritional status followed by demographic and socio-economic status indicators. In the context of poverty, this thesis illuminates how socio-economic status indicated by income, food expenditure, financial support, and social network contribute to nutritional status (Study II). Malnutrition among Bangladeshi older persons is thus a result of a combination of ill health and poverty. Furthermore, the current thesis provides evidence of how physical (Study III) and cognitive (Study IV) functions in an aged population are affected by poor health and nutritional status.

Research on malnutrition among older people in high-income countries has mainly focused on health status [12, 14, 55, 158]. In low-income countries, the focus is largely on individuals' socio-economic status [29, 62]. This thesis indicates that malnutrition is not associated only with health status or only with socio-economic condition. The main message is that nutritional status among older persons in low income countries needs to be recognized both from the perspective of health and socio-economic circumstances. The current studies show that both good health and good nutritional status is essential for older persons to be functionally active. The health condition and nutritional status of older people as described in this thesis indicate that it is time for policy makers and planners to offer a comprehensive health policy for the old people of Bangladesh.

It has been a decade since the MDGs were adapted by all members of the United Nations as a blueprint for building a better world in the 21st century [142]. The first of the eight goals of the MDGs is to eradicate extreme poverty and hunger, and one of the targets is to reduce, by half, the proportion of undernourished in the world's population [191]. Findings from this thesis may provide valuable information relevant to these development programs as eradication of extreme poverty and hunger may not be enough to reduce the proportion of the undernourished population. Health related issues also need to be addressed. Around 60% of the world's older population are now living in low-income countries [113]. Their economic and practical contributions to their families as well as to the country is significant [137]. Without addressing this large segment of the population, a better world cannot be built.

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References

1. Elia M, Zellipour L, and Stratton R, *To screen or not to screen for adult malnutrition.* Clinical Nutrition, 2005. **24**: p. 867–884.
2. World Health Organization, *Malnutrition: the global picture*. 2000, World Health Organization: Geneva.
3. Hickson M, *Malnutrition and ageing.* Postgraduate Medical Journal, 2006. **82**: p. 2-8.
4. Lochs H, Allison SP, Meier R, Pirlich M, Kondrup J, Schneider S, Berghe Gvd, and Pichard C, *Introductory to the ESPEN guidelines on enteral nutrition: terminology, definitions and general topics.* Clinical Nutrition, 2006. **25**: p. 180-186.
5. Klein S, *Protein-energy malnutrition*, in *Cecil Textbook of Medicine*, L. Goldman and J.C. Bennett, Editors. 2000, W. B. Saunders Company: Philadelphia. p. 1148-1152.
6. Persson M, Brismar K, Katzarski K, Nordenström J, and Cederholm T, *Nutritional status using Mini Nutritional Assessment and Subjective Global Assessment predict mortality in geriatric patients.* Journal of the American Geriatrics Society, 2002. **50**: p. 1996–2002.
7. Thomas D, Zdrowski C, Wilson M-M, Conright K, Lewis C, Tariq S, and Morley J, *Malnutrition in subacute care.* The American Journal of Clinical Nutrition, 2002. **75**: p. 308–313.
8. Pauly L, Stehle P, and Volkert D, *Nutritional situation of elderly nursing home residents.* Zeitschrift für Gerontologie und Geriatrie : Organ der Deutschen Gesellschaft für Gerontologie und Geriatrie, 2007. **40**: p. 3-12.
9. Kulnik D and Elmadfa I, *Assessment of the nutritional situation of elderly nursing home residents in Vienna.* Annals of Nutrition & Metabolism, 2008. **52**: p. 51-53.
10. Irving GF, Olsson BA, and Cederholm T, *Nutritional and cognitive status in elderly subjects living in service flats, and the effect of nutrition education on personnel.* Gerontology, 1999. **45**: p. 187-194.
11. Saletti A, Lindgren EY, Johansson L, and Cederholm T, *Nutritional status according to Mini Nutritional Assessment in an institutionalized elderly population in Sweden.* Gerontology, 2000. **46**: p. 139-145.
12. Wikby K, EK A-C, and Christensson L, *Nutritional status in elderly people admitted to community residential homes: comparisons between two cohorts.* The Journal of Nutrition, Health & Aging, 2006. **10**: p. 232-238.

13. Raynaud-Simon A, *Virtual Clinical Nutrition University – Malnutrition in the elderly, Epidemiology and consequences.* e-SPEN, the European e-Journal of Clinical Nutrition and Metabolism, 2008. **In Press**.
14. Johansson Y, Bachrach-Lindström M, Carstensen J, and Ek A-C, *Malnutrition in a home-living older population: prevalence, incidence and risk factors. A prospective study.* Journal of Clinical Nursing, 2009. **18**: p. 1354-1364.
15. Iizaka S, Tadaka E, and Sanada H, *Comprehensive assessment of nutritional status and associated factors in the healthy, community-dwelling elderly.* Geriatrics and Gerontology International, 2008. **8**: p. 24-31.
16. Kuzuya M, Kanda S, Koike T, Suzuki Y, Satake S, and Iguchi A, *Evaluation of Mini-Nutritional Assessment for Japanese frail elderly.* Nutrition, 2005. **21**: p. 498-503.
17. Tsai AC and Ku P-Y, *Population-specific Mini Nutritional Assessment effectively predicts the nutritional state and follow-up mortality of institutionalized elderly Taiwanese regardless of cognitive status.* British Journal of Nutrition, 2008. **100**: p. 152–158.
18. Arlappa N, Balakrishna N, Brahmam G, and Vijayaraghavan K, *Nutritional status of the tribal elderly in India.* Journal of nutrition for the elderly, 2005. **25**: p. 23-39.
19. Shahar S, Ibrahim Z, Fatah AR, Rahman SA, Yusoff NA, Arshad F, Yassin Z, and Adznam SN, *A multidimensional assessment of nutritional and health status of rural elderly Malays.* Asia Pacific Journal of Clinical Nutrition, 2007. **16**: p. 346-353.
20. Yap KB, Niti M, and Ng TP, *Nutrition screening among community-dwelling older adults in Singapore.* Singapore Medical Journal, 2007. **48**: p. 911-916.
21. Han Y, Li S, and Zheng Y, *Predictors of nutritional status among community-dwelling older adults in Wuhan, China.* Public Health Nutrition, 2008. **In Press**: p. 1-8.
22. World Health Organization, *Nutrition for health and development - A global agenda for combating malnutrition*, in *Progress report*. 2000, World Health Organization: Geneva.
23. Nyaruhucha CN, Msuya JM, and Matrida E, *Nutritional status, functional ability and food habits of institutionalised and non-institutionalised elderly people in Morogoro region, Tanzania.* East African Medical Journal, 2004. **81**: p. 248-253.
24. Kimokoti RW and Hamer DH, *Nutrition, health, and aging in sub-Saharan Africa.* Nutrition Reviews, 2008. **66**: p. 611–623.
25. Hajjar RR, Kamel HK, and Denson K, *Malnutrition in aging.* The International Journal of Geriatrics and Gerontology, 2004. **1**: p. 1-35.
26. Mowe M and Bohmer T, *The prevalence of protein-calorie undernutrition in a population of hospitalised elderly patients.* Journal of the American Geriatrics Society, 1991. **39**: p. 1089-1092.

27. Omran ML and Morley JE, *Assessment of protein energy malnutrition in older persons, part I: history, examination, body composition, and screening tools.* Nutrition, 2000. **16**: p. 50-63.
28. Omran ML and Morley JE, *Assessment of protein energy malnutrition in older persons, part II: laboratory evaluation.* Nutrition, 2000. **16**: p. 131–140.
29. Suzana S, Earland J, Suriah A, and Warnes A, *Social and health factors influencing poor nutritional status among rural elderly Malays.* The Journal of Nutrition, Health & Aging, 2002. **6**: p. 363-369.
30. Charlton KE and Rose D, *Nutrition among older adults in Africa: the situation at the beginning of the millennium.* Journal of Nutrition 2001. **131**: p. 2424S-2428S.
31. Faruque ASG, Khan AL, Roy CN, Malek MA, Salam MA, and Khaled MA, *Anthropometric characteristics of elderly people: observations at a large diarrheal hospital in Dhaka, Bangladesh.* The Southeast Asian Journal of Tropical Medicine and Public Health 2006. **37**: p. 784-792.
32. Dey D, Rothenberg E, Sundh V, Bosaeus I, and Steen B, *Height and body weight in the elderly. I. A 25-year longitudinal study of a population aged 70 to 95 years.* European Journal of Clinical Nutrition, 1999. **53**: p. 905-914.
33. Steen B, Bruce A, Isaksson B, Lewin T, and Svanborg A, *Body composition in 70-year-old males and females in Gothenburg, Sweden: A population study.* Acta medica Scandinavica Supplementum, 1977. **611**: p. 87-112.
34. Morley JE, Baumgartner RN, Roubenoff R, Mayer J, and Nair KS, *Sarcopenia.* The Journal of Laboratory and Clinical Medicine, 2001. **137**: p. 231-243.
35. Morley JE and Thomas DR, *Anorexia and aging: pathophysiology.* Nutrition, 1999. **15**: p. 499-503.
36. Morley JE, *Anorexia, sarcopenia, and aging.* Nutrition, 2001. **17**: p. 660-663.
37. NIH, *The practical guide: Identification, evaluation, and treatment of overweight and obesity in adults*. 2000, National Institutes of Health. National Heart, Lung, and Blood Institute.
38. Guigoz Y, Vellas B, and Garry PJ, *Mini Nutritional Assessment: a practical assessment tool for grading the nutritional state of elderly patients*, in *Facts and Research in Gerontology 1994/1995 Supplement* Y. Guigoz, et al., Editors. 1994, Serdi Publishing Company: New York. p. 15–81.
39. Shahar S, Fun WS, and Chik WCPW, *A prospective study on malnutrition and duration of hospitalisation among hospitalised geriatric patients Admitted to surgical and medical wards of Hospital Universiti Kebangsaan Malaysia.* Mal J Nutr, 2002. **8**: p. 55-62.
40. Rolland Y, Lauwers-Cances V, Cournot M, Nourhashémi F, Reynish W, Rivière D, Vellas B, and Grandjean H, *Sarcopenia, calf circumference, and physical function of elderly women: a cross-*

sectional study. Journal of American Geriatric Society, 2003. **51**: p. 1120-4.
41. Guigoz Y, *The Mini Nutritional Assessment (MNA): Review of literature - what does it tell us.* The Journal of Nutrition, Health & Aging, 2006. **10**: p. 466-487.
42. Irving GF, Basun H, and Cederholm T, *Nutritional and cognitive relationships and long-term mortality in patients with various dementia disorders.* Age and Ageing 2005. **34**: p. 136-141.
43. Seiler WO, *Clinical pictures of malnutrition in ill elderly subjects.* Nutrition, 2001. **17**: p. 496–498.
44. Bouillanne O, Hay P, Liabaud B, Duche C, Cynober L, and Aussel C, *Evidence that albumin is a prognostic marker of morbidity and mortality and not nutritional marker in elderly patients*, in *30th ESPEN Congress*. 2008, Elsevier Science Inc: Florence; Italy.
45. Sullivan DH, *What do the serum proteins tell us about our elderly patients?* . Journal of Gerontology, 2001. **56A**: p. M71-M74.
46. Kondrup J, Allison SP, Elia M, Vellas B, and Plauth M, *ESPEN guidelines for nutritona screening 2002.* Clinical Nutrition, 2003. **22**: p. 415-421.
47. Bauer JM, Kaiser MJ, Anthony P, Guigoz Y, and Sieber CC, *The Mini Nutritional Assessment®—its history, today's practice, and future perspectives.* Nutrition in Clinical Practice 2008. **23**: p. 388-396.
48. Schroeder DG, *Malnutrition*, in *Nutrition and health in developing countries*, R.D. Semba and M.W. Bloem, Editors. 2001, Humana Press Inc: Totowa, New Jersey.
49. World Health Organization, *The World Health Report 1997*, in *Conquering suffering enriching humanity*. 1997, World Health Organization: Geneva.
50. Joshi K, Kumar R, and Avasthi A, *Morbidity profile and its relationship with disability and psychological distress among elderly people in Northern India.* International Journal of Epidemiology, 2003. **32**: p. 978-987.
51. Shahar S, Earland J, and Rahman SA, *Social and health profiles of rural elderly Malays.* Singapore Medical Journal, 2001. **42**: p. 208-213.
52. Clausen T, Romoren TI, Ferreira M, Kristensen P, Ingstad B, and Holmboe-Ottesen G, *Chronic diseases and health inequalities in older persons in Botswana (southern Africa): a national survey.* Journal of Nutrition Health & Aging, 2005. **9**: p. 455-461.
53. Mostafa G and Streatfield PK, *Health implications of an ageing Bangladeshi population*, in *The elderly, contemporary issues*, M. Kabir, Editor. 2003, Bangladesh Association of Gerontology: Dhaka.
54. Stratton RJ, Green CJ, and Elia M, *Causes of disease-related malnutrition*, in *Disease related malnutrition: An evidence-based approach to treatment*. 2003, CAB International: USA.

55. Cederholm T and Hellström K, *Nutritional status in recently hospitalized and free-living elderly subjects* Gerontology, 1992. **38**: p. 105-110.
56. Cederholm T, Jägren C, and Hellström K, *Nutritional status and performance capacity in internal medical patients.* Clinical Nutrition, 1993. **12**: p. 8-14.
57. Benzeval M and Judge K, *Income and health: the time dimension.* Social Science & Medicine, 2001. **52**: p. 1371-1390.
58. Chen C-H, Schilling L, and Lyder C, *A concept analysis of malnutrition in the elderly.* Journal of Advanced Nursing, 2001. **36**: p. 131-142.
59. Chen C-H, Bai Y-Y, Huang G-H, and Tang ST, *Revisiting the concept of malnutrition in older people.* Journal of Clinical Nursing, 2007. **16**: p. 2015-16.
60. Goldstein J, Jacoby E, Aguila Rd, and Lopez A, *Poverty is a predictor of non-communicable disease among adults in Peruvian cities.* Preventive Medicine, 2005. **41**: p. 800-806.
61. Ahmed S, Adams A, Chowdhury A, and Bhuiya A, *Chronic energy deficiency in women from rural Bangladesh: some socioeconomic determinants.* Journal of Biosocial Science, 1998. **30**: p. 349-358.
62. Pryer J and Rogers S, *Epidemiology of undernutrition in adults in Dhaka slum households, Bangladesh.* European Journal of Clinical Nutrition, 2006. **60**: p. 815-822.
63. Morley JE, *Protein-energy malnutrition in older subjects.* Proceedings of fhe Nutrition Society, 1998. **57**: p. 587-592
64. Bulut S, *Late life depression: A literature review of late-life depression and contributing factors.* anales de psicología, 2009. **25**: p. 21-26.
65. Blaum C, Fries B, and Fiatarone M, *Factors associated with low body mass index and weight loss in nursing home residents.* The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 1995. **50**(3): p. M162-M168.
66. Cabrera M, Mesas A, Garcia A, and de Andrade SM, *Malnutrition and depression among community-dwelling elderly people.* Journal of the American Medical Directors Association, 2007. **8**: p. 582-584.
67. Brownie S, *Why are elderly individuals at risk of nutritional deficiency.* International Journal of Nursing Practice, 2006. **12**: p. 110-118.
68. Kullberg K, Aberg AC, Bjorklund A, Ekblad J, and Sidenvall B, *Daily eating events among co-living and single-living, diseased older men.* Journal of Nutrition Health & Ageing, 2008. **12**: p. 176-82.
69. Stratton RJ, Green CJ, and Elia M, *Consequences of disease-related malnutrition*, in *Disease related malnutrition: An evidence-based approach to treatment*. 2003, CAB International: USA.
70. Parker M, *Functional limitations among the oldest old.* 1994, Uppsala University: Uppsala.

71. Kierkegaard M, Harms-Ringdahl K, Holmqvist LW, and Tollbäck A, *Perceived functioning and disability in adults with myotonic dystrophy type 1: A survey according to the International Classification of Functioning, Disability and Health.* Journal of Rehabilitation Medicine, 2009. **41**: p. 512-520.
72. Bartali B, Semba RD, Frongillo EA, Varadhan R, Ricks MO, Blaum CS, Ferrucci L, Guralnik JM, and Fried LP, *Low micronutrient levels as a predictor of incident disability in older women.* Archives of Internal Medicine, 2006. **27**: p. 2335-2340.
73. Busetto L, Romanato G, Zambon S, Calo` E, Zanoni S, Corti M, Baggio G, Enzi G, Crepaldi G, and Manzato E, *The effects of weight changes after middle age on the rate of disability in an elderly population Sample.* Journal of the American Geriatrics Society, 2009. **57**: p. 1015–1021.
74. von Strauss E, Fratiglioni L, Viitanen M, Forsell Y, and Winblad B, *Morbidity and comorbidity in relation to functional status: a community-based study of the oldest old (90+ years).* Journal of the American Geriatrics Society, 2000. **48**: p. 1462-1469.
75. World Health Organization, *International Classification of Impairments, Disabilities and Handicaps. A manual of Classification relating to the consequences of disease*. 1980, World Health Organization: Geneva.
76. Grimby G, Finnstam J, and Jette A, *On the application of the WHO handicap classification in rehabilitation.* Scandinavian Journal of Rehabilitation Medicine, 1988. **20**: p. 93-98.
77. Nordenfelt L, *On the notions of disability and handicap.* Scandinavian Journal of Social Welfare, 1993. **2**: p. 17-24.
78. World Health Organization, *ICF International Classification of Functioning, Disability and Health*. 2001, World Health Organization: Geneva.
79. Verbrugge L and Jette A, *The disablement process.* Social Science & Medicine, 1994. **38**: p. l-14.
80. Chevalier S, Saoud F, Gray-Donald K, and Morais JA, *The physical functional capacity of frail elderly persons undergoing ambulatory rehabilitation is related to their nutritional status.* The Journal of Nutrition, Health & Aging, 2008. **12**: p. 721-726.
81. Stuck AE, Walthert JM, Nikolaus T, Büla CJ, Hohmann C, and Beck JC, *Risk factors for functional status decline in community-living elderly people: a systematic literature review.* Social Science & Medicine, 1999. **48**: p. 445-469.
82. Bannerman E, Miller MD, Daniels LA, Cobiac L, Giles LC, Whitehead C, Andrews GR, and Crotty M, *Anthropometric indices predict physical function and mobility in older Australians: the Australian Longitudinal Study of Ageing.* Public Health Nutrition, 2002. **5**: p. 655–662.
83. Olin A, Koochek A, Ljungqvist O, and Cederholm T, *Nutritional status, well-being and functional ability in frail elderly service flat*

residents. European Journal of Clinical Nutrition, 2005. **59**: p. 263-270.
84. Kikafunda JK and Lukwago FB, *Nutritional status and functional ability of the elderly aged 60 to 90 years in the Mpigi district of central Uganda.* Nutrition, 2005. **21**: p. 59-66.
85. Kabir ZN, Parker MG, Szebehely M, and Tishelman C, *Influence of socio-cultural and structural factors on functional ability: the case of elderly people in Bangladesh.* Journal of Aging and Health, 2001. **13**: p. 355-378.
86. Guralnik JM, Branch LG, Cummings SR, and Curb JD, *Physical performance measures in aging research.* Journal of Gerontology, 1989. **44**: p. M141-M146.
87. McDowell I and Newell C, *Measuring health: A guide to rating scales and questionnaires*. 1996, New York: Oxford University Press.
88. Medical Dictionary, *Webster's New World™ Medical Dictionary (3rd Edition)*, W.C. Shiel and M C Stöppler (Eds), Editors. 2008, Wiley Publishing, Inc.
89. Salthouse TA, *Cognitive competence and expertise in aging*, in *Handbook of the Psychology of Aging (3rd Edition)*, J E Birren and K W Schaie (Eds.), Editor. 1990, Academic Press, Inc.: San Diego, California.
90. Eysenck MW and Keane MT, *Cognitive Psychology: A student's handbook (5th edition),*. 2007, New York: Psychology Press Ltd.
91. Tulving E, *Episodic and semantic memory*, in *Organization of memory*, In W Dionaldsson (Ed), Editor. 1972, Academic Press: London.
92. Bäckman L, Small B, Wahlin Å, and Larsson M, *Cognitive functioning in very old age*, in *Handbook of aging and cognition*, F.I.M. Craik and T A Salthouse (Eds.), Editors. 2000, Erlbaum: Hillsdale, NJ.
93. Wahlin Å, *Health, disease and cognitive functioning in old age*, in *New frontiers in cognitive ageing*, R. Dixon, L. Bäckman, and LG Nilsson (Eds.), Editors. 2004, Oxford University Press: Oxford, UK. p. pp 279-302.
94. Budson AE and Price BH, *Memory dysfunction.* The New England Journal of Medicine, 2005. **352**: p. 692-699.
95. Faxén-Irving G, Andrén-Olsson B, and Cederholm T, *Nutritional and Cognitive Status in Elderly Subjects Living in Service Flats, and the Effect of Nutrition Education on Personnel.* Gerontology 1999. **45**: p. 187–194.
96. Leite M, Nicolosi A, Cristina S, Hauser W, and Nippi G, *Nutrition and cognitive deficit in the elderly: a population study.* European Journal of Clinical Nutrition, 2001. **55**: p. 1053-1058.
97. Lee L, Kang S, Lee H, Lee B-H, Park J, Kim J-H, Jung I, Park Y, and Lee J, *Relationships between dietary intake and cognitive function level in Korean elderly people.* Public Health 2001. **115**: p. 133-138.

98. González-Gross M, Marcos A, and Pietrzik K, *Nutrition and cognitive impairment in the elderly.* British Journal of Nutrition 2001. **86**: p. 313–321.
99. Calvaresi E and Bryan JB, *Vitamins, cognition and ageing: A review.* Journal of Gerontology, 2001. **56**: p. 327-339.
100. Wahlin Å, Hill R, Winblad B, and Bäckman L, *Effects of serum vitamin B12 and folate status on episodic memory performance in very old age: A population-based study.* Psychology and Aging 1996. **11**: p. 487-496.
101. Wang H-X, Wahlin Å, Basun H, Fastbom J, Winblad B, and Fratiglioni L, *Vitamin B12 and folate in relation to the development of Alzheimer's disease.* Neurology 2001. **56**: p. 1188-1194.
102. Black MM, *Micronutrient deficiencies and cognitive functioning.* Journal of Nutrition, 2003. **133**: p. 3927S–3931S.
103. Irving GF, *Nutrition and cognitive function in the elderly.* Scandinavian Journal of Nutrition, 2003. **47**: p. 139–142.
104. Folstein MF, Folstein SE, and McHugh PR, *Mini Mental State: A practical method for grading the cognitive state of patients for the clinicians.* Journal of Psychiatric Research, 1975. **12**: p. 189-198.
105. Salmon DP, Riekkinen PJ, Katzman R, Zhang M, Jin H, and Yu E, *Cross-cultural studies of dementia: A comparison of MMSE performance in Finland and China.* Archives of Neurology, 1989. **46**: p. 769-772.
106. Park JH and Kwon YC, *Modification of the MMSE for use in the elderly in a non-western society. Part I, Development of Korean version of MMSE.* International Journal of Geriatric Psychiatry, 1990. **5**: p. 381-387.
107. Lowenstein DA, Arguelles T, Barker WW, and Duara R, *A comparative analysis of neuropsychological test performance of Spanish-speaking and English-speaking patients with Alzheimer's disease.* Journal of Gerontology, 1993. **48**: p. 142-149.
108. Ganguli M, Ratcliff G, Chandra V, Sharma S, Gilby JE, Pandav R, Belle S, Ryan CM, Baker CR, Seaberg CR, and DeKosky ST, *A Hindi version of the MMSE: the development of a cognitive screening instrument for a largely illiterate rural elderly population in India.* International Journal of Geriatric Psychiatry, 1995. **10**: p. 367-377
109. Kabir ZN and Herlitz A, *The Bangla Adaptation of Mini-Mental State Examination (BAMSE): An Instrument to Assess Cognitive Function in Illiterate and Literate Individuals.* International Journal of Geriatric Psychiatry, 2000. **15**(5): p. 441-450.
110. United Nations, *World Population Ageing:1950-2050. Available at: http://www.un.org/esa/population/publications/worldageing19502050/ (accessed on November 29 2006)*. 2006, Department of Economic and Social Affairs Population Division, DESA, United Nations.: New York.

111. World Health Organization, *Men ageing and health: Achieving health across the life span*. 2001, Noncommunicable disease prevention and health promotion department.: Geneva.
112. World Health Organization, *Active ageing: A policy framework*. 2002, Noncommunicable disease prevention and health promotion department, World Health Organization Geneva.
113. Kinsella K and Phillips DR, *Global aging: The challenge of success.* Population Bulletin, 2005. **60**.
114. PRB, *The 2008 World Population Data Sheet*. 2009, Population Reference Bureau, NW, Washington Available at: http://www.prb.org/Publications/Datasheets/2008/2008wpds.aspx. Accessed on March 16, 2009.
115. WHOSIS, *Core Health Indicators*. 2008, WHO Statistical Information System (WHOSIS) Available at: http://www.who.int/whosis/database/core/core_select.cfm. Accessed on March 16, 2009
116. United Nations, *World Population Prospects: The 2008 Revision Population Database* 2009, United Nations Population Division. Available at: http://esa.un.org/unpp/p2k0data.asp. Accessed on March 11, 2009.
117. WFB, *The World Fact Book 2009*. 2009, https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html. Accessed on April 20, 2009.
118. BBS, *Statistical Pocketbook of Bangladesh 2008*, BBS, Editor. 2009, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh: Dhaka.
119. UNDP, *Human Development Report 2007/2008*, in *Fighting Climate Change: Human solidarity in a divided world*. 2007, The United Nations Development Program: New York.
120. Chazan D, *Bangladesh healthcare crisis* 2000, BBC News. Available at http://news.bbc.co.uk/2/hi/south_asia/659674.stm. Accessed on April 20, 2009.
121. Hels O, Hassan N, Tetens I, and Thilsted SH, *Food consumption, energy and nutrient intake and nutritional status in rural Bangladesh: changes from 1981 – 1982 to 1995 – 96.* European Journal of Clinical Nutrition, 2003. **57**: p. 586–594.
122. FAO, *Nutrition country profiles - Bangladesh*, in *Nutrition country profile*. 1999, Food and agriculture organization of the United Nations.
123. Hillbruner C and Egan R, *Seasonality, household food security, and nutritional status in Dinajpur, Bangladesh.* Food and Nutrition Bulletin, 2008. **29**: p. 221-231.
124. Bhattacharjee L, Saha SK, and Nandi BK, *Food-based nutrition strategies in Bangladesh: Experience of integrated horticulture and nutrition development*. 2007, Department of Agricultural Extension, Ministry of Agriculture, The People's Republic of Bangladesh; Food

and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific.
125. Hossain M, Naher F, and Shahabuddin Q, *Food security and nutrition in Bangladesh: Progress and determinants. electronic* Journal of Agricultural and Development Economics, 2005. **2**: p. 103-132.
126. WFP, UNICEF, and IPHN. *Child malnutrition and household food insecurity remain major concerns for Bangladesh. Available at: http://www.unicef.org/bangladesh/media_4942.htm.* March, 2009 [cited 2009 April 30].
127. Bose ML and Dey MM, *Food and nutritional security in Bangladesh: going beyond carbohydrate counts.* Agricultural Economics Research Review, 2007. **20**: p. 203-225.
128. Bouis HE and Novenario-Reese MJG, *The determinants of demand for micronutrients: an analysis of rural households in Bangladesh*. 1997, Food Consumption and Nutrition Division, International Food Policy Research Institute, Washington DC, USA.
129. National Institute of Population Research and Training, Mitra and Associates, and Macro International, *Bangladesh Demographic and Health Survey 2007*. 2007, National Institute of Population Research and Training, Mitra and Associates, and Macro International: Dhaka, Bangladesh and Calverton, Maryland, USA.
130. Shafique S, Akhter N, Stallkamp G, Pee Sd, Panagides D, and Bloem MW, *Trends of under- and overweight among rural and urban poor women indicate the double burden of malnutrition in Bangladesh.* International Journal of Epidemiology, 2007. **36**: p. 449–457.
131. World Health Organization, *Nutrition in South-East Asia*. 2000, Regional Office for South-East Asia, World Health Organization: New Delhi.
132. Lee V, Ahmed F, Wada S, Ahmed T, Ahmed AMS, Banu CP, and Akhter N, *Extent of vitamin A deficiency among rural pregnant women in Bangladesh.* Public Health Nutrition, 2008. **11**: p. 1326-1331.
133. Islam Z, Shamim AA, Kemi V, Nevanlinna A, Akhtaruzzaman M, Laaksonen M, Jehan AH, Jahan K, Khan HU, and Lamberg-Allardt C, *Vitamin D deficiency and low bone status in adult female garment factory workers in Bangladesh.* British Journal of Nutrition, 2008. **99**: p. 1322–1329.
134. Hyder SMZ, Persson L-Å, Chowdhury AMR, and Ekström E-C, *Anaemia among non-pregnant women in rural Bangladesh.* Public Health Nutrition 2000. **4**: p. 79-83.
135. Hyder SMZ, Persson L-Å, Chowdhury M, Lönnerdal B, and Ekström E-C, *Anaemia and iron deficiency during pregnancy in rural Bangladesh.* Public Health Nutrition 2004. **7**: p. 1065-1070.
136. Streatfield P and Karar ZA, *Population challenges for Bangladesh in the coming decades.* Journal of Health Population and Nutrition, 2008. **26**: p. 261-272.

137. Kabir ZN, *The emerging elderly population in Bangladesh: Aspects of their health and social situation*, in *Division of Geriatric Medicine and Department of Public Health Sciences*. 2001, Karolinska Institutet: Stockholm, Sweden.
138. Banu D, *Health for population aging: Bangladesh perspective*, in *The elderly, contemporary issues*, M. Kabir, Editor. 2003, Bangladesh Association of Gerontology: Dhaka.
139. HelpAge Int, *Uncertainty rules our lives: The situation of older people in Bangladesh*. 2000, HelpAge International: ChiangMai, Thailand.
140. Martin L, *The status of South Asia's growing elderly population.* Journal of Cross-Cultural Gerontology, 1990. **5**: p. 92-117.
141. Abeykoon A, *Ageing and the health sector in Sri Lanka.* The Ceylon Medical Journal, 2000. **45**: p. 52-54.
142. United Nations, *UN Millennium Development Goals*. 2006, http://www.un.org/millenniumgoals/. Accessed September 25, 2006.
143. Svedberg P, *Poverty and Undernutrition: Theory, Measurement, and Policy*. 2000, Oxford: Oxford University Press.
144. Banglapedia, *Matlab Upazila* 2009, http://www.banglapedia.org/httpdocs/HT/M_0183.HTM. Assessed April 27 2009.
145. Banglapedia, *Chandpur District*. 2006, http://banglapedia.search.com.bd/Maps/MC_0122.GIF (accessed November 27, 2006).
146. Health and Demographic Surveillance Unit PHSD, *Health and demographic surveillance system - Matlab: Registration of health and demographic events 2005* 2007, ICDDR,B: Dhaka, Bangladesh.
147. Haque Z, *HDSS Study Area, Matlab*. 2006, Geographic Information Systems, Health and Demographic Surveillance Unit, PHSD, ICDDR,B: Dhaka.
148. Amin S, *Family structure and change in rural Bangladesh.* Population Studies, 1998. **52**: p. 201-213.
149. Christensson L, Unosson M, and Ek A-C, *Evaluation of nutritional assessment techniques in elderly people newly admitted to municipal care.* European Journal of Clinical Nutrition, 2002. **56**: p. 810-818.
150. Visvanathan R, Zaiton A, Sherina M, and Muhamad Y, *The nutritional status of 1081 elderly people residing in publicly funded shelter homes in Peninsular Malaysia.* European Journal of Clinical Nutrition, 2005. **59**: p. 318-324.
151. Tietz NW, *Clinical Guide to Laboratory Tests*. 3rd Edition ed, ed. N.W. Tietz. 1995, Philadelphia: W.B. Saunders Company.
152. Harding TW, de Arango MV, Baltazar J, Climent CE, Ibrahim HH, Ladrido-Ignacio L, Murthy RS, and Wig NN, *Mental disorders in primary health care: A study of their frequency and diagnosis in four developing countries.* Psychological Medicine 1980. **10**: p. 231-241.

153. Sack DA, *Achieving the Millennium Development Goals for health and nutrition in Bangladesh: key issues and interventions - an introduction.* Journal of Health Population and Nutrition, 2008. **26**: p. 253-260.
154. Persson V, Ahmed F, Gebre-Medhin M, and Greiner T, *Relationships between vitamin A, iron status and helminthiasis in Bangladeshi school children.* Public Health Nutrition, 1999. **3**: p. 83–89.
155. Gilgen D, Mascie-Taylor CGN, and Rosetta L, *Intestinal helminth infections, anaemia and labour productivity of female tea pluckers in Bangladesh.* Tropical Medicine and International Health, 2001. **6**: p. 449-457.
156. Gilgen D and Mascie-Taylor CGN, *The effect of anthelmintic treatment on helminth infection and anaemia.* Parasitology, 2001. **122**: p. 105-110.
157. Müller O and Krawinkel M, *Malnutrition and health in developing countries.* Canadian Medical Association Journal 2005. **173**: p. 279-286.
158. Cederholm T, Jägren C, and Hellström K, *Outcome of protein-energy malnutrition in elderly medical patients.* The American Journal of Medicine, 1995. **98**: p. 67-74.
159. Sen A, *Development As Freedom*. 2006, New Delhi: Oxford University Press.
160. Davis MA, Murphy SP, Neuhaus JM, Gee L, and Quiroga SS, *Living arrangements affects dietary quality for US adults aged 50 years and older.* Journal of Nutrition, 2000. **130**: p. 2256-2264.
161. Locher JL, Ritchie CS, Roth DL, Baker PS, Bodner EV, and Allman RM, *Social isolation, support, and capital and nutritional risk in an older sample: ethnic and gender differences.* Social Science Medicine, 2005. **60**: p. 747-761.
162. Gustafsson K and Sidenvall B, *Food-related health perceptions and food habits among older women.* Journal of Advanced Nursing, 2002. **39**: p. 164–173.
163. Kabir ZN, Szebehely M, Tishelman C, Chowdhury AM, Hojer B, and Winblad B, *Aging trends - making an invisible population visible: the elderly in Bangladesh.* Journal of Cross-Cultural Gerontology, 1998. **13**: p. 361-378.
164. Bartali B, Frongillo EA, Guralnik JM, Stipanuk MH, Allore HG, Cherubini A, Bandinelli S, Ferrucci L, and Gill TM, *Serum micronutrient concentrations and decline in physical function among older persons.* JAMA : the Journal of the American Medical Association, 2008. **299**: p. 308-315.
165. Bartali B, Frongillo EA, Bandinelli S, Lauretani F, Semba RD, Fried LP, and Ferrucci L, *Low nutrient intake is an essential component of frailty in older persons.* The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 2006. **61**: p. 589-593.
166. Rolland Y, Czerwinski S, Kan G, Morley J, Cesari M, Onder G, Woo J, Baumgartner R, Pillard F, Boirie Y, Chumlea W, and Vellas

B, *Sarcopenia: Its assessment, etiology, pathogenesis, consequences and future perspectives.* The Journal of Nutrition, Health & Aging, 2008. **12**: p. 433-450.
167. Leite MLC, Nicolosi A, Cristina S, Hauser WA, and Nappi G, *Nutrition and cognitive deficit in the elderly: a population study.* European Journal of Clinical Nutrition 2001. **55**: p. 1053-1058.
168. Requejo AM, Ortega RM, Robles F, Navia B, Faci M, and Aparicio A, *Influence of nutrition on cognitive function in a group of elderly, independently living people.* European Journal of Clinical Nutrition, 2003. **57**: p. 54-57.
169. Johansson B and Wahlin Å, *Cognition and geropsychological assessment*, in *Comprehensive clinical psychology: Clinical geropsychology*, B Edelstein (Ed), Editor. 1998, Elsevier Sciences: Amsterdam.
170. Thyberg I, Hass U, Nordenskiöld U, Gerdle B, and Skogh T, *Activity limitation in rheumatoid arthritis correlates with reduced grip force regardless of sex: the Swedish TIRA project.* Arthritis & Rheumatism, 2005. **53**: p. 886-896.
171. Williams G, *Disablement and the social context of daily activities.* International Disability Studies 1987. **9**: p. 97–102.
172. Freund-Levi Y, Basun H, Cederholm T, Faxén-Irving G, Garlind A, Grut M, Vedin I, Palmblad J, Wahlund LO, and Eriksdotter-Jönhagen M, *Omega-3 supplementation in mild to moderate Alzheimer's disease: effects on neuropsychiatric symptoms.* International Journal of Geriatric Psychiatry, 2008. **23**: p. 161-9.
173. Freund-Levi Y, Eriksdotter-Jönhagen M, Cederholm T, Basun H, Faxén-Irving G, Garlind A, Vedin I, Vessby B, Wahlund LO, and Palmblad J, *Omega-3 fatty acid treatment in 174 patients with mild to moderate Alzheimer disease: OmegAD study: a randomized double-blind trial.* Archives of Neurology, 2006. **63**: p. 1402-8.
174. Melton LJ, Lane AW, Cooper C, Eastell R, O'Fallon WM, and Riggs BL, *Prevalence and incidence of vertebral deformities* Osteoporosis International, 1993. **3**: p. 113-119.
175. World Health Organization, *Women, Ageing and Health: A Framework for Action: Focus on Gender*. 2007, World Health Organization: Geneva.
176. Basu S and Sidh SN, *Work status and health of women: a comparative study of northern and southern states of rural India.* World Health & Population, 2008. **10**: p. 40-52.
177. Prakash IJ, *Ageing in India: Prepared for World Health Organization* 1999, World Health Organization: Geneva.
178. Bonita R, *Women, ageing and health: Achieving health across the life span*. 1998, World Health Organization: Geneva.
179. Haddad L, *Women's status: levels, determinants, consequences for malnutrition, interventions, and policy.* Asian Development Review, 1999. **17**: p. 96-113.

180. Ahmed SM, Adams AM, Chowdhury M, and Bhuiya A, *Gender, socioeconomic development and health-seeking behaviour in Bangladesh.* Social Science & Medicine, 2000. **51**: p. 361-371.
181. Ramalingaswami V, Jonsson U, and Rohde J, *The Asian Enigma. The Progress of Nations*. 1997, UNICEF: Geneva.
182. Herlitz A and Kabir ZN, *Sex differences in cognition among illiterate Bangladeshis: A comparison with literate Bangladeshis and Swedes.* Scandinavian Journal of Psychology, 2006. **47**: p. 441–447.
183. Roubenoff R, *The pathophysiology of wasting in the elderly.* The Journal of Nutrition, 1999. **129**: p. 256S-259S.
184. de Groot LCPGM, Beck A, Schroll M, and van Staveren WA, *Evaluating the DETERMINE Your Health Checklist and the Mini Nutritional Assessment as tools to identify nutritional problems in elderly Europeans* European Journal of Clinical Nutrition, 1998. **52**: p. 877-883.
185. Bauer J, Vogl T, Wicklein S, Trögner J, Muhlberg W, and Sieber C, *Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients.* Zeitschrift für Gerontologie und Geriatrie : Organ der Deutschen Gesellschaft für Gerontologie und Geriatrie, 2005. **38**: p. 322-327.
186. Tsai AC, Chang JM, Lin H, Chuang Y-L, Lin S-H, and Lin Y-H, *Assessment of the nutritional risk of >53-year-old men and women in Taiwan.* Public Health Nutrition 2004. **7**: p. 69–76.
187. Chumlea WC, *The state of the Mini Nutritional Assessment.* Nutrition, 1999. **15**: p. 159-161.
188. Tsai AC-H, Ho C-S, and Chang M-C, *Population-specific anthropometric cut-points improve the functionality of the Mini Nutritional Assessment (MNA) in elderly Taiwanese.* Asia Pacific Journal of Clinical Nutrition, 2007. **16**: p. 656-662.
189. Kaiser M, Bauer J, Rämsch C, Uter W, Guigoz Y, Anthony P, Cederholm T, Thomas DR, Vellas B, and Sieber C, *The Short-Form Mini Nutritional Assessment (MNA-SF): Can it be improved to facilitate clinical use?* , in *19th IAGG World Congress of Gerontology and Geriatrics*. 2009, Journal of Nutritional Health & Aging: Paris, France.
190. Guralnik JM, Branch LG, Cummings SR, and Curb JD, *Physical performance measures in aging research.* Journal of Gerontology, 1989. **44**: p. M141-M146.
191. UNDP, *MDG Targets and Indicators*. 2006, http://www.undp.org/mdg/goallist.shtml. Accessed on November 25, 2006.

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