

## Diabetes & its Complications

# Looking at Selected Micronutrients and the Implications for Diabetes Control and Management

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### ABSTRACT

*The prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030. This increase in prevalence is likely to increase the number of persons with kidney disease and other related comorbidities as compelling evidence support a direct relationship. The heavy burden of these diseases on health care budgets, the debilitating effects on affected individuals and their families force healthcare providers to examine different ways to help with managing these illnesses. Intensive management of blood glucose levels is predicted to be beneficial to patients to reduce associated morbidities and to delay or prevent progression of secondary complications. Managing carbohydrate intakes and enforcing dietary restrictions have become the mainstay of education for person living with diabetes. However compelling evidence suggests that several micronutrients are important in achieving blood sugar control. Could we be overlooking the therapeutic importance of micronutrient balance? This review will explore dietary intake data and implications for five micronutrients where deficiencies may play a role in poor blood sugar control.*

### Keywords

Diabetes, Micronutrient deficiencies, Food consumption, Dietary intake.

### Aim

The aim of this review is to explore food consumption patterns and dietary intake data (from Jamaica, United States of America (USA) and Australia) and to assess the implications of five micronutrients where deficiencies may play impact blood sugar control. The micronutrients are: Magnesium, Zinc, Vitamin B6, Calcium & Vitamin D.

### Introduction

The productivity, health and wellness of a population are important in advancing the other economic factors to ensure creation of wealth [1]. The simple act of eating becomes very important when considered in this manner. What is eaten and how much are important questions that each individual must ask themselves. Developing eating patterns and behaviors are deeply entrenched in our families and cultures [2] but has gained global prominence because of the devastating effects of obesity, diabetes and other diseases related to poor food choices [3].

The prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [4]. This increase in prevalence is likely to increase the number of persons with kidney disease and other related comorbidities as compelling evidence supports a direct relationship [5,6]. Illness affects the outputs of individuals and their families in many ways, lost work days due to illness, costs for medical care, transportation costs to access these medical services, family members may have to accompany ill family members and costs for medications [7]. The heavy burden of these diseases on health care budgets, the debilitating effects on affected individuals and their families force patients, family members and healthcare providers to examine different ways to help with managing these illnesses. Intensive management of blood glucose levels is predicted to be beneficial to patients to reduce associated morbidities and to delay or prevent progression of secondary complications [8].

This is where it could be described as a crossroad with the healthcare provider giving one instruction to go in one direction and the patient going in another direction. At times we may think that

people living with diabetes must adjust, but the illness or factors associated with the illness can make life more uncomfortable for these patients [9]. At Camp Yellow Bird, a residential camp for children living with diabetes in Jamaica, a simple activity such as squeezing limes was uncomfortable for the children. Yes! Due to the frequent use of the fingers for testing blood sugar levels. People living with diabetes want to eat like their families and friends [2]. Managing carbohydrate intakes and enforcing dietary restrictions have become the mainstay of education for persons living with diabetes [10]. The restrictions and dietary modifications are sometimes presented in such a manner that they become onerous to the patient [11]. The food restrictions imposed either by the patient or what they understand from the healthcare provider coupled with poor food choices will influence the overall quality of their diet. However compelling evidence suggests that several micronutrients are important in achieving blood sugar control [19-29]. Could we be overlooking getting the micronutrient balance, right?

### General Consequences of Micro-nutrient Deficits

Scientific evidence abounds on the role of micronutrients and their connections to health and disease. Some common general consequences of micronutrients deficits include:

- Poor wound healing
- Impaired vision
- Increased risk for diseases:
  - Certain cancers
  - Osteoporosis
  - Heart disease
  - Hypertension
- Impaired immune function
- Altered glucose and lipid metabolism
- Decreased mental acuity/dementia
- Depression
- Bone fractures
- Declining muscle function
- Reduced ability to taste
- Anemia
- Poor appetite
- Fatigue
- Insomnia

The importance of micronutrients to health and disease is well recognized [12] and several governments, recognizing the importance of their population making healthy food choices have published healthy eating guidelines. The emphasis on making choices to obtain the required nutrients could be lost in the vast amount of information that has become so easily available or accessible. Governments, dietitian nutritionists and other healthcare providers continue to compete with these other sources and the availability of less expensive, energy dense nutrient poor choices in promoting healthy food choices [13].

### Dietary Patterns and Implications

The United States of America (USA) dietary guidelines summarizes the gist of many population guidelines for healthy eating. Healthy eating guidelines for Americans are as follows:

- Consume a healthy eating pattern that accounts for all foods and beverages within an appropriate calorie levels. A healthy eating pattern includes:
- A variety of vegetables from all of the subgroups—dark green, red and orange, legumes (beans and peas), starchy, and other
- Fruits, especially whole fruits
- Grains, at least half of which are whole grains
- Fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages
- A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds, and soy products
- Oils - A healthy eating pattern limits:
- Saturated fats and trans fats, added sugars, and sodium [14]

The process of developing the various country specific food-based dietary guidelines requires much research and consultation with stakeholders. They are usually developed with thought for reading and understandability levels of the population. The food-based dietary guidelines are written in simple language with pictograms to aid interpretation [15,16]. You might be thinking at this time, what is the fuss about, the information for eating healthy is everywhere. The over forty nutrients needed for health is in the food we should consume. That points us to examining actual food consumption trends and patterns.

### Findings from Jamaica Food Consumption Survey

Culminating in 2019, a team (including this author) from the College of Health Sciences, University of Technology, Jamaica conducted a food consumption survey on a nationally representative sample of Jamaicans. Data collected on reports of diagnosed chronic non-communicable diseases revealed a prevalence of just over 27% for hypertension, 9.87% for diabetes and only 2.47% reported that they were diagnosed as overweight or obese. The percentage of persons reporting that they were diagnosed as overweight or obese was quite interesting and different from calculated body mass index (BMI) from data collected for height and weight. The prevalence of overweight and obesity was found to be 22.41% and 29.12 respectively, moving the combined percentage to 51.53% in the sample. The table below show the number of persons reporting that they were diagnosed with chronic non communicable diseases (CNCDs).

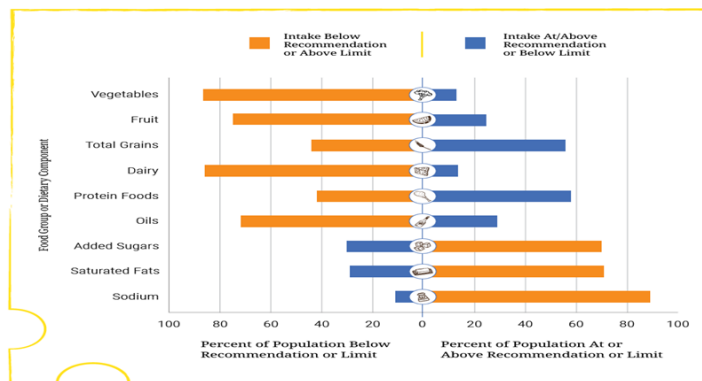
CNCDs	Percentage of persons diagnosed (%)
Hypertension	27.05
Diabetes	9.87
High cholesterol	6.32
Cardiovascular disease	0.59
Stroke	0.69
Overweight and obesity	2.47
Cancer	0.89
Nutrient deficiency	0.3

**Table 1:** Number of persons reporting that they were diagnosed with CNCDs.

The survey further investigated the availability, choices and amounts of fruits and staple foods consumed. Findings revealed that the majority of households at 78% reported they had fruit trees at home. Staple food intakes were high within the sample. An interesting trend that was identified was that as BMI increased staple food intakes decreased. This suggests that extra energy for these persons were not coming from intake of staples. In examining staple choices, results revealed that the majority of persons chose bread and white rice daily. Other findings also revealed that the most frequently eaten takeout/fast foods at once/day by the respondents were: Chicken and chips, fish and chips, patty and cocoa bread (NB. These are all high fat choices). Several sugary and salty foods were also reported as consumed once per day. Summary of the preliminary findings were that staple food intakes were high, legumes and nuts consumption were low, food from animal consumption was high, a variety of vegetables were consumed, a variety of fruits were consumed, several high fat foods were frequently consumed and several sweet or salty snacks were frequently consumed [17].

### Review of food consumption data for the USA

In examining published data on food consumption and dietary patterns for the USA, the following figure shows combined results from several well conducted surveys in the American population. The USA published their Dietary guidelines for 2015-2020. In Chapter 2 under the heading “Shifts Needed to Align with Healthy Eating Patterns” they published the figure below:



**Figure 1:** Dietary Intakes Compared to Recommendations. Percent of the U.S. Population Ages 1 Year and Older Who Are Below, At, or Above Each Dietary Goal or Limit.

According to the publication the data sources were obtained from: What We Eat in America, National Health and Nutrition Examination Survey (NHANES) 2007-2010 for average intakes by age-sex group. Healthy U.S.-Style Food Patterns, which vary based on age, sex, and activity level, for recommended intakes and limits. It can be interpreted from the figure that only about 10% of the American population consumed vegetable at or above the recommended amount. Fruit consumption fared better at about 25% of the population consuming at or above recommendations. Just over 40% did not consume at or above the recommendations for total grains. Again, suggesting that extra calories do not come from the grains group. A majority at about 85% did not consume at or above the recommendations for dairy. More than 75% of the

population reportedly consumed above limits for added sugars and saturated fats and sodium was also consumed above limits by close to 90% of the population [18].

### Review of Food Consumption Data for Australia

Food Consumption Data for Australia and published on the Australian Bureau of Statistics site revealed data from the Australian Health Survey: Consumption of food groups from the Australian Dietary Guidelines Australia 2011-12. The data was summarized in a Media release on May 11, 2016. The headline was quite riveting “Australians failing to meet dietary guidelines”, the content of the media release was as follows:

- Most Australians do not meet the minimum recommended serves for the five major food groups, according to new figures released by the Australian Bureau of Statistics (ABS).
- The report shows that Australian diets are not in line with the 2013 Australian Dietary Guidelines, which recommend minimum serves for vegetables, fruit, dairy products, lean meats and alternatives, and grain-based foods.
- Australian Bureau of Statistics (ABS) Director of Health, Louise Gates said that adults and children over eight consumed an average of 2.7 serves of vegetables, rather than the 5 serves recommended by the Australian Dietary Guidelines, according to the latest results from the 2011-12 National Nutrition and Physical Activity Survey.
- "Less than 4 per cent of the population consumed enough vegetables and legumes or beans each day,".
- "One in 10 was meeting the guidelines for dairy products, while one in seven consumed the minimum number of serves of lean meats and alternatives per day."
- "Among the five food groups, fruits and grains had the best compliance, with nearly one in three people consuming the minimum recommended number of serves for each group. However, one-third of the fruit serves was from juice and dried fruit, and two-thirds of the grains and cereals were from refined grains rather than whole grain or high fibre sources,".
- The report also found that over one-third of the population’s total daily energy intake came from energy-dense, nutrient-poor ‘discretionary foods’ (such as sweetened beverages, alcohol, cakes, confectionary and pastry products) [19].

The summary deductions that can be made from these three (3) dietary intake data reviews are that generally Jamaicans, Americans and Australians are making poor food choices. They commonly make high fat choices also there are high intakes of sugary foods and sugar sweetened beverages. The sodium intake was also high, much higher than recommendations. The food groups that should be consumed in higher amounts were generally consumed in lower amounts, these include peas, beans, legumes, whole fruits, vegetables and whole grain-based foods [17-19].

Having reviewed the general consequences of micronutrient deficits [12], recommendations for healthy eating and food consumption data, [14,17-19] consider this profile of patients living with diabetes. There is usually restricted food intake and from my experience they also make poor food choices – choosing foods

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high in fat & sugar. Their consumption of fruits and vegetables may also be low, with higher intakes of refined carbohydrate sources. Several are obese and some are inconsistent with taking medications as prescribed. The food restrictions and choices could be due to disease state, cultural preferences, likes, availability or costs [20]. In the food consumption survey conducted on a nationally representative sample of Jamaicans by a team from the COHS, UTech, Jamaica, it was found that costs and likes were the main reasons for the food choices consumed [17]. The indications are that most persons don't make choices based on the nutritional value of foods, and from the data for the three countries presented many micronutrients are not consumed as recommended.

### **Micronutrients under Review**

The micronutrients chosen for this review are Magnesium, Zinc, Vitamin B6, Calcium and Vitamin D.

### **Magnesium**

Generally, it could be assumed that magnesium intake should be adequate especially if people follow the healthy eating guidelines and make healthy food choices. Magnesium is widely available in dark green leafy vegetables, nuts, legumes, whole-grain breads and cereals, seafood, chocolate, and cocoa products. However dietary surveys of people in the United States consistently show that intakes of magnesium are lower than recommended amounts. One analysis of data from the NHANES of 2005-2006 found that a majority of Americans of all ages ingest less magnesium from food than their respective estimated average requirements (EARs) [21,22]. James, DiNicolantonio, O'Keefe, and Wilson in their article entitled "Subclinical magnesium deficiency: a principal driver of cardiovascular disease and a public health crisis" concluded that subclinical magnesium deficiency was a common and under-recognised problem throughout the world. Deductions we could make in examining the food consumption data presented above for Jamaica, USA and Australia support his assessment of the prevalence of subclinical magnesium deficiency [23].

Another contributory factor to magnesium deficiency is the role of magnesium in sugar metabolism [24]. It is reported that for every molecule of sugar consumed it requires fifty-four molecules of magnesium for the body to process it. If this is so, contextualizing the review of the dietary intake from sugary food and beverages, which was found to be high, in the dietary intake data presented, this would also contribute to magnesium deficiencies in these populations.

The evidence is strong relating to the fact that insulin secretion requires magnesium. Magnesium deficiency results in impaired insulin secretion while magnesium replacement restores insulin secretion. Studies are inconclusive about magnesium supplementation [24].

Their conclusion about supplementation is worthy of mention here as the emphasis for this review is on the dietary intake of magnesium and meeting an individual's requirement especially for people living with diabetes.

The implications are that magnesium levels maybe low in people with diabetes due to high consumption of sugary foods and beverages, low magnesium intake and disease demands.

### **Zinc**

Well documented evidence from in-vitro and in-vivo studies in animals and humans have shown that zinc has numerous beneficial effects in both type-1 and type-2 diabetes [25]. The Editor for Global Diabetes Community, summarized results from a Russian based study entitled "Serum Trace Elements and Electrolytes Are Associated with Fasting Plasma Glucose and HbA1c in Postmenopausal Women with Type 2 Diabetes Mellitus" and reported that these Russian researchers from Peoples' Friendship University of Russia (RUDN) University and P. G. Demidov Yaroslavl State University believe that investigating zinc metabolism in diabetes pathogenesis merits further investigation, and speculate that zinc-containing foods should be explored as a preventative measure for prediabetes [26,36,37]. High zinc losses from frequent urination will also affect zinc status of peoples living with DM [27].

### **Zinc Deficiency**

World Health Organization in the World Health Report of 2002 estimated that zinc deficiency affects about one-third of the world's population, with estimates ranging from 4% to 73% across subregions. They further stated that although severe zinc deficiency was rare, mild-to-moderate zinc deficiency was quite common throughout the world [28]. Kenneth H. Brown et al. in 2001 using an alternative method estimated zinc content of national food supplies, they used the Food and Agriculture Organization of the United States (FAO) food balance sheets. They assumed bioavailability of that zinc based on phytate: zinc molar ratios; and the relation between absorbable zinc and theoretical requirements according to country-specific demographics. They concluded that the results of the analyses indicated that nearly half of the world's population was at risk for inadequate zinc intake, and it was their view that public health programs were urgently needed to control zinc deficiency [29].

### **Vitamin B6 (Pyridoxine)**

Vitamin B6 is significant to protein, fat and carbohydrate metabolism and the creation of red blood cells and neurotransmitters. Okada et al in 1999 in a study entitled "Effect of diabetes on vitamin B6 requirement in experimental animals" found that Vitamin B6 content in all tissues of rats examined, except for the liver, was lower in the diabetics than in controls. They concluded that these data might indicate that diabetic animals should have a higher intake of vitamin B6 because a diabetic state can lead to a vitamin B6-deficiency [30].

### **Calcium & Vitamin D**

Pittas et al. in 2006 followed 83,779 women in the Nurses' Health Study, who had no history of diabetes, cardiovascular disease, or cancer at baseline for the development of type 2 diabetes. They concluded that the results of the large prospective study suggest a potential beneficial role for both vitamin D and calcium intake in

reducing the risk of type 2 diabetes [31].

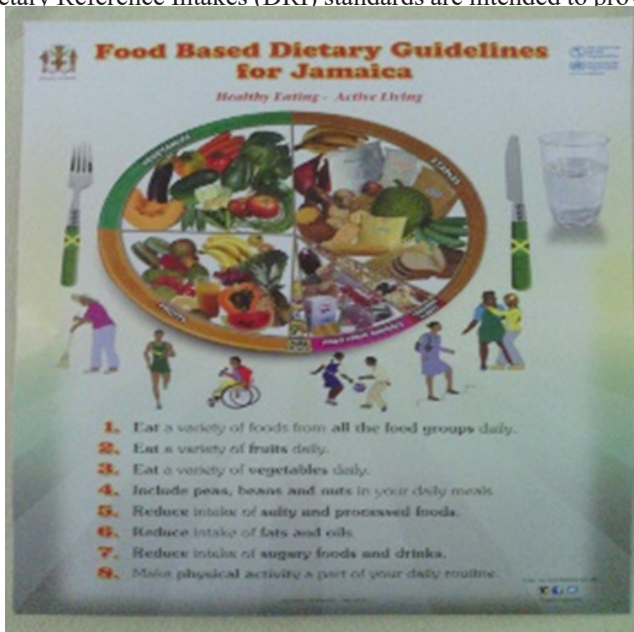
The Jamaican food consumption survey revealed that food choices were mainly based on costs and likings and the food choices were from energy dense sources that were low in micronutrients [17]. The same conclusions were made about the American and Australian populations. Inferences from these food consumption patterns across countries are that micronutrient intakes for magnesium, zinc, Vitamin B6, calcium and vitamin D, are more than likely low in people living with diabetes. This is coupled with the fact that diabetes affects the stated nutrient requirements as described above.

The intent here is to highlight the real possibility that the patients living with diabetes that we manage may have suboptimal levels of several micronutrients. Combined suboptimal levels of these micronutrients in people living with diabetes could be devastating to their fight to manage their blood glucose levels. Superimposed on low micronutrient intake, my experience with managing people living with DM in Jamaica is that they tend to be non-adherent with medications.

But why not just give supplements? It is the position of The Academy of Nutrition and Dietetics, USA that .... the routine and indiscriminate use of micronutrient supplements for the prevention of chronic disease is not recommended, given the lack of available scientific evidence. There is a place for supplementation but it should not be considered a replacement for poor dietary choices [32].

The Ministry of Health, Jamaica having identified the main nutritional risks to the population developed the Food Based Dietary Guidelines for Jamaicans which was published in 2015. Again, it is important that we emphasize the information on population food-based dietary guidelines. See image of the Jamaican food-based dietary guidelines below [33]:

Dietary Reference Intakes (DRI) standards are intended to provide



nutrient goals for dietary planning and evaluation. Guidelines for using the DRIs include: not exceeding the Tolerable Upper Limits (UL) or meeting the Recommended Dietary Allowance (RDA) or Adequate Intake (AI) goals for individuals. These guidelines are intended for healthy people and dietary planners must do an in-depth nutritional assessment with considerations that each individual's true requirement for a nutrient is unknown. Dietary intakes, if assessed as falling below RDA or AI standards should not be interpreted as inadequate without also assessing clinical status & biochemical indices. Of relevance, is that intakes that meet the RDA or AI should not necessarily be considered adequate without also taking into account other clinical factors [34,35].

### Traditional Approach to the Management of Diabetes

For too long the focus has been on reduction of the intake of simple sugars, carbohydrate restriction, intensive calorie restriction and use of artificial sweeteners. Clearly this has not halted the burden of the disease and the prevalence of diabetes is expected to continue to climb. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [4]. Could we be overlooking getting the micronutrient balance right?

### The way forward

Based on current practices and the continued rise in the number of people diagnosed with diabetes it is clear that a different approach is needed. Strategies must be put in place to prevent micronutrient deficiencies by encouraging diets that are rich in micronutrients, each country will have to develop the list of foods that will be encouraged for nutrient density.

Choices are important to what is consumed daily. Costs, likes and availability were the main reasons given for food choices and not nutritive value, but with some focused planning a great difference could ensue to the health of individuals and to populations. What is purchased and kept on hand at home will also influence food choices, there needs to be investment in time for meal preparation since this time is an investment in health.

Physicians, dietitian nutritionists and other healthcare practitioners must get involved in proper monitoring of micronutrient levels. These could be added to the existing protocols for managing diabetes. Dietitian nutritionists will have to play a key role in evaluating individual patients' dietary intakes for deficiencies and improve the quality of the diets for these patients. Registered dietitian nutritionists are equipped with the skills to prepare the individualized meal plan to correct deficiencies. The medical nutrition therapy (MNT) should include nutrient rich sources of magnesium, zinc, vitamin B6, calcium and vitamin D among other micronutrients. The literature expounds that Hippocrates was a firm believer in dietetics and nutrition. The famous quote attributed to Hippocrates "Let food be thy medicine and medicine be thy food" takes us back hundreds of years. This review suggests that we could be overlooking getting the nutrient balance right, for improved blood sugar control in managing patients living with diabetes.

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