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More evidence for 5-a-day for fruit and vegetables and a greater need for translating dietary research evidence to practice

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Running Title: Increasing fruit and vegetable intake

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Improvements in life expectancy in recent decades have been accompanied by increasing rates of noncommunicable diseases and multimorbidity, placing untenable burdens on individuals, healthcare professionals and health services. The reasons are multifactorial, but prime amongst them are shared underlying risk factors with a major contribution of health behaviours including smoking, alcohol, physical activity, and diet. The critical role of diet and nutrition is unquestionable. However, teasing out specific components to target has been challenging because the human diet is complex, multi-dimensional and hierarchical with nutrients from thousands of foods that are, in turn, part of numerous overall dietary patterns and eating habits. Moreover, nutritional research is challenging because assessment typically relies on self-report rather than objective methods, and study designs are largely observational. Amidst the noise and confusion of conflicting dietary research findings, there is relative agreement on the beneficial role of fruit and vegetables. The World Health Organization and several countries globally have adopted the public health message of “five-a-day” to encourage the consumption of at least five portions of fruit and vegetables daily, but some advocate higher consumption such as seven, eight or even 10 portions or servings per day. So, how many fruit and vegetable portions per day should people consume for ‘optimal’ health benefits?

In this issue of *Circulation*, Wang and colleagues¹ related fruit and vegetable intakes to future total, cardiovascular, respiratory and cancer mortality outcomes across a near three-decade follow-up of the Nurses’ Health Study (NHS) and the Health Professionals Follow-Up Study (HPFS). The authors are highly experienced at using these two resources to relate dietary factors to outcomes and justifiably claim the multiple strengths of their work, including data capture from multiple repeated validated food frequency questionnaires and near complete (98%) ascertainment of causes of death. Additionally, the effect estimates are statistically adjusted for measured characteristics that differ in people with low and high fruit and vegetable intakes. Findings proved robust in a series of sensitivity analyses and the authors contextualised their results by combining the NHS and HPFS results into a meta-analysis of a total of 26 prospective studies.

The results suggested that in adults who ate five fruit and vegetable portions per day versus those eating only two the relative risk for total, cardiovascular and cancer mortality in NHS and HPFS cohorts combined was lower by 10-13%; notably, respiratory mortality was lower by 35%.¹ The findings were broadly similar in their meta-analysis. More interestingly, there did not appear any further lowering of risks beyond five portions per day in either NHS, HPFS or indeed in the meta-analyses of 26 cohorts, leading the authors to state that “the succinct ‘5-a-day’ message is consistent with available evidence.” A further interesting finding was that not all fruit and vegetables appeared to associate with lower mortality risks, with no clear associations for fruit juice, starchy vegetables or potatoes, findings the authors say should lead to more nuanced messages on which types of fruit and vegetables should be included in the 5-a-day messaging. We agree.

Many readers who are accustomed to evidence from randomised trials will worry that, regardless of its strengths or types of sensitivity analyses done, residual confounding in observational studies lessens certainty and that correlation is not causality. However, foods are not drugs and placebos, and randomizing people to different dietary regimes and participant adherence over long durations necessary for outcome data is unrealistic. Confidence in the findings is enhanced when observational studies from different populations with varying eating practices all point in the same direction and are supported by nutritional biomarkers data² and with results of small-scale trials of intermediate endpoints that reflect pathways to disease (e.g. weight, blood pressure, lipids).³ As the authors highlight, eating fruit and vegetables provides excellent sources of fibre, potassium and a range of micronutrients and bioactive compounds that are necessary for good health (Figure). The evidence for fibre is strong,⁴ incorporating prospective evidence for clinical events and randomised trial evidence for benefits on weight, blood pressure and cholesterol levels, factors causally related to cardiovascular outcomes. Indeed, fibre is the ‘gut lubricant’ and gut health and associated microbiome status may be more important to health than previously recognised, including potential impacts on metabolism,

immunity and lung health via the gut-lung connection,⁵ areas requiring further research. That noted, the markedly lower respiratory death risk by fruit and vegetables intake reported by Wang et al requires further study and should be placed in context alongside other emerging evidence⁶ including investigating relationships or possible interaction with smoking. Furthermore, it would have been informative if the authors had taken a more specific look at gastrointestinal-related deaths or cancers. Considering prior concern raised about frozen/canned fruit consumption and mortality,⁷ it is important to extend research to examining differences across raw, tinned, frozen or cooked vegetables.

Still, the totality of the evidence presented by Wang et al together with that from other existing research should convince health professionals to promote eating more fruits and vegetables as a key dietary strategy, and for citizens to embrace this.

Given the evidence the following question remains: why do more people not eat sufficient fruit and vegetables? There are low intakes globally, in the US adults average two portions per day, only one in seven people over 15y in Europe meet the guidelines and 33% of adults and 12% of children meet 5-a-day in the UK. The answers are complex, but the availability of cheap, highly processed, and less healthy foods has increased over the last few decades while costs for better quality and tasty fruit and vegetables are high. If meaningful dietary progress is to be made, this imbalance must change. But how?

Health professionals cannot change food policy – that is the role of Governments – but they can help people understand how to implement simple dietary changes. The biggest gains may come from encouraging those who rarely eat fruit or vegetables since diets rich in even modestly higher fruit and vegetable consumption are beneficial.² Among the youngest children, the concept of repeated exposure has gained traction to train the palate to start enjoying fruit and vegetables.⁸ Adults can take up a similar ‘*palate retraining challenge*’ to learn to enjoy fruit and vegetables. Digital technology and gamification are tools that can be used to increase fruit and vegetable intake in youth.⁹

Currently, diet is discussed in our clinics in a superficial and ineffective manner, if at all. However, with nutrition education of health professionals and better investment from funders, we can try to optimise new cost-effective and simpler ways of communicating such evidence for dietary gains. As we have recently argued,¹⁰ even helping our patients to try and then adopt one or two sustainable dietary changes may be enough for some health gains and could set the foundation for them to try additional adjustments.

However, to effect population-wide dietary improvements, we need structural changes and national policy level interventions that lower costs and improve availability of healthy foods via subsidies from taxing unhealthy foods. In children, there is emerging evidence for the effectiveness of family-based, school-based and school-nutrition programmes.¹¹ Population level health promotion and awareness programmes can help, such as government sponsored programmes of social marketing, including information on healthy food swaps.¹² Low ‘agency’ population intervention options (that enable automatic easier decisions and action on consumption e.g., vouchers for free fruit and vegetables for low-income families), have been cogently argued¹³ as better than the high agency approaches (e.g., nutritional labelling or mass media campaigns) most governments normally favour. Nudge interventions that influence choice architecture are also a potential strategy. Recently, it has become apparent that free provision of medically tailored meals or groceries, or (food) produce prescription programmes to people with complex medical conditions and barriers to healthy eating (e.g., poverty, food insecurity), may lessen hospital inpatient admissions by 50%, thereby being highly cost saving.^{14,15} Whilst the mechanisms for such benefits may be multifactorial, such interventions can increase fruit, wholegrains and vegetables intake, and lessen alcohol and added sugar intakes.¹⁴

The take home point is that *food is indeed medicine*, and that health professionals and governments would do well to up their games to improve dietary intakes at individual and population levels. Increasing people's enjoyment for and intakes of fruit and vegetables must be a key part of future dietary interventions. In the post COVID world, where diets and other health behaviours have been adversely impacted due to lockdowns, more, not less, needs to be done to tackle the epidemic of unhealthy eating.

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Conflicts of interest

NS has consulted for or received lecture fees from Amgen, AstraZeneca, Boehringer Ingelheim, Eli Lilly, Merck Sharp & Dohme, Novartis, Novo Nordisk, Pfizer and Sanofi, and received grant support through institution from Boehringer Ingelheim, outside the submitted work. NGF has no disclosures.

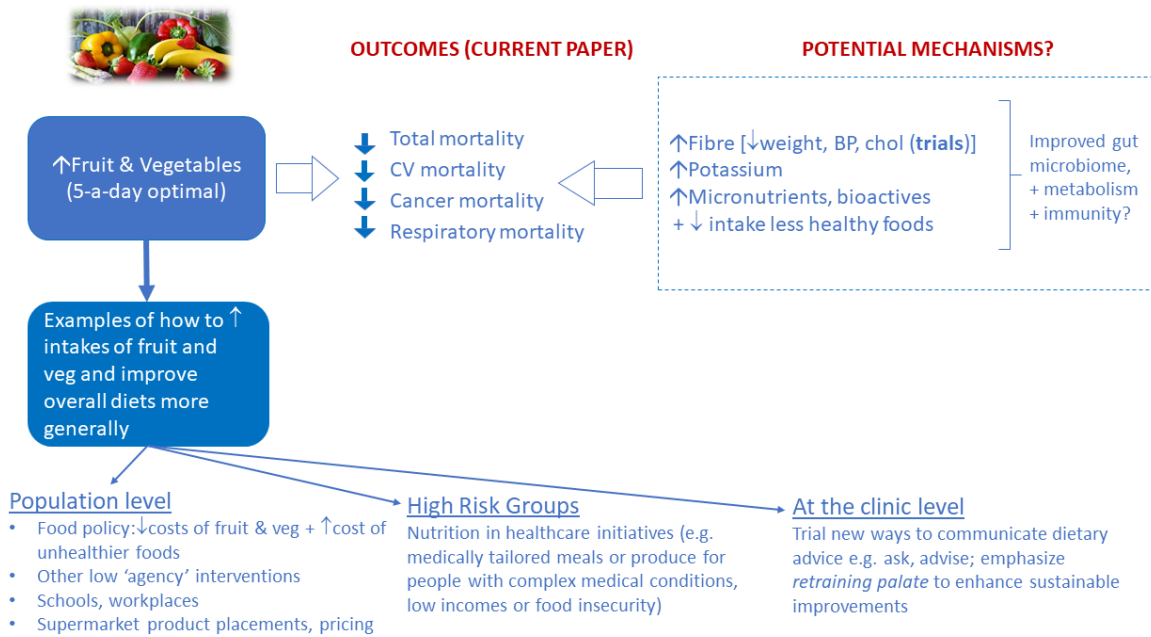


Figure Legend

Optimal fruit and vegetable intakes for health gain, potential mechanisms, and some examples of how to improve dietary intakes

The paper by Wang and colleagues adds to considerable prior evidence for benefits of fruit and vegetables intakes on health outcomes. Potential mechanisms are plentiful and include enhanced fibre intake (for which there is trial evidence for benefits on causal risk factors), plus greater potassium, and other micronutrient /bioactive factors, and beneficial effects on gut microbiome. In addition, by eating more fruit and vegetables, people may eat less unhealthy foods (food displacement effects). To what extent altered microbiome linked to greater fruit and vegetables consumption may improve immune function and help prevent lung and other diseases, requires more study. Improving intakes of fruit and vegetables could be achieved in multiple ways and few newer and important emerging concepts are highlighted, although this list is not designed to be comprehensive.

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