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Original article

Association between nutrition and the evolution of multimorbidity: The importance of fruits and vegetables and whole grain products

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SUMMARY

Background & aims: Multimorbidity is a common health status. The impact of nutrition on the development of multimorbidity remains to be determined. The aim of this study is to determine the association between foods, macronutrients and micronutrients and the evolution of multimorbidity.
Methods: Data from 1020 Chinese who participated in the Jiangsu longitudinal Nutrition Study (JIN) were collected in 2002 (baseline) and 2007 (follow-up). Three-day weighted food records and status for 11 chronic diseases was determined using biomedical measures (hypertension, diabetes, hypercholesterolemia and anemia) or self-reports (coronary heart disease, asthma, stroke, cancer, fracture, arthritis and hepatitis). Participants were divided in six categories of stage of evolution of multimorbidity. Association of foods, macronutrients and micronutrients at baseline with stages in the evolution of multimorbidity were determined. Data were adjusted for age, sex, BMI, marital status, sedentary lifestyle, smoking status, annual income, education and energy intake.
Results: The prevalence of multimorbidity increased from 14% to 34%. A high consumption of fruit and vegetables ($p < 0.05$) and grain products other than rice and wheat ($p < 0.001$) were associated with healthier stages in the evolution of multimorbidity. The consumption of grain products other than rice and wheat was highly correlated with dietary fibers ($r = 0.77$, $p < 0.0001$), iron ($r = 0.46$, $p < 0.0001$), magnesium ($r = 0.49$, $p < 0.0001$) and phosphorus ($r = 0.57$, $p < 0.0001$) intake which were also associated with healthier stages.
Conclusion: This study provides the first evidence of an association between nutrition and evolution towards multimorbidity. More precisely, greater consumption of fruits and vegetable and whole grain products consumption appear to lower the risk of multimorbidity.

1. Introduction

Multimorbidity, mainly defined as the presence of two or more medical conditions in an individual,[1] is common.[2–4] Multimorbidity is part of a continuum which starts when a healthy individual develops a chronic disease. Thereafter, this patient lives with the chronic disease and, in time, may develop other chronic disease(s). In the present paper, the term evolution of multimorbidity encompasses this continuum. This continuum implies transitions in chronic disease development stages that could be associated with an increased patient vulnerability but also periods of stability.

Some risk factors, such as smoking, physical activity and nutrition are known to modify the development of chronic disease. In this regard, malnutrition is consistently associated with increased multimorbidity and comorbidity rates[5,6] leading to food consumption recommendations toward daily reference intakes for specific macronutrients and micronutrients.[7] However, the impact of malnutrition on mortality in older and hospitalized populations

Non-standard abbreviations: FBG, fasting blood glucose; Hb, hemoglobin; JIN, Jiangsu longitudinal Nutrition Study.

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seems to be secondary when compared to the impact of comorbidities.[8] In this context the impact of nutrition on chronic disease development and treatment has increased. Studies on the impact of nutrition on chronic disease development are mainly undertaken for individual chronic disease. For example, numerous dietary approaches were developed to treat specific chronic disease including the Dietary Approach to Stop Hypertension (DASH),[9] the Portfolio diet for hypercholesterolemia,[10] the American Heart Association diet for cardiovascular disease.[11] General nutritional recommendations, such as those provided by food guides and the WHO/FAO consultation on the nutrition, diet and prevention of chronic disease, are mainly based on daily recommended intakes and on nutritional evidence for individual chronic disease. On the other hand, general approaches investigating the impact of nutrition on many chronic diseases simultaneously will provide an overview of the impact of nutrition on the large spectrum of chronic diseases in the general population and could be useful for food guide creation.

There are few studies investigating the evolution of multimorbidity, conceptualized as a gradual progression through different health stages. To the best of our knowledge, none have examined its relationship with nutrition. The main goal of this study was to determine the associations between nutrition and the evolution of multimorbidity. More specifically, the association of macronutrients, micronutrients and food categories with different steps of evolution of multimorbidity was assessed.

2. Materials and methods

2.1. Study design

The Jiangsu longitudinal Nutrition Study (JIN) is an ongoing cohort study investigating the relationship between nutrition and non-communicable chronic disease.[12] It uses the sub-sample from Jiangsu Province of the Chinese National Nutrition and Health Survey in 2002 as baseline. The rural sample was selected from six counties (Jiangyin, Taichang, Shuining, Jurong, Sihong and Haimen). From each of the six counties, three smaller towns were randomly selected. The urban sample was selected from the capital cities of the two prefectures, Nanjing and Xuzhou; and from each capital city three streets were randomly selected. The six counties and the two prefectures represented a geographically and economically diverse population. In each town/street, two villages/neighbourhoods were randomly selected, and ninety households were further selected randomly from each village/neighbourhood. All the members in the households were invited to take part in the study. In addition, one-third of the households gave dietary information, and all family members aged 20 years and older from these households were invited to give fasting blood samples. Flow chart has been described elsewhere.[12] Briefly, at baseline, complete dietary information was available for 2849 individuals. Of those, 1682 were identified for follow-up in 2007 and 1282 participated to the follow-up interview (76%). Among those, 1020 had complete information for every chronic disease status both at baseline and follow-up (80%) and were included in the present study. Individuals lost to follow-up were younger and had higher Body mass index (BMI) but no difference was found for energy intake and sex.[13] The study was approved by the Jiangsu Provincial Center for Disease Control and Prevention. Written consents were obtained from all participants.

2.2. Physical and socio-demographic characteristics

Health professionals measured height, weight and waist circumference. Waist circumference was measured midway between the inferior margin of the last rib and the iliac crest in a horizontal plane. Participants were interviewed by trained health workers using a pre-coded questionnaire. Interviews took approximately two hours to complete and included questions on socio-demographic information, medical history, cigarette smoking, physical activity and other lifestyle factors. Smoking was assessed by asking about the frequency of daily cigarette smoking. Household income was assessed by questions on family income and number of persons in the household. Education was based on six categories of education levels in the questionnaire. Occupational information was based on a question with twelve categories.

2.3. Chronic disease status assessments

Chronic disease status was determined at baseline and follow-up for the following 11 conditions: anemia, hypertension, hypercholesterolemia, diabetes, arthritis, hepatitis, coronary heart disease, asthma, stroke, fracture and cancer. Anemia, hypercholesterolemia and diabetes status were measured using overnight fasting blood samples collected from study participants. The blood samples were analyzed for fasting blood glucose (FBG), cholesterol and hemoglobin (Hb) in the local Centers for Disease Control and Prevention. FBG was measured using a hexokinase colorimetric test. Diabetes was defined by a FBG of above 7.0 mmol/l or the self-report use of glucose-lowering medication. Concentrations of total cholesterol were assessed enzymatically with commercially available reagents. Hypercholesterolemia was defined as a total cholesterol level of above 6.2 mmol/L or the self-report use of cholesterol-lowering medication.[14] Hb was measured using the cyanmethaemoglobin method. Anemia was defined as Hb below 13 g/dl for men and 12 g/dl for women.[15] Blood pressure was measured twice by mercury sphygmomanometer on the right upper arm of the participant, who was seated for five minutes before the measurement. The mean of these two measurements was used in the analyses. The cuff size was selected on the basis of the upper arm circumference to ensure that the cuff did not overlap. Hypertension was defined as systolic blood pressure above 140 mmHg and/or diastolic blood pressure above 90 mmHg, or the self-report use of antihypertensive drugs. Arthritis, hepatitis, coronary heart disease, asthma, stroke, fracture and cancer status were determined by participants' self-report of a medical diagnosis from a physician. Individuals with a positive status for a chronic disease at baseline were considered as having the chronic disease at follow-up. While some chronic diseases, such as anemia, could be considered as curable, those chronic diseases could exert some long term consequences on health that should be taken into account.[16]

2.4. Stages of evolution of multimorbidity

The present authors conceptualize the evolution of multimorbidity as a continuum including the stages leading to multimorbidity and those following its development. Participants were divided according to chronic disease status at baseline and chronic disease transition stages in 6 groups (Fig. 1, **Panel A**): healthy, healthy to a single chronic disease, stable with a single chronic disease, healthy to multimorbidity, stable multimorbidity, and increasing multimorbidity. Briefly, healthy individuals at baseline could stay the same (healthy), develop one chronic disease (healthy to a single chronic disease) or more chronic disease (healthy to multimorbidity) and were grouped accordingly. Other groups had one chronic disease (stable with one chronic disease) or more (stable multimorbidity) throughout the study. Finally, the increasing multimorbidity group had at least one chronic disease at baseline and developed at least another chronic disease.

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