Embracing systems biology: a paradigm shift in modern medicine for identifying and treating nutritional deficiencies

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INTRODUCTION

Modern medicine traditionally has focused on discovering treatments in response to diseases. There is a growing recognition that when clinicians look first to biology to seek answers, we can better define and apply more effective treatments, particularly to address and often reverse the many sources of ill health that afflict people today. This shift in perspective is well illustrated when, for example, we examine micronutrient deficiencies, more common than many suspect. If micronutrients are not routinely tested for, this specific driver of many chronic ills can often be overlooked as a potential and sometimes pivotal clinical intervention. Here, I will use vitamin C deficiency as a model, but other micronutrient deficiencies—B vitamins, vitamin D and minerals—similarly could illustrate the problem. To give two brief examples: it is well known that older people and those with psychiatric issues might be B-vitamin deficient, and supplementing them improves their conditions; those with very indoor lifestyles—including physicians—are often vitamin D deficient.[1] The symptoms of vitamin C deficiency, including fatigue, depression, chronic pain, dental issues and poor wound healing, are common reasons why people seek medical care.[2] Yet, vitamin C deficiency might be overlooked and not tested for, while the patient is given yet another medication or specialist appointment in an attempt to deliver better health. Perhaps this scenario seems familiar.

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Where do micronutrient deficiencies come from? In the case of vitamin C and minerals, humans cannot synthesise them; vitamin C deficiency highlights the importance of consuming certain micronutrients through food and being aware there may be a genetic predisposition for the deficiency. Some medical procedures (eg, bariatric surgery) and syndromes (eg, colitis, malabsorption, an unhealthy gut microbiome), as well as smoking can deplete vitamin C. Vitamin C and other micronutrient deficiencies also often arise in tandem with other factors that impact health, now frequently referred to as social determinants of health (SDOH): low health literacy, food insecurity, inadequate housing, substance use disorder, exposure to toxins and more. These environmental impacts together constitute our 'exposome' and modulate our health status. Therefore, they need to be understood and incorporated as causes of micronutrient deficiency and of ill health, in the context of systems biology and updated approaches to clinical care. This editorial discusses the vital role of systems biology in evaluating the root causes of diseases and emphasises the urgent need for nutrition education in the medical field.

SYSTEMS BIOLOGY AND MITIGATING CHRONIC DISEASE

By adopting a systems biology lens, medicine can better identify and address the root causes of chronic diseases. These deficiencies are not common, but nonetheless way too common in clinical practice, and set protocols should be taught to address them. Our research can offer the compelling example of 166 of 1800 patients who exhibited various risk factors for vitamin C deficiency and had vitamin C levels that were considered moderately to significantly deficient, evaluated by (inexpensive) standard lab testing, (liquid chromatography-tandem mass spectrometry). Blood testing, clinical signs and symptoms, and other biological markers aid in the diagnosis of nutritional deficiencies. All of these patients had several risk factors such as inadequate intake of fresh fruits and vegetables, and tobacco use or exposure. Many of them had many physical and emotional symptoms for which they sought multiple treatments, and received multiple medications and standard diagnostic testing, without resolution of their issues. Only after the manifestations were correctly identified as vitamin C deficiency (and sometimes frank scurvy), and this deficiency was addressed, did their symptoms improve. Clinical success with this group of patients illustrates how incorporating a systems biology perspective can strengthen conventional medical care by identifying the root cause of a symptom or ailment, resulting in more effective treatments. It is well published that by addressing food insecurity, risk factors for malnutrition and micronutrient deficiencies will improve patient outcomes and reduce healthcare costs.[3]

ADDRESSING THE GAP IN MEDICAL EDUCATION

Micronutrient deficiency syndromes are not new, but they still exist particularly in those populations at risk for food insecurity and conditions that are genetic or medically based, that interfere with synthesis and absorption. Teaching learners to recognise the risk factors and symptoms associated with these deficiencies can add to the diagnostic and therapeutic toolkit. There is a yawning gap in the medical education curriculum with respect to nutrition.[4] The rapidly expanding field of medical nutrition encompasses the exposome, genetics and epigenetics, all of which should be integrated into the standard curriculum. Numerous intrinsic and extrinsic factors cause micronutrient deficiencies, and when they converge in individuals and communities, can create a 'perfect storm' of ill health. These manifestations range from the

overt to the subtle. However, many of our learners remain largely uninformed about these scenarios, even though they are likely to encounter them in virtually any medical setting. If we do not educate physicians to identify these nutritionally driven health issues, they will remain unseen and untreated.

In a Midwestern city in the USA, beginning in August of 2019 and ongoing, we have identified 650 out of 1800 patients with at least one micronutrient deficiency (all micronutrients were represented to various degrees). Our continuing documentation of micronutrient deficiencies elucidates the stark reality that food insecurity and low health literacy exist in well-resourced countries, and underscores the necessity of incorporating comprehensive nutrition education into medical curricula. Further, it is little recognised that chronic consumption of the many prescription and over-the-counter medications Americans take—nearly half of all Americans take one or more prescription drugs—also can deplete micronutrients, including vitamin C, via several possible mechanisms.[5 6] Only by equipping future medical practitioners with a solid foundation in nutrition, and education about all the many factors that may impact obtaining proper nutrition, can we better address nutritional deficiencies and their relevance for overall health over the lifespan.

THE ROLE OF NUTRITION IN MODERN HEALTHCARE

Nutrition is foundational to health. Yet nutritional deficiencies exist, especially micronutrient deficiencies, and are often overlooked as potential comorbidities to chronic diseases. The lack of nutrition education in the healthcare system is a significant contributing factor to this oversight. Many patients with unresolved symptoms are increasingly turning to supplements—if they can afford them—but without proper guidance from healthcare providers, this self-care may not be effective or safe. Often the supplement will have a notice on the label: 'consult your provider before taking this supplement'. But most providers lack the knowledge to support their patients.

Nutrition science—with relevance for cardiovascular and metabolic health, gut health, psychiatry and many more medical domains—has made great advances in recent years.[7] Attention to nutrition in clinical practice, driven by multidecade professional activity in the integrative medicine (IM)/functional medicine (FM)/lifestyle medicine (LM) movements, has existed mostly as a counterpoint to conventional medicine. To the extent that discussions of nutrition and health have entered the mainstream, it is largely due to the better understanding and implementation of supportive, comprehensive healing championed by many physicians who have obtained postgraduate training in excellent, accredited IM/FM/LM programmes in the USA. Patients, and medical culture, are the beneficiaries.[7] To these understandings, we also can now add more universal culturally sensitive healthcare that promotes better awareness of cultural beliefs and practices, as well as better and earlier identification of any relevant SDOH.[8]

We now know that better nutrition over the lifespan can prevent or mitigate many ills, such as Alzheimer's disease, cardiovascular disease, mood disorders, type II diabetes and more. Extensive study of nutrition and its many impacts on health should be integrated into mainstream medical curriculum as a primary and essential medical subject, not mostly be obtained via continuing medical education and other professional expedients.

CONCLUSION

The example of vitamin C deficiency serves as a powerful illustration of how a systems biology approach, and a strengthened focus on nutritional status, can revolutionise modern clinical medicine. By focusing on biology first and identifying the root causes of diseases, healthcare professionals can better treat patients and mitigate chronic diseases. Adopting this perspective will also reduce healthcare costs, via better outcomes, sooner and in many cases, decreased use of unnecessary medical specialist visits, tests and medications. Addressing the gap in nutrition education in the medical field is essential to effectively recognise nutritional deficiencies and their associated comorbidities; this is not new but it needs to be addressed as part of our healthcare system. Emphasising the vital connection between food and health can lead to improved patient outcomes over the lifespan and a healthier society overall. As we move forward, let us remember that food is indeed medicine.

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