Would an increase in vegetable and fruit intake help to reduce the burden of nutrition-related disease in South Africa? An umbrella review of the evidence

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Abstract

Evidence indicates that increased vegetable and fruit intake improves health. The intake of vegetables and fruit in South Africa is much lower than recommended. When considering the promotion of greater vegetable and fruit intake in South Africa, it is necessary to view the available evidence on the relationship between vegetable and fruit intake and disease risk reduction through a South African lens. This will help to determine whether or not interventions to optimise vegetable and fruit intake would contribute to reducing the burden of nutrition-related disease in South Africa. The aim of this umbrella review was to compile the best available evidence from multiple reviews and scientific reports on the link between vegetable and fruit intake and the nutrition-related burden-of-disease profile in South Africa. Vegetable and fruit intake has been associated with prevalent nutrition-related problems in South Africa, including vitamin A status and adiposity in children; and cancer, cardiovascular disease, type 2 diabetes and adiposity in adults. Reviewed evidence from systematic reviews and scientific reports has suggested that increasing vegetable and fruit intake in South Africa could potentially contribute to reducing the burden of nutrition-related conditions in this country. Increasing vegetable and fruit intake in preschool children could improve their vitamin A nutriture. Enhancing vegetable and fruit intake in adults could contribute to reducing the risk of certain prevalent cancers (lung and gastrointestinal) and cardiovascular disease (coronary heart disease, ischaemic heart disease and cerebrovascular accidents). It should be kept in mind that the methodological quality of the included systematic reviews ranged from low to high (AMSTAR), and most reviews did not assess the scientific quality of the included studies. This evidence supports the need to promote greater vegetable and fruit intake in South Africa.

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Introduction

Surveillance indicates the presence of a double burden of nutrition-related disease in South Africa of under- and overnutrition.[1-3] Both the 1999 National Food Consumption Survey (NFCS) and the 2005 National Food Consumption Survey Fortification Baseline (NFCS-FB-I) in South African children aged 1-9 years reported that approximately one in five children were stunted, and one in 10 underweight.[2,4] Hypovitaminosis A is also documented as being problematic in children. In 1994, national data reported marginal vitamin A status in one in three children,[5] which worsened in 2005 to two in three children.[4] National and regional studies in South African children have also demonstrated a risk of inadequate dietary intake of micronutrients.[2,6-8] Meanwhile, a secondary analysis of NFCS anthropometric data, using the World Health Organization (WHO) 2006 growth standards, showed a prevalence of overweight or obesity of 30%.[1] In line with this, the Comparative Risk Assessment Study (CRA) for South Africa reported on the prominence of risk factors that relate to poverty and underdevelopment, e.g. undernutrition, unsafe water and poor hygiene, as well as the prominence of risk factors associated with noncommunicable diseases (NCDs), e.g. excess body weight, alcohol, tobacco, diabetes, hypertension and hypercholesterolaemia.[3]

Globally, the burden of NCDs is a cause for concern, particularly in developing countries. In 2008, NCDs represented almost two thirds of all deaths globally. Nearly 80% of NCD deaths occurred in low- and middle-income countries, and approximately 29% of deaths involved people younger than 69 years of age. The NCD burden is projected to rise disproportionately in lower-income populations over the next 10 years.[9] In line with these reports, the prevalence of NCDs in South Africa is increasing. The major NCDs are cardiovascular disease (CVD), diabetes, cancer, chronic respiratory diseases and mental illness.[10] National surveillance suggests that patterns of unhealthy lifestyle and diet which increase NCD risk are already present in our children and youth.[3, 11]

In summary, the primary nutrition-related conditions and risk factors in South African children include stunting, underweight, vitamin A deficiency, the risk of inadequate micronutrient intake, overweight and obesity and early NCD risks (the presence of patterns of unhealthy dietary and physical activity behaviour that relates to NCDs in children and youth). The primary nutrition-related conditions and risk factors in South African adults, include CVD, cancer, diabetes, chronic respiratory diseases, overweight and obesity, and hypertension and hypercholesterolemia.

It is commonly accepted that vegetables and fruit are essential components of a healthy diet. A multitude of substances, both nutrients and non-nutrients, are found in vegetables and fruit.[12] Evidence that suggests an association between vegetable and fruit intake and a reduced risk of disease, particularly NCDs and associated risk factors, has grown over the past few decades.[12-16] Most of the research on humans that has examined the association between vegetable and fruit intake and disease risk has been observational. There have been relatively few randomised controlled trials (RCT). The number of publications synthesising this observational data also continue to increase. While the majority of investigations have examined NCD risks, data that have examined vegetable and fruit intake, and other health problems is also available. The available data indicate that vegetable and fruit intake is much lower than recommendations[15,17] in both South African children and adults.[7,8,18-21] When considering the promotion of vegetable and fruit intake in South Africa, it is necessary to view the available evidence on the relationship between vegetable and fruit intake and disease risk reduction through a South African lens. This will shed light on the need to promote vegetable and fruit intake, and help to determine whether or not interventions aimed at optimising vegetable and fruit intake have the potential to contribute to reducing the burden of nutrition-related disease in South Africa.

An umbrella review refers to a review that compiles evidence from multiple reviews into one accessible and usable paper.[22] The aim of this umbrella review was to compile the best available evidence from multiple reviews and reports on the link between vegetable and fruit intake and disease risk reduction, and specifically to focus on the nutrition-related, burden-of-disease profile in children and adults in South Africa.

Method

This review was based on data extracted from published systematic reviews and scientific health reports, e.g. burden-of-disease reports, by authoritative organisations, both globally and in South Africa. The objective was to identify which of the prevalent nutrition-related conditions in South African children and adults have been associated with vegetable and fruit intake, document evidence of this association, and assess the methodological quality of the evidence from systematic reviews.

Eligibility criteria

Systematic reviews of experimental and observational studies on humans of all age groups and health status, as well as scientific health reports, were included. The studies had to report synthesised or summarised data or risk estimates on vegetable and fruit intake and the risk or incidence of specific nutrition-related conditions or risk factors that are prevalent in the South African population, or associated and total mortality. Specific conditions or risk factors in children were stunting, underweight, vitamin A deficiency, the risk of inadequate micronutrient intake, overweight, obesity and adiposity, and early NCD risks; and CVD, cancer, diabetes, chronic respiratory diseases, overweight, obesity and adiposity, hypertension and hypercholesterolemia in adults. Studies of specific classes of vegetables and fruit, e.g. allium vegetables, were included. Only English language studies were included. Studies on single vegetables and fruit; specific nutrients or components in vegetables and fruit (e.g. fibre); preserved vegetables and fruit (salted, dried, canned, fermented and pickled); diet patterns where vegetable and fruit intake was not assessed independently; and vegetable and fruit supplements and extracts, were excluded.

Search strategy and selection of evidence

A search was performed for all relevant studies in the electronic databases, TRIP, MEDLINE and the Cochrane Library. The African database, Africa-Wide (NiPAD) was searched for African-based research, from January 1958 to February 2012. Searches of titles and abstracts used combinations of full and truncated keywords, including "vegetable", "fruit", "systematic review", "cohort studies", "longitudinal studies", "follow-up studies", "prospective studies", "retrospective studies", "infant nutrition disorders", and "child nutrition disorders". Medical subject headings were used when appropriate. The keywords "vegetable" and "fruit" were linked with "or" in order not to limit the search. The strategy was adapted according to the specific requirements of each database, and was not limited to any specific condition is order to be less restrictive. The websites of authoritative organisations were searched for relevant scientific health reports, including the WHO, Food and Agricultural Organization of the United Nations, American Institute for Cancer Research (AICR), United Kingdom Department for International Development, South African Medical Research Council and the Human Sciences Research Council of South Africa.

All the titles and abstracts of articles identified by searches were screened, and pre-specified eligibility criteria applied. All potentially relevant publications were retrieved in full text for detailed evaluation and consideration for final inclusion. Data from included systematic reviews and reports were extracted and documented by tabular synthesis and narrative description. Only data reported in the published systematic review or report were used. The methodological quality of included systematic reviews was determined using the assessment of multiple systematic reviews (AMSTAR) tool. This reliable, validated tool[23] was applied to each systematic review to obtain a score. The maximum AMSTAR score was 11 for systematic reviews with meta-analyses, and 10 for systematic reviews without meta-analyses. Scores of 0-4 indicated low quality, 5-8 moderate quality, and 9-11 high quality.[24]

Results

The results of the electronic database and website searches, screening and study selection process are outlined in Figure 1. The most recent report on *Food, nutrition, physical activity, and the prevention of cancer,* by the AICR/World Cancer Research Fund (WCRF),[13] was included to provide evidence on cancer. Because of the comprehensive nature of this report, only eligible studies that were published after its release were also included. Two of these studies were updates or extensions of specific components of the AICR/WCRF report.[25-26] A total of 20 studies were included, 16 systematic reviews and four scientific health reports. The included studies for each specified nutrition-related condition or prevalent risk factor in the South African population are presented in Table I.

Preschool children (< 5 years)

The included and reviewed evidence showed that vegetable and fruit intake has been associated with vitamin A status and adiposity in

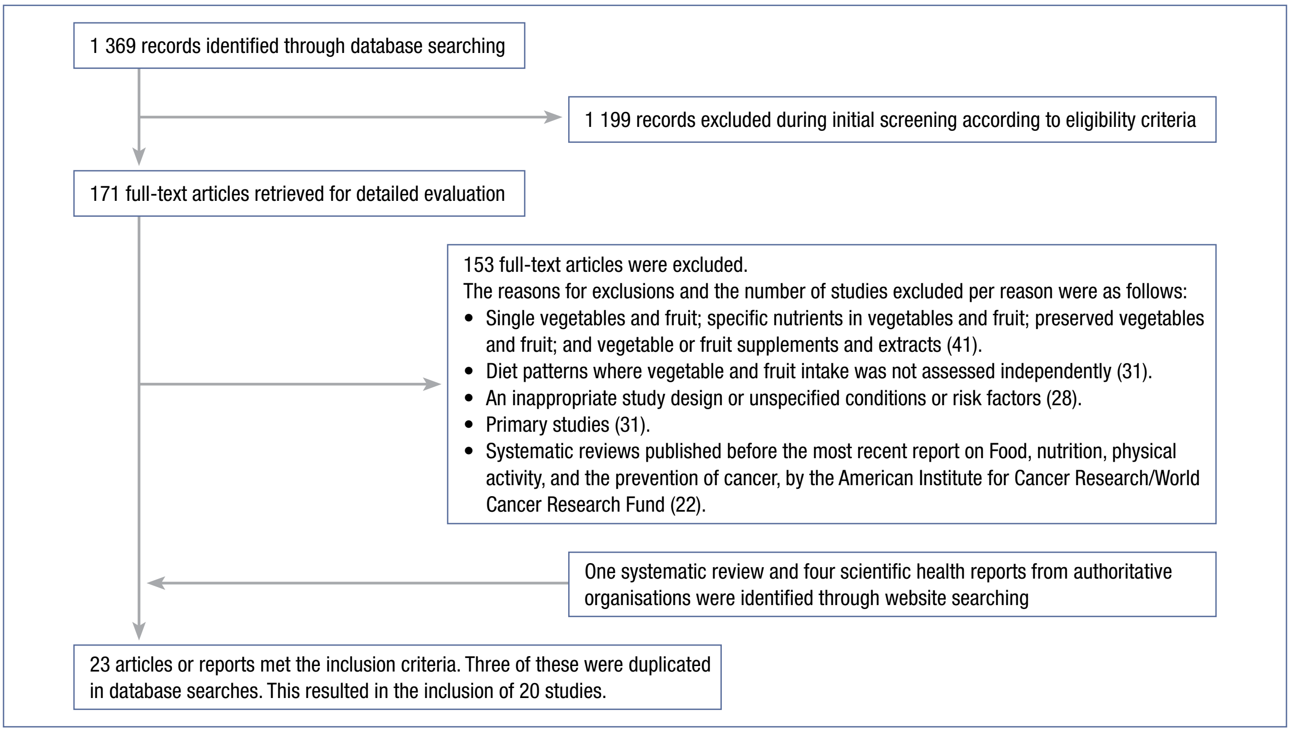


Figure 1: Results of the electronic database and website searches, screening and study selection process

Table I: Systematic reviews and reports on vegetable and fruit intake and each specified nutrition-related condition or prevalent risk factor in the South African population

Children	
Stunting	No systematic reviews or reports
Underweight	No systematic reviews or reports
Vitamin A deficiency	One systematic review[27]
Risk of inadequate micronutrient intake	No systematic reviews or reports
Overweight, obesity and adiposity	One systematic review[28]
Early noncommunicable disease risk	No systematic reviews or reports
Adults	
Cancer	Six systematic reviews, [25,26,29-32] and four reports[13,16,33,34]
CVD: Coronary heart disease	Two systematic reviews[35,36]
CVD: Ischaemic heart disease	One systematic review[37] and three reports[16,33,34]
CVD: Cerebrovascular accidents	Two systematic reviews[38,39] and three reports[16,33,34]
Type 2 diabetes mellitus	Two systematic reviews[40,41]
Chronic respiratory diseases	No systematic reviews or reports
Overweight, obesity and adiposity	Two systematic reviews[28,42]
Hypertension	No systematic reviews or reports
Hypercholesterolaemia	No systematic reviews or reports

CVD: cardiovascular disease

preschool children (< 5 years), both of which are prevalent nutrition-related conditions or risk factors in South African preschool children.

Vitamin A

Searches produced a single eligible systematic review of agricultural interventions that aimed to improve the nutritional status of children, and in which vitamin A status was a selected outcome.[27] This systematic review included a meta-analysis of four intervention studies that examined the effect of home and communal food gardens on serum retinol concentrations in children younger than five years of age in Thailand and South Africa. The summary effect of the interventions was an overall improvement of 2.42 µg/dl serum retinol [95% confidence interval (CI): 1.67-3.16] in intervention areas, compared to control areas, in children younger than five years of age (p-value < 0.001), indicating an improvement in vitamin A intake. This systematic review was judged to be of high quality, and obtained an AMSTAR score of 9. The review fell short in domain 4, where the status of publication was used as an inclusion criterion, and domain 10, where the likelihood of publication bias was not assessed.

Overweight, obesity and adiposity

A recent systematic review of experimental and longitudinal studies in children and adults by Ledoux examined the relationship between vegetable and fruit consumption (whole vegetables and fruit; not fruit juice alone) and adiposity (12 experimental studies: 11 on adults and one on schoolchildren; and 11 longitudinal studies: seven on adults, two on schoolchildren and two on preschool children).[28] This systematic review did not include a meta-analysis. The two studies on preschool children were conducted in the USA on children from low-income homes. The first study (n = 971, aged 1-5 years, with follow-up to two years) found no relationship between vegetable and fruit intake and adiposity [body mass index (BMI) z-score]. However, increased fruit juice intake was associated with excess adiposity gain (each additional daily serving of fruit juice intake was associated with an additional BMI z-score gain of 0.009 standard deviations (SD) per month, p-value < 0.01), in children who were initially either at risk for overweight or obesity. The parental offering of whole fruit was associated with reduced adiposity gain (p-value

Table II: Judgements by the expert panel, based on the systematic reviews of the evidence for nonstarchy vegetables and allium vegetables and fruit reported for relevant cancer sites included in American Institute for Cancer Research/World Cancer Research Fund report[13]

	Cancer sites									
	MPL	N	O	Lung	Stomach	Pancreas	Liver	C	Ovary	E
Nonstarchy vegetables	++	+	++	+	++			+	+	+
Allium vegetables					++					
Fruit	++	+	++	++	++	+	+	+		

C: colorectum, E: endometrium, MPL: mouth, pharynx and larynx, N: nasopharynx, O; oesophagus; +: limited suggestive risk, ++: probable decreased risk

0.06).[43] The second study reported on a positive relationship between vegetable intake and adiposity (n = 1 379, in children aged 2-5 years, with follow-up from six months to one year). However, vegetable consumption ceased to significantly relate to weight change when all food groups were included in the analyses.[44] This was a moderate-quality systematic review (an AMSTAR score of 6 out of 10). It was unclear whether or not duplicate screening and data extraction were performed (domain 2). Status of publication was used as an inclusion criterion (domain 4), lists of included and excluded studies were not provided (domain 5) and the likelihood of publication bias was not assessed (domain 10).

Schoolchildren and adults (5 years and older)

The included and reviewed evidence showed that some of the prevalent nutrition-related conditions and risk factors in South African schoolchildren and adults (five years and older) have been associated with vegetable and fruit intake, namely cancer, CVD [coronary heart disease (CHD), ischaemic heart disease (IHD) and cerebrovascular accidents CVAs)], type 2 diabetes mellitus, and overweight, obesity and adiposity. The classification system or definition used for vegetables and fruit was reported only if available in the article, where applicable.

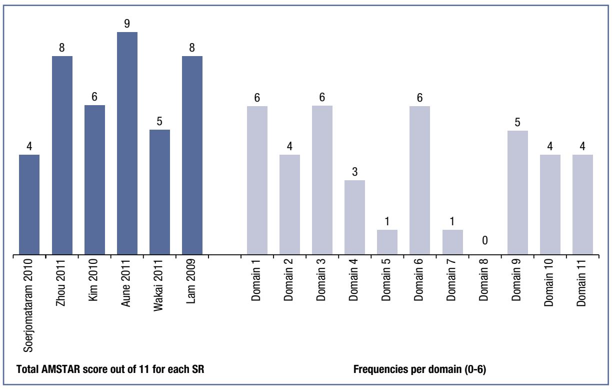
Cancer

Evidence from systematic reviews of the association between vegetable and fruit intake and cancer presented in the most recent report on *Food, nutrition, physical activity, and the prevention of cancer* by the AICR/WCRF[13] was included, as well as six systematic reviews that met the eligibility criteria, and were published after the release of the report.

The strength of the evidence causally relating vegetable and fruit intake with the risk of cancer of the sites reviewed in the AICR/WCRF report was judged as follows: "convincing", "probable", "limited, but suggestive", and "substantial effect on risk unlikely". Judgements of "convincing" and "probable" generally justify public health goals and personal recommendations.[13] Conclusions by the expert panel, based on the systematic reviews of the evidence for nonstarchy vegetables and allium vegetables and fruit for relevant cancer sites, are presented in Table II.[13]

Findings from the six included systematic reviews published after the AICR/WCRF report are summarised in Table III. The majority of these reported findings were in line with those in the AICR/WCRF report.[13]

The total scores and frequencies per AMSTAR domain for the six systematic reviews are presented in Figure 2. One of the included systematic reviews was judged to be of high quality, four of moderate



AMSTAR: assessment of multiple systematic reviews, SR: systematic review
Frequencies: 0: No systematic reviews met the criteria for the domain, 6: All systematic reviews met the criteria for the domain

Figure 2: Total AMSTAR scores for included systematic reviews examining the association between vegetable and fruit intake and cancer at various sites, and frequencies of systematic reviews that met each AMSTAR domain

quality and one of low quality. The weakest AMSTAR domains in these systematic reviews were domains 4 (status of publication used as an inclusion criterion), 5 (inclusion of lists of included and excluded studies), as well as domains 7 and 8 (assessment of scientific quality of the included studies and appropriate use thereof in formulating conclusions) (Figure 2).

According to the recent WHO global health risk report, an insufficient intake of vegetables and fruit has been estimated to cause approximately 14% of gastrointestinal cancer deaths globally.[16] In the WHO comparative quantification of health risks study, the protective effects of vegetables and fruit were expressed as relative risk estimates associated with an 80 g/day increase in vegetable and fruit intake. The relative risk estimates were 0.96 (0.93-0.99) for lung cancer, 0.94 (0.86-1.03) for gastric cancer, 0.99 (0.97-1.02) for colorectal cancer and 0.94 (0.88-1.01) for oesophageal cancer. This study estimated that increasing individual fruit and vegetable consumption up to the theoretical minimum-risk distribution (adults: 600 ± 50 g/day) could reduce the global burden of disease for stomach and oesophageal cancer by roughly 19% and 20%, respectively. Attributable risk fractions for lung and colorectal cancer were lower (12% and 2%, respectively). Theoretical minimum risk is the exposure distribution that would result in the lowest population health risk, irrespective of whether or not currently attainable in practice.[33] Data from the CRA in South Africa indicated that 23.9% of all healthy years of life lost due to oesophageal cancer in 2000 could be attributed to low vegetable and fruit intake. The corresponding figures for gastric cancer, and trachea, bronchi and lung cancer, were 23.6% and 15.4%, respectively.[34]

Table III: Summary of included systematic reviews that examined the relationship between vegetable and fruit intake and cancer at various sites

Systematic reviews	Number, type of study, n, country	Findings	Comments
Soerjomataram et al[30]	• *Oropharynx:* Four case control (n = 9 385) • *Oesophagus:* Five case control and one cohort (n = 490 904) • *Stomach:* Seven case control and two cohort (n = 575 757) • *Lung:* Six case control and one cohort (n =37 485) Europe only	*Pooled RR/g increase in daily fruit intake for cancer of:* • *Oropharynx:* 0.994 (95% CI: 0.992-0.997) • *Oesophagus:* 0.995 (95% CI: 0.994-0.997) • *Stomach:* 0.9981 (95% CI: 0.9976-0.9995) • *Lung:* 0.999 (95% CI: 0.998-0.999) *Pooled RR/g increase in daily vegetable intake for cancer of:* • *Oropharynx:* 0.986 (95% CI: 0.979-0.992) • *Oesophagus:* 0.996 (95% CI: 0.994-0.998) • *Stomach:* 0.996 (95% CI: 0.994-0.998) Assessment of heterogeneity was not reported	• The findings were comparable to those in the AICR/WCRF report[13] • Only significant findings have been included in this table
Zhou et al[32]	Eleven population-based, eight hospital-based case control and two cohort (n = 543 220) Japan, Greece, China, Spain, Poland, Italy, Sweden, Uruguay, the Netherlands, Venezuela, Korea, Lithuania, Iran, Serbia and Europe	*High-intake allium vegetables and gastric cancer:* Pooled OR 0.54 (95% CI: 0.43-0.65), comparing highest with lowest intake categories Heterogeneity: $I^2 = 83.6\%$	• The findings were comparable to those in the AICR/WCRF report[13] • Similar results were obtained with subgroup analysis in the study-design, hospital-based case-control studies, and the population-based case-control and cohort studies
Kim et al[29]	Seven hospital-based case control and one hospital-based cohort Japan and China	*Fresh vegetables and gastric cancer:* OR 0.62 (95% CI: 0.46-0.85), comparing highest with lowest intake categories Heterogeneity: $I^2 = 71.8\%$	The findings were comparable to those in the AICR/WCRF report [13]
Aune et al[25]	Nineteen cohort, an update of the AICR/WCRF report, not all cohorts were used in every analysis The USA, Finland, the Netherlands, Sweden, England, Japan, Singapore, Europe and China	*Colorectal cancer (colon and rectal combined:* • RR for vegetable and fruit intake 0.92 (95% CI: 0.86-0.99) Heterogeneity: $I^2 = 22\%$ • RR for fruit intake 0.90 (95% CI: 0.83-0.98) Heterogeneity: $I^2 = 42\%$ • RR for vegetable intake 0.91 (95% CI: 0.86-0.96), comparing highest with lowest intake categories Heterogeneity: $I^2 = 0\%$ (All associations were mostly colon) • RR for vegetable intake per 100 g/day 0.98 (95% CI: 0.97-0.99) Heterogeneity: $I^2 = 0\%$	• Five large prospective cohort studies were published since the 2007 AICR/WCRF report[13] • These were added to the analysis that was completed for the AICR/WCRF report • There were nonlinear associations for fruit intake. Most risk reduction was up to 100 g/day for fruit intake and from 100-200 g/day for vegetable intake.
Wakai et al[31]	Four hospital-based case control, three population-based and three hospital-based cohort Japan	*Pooled RR for fruit intake for highest versus lowest intake category and lung cancer:* 0.85 (95% CI: 0.75-0.96, p-value < 0.05) Heterogeneity: Q statistic, p-value < 0.05 *Pooled RR for fruit intake per serving per day and lung cancer:* 0.92 (95% CI: 0.84-1, p-value < 0.05) Heterogeneity: Q statistic, p-value < 0.05	Fruit juices were included in some studies, and not in others
Lam et al[26]	Thirteen hospital-based and population-based case control, and six cohort Hong Kong, Australia, Spain, Sweden, Eastern and Western Europe, the USA, Singapore, South America, Canada and the Netherlands	*Pooled OR for total cruciferous vegetable intake and lung cancer for case-control studies:* 0.77 (95% CI: 0.68-0.88) Heterogeneity: $I^2 = 13.8\%$ *Pooled RR for total cruciferous vegetable intake and lung cancer for cohort studies:* 0.83 (95% CI: 0.62-1.08) Heterogeneity: $I^2 = 62.8\%$, comparing highest with lowest intake categories	

AICR: American Institute of Cancer Research, CI: confidence interval, OR: odds ratio, RR: relative risk, WCRF: World Cancer Research Fund

Table IV: Summary of included systematic reviews that examined the relationship between vegetable and fruit intake and coronary heart disease

Systematic reviews	Studies, countries	n, age, number of events, follow-up	Findings	Comments
He et al[36]	Twelve studies (13 independent cohorts) The USA, Finland, France, Northern Ireland and the UK	• n = 278 459 • Age range of 16-84 years in the cohorts • 9 143 CHD events • Median follow-up of 11 years	Pooled RR of CHD: • 3-5 servings of vegetables and fruit/day 0.93 (95% CI: 0.86-1.00) Heterogeneity: I^2 = 58.8% • 5 servings of vegetables and fruit/day 0.83 (95% CI: 0.77-0.89) Heterogeneity: I^2 = 37.5% (compared to < 3 servings of vegetables and fruit per day)	• *Subgroup analyses:* Both vegetables and fruit only had a significant protective effect on CHD • Potatoes as vegetables were included and excluded in some studies. In others, this information was not reported
Dauchet et al[35]	Nine studies (all included)[36] USA and Finland	• n = 91 379 men and 129 701 women • Age range of 25-84 years in the cohorts • 5 007 CHD events • Mean follow-up duration of 5-19 years	*Pooled RR of CHD:* • Each additional serving of vegetables and fruit/day 0.96 (95% CI: 0.93-0.99) Heterogeneity: Q statistic, p-value = 0.17 • Each additional serving of fruit/day 0.93 (95% CI: 0.89-0.96) Heterogeneity: Q statistic, p-value = 0.91 *RR for cardiovascular mortality:* • Each additional serving of a vegetable/day 0.74 (95% CI: 0.75-0.84) Heterogeneity: Q statistic, p-value = 0.36 *RR for fatal/nonfatal myocardial infarction:* • Each additional serving vegetable/day 0.95 (95% CI: 0.92-0.99) Heterogeneity: Q statistic, p-value = 0.66	• Fruit juices were included with fruit in some studies • Potatoes were included with vegetables in some studies

CHD: coronary heart disease, CI: confidence interval, RR: relative risk

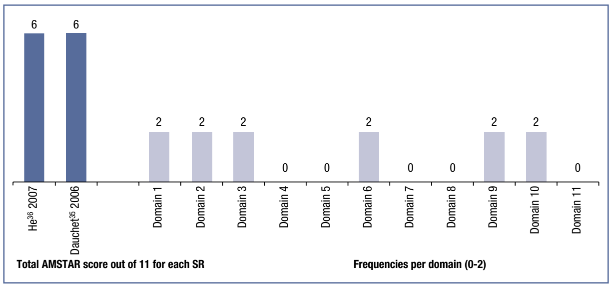
Cardiovascular disease and related risk factors

Coronary heart disease

Two systematic reviews of prospective cohort studies that assessed vegetable and fruit intake and CHD were included.[35,36] The findings are summarised in Table IV. These reviews used most of the same cohort studies, but quantified vegetable and fruit intake differently. However, their findings were similar. The total AMSTAR scores and frequencies per AMSTAR domain for the two included systematic reviews are presented in Figure 3. Both these reviews were of a moderate quality (total AMSTAR score of 6). The weakest AMSTAR domains in these systematic reviews were domains 4 (status of publication used as an inclusion criterion), 5 (inclusion of lists of included and excluded studies), as well as domains 7 and 8 (assessment of the scientific quality of the included studies and appropriate use thereof in formulating conclusions) (Figure 3).

Ischaemic heart disease

The dietary intake of fruit (n = 42 678, 702 IHD events, follow-up of 6-14 years) and vegetables (n = 15 935, 308 IHD events, follow-up of 14 years) was related to IHD risk in a systematic review and meta-analysis of cohort studies that examined the relationship between IHD and markers of vegetable and fruit consumption. This review included cohorts from Finland, the USA, Britain and Wales. Compared to the tenth percentile of fruit intake, the pooled relative risk of IHD at the 90th percentile of intake was 0.86 (95% CI: 0.71-1.05, p-value 0.14) and 0.82 (95% CI: 0.66-1.02, p-value 0.08) for vegetable intake.[37] This systematic review was judged to be of low quality, and obtained an AMSTAR score of 4 out of 11. It was unclear



AMSTAR: assessment of multiple systematic reviews, SR: systematic review
Frequencies: 0: No systematic reviews met the criteria for the domain, 2: All systematic reviews met the criteria for the domain

Figure 3: Total AMSTAR scores for included systematic reviews examining the association between vegetable and fruit intake and coronary heart disease, and frequencies of systematic reviews that met each AMSTAR domain

if duplicate screening and data extraction was performed (domain 2), status of publication was used as an inclusion criterion (domain 4), and lists of included and excluded studies were not provided (domain 5). Additionally, the scientific quality of the included studies was not assessed and used appropriately in formulating conclusions (domains 7 and 8), the likelihood of publication bias was not assessed (domain 10) and information on conflict of interest was not provided (domain 11).

According to the recent WHO global health risks report, an insufficient intake of vegetables and fruit has been estimated to cause approximately 11% of IHD deaths globally.[16] The relative risk estimate for IHD associated with an 80 g/day increase in vegetable and fruit intake in the WHO comparative quantification of health risks

Table V: Summary of included systematic reviews that examined the relationship between vegetable and fruit intake and cerebrovascular accidents

Systematic reviews	Included studies and countries	n, age, number of events, follow-up	Findings	Comments
He et al[39]	Eight studies (nine independent cohorts) The USA, Finland, Denmark, Japan and the Netherlands	• n = 257 551 • Age ranges of 25-103 in the cohorts • 4 917 stroke events • An average follow-up of 13 years	*Pooled RR of CVA:* • 3-5 servings of vegetables and fruit/day 0.89 (95% CI: 0.83-0.97, p-value 0.005) • 5 servings of vegetables and fruit/day 0.74 (95% CI: 0.69-0.79, p-value < 0.0001), (compared to < 3 servings of vegetables and fruit per day) Heterogeneity: p-value < 0.1	*Subgroup analyses:* Vegetables and fruit had a significant protective effect against both ischaemic and haemorrhagic strokes
Dauchet et al[38]	Seven cohorts (all included in ref 39) The USA, Europe and Japan	• n = 232 049 persons • Age range of 25-103 years in the cohorts • 2 955 stroke events • Follow-up duration of 3-20 years	*Pooled RR of CVA:* • Each additional serving of vegetables and fruit/day 0.95 (95% CI: 0.92-0.97) Heterogeneity: Q statistic, p-value 0.92 • Each additional serving of fruit/day 0.89 (95% CI: 0.85-0.93) Heterogeneity: Q statistic, p-value 0.49 • Each additional serving of vegetables/day 0.97 (95% CI: 0.92-1.02) Heterogeneity: Q statistic, p-value 0.40 The association between fruit or vegetables and fruit and CVAs was linear, suggesting a dose-response relationship	• Fruit juices were included with fruit in some studies • Potatoes were included with vegetables in some studies

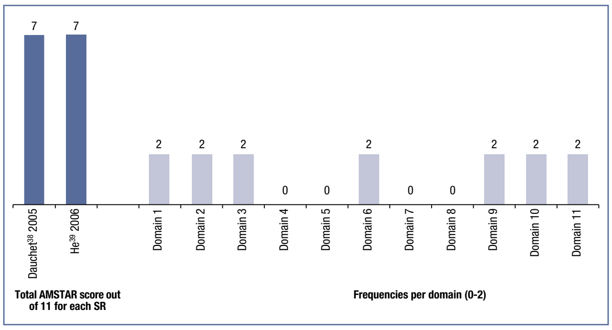
CI: confidence interval, RR: relative risk, CVA: cerebrovascular accidents

study was 0.90 (95% CI: 0.82-0.99). It was estimated that increasing individual fruit and vegetable consumption up to the theoretical minimum-risk distribution (adults: 600 ± 50 g/day) could decrease the global burden of disease for IHD by roughly 31% (30% in men and 31% for women).[33] The South African CRA indicated that 34.6% of all healthy years of life lost due to IHD in 2000 could be attributed to low vegetable and fruit intake, making it the largest proportion of total years of life lost as a result of low vegetable and fruit intake.[34]

Cerebrovascular accidents

Two systematic reviews and meta-analyses of prospective cohort studies that assessed vegetable and fruit intake and CVAs were included.[38,39] The results are summarised in Table V. These reviews used most of the same cohort studies, but quantified vegetable and fruit intake differently. However, their results were comparable. Their total AMSTAR scores and frequencies per AMSTAR domain are presented in Figure 4. Both reviews were of moderate quality (total AMSTAR score of 7). They were lacking in AMSTAR domains 4 (status of publication used as an inclusion criterion), 5 (inclusion of lists of included and excluded studies), as well as domains 7 and 8 (assessment of the scientific quality of the included studies and appropriate use thereof in formulating conclusions) (Figure 4).

The recent WHO global health risks report states that an insufficient intake of vegetables and fruit has been estimated to cause approximately 9% of CVA deaths globally.[16] The relative risk estimate for ischaemic strokes associated with an 80 g/day increase in vegetable and fruit intake in the WHO comparative quantification of health risks study was 0.96 (95% CI: 0.93-0.99). It was estimated that increasing individual fruit and vegetable consumption up to the theoretical minimum-risk distribution could reduce the global burden of disease for ischaemic strokes by roughly 19% (18% in men and 19% in women).[33] The CRA in South Africa indicated that 22.2% of



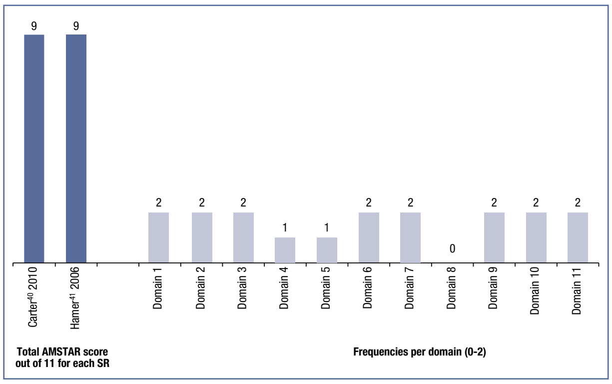
AMSTAR: assessment of multiple systematic reviews, SR: systematic review
Frequencies: 0: No systematic reviews met the criteria for the domain, 2: All systematic reviews met the criteria for the domain

Figure 4: Total AMSTAR scores for included systematic reviews examining the association between vegetable and fruit intake and cerebrovascular accidents, and frequencies of systematic reviews that met each AMSTAR domain

all healthy years of life lost due to of ischaemic CVAs in 2000 could be attributed to low vegetable and fruit intake.[34]

Type 2 diabetes mellitus

Recently, Carter et al published a systematic review and meta-analysis of prospective cohort studies in the USA, Finland and China (six studies, n = 223 512, age range of 30-74 years in the cohorts, 4 858 incident cases, median follow-up of 13.4 years) that investigated the association between vegetable and fruit intake and the incidence of type 2 diabetes.[40] Four of the studies examined the consumption of green leafy vegetables. Summary estimates demonstrated that eating 1.35 servings per day of green leafy vegetables (highest intake) compared with 0.2 servings (lowest intake) resulted in a 14% reduction in type 2 diabetes risk (hazard ratio 0.86, 95% CI: 0.77-0.96, p-value 0.01). The meta-analysis did not show any significant reduction in the risk of type 2 diabetes incidence for the intake of fruit



AMSTAR: assessment of multiple systematic reviews, SR: systematic review

Frequencies: 0 : No systematic reviews met the criteria for the domain, 2: All systematic reviews met the criteria for the domain

Figure 5: Total AMSTAR scores for included systematic reviews examining the association between vegetable and fruit intake and type 2 diabetes mellitus, and frequencies of systematic reviews that met each AMSTAR domain

or vegetables, or vegetables and fruit combined, although the data suggest a trend towards a benefit of consuming greater amounts.[40] A systematic review and meta-analysis of prospective cohort studies in the USA and Finland (five studies, n = 167 128, age range of 25-74 years in the cohorts, 9 581 incident cases, mean follow-up of 13 years) that was published a few years earlier also examined the relationship between vegetable and fruit intake and type 2 diabetes risk. It included four of the same studies that were included by Carter et al, and another one that they had not included.[41] Similarly, no significant reduction in type 2 diabetes risk was observed with the consumption of either fruit or vegetables, or a combination thereof.[41]

The total AMSTAR scores and frequencies per AMSTAR domain for these two systematic reviews are presented in Figure 5. Both reviews were of high quality (total AMSTAR score of 9). The problematic AMSTAR domains for Carter[40] were 5 (inclusion of lists of included and excluded studies) and 8 (appropriate use of scientific quality of included studies in formulating conclusions). Hamer[41] fell short in domains 4 (status of publication used as an inclusion criterion) and 8 (appropriate use of the scientific quality of the included studies in formulating conclusions).

Overweight, obesity and adiposity

The reported results for schoolchildren and adults in the systematic review of vegetable and fruit intake and adiposity by Ledoux et al are presented here (12 experimental studies: 11 on adults and one on schoolchildren; and 11 longitudinal studies: seven on adults, two on schoolchildren and two on preschool children).[28] The experimental studies were carried out in Brazil, the USA, the UK, Spain, Norway and Scotland. The longitudinal studies were from the USA, Spain, the Netherlands, Denmark, China and Canada. Most experimental studies (eight of 11) found that increased vegetable and fruit intake, in conjunction with other behaviour, contributed to reduced adiposity in overweight or obese adults, but no association was shown in the study on schoolchildren from the USA.

These studies were mostly aimed at testing the effect of diet changes, namely increased vegetable and fruit intake, on adiposity using more intensive interventions to improve compliance, such as frequent face-to-face counselling and frequent adiposity assessments. The duration of interventions ranged from six weeks to seven years. Three of the seven longitudinal studies found a weak inverse association between vegetable and fruit intake and adiposity, three obtained mixed results, and one did not establish a relationship. The six studies which found an inverse association or reported mixed findings followed participants for a longer time, and provided a more detailed quantification of vegetable and fruit intake. In the longitudinal studies, high vegetable and fruit intake was associated with less or slower weight gain over lengthy time intervals in adults. One of the longitudinal studies on schoolchildren found an inverse association between vegetable and fruit intake and adiposity. Overweight children in China (n = 95, aged 6-13 years) with a high vegetable and fruit intake at baseline were less likely to remain overweight at two years follow-up than overweight children who followed a diet that was lower in vegetables and fruit at baseline. The other longitudinal study on schoolchildren in the USA (n = 16 882, aged 9-14 years, a follow-up of three years) reported mixed results. An inverse relationship between vegetable and fruit intake and adiposity was obtained, mainly in overweight adults and children, in the experimental and longitudinal studies.[28] This was a moderate-quality systematic review (AMSTAR score of 6 out of 10).

A systematic review (three intervention studies, eight prospective observational studies, five cross-sectional studies) on fruit intake and body weight in adults reported that most evidence pointed towards a possible inverse association between fruit intake and body weight.[42] Nearly half of the studies were carried out in the USA, but there were also studies from Canada, Brazil, Spain, the Netherlands, Sweden, Germany and Portugal. The majority of the subjects in the included studies were overweight or obese, but apparently healthy, except in two of the intervention studies, where subjects were hypercholesterolaemic or had metabolic syndrome. All of the intervention studies were randomised, controlled trials that examined the effect of a high fruit diet compared to a control diet on body weight in overweight or obese individuals. Two of the experimental studies found that increased fruit intake (adding roughly one-and-a-half to three pieces of fruit per day) significantly decreased mean body weight by 0.84-1.6 kg. The other intervention study found no effect. Five of the eight prospective observational studies reported that fruit intake reduced the relative risk of developing overweight or obesity. Four of the five cross-sectional studies found an inverse association between fruit intake and body weight. However, in two of the studies, the inverse association was observed only in women.[42] This systematic review was judged to be of a low quality, and obtained an AMSTAR score of 4 out of 10. It was unclear whether duplicate screening and data extraction were performed (domain 2). The status of publication was used as an inclusion criterion (domain 4) and lists of included and excluded studies were not provided (domain 5). Additionally, the scientific quality of the included studies was not assessed and used appropriately in formulating conclusions (domains 7 and 8), and the likelihood of publication bias was not assessed (domain 10).

Discussion

Prevalent nutrition-related conditions associated with vegetable and fruit intake in South African children and adults

Based on the reviewed data, it is clear that many nutrition-related diseases and risks that contribute substantially to the burden of disease in South Africa have been associated with vegetable and fruit intake. Evidence has suggested that increasing vegetable and fruit intake in preschool children has the potential to improve vitamin A status and to reduce the risk of certain prevalent cancers (lung and gastrointestinal) and CVD (CHD, IHD and CVAs) in adults.

Preschool children (< 5 years)

The reviewed data support the hypothesis that home and communal food gardens can increase the intake of vitamin-A rich vegetables and fruit, thereby improving biochemical vitamin A status in children younger than five years of age. The synthesised evidence is of high quality, although limited. There were too few studies to generate robust findings as the pooled results were sensitive to the inclusion of one or two studies. However, further studies in South Africa (not included in the synthesised data) corroborate these findings. Faber et al determined the contribution of dark-green leafy vegetables to total micronutrient intake in two- to five-year-old children in rural KwaZulu-Natal, where the production and consumption of these vegetables was promoted.[45] Using five repeated 24-hour dietary recalls for each of the four contact sessions (n = 74-79) over a one-year period, they found that the consumption of dark-green leafy vegetables contributed significantly to the dietary intake of vitamin A (42-68%) in children.

A second study by Faber et al to determine the dietary intake of beta carotene-rich vegetables and fruit in two- to five-year-old children (n = 187) over a two-year period in a rural South African community growing these crops at household level, reported that beta carotene-rich vegetables and fruit contributed 49-74% to total vitamin A intake. The intake of individual beta carotene-rich vegetables and fruit varied according to the season. However, the authors reported that an adequate dietary vitamin A intake was maintained throughout the year for the majority of the study population.[46]

Longitudinal data on the association between vegetable and fruit intake and adiposity in preschool children was limited to two studies in low-income groups from the USA. Evidence of a protective relationship between vegetable and fruit intake and adiposity in preschool children was not convincing and was of moderate quality.

Schoolchildren and adults (5 years and older)

According to the revised burden of disease estimates for the CRA in South Africa, cancer accounted for 8% of deaths in 2000, and was ranked as the fourth leading cause of death in all persons. In males, trachea, bronchi and lung cancer was the leading cause of death, (21.9% of all cancer deaths), followed by oesophageal cancer (16.7% of cancer deaths) and prostate cancer (11.8% of cancer deaths). Cancer of the cervix (17.2%), breast (15.6%) and lung (10.9%) were among the top causes of cancer deaths in females.[47] Data from observational studies (population- and hospital-based, case-control and cohort studies) on humans in developed and developing countries support an inverse relationship between vegetable and fruit intake and cancer risk. According to the AICR/WCRF report, the consumption of nonstarchy vegetables and fruit is associated with a lower risk of cancer. Evidence suggests a stronger relationship with gastrointestinal cancers (mouth, pharyngeal, laryngeal, oesophageal and gastric). Allium vegetable intake was reported to be strongly linked to a reduced risk of gastric cancer.[13] This association was confirmed by[13,25] subsequent high-quality synthesised observational data.[32] According to the AICR/WCRF report, greater vegetable and fruit intake was associated with a modest reduction in colorectal cancer risk. Thereafter, a high-quality, meta-analysis of cohort studies also reported a relative risk reduction (1-14%) for highest versus lowest intake. An inverse relationship between higher vegetable and fruit intake and lung cancer risk was reported. A stronger relationship was reported for fruit intake, although it should be noted that the pooled observational data by Wakai et al (relative risk reduction of 4-25%) was of moderate quality.[13,31] Cruciferous vegetable intake was inversely linked to reduced lung cancer risk (relative risk reduction of 12-32%) by a high-quality, meta-analysis of case-control studies published after the AICR/WCRF report.[26] Comparative risk estimates indicate that a substantial proportion of the global and South African cancer burden can been attributed to low vegetable and fruit intake, and particularly oesophageal and gastric cancer in South Africa. Improving vegetable and fruit intake could help to reduce this burden.[16,33,34]

CVD and related risk factors contribute greatly to the burden of disease in South Africa.[10,48] In 2000, CVD was the greatest cause of NCD mortality (1 468 age-standardised deaths per 100 000).[3] In the case of specific cardiovascular conditions, reviewed data from meta-analyses of observational studies in developed countries judged to be of moderate quality, suggested an inverse association between vegetable and fruit consumption and CHD risk. A greater intake showed a greater risk reduction (11 to 23% relative risk reduction with > 5 servings per day).[35,36] The consumption of vegetables was also inversely linked to a reduced CVD mortality risk (relative risk reduction of 16-25%) in one of the reviewed meta-analyses.[35] The risk of IHD has been associated with vegetable and fruit intake in developed countries, although the study was of low methodological quality.[37] In 2000, approximately a third of premature mortality from IHD in South Africa was attributable to low vegetable and fruit intake.[34] Comparative risk assessments indicate that greater vegetable and fruit intake could reduce the global burden of IHD by roughly a third.[33] Eating vegetables and fruit has also been shown to reduce the risk of CVAs. Moderate-quality pooled evidence from prospective studies in developed countries has suggested a dose-response relationship.[38,39] Eating more than five servings of vegetables and fruit per day, compared to less than three servings, was associated with a 21-31% relative risk reduction in CVAs.[39] One fifth of premature mortality from ischaemic strokes in South Africa has been ascribed to low vegetable and fruit intake. Improving vegetable and fruit intake could reduce the global ischaemic stroke burden by approximately 20%.[33-34]

Reviewed pooled evidence from high-quality systematic reviews of cohort studies found no association between vegetable and fruit consumption and type 2 diabetes mellitus.[40,41] Combined data from four cohort studies suggested an inverse association between the intake of green leafy vegetables and the incidence of type 2 diabetes (4-23% relative risk reduction).[40]

Some of the reviewed evidence from experimental and longitudinal studies in developed countries points to a possible inverse association between vegetable and fruit intake, together with other behaviour, and adiposity,[28] as well as fruit intake and body weight.[42] However, the reported effects and associations were inconsistent. Furthermore, they seem modest, particularly in terms of clinical significance and were derived from systematic reviews judged to be of low to moderate methodological quality. In multi-component experimental studies that promoted behaviour to induce negative energy balance, higher vegetable and fruit intake was weakly associated with weight loss in overweight or obese adults, but not in schoolchildren. High vegetable and fruit intake was associated with less or slower weight gain over lengthy time intervals in adults in longitudinal studies, but to a lesser degree in schoolchildren.[28] Two randomised controlled trials found that increased fruit intake decreased body weight. However, the reduction had questionable clinical significance, and a third reported no effect.[42]

Research shows the early consolidation and tracking of dietary behaviour from childhood into adulthood.[49,50] This corroborates the notion that poor-quality dietary intake during childhood is a plausible contributor to NCD risk in adulthood. To this effect, observational data in the UK investigated childhood diet and cardiovascular mortality [n = 4 028, average baseline age 7.5 years (SD 4.8), 1 010 deaths after age 30 years, and an average follow-up of 37 years]. The study reported that a higher childhood intake of vegetables, excluding potatoes, was associated with a lower risk of strokes after controlling for confounders (rate ratio between the highest and lowest quartiles of intake 0.40 (95% CI: 0.19-0.83, p-value for trend 0.01).[51] National data show that schoolchildren in South Africa do not eat vegetables and fruit every day, and have low levels of physical activity.[11] The presence of patterns of unhealthy dietary behaviour, which relate to NCDs in children in South Africa,[3,11] is a cause for concern.

The methodological quality of the included systematic reviews ranged from low (AMSTAR score of 4) to high (AMSTAR score of 9). Most of the systematic reviews did not assess the scientific quality (validity) of the studies that they included. Therefore, it could not be used to formulate conclusions. This was a limitation since the extent to which a systematic review can draw valid conclusions depends on whether or not the data and results from the included studies are valid.

Other important points to consider in this umbrella review were that most of the available evidence was from observational studies. Few intervention studies were available, thus the causal mechanisms of the described associations between vegetables and fruit, and disease risks, remain to be demonstrated. Furthermore, studies on the associations between vegetables and fruit and disease are predominantly from developed countries with less evidence from the developing world being available. There is less evidence from the developing world. Estimates may be influenced by the differing prevalence of confounding risk factors, for example smoking, obesity and infection, in developing countries such as South Africa. The included studies differed according to the types of vegetables and fruit consumed. The production methods, storage conditions, nutrient content, and cooking and preparation methods of vegetables and fruit varied across the studies. The classification system used for vegetables and fruit also differed in the studies, i.e. which foods were considered to be vegetables and fruit, as well as the measurement units used to quantify vegetable and fruit intake, e.g. servings per day or g/day. These are important to consider when comparing, interpreting and generalising findings. Further cohort studies on the impact of measurement errors on disease risk estimates in different populations are needed.

Various assumptions were made when data were pooled to reconcile the variety of approaches to dietary assessment, inconsistent classification of vegetable and fruit intake and quantities, diverse outcome measures, highly variable follow-up periods, and different exposure to vegetables and fruit. It is also important to note that inconsistent findings relating to vegetables and fruit and nutrition-related health conditions were reported in the meta-analyses and reviewed studies. The authors of many of the pooled studies reported a significant degree of heterogeneity between studies that examined vegetable and fruit intake and human health. It is important that the definitions of vegetables and fruit are clear for accurate quantification of vegetable and fruit consumption. The inclusion of potatoes and tubers as vegetables is a somewhat controversial issue. As a group, potatoes and tubers include yams, sweet potatoes, cassava or manioc and taro, and the starch content of these foods varies from 12-50%. Many dietary guidelines place potatoes in the cereals group as a starchy food, while potatoes are also sometimes considered to be vegetables. Some dietary guidelines overtly exclude potatoes from the recommendation to increase vegetable intake.[52] According to the WHO, potatoes and starchy tubers should not be included with vegetables and fruit.[17] The 5-a-Day for Better Health Trust recommends potatoes as one of the five daily portions of vegetables and fruit. This classification is based on the nutrient density of potatoes, which is deemed to be similar to the profile of other vegetables.[53] There is less deliberation about the classification of fruit, although the inclusion of nuts and fruit juices is also a contentious issue.[52]

Micronutrients

Within this context, the contribution of vegetable and fruit intake to micronutrient adequacy should also be briefly mentioned. At recommended levels, vegetable and fruit intake provides sufficient micronutrients, particularly vitamin A, vitamin C, folate, vitamin E, potassium and fibre in the diet.[15] This is particularly relevant to the South African population, where the diets of many South African children and adults have a low dietary diversity score[19,54] and thus poor micronutrient adequacy, since the dietary diversity score is regarded as a valid indicator of the micronutrient adequacy of the diet.[19] Improved vegetable and fruit intake in the diet of South Africans across the life cycle would contribute to increased dietary diversity and improved micronutrient intake.

Conclusions and recommendations

This review aimed to compile the best available evidence from multiple reviews and reports on the link between vegetable and fruit intake, and the nutrition-related burden-of-disease profile in children and adults in South Africa. Based on the reviewed evidence, it is clear that increasing vegetable and fruit intake in the South African population has the potential to contribute to reducing the burden of nutrition-related conditions in this country. Evidence suggests that increasing vegetable and fruit intake in preschool children could improve their vitamin A nutriture. This was the case for the reduced risk of certain prevalent cancers (lung and gastrointestinal) and CVD, specifically CHD, IHD and CVAs, in adults. It should be kept in mind that the methodological quality of the included systematic reviews ranged from low to high (AMSTAR), and that most of the reviews did not assess the scientific quality of the studies that they included.

However, this evidence motivates the need to promote vegetable and fruit intake in South Africa. Ideally, the promotion of vegetables and fruit should form part of wider health-promotion and disease-prevention strategies and campaigns at population level.

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