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THE WORLDWIDE EVIDENCE-BASED EFFECTIVE INTERVENTIONS AND PROGRAMMES
DESIGNED TO INCREASE FRUIT AND VEGETABLE INTAKE
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IMPROVING THE WORLDWIDE EVIDENCE-BASED EFFECTIVE INTERVENTIONS AND PROGRAMMES DESIGNED TO INCREASE FRUIT AND VEGETABLE INTAKE

MEJORANDO LA EVIDENCIA DE INTERVENCIONES Y PROGRAMAS EFECTIVOS DISEÑADOS PARA AUMENTAR EL CONSUMO DE FRUTAS Y VERDURAS A NIVEL MUNDIAL

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ABSTRACT

This paper discusses the implications for future policy and research of a systematic literature review on the effectiveness of interventions and programs promoting fruit and vegetable intake in both adults and children worldwide which was carried out in 2004. The results indicate that small increases in fruit and vegetable intake are possible in population subgroups, and that these can be achieved by a variety of approaches (individual-level, population-level and «upstream» macro-level policy and environmental interventions) in both children and adults. While many fruit and vegetable promotion programmes have been conducted or initiated in all world regions, our review indicated that the study design used was often suboptimal to assess effectiveness, particularly in less developed countries. Although more work needs to be done in order to improve the design and evaluation of such interventions worldwide, these encouraging results suggest that national governments should continue to develop policies to improve nutrition which have a strong emphasis on fruit and vegetable intake.

Key words: Promotion, fruit and vegetable consumption, programmes.

RESUMEN

Este artículo de revisión sistemática de literatura, discute las implicancias de políticas futuras y de investigación científica sobre la efectividad de las intervenciones y programas
promoviendo el consumo de frutas y verduras en ambos adultos y niños a lo largo del mundo, realizadas en 2004. Los resultados indican que pequeños aumentos en el consumo de frutas y verduras son posibles en subgrupos poblacionales y que estos cambios pueden ser alcanzados desde varios acercamientos (a niveles individual, poblacional y desarrollo de políticas macro e intervenciones ambientales) tanto en niños como en adultos. Mientras muchos programas de promoción de frutas y verduras han sido conducidos o iniciados en todas las regiones del mundo, nuestro artículo muestra que los diseños de estudio utilizados han sido frecuentemente sub-óptimos para evaluar efectividad, particularmente en países menos desarrollados. Aunque es necesario mayor esfuerzo para mejorar el diseño y la evaluación de dichas intervenciones a lo largo del mundo, estos resultados son estimulantes y sugieren que los gobiernos deben seguir desarrollando políticas para mejorar la nutrición que tengan un énfasis fuerte en el consumo de frutas y verduras.

**Palabras claves:** ingesta, frutas y vegetales, intervención.

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**INTRODUCCION**

There is now strong evidence that fruit and vegetable consumption can prevent a number of chronic non-communicable diseases including cardiovascular disease and some cancers (1-5). Although most research has examined the association between consumption in adulthood and a range of non-communicable diseases, some longitudinal studies have examined the influence of childhood diet on disease in later life. For example, a recent follow-up to the 1930s Boyd Orr cohort (6, 7) found that childhood fruit consumption appeared to be protective against development of cancer in adulthood (8).

While evidence increases for the population health benefits of consuming more fruit and vegetables, nutritional surveys worldwide show that children and adults in most world regions are not meeting the minimum consumption goals of 400 g per person per day advocated by the World Health Organisation and many national governments (9, 10). Consumption of fruit and vegetables is relatively lower amongst children and young people, and in lower socio-economic groups. Families experiencing food insecurity are particularly vulnerable to low fruit and vegetable consumption (11, 12).

There is an increasing expectation that policies will be based on evidence (13, 14). The WHO has developed a global fruit and vegetable promotion initiative (15) which fits within the framework of the Global Strategy on Diet, Physical Activity and Health and complies with the mandate of the WHO Global strategy for the prevention and control of non-communicable disease. One of the key conclusions of the 2003 Fruit and Vegetable Promotion Initiative meeting was the need for an up-to-date review of all types of interventions focused on increasing fruit and vegetable intake in all settings and world regions to help the development of effective and appropriate policies in countries worldwide, and to ensure that current fruit and vegetable programmes (such as those underway in the USA, Europe and Latin America) have maximized their potential to improve public health. As a result of this, a systematic review of the effectiveness of interventions and programs promoting fruit and vegetable intake in both adults and children which was carried out in 2004. This paper summarizes the results of this review and discusses the implications of the findings for future policy and research to improve the evidence-base of effective approaches particularly in less developed countries. Full methods and results of the systematic review have been published elsewhere (16, 17).
METHODS

In April 2004, thirteen publication databases were searched from the earliest record, including PUBMED, and the Cochrane Library. The search strategy was designed to be used in PUBMED and adapted to the other databases. We also searched reference lists of articles found and contacted 139 experts in the field from all regions of the world. We considered all publications in eight languages including English and Spanish that reported on interventions and promotion programs planned to increase intake of fruit and/or vegetables in free-living adults and children who were not acutely ill. The studies had follow-up periods greater or equal to three months and had a control group. The outcome of interest was a change in fruit and/or vegetable intake, derived from self-reported measures or observation, or from availability data (if used as a proxy for intake).

The effect size was estimated using one of three methods depending on data available in the publications; (i) the difference between intervention and control groups in the change in intake between baseline and follow-up (net effect); (ii) the differences between the intervention and control groups at follow-up; (iii) change in intakes within each group.

RESULTS

Of the nearly 3500 unduplicated records identified by the search, 69 articles reporting results of 59 independent studies met our inclusion criteria and were thus selected for review. Of these, forty-four studies were of adults (16-69 years) and fifteen studies focused on children. Because of the heterogeneity in the study populations, types of interventions and outcome assessment measures, a meta-analysis was not attempted. The general characteristics of the included studies are briefly summarised in tables 1 and 2.
RESULTS FOR CHILDREN

None of the 15 studies of fruit and vegetable intake promotion among children of primary and secondary school-age showed a detrimental effect on fruit and vegetable consumption. Eleven studies had a significant effect in increasing intake.

A closer examination of the studies revealed that certain intervention components are associated with successful results (though these interpretations could not be directly and systematically tested), and that the more students are exposed to fruit and vegetables, the
more consumption patterns improve (17). Intervention components include giving children ownership of projects to promote fruit and vegetables, for example encouraging them to be peer leaders and teach a class on the subject, as described in the TEENS intervention (18). Another sort of peer educator, that seen in cartoon characters such as the «Food Dudes» primary school intervention in the UK, has proved to be an effective motivator for change in children’s fruit and vegetable consumption. Since our original review was published more evidence on the ‘Food Dudes’ programme further demonstrates the effectiveness of combining video-based peer modelling with rewards for increasing children’s fruit and vegetable intake (19). Actively involving as many partners as possible in the promotion of fruit and vegetables was also cited as a key factor for success, such as teachers, food service staff, parents, local shops. In the Eat Well and Keep Moving intervention (20), the school provided links with local low-cost nutrition courses to parents; in one study, verbal encouragement by the school food service staff was associated with significantly higher intakes on at least one occasion (21).

RESULTS FOR ADULTS

The review of 44 studies of interventions intended to promote fruit and vegetable intake in adults found that none led to a lowering of fruit and vegetable intake in the target populations. On the contrary, most interventions led to an increase in intake compared with control groups. Table 2 gives an overview of the included studies, full details are contained elsewhere (16).
### TABLE 2

Summary of the study results for adults by study setting

<table>
<thead>
<tr>
<th>Study Design/Type of Intervention</th>
<th>General population</th>
<th>African-American Churches</th>
<th>Supermarkets or other retail settings</th>
<th>Worksites</th>
<th>Health care settings</th>
<th>Low-income populations</th>
<th>Pre-existing cardiovascular disease or risk factors, or cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of studies</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>9</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Number of studies by country</td>
<td>Japan (1), USA (2)</td>
<td>USA (3)</td>
<td>USA (2)</td>
<td>New Zealand (1), USA (10)</td>
<td>UK (2), USA (7)</td>
<td>USA (5)</td>
<td>USA (3), UK (2), India (3), France (1), Netherlands (1)</td>
</tr>
<tr>
<td>Study design</td>
<td>Randomized controlled trial</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Type of intervention</td>
<td>Non-randomized controlled trial</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Prompt sheets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Point of purchase information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Computer based tool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Personal counselling/ education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Personal counselling/ education + other interventions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Group counselling/ education Peer-education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Multi-component community including worksite interventions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Length of follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3-5 months</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>6-11 months</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>≥12 months</td>
<td>2</td>
<td></td>
<td></td>
<td>1</td>
<td>11</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>
The largest effects were generally observed among individuals who were already at a higher risk for disease. This could reflect an elevated motivation among these individuals to improve their dietary intake, suggesting that they should be considered separately from the general population. In other study populations the increase in fruit and vegetable intake ranged from about +0.1 to +1.4 serving/day. Relatively greater effects were seen in those studies involving face-to-face counselling interventions, but there was no consistent change in intake related to the intensity of contact. The observation that interventions employing a more personal approach appeared slightly more effective seems intuitive. However, this must be balanced against the higher cost, the greater time demands and need for trained staff that this approach would require. This does not seem to be a feasible whole-population approach.

Printed, individually-tailored information and computer-based information (particularly if this was individually tailored) appeared to be a reasonable alternative to face-to-face or telephone contact. Clearly this is the easiest and cheapest individual-based approach. Computer-tailored education is an innovative tool to encourage people to make healthy dietary changes. Because it provides individualized feedback about one’s dietary behaviours, motivation, attitudes, norms, and/or skills, it mimics the process of “person-to-person” dietary counselling. Available evidence suggests that computer-tailored nutrition education is more effective in motivating people to make dietary changes than general nutrition information. However, no trials of this were found outside Europe and the United States and potential use of this technique in rural settings (especially in developing countries) is low.

Worksites are a potentially valuable setting for delivering interventions promoting fruit and vegetables in adults. However, they require a comprehensive approach with many components, which is time and resource intensive, as well as requiring the collaboration of

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**TABLE 2**

Summary of the study results for adults by study setting

<table>
<thead>
<tr>
<th>Number of studies with measured effect</th>
<th>General population</th>
<th>African-American Churches</th>
<th>Supermarkets or other retail settings</th>
<th>Worksites</th>
<th>Health care settings</th>
<th>Low-income populations</th>
<th>Pre-existing cardiovascular disease or risk factors, or cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Differences between groups in change in intakea</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>- Positive net effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Non-significant difference</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Differences between groups at follow-upb</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Higher intake in intervention group at follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Higher intake in control group at follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- No difference at follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Change in intakes within groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Greater change in the intervention group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Non significant change</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
the company and other stakeholders. Unfortunately, so far, the effect sizes reported in such programmes have not been very large. However, this may reflect the diffuse nature of such multi-component interventions.

**Community-wide approaches (including those that did not meet the review inclusion criteria)**

Although our review identified reports of various local, regional and national programmes from countries worldwide, most evaluations did not use a control group and had to be excluded from the review. For this and other reasons, it was difficult to assess the effectiveness of national and community-wide approaches. Some examples of programmes that were not included in this review are provided in tables 3 and 4 to give a clear understanding of the range of fruit and vegetable promotion initiatives that have been undertaken worldwide. These include «5 a Day» and equivalent marketing campaigns, or nutrition education and information programmes. Many of these have been established for several years but with no formal evaluation of their effectiveness on fruit and vegetable intake. National fruit and vegetable programmes have been set up in many countries worldwide and have used a variety of approaches (Table 3 lists various national schemes to promoting fruit and vegetable consumption). In developing countries, a range of intersectorial projects have also been established to encourage production and consumption of fruit and/or vegetables, often as local food-based initiatives to reduce micronutrient deficiency or focused on household income (Table 4 includes examples from different world regions).
<table>
<thead>
<tr>
<th>Country</th>
<th>Name of fruit and vegetable programme</th>
<th>Types of activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>5 al día</td>
<td>Event sponsorship, seminars, partnership with horticulture sector</td>
</tr>
<tr>
<td>Australia (West</td>
<td>Go for 2 and 5</td>
<td>Mass media campaign including television advertisements and television series, cookbooks, consumer literature. School canteen accreditation (STARCAP), school fruit and vegetable week, under-five daycare scheme, low-income project</td>
</tr>
<tr>
<td>ern Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>5 to 10 a day</td>
<td>Three-year media campaign including television, radio stations, and print media. Information materials distributed to health offices, schools, grocery retail stores and dieticians</td>
</tr>
<tr>
<td>Denmark</td>
<td>6 om dagen, School fruit programme</td>
<td>Media campaign and educational material, worksite interventions, subscription school fruit scheme</td>
</tr>
<tr>
<td>France</td>
<td>10 par jour</td>
<td>Newsletters, media campaigns, recipes</td>
</tr>
<tr>
<td>Hungary</td>
<td>3 a day</td>
<td>Started in 1997 as a partnership funded both by agriculture and health. Target groups: children, young people and housewives. Activities include supermarket promotions, cooking shows, taste-testing at school, advertising and public relations materials</td>
</tr>
<tr>
<td>Japan</td>
<td>Vegefru-7</td>
<td>Started in 2002 as a partnership between government (agriculture, education) and the Japan Produce Alliance for Better Health (producers, retailers, industry). Dietary education tool distributed to classrooms, supermarket tours, harvesting tours, communications strategy and materials</td>
</tr>
<tr>
<td>Mexico</td>
<td>5 x dia</td>
<td>Formation of Fundacion Campo Y Salud Organisation, communications strategy</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2+2</td>
<td>Interactive website for children, recipes, communication strategy</td>
</tr>
<tr>
<td>New Zealand</td>
<td>5 a day</td>
<td>National media campaign, 5 a day week, 5 a day school programme, various projects</td>
</tr>
<tr>
<td>Norway</td>
<td>5 om dagen, school fruit programme</td>
<td>Subscription school fruit scheme</td>
</tr>
<tr>
<td>Poland</td>
<td>5 a day</td>
<td>National campaign co-organized between cancer centres and private sector (producers, processors, retailers). «5 a day» promotion activities in kindergarten, primary and secondary schools</td>
</tr>
<tr>
<td>Spain</td>
<td>5 al día</td>
<td>Information campaign, activities for children, symposia, events with agricultural sector</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5 a day</td>
<td>Communications programme including media campaigns and written information, school fruit scheme, local «5 a day» community projects and local project workers, work with retail sector applying «5 a day» logo to foodstuffs</td>
</tr>
<tr>
<td>Uruguay</td>
<td>5 por día</td>
<td>Series of activities involving health, nutrition, education and commercial sectors</td>
</tr>
<tr>
<td>United States of America</td>
<td>5 a day (Produce for Better Health Foundation)</td>
<td>Public/private partnership, communications strategy, «5 a day» week, endorsement of «5 a day» logo.</td>
</tr>
</tbody>
</table>

Source: adapted from Pomerleau et al.30
Discussion

This review clearly indicated that the majority of the fruit and vegetable interventions examined were effective in increasing intake.

In terms of promoting fruit and vegetables to children, several lessons were learnt from the systematic review. First, researchers and public health practitioners have to continue to improve the ways in which fruit and vegetable promotion interventions are carried out. Most importantly, the interventions or programmes need to have longer timeframes and they need to be evaluated from the start so that their effectiveness can be properly assessed. Second, merely improving knowledge about fruit and vegetables alone is unlikely to have an impact on eating behaviours, particularly in children. This is critical as fruit and vegetable intake in children is significantly lower than national and international guidelines in most countries, as reflected in the recent Pro Children Cross sectional Survey of a representative sample of 11 year olds across 9 European countries (22). Policymakers need to understand that social, economic and physical environments need to be conducive to enable increased fruit and vegetable consumption. A final lesson for increasing intake in children is that schools need to focus on finding adequate resources to provide healthy foods and supportive school based nutrition activities. Clearly this should include provision of fresh fruit and vegetables (bought...
locally and presented in attractive ways) which are affordable and readily available to children at breakfast, snack breaks and/or lunch.

A few lessons can also be learnt from studies in adults. A main finding was that positive results were observed in a variety of settings and using a number of approaches. While consistent positive effects were found in studies involving a more intense approach (e.g. face-to-face education or counselling), it was interesting to observe that reasonable effects were also found when less intensive, and thus cheaper, interventions were used (e.g. telephone contacts or computer-tailored information).

Our findings are generally consistent with those of previous reviews of the literature, but which were generally more limited in scope focusing for example on community intervention programmes, nutrition education, counselling in primary care units, or behavioural interventions), or geographically limited, focused on North America, Europe, or even on the United States only (23,24 25, 26 27). It is also interesting to see that several fruit and vegetable intake interventions which were published after April 2004 (the cut-off date of our review search) also showed positive findings in line with our results. For example Block et al (2004) (28) tested the effectiveness of an interactive software on a low-income ethnically diverse group of women in the United States and they found that at follow-up, intervention groups reported significantly higher intakes of fruits and vegetables than the control group.

**METHODOLOGICAL LIMITATIONS**

The systematic review described here identify a wide range of interventions and programmes promoting fruit and vegetable intake that have been undertaken in many parts of the world. There are some methodological limitations which need to be considered. First, although several bibliographic databases was searched and numerous experts from all world regions contacted, some studies might have been missed. These include for example studies published after April 2004. The possibility of publication bias was not assessed; if present it could have led to an overly optimistic impression of the effectiveness of fruit and vegetable promotion interventions. Secondly, the inclusion criteria for the review meant that most studies included in the review were from industrialized countries. For example, excluding studies that lacked a control group had the unfortunate effect of excluding the majority of interventions from developing countries, national or large-scale promotion interventions (some of which having shown positive effects on increasing fruit and vegetable consumption in pre-test and post test evaluations). Searches of the literature and contact with experts indicated that fruit and vegetable promotional activities (for example, education materials, leaflets, posters, advertising, radio programmes, special events) are taking places in many countries. However, their effectiveness is either not being evaluated at all, or not being reviewed with sufficient rigour. This is particularly the case in developing countries, with no studies from Africa meeting the selection criteria. Third, fruit and vegetable intake was based most cases on self-reported information (e.g. food-frequency questionnaires, 24-hour recalls, food diaries) and is thus subject to the limitations of dietary assessment methods, particularly for measuring small changes in dietary intake. In addition, the inability to blind those involved means that individuals receiving the interventions might have been more likely to report positive changes (reporting bias) compared with individuals in control groups, which could lead to an overestimation of the effect size. Few studies included a clear definition of the foods considered as fruit and vegetables or of what constituted a serving. Some studies even included potatoes in the count of fruit and vegetable servings consumed, contrary to current international recommendations. Fourth, although a large proportion of the studies examined had relatively long follow-up times (at least one year), they could not provide information on the long-term effectiveness of the interventions in terms of fruit and
vegetable intakes, on the risk factors for relapses to lower intakes, nor could they examine the long-term effects on the risk of major chronic diseases. Finally, the cost-effectiveness of the different types of interventions could not be compared because of the lack of information on the costs of the interventions.

**BARRIERS TO CONSUMPTION**

There is an extensive research literature on barriers to increasing consumption of fruit and vegetables which need to be understood when discussing the results of previous interventions and when designing new interventions. At an individual level, people often perceive that they eat enough, or that some foods (particularly fruits) have a high cost, while family eating habits can be difficult to change (29). Other environmental barriers include the limited supply of fruit and vegetables (for example little variety on offer in work canteens or local shops), poor quality and high cost in low-income areas, lack of skills in preparing fruits and vegetables, and misperceptions that they are time-consuming to cook (30). A major barrier to school-based interventions is competition against other school priorities, with nutrition generally not seen as a priority in increasingly crowded curricula.

Fruit and vegetable promotion programmes directed at the general public (for example, through social marketing) have been popular. There are perceived barriers involving both the fruit and vegetable industry (where there is often mixed support for generic fruit and vegetable promotion) and the health sector, where the small promotional budgets and lack of sustained funding for social marketing have limited the ability to produce long-term changes in intake.

Worksite interventions offer the possibility to influence the fruit and vegetable intake of large numbers of adults, especially men, who tend to have a lower consumption of these foods. However, for many interventions there have been low rates of recruitment and retention, and perhaps a limited understanding and assessment of environmental barriers in different workplaces. Few food-service interventions have focused solely on fruit and vegetables. Some studies have showed that price reductions could lead to short-term increases in fruit and vegetable purchases; however, purchases generally returned to baseline levels within a few weeks after the intervention.

Several studies have identified that barriers to increasing fruit and vegetable intake differ in different population groups due to different social and environmental conditions that affect their dietary intake. In a US study of elderly people those who were socially isolated, with missing pairs of posterior teeth, poor self-reported health and those who were obese had the lowest fruit and vegetable intakes (31). Innovative programmes such as home delivery schemes may be the only way by which housebound elderly can increase consumption (32). In low income groups in developed countries, cost appears to be important but not the sole barrier. In a US Study, providing vouchers for fruit and vegetables in social feeding programmes uptake resulted in high uptake (33). In a UK study, although eating additional fruits and vegetables was perceived as being prohibitively expensive, overall access and affordability were only a small part of the ‘problem’ surrounding low fruit and vegetable consumption in low income consumers (34).

**GENERALIZABILITY OF THE FINDINGS**
While this review of the literature contributed important information for policy makers, its findings cannot be generalised to all populations worldwide since the great majority of studies were carried out in industrialized countries and in particular in Europe and the United States. Not only are there differences in the cultural and socioeconomic contexts but also in nutrition priorities. In developing countries, priorities are still mainly focused on the control of micronutrient deficiencies and the alleviation of hunger although the nutrition transition observed in most regions means that this emphasis is shifting and adults and children are increasingly suffering the double burden of overnutrition and undernutrition (35). In developing countries fruit and vegetable promoting programmes are mainly developed as food-based strategies to alleviate these shortages (36), compared to the focus of fruit and vegetable programmes in developed countries, which generally aim to reduce non-communicable disease risks.

In children, another factor that limits the generalisability of our findings is the fact that the majority of the studies reviewed were school-based. In contrast it was estimated that in 2003 121 million school-age children were not in school, with the majority of these living in sub-Saharan Africa and South-East Asia (37). This warrants a continued effort to focus both on promoting school attendance as well as a special emphasis on non-school-based approaches to food and nutrition, such as home-based food production programmes (36). Other generalisability issues include the fact that there is very little information on the effectiveness of fruit and vegetable interventions among subgroups of the adult population, for example in different ethnic groups, those at high risk of disease.

**IMPROVING THE EVIDENCE-BASE OF EFFECTIVE INTERVENTIONS WORLDWIDW**

While many fruit and vegetable proportion interventions and programmes have been conducted or initiated throughout the world, our review indicated that the study design used was in several cases suboptimal particularly to assess effectiveness. There is thus currently a strong need to improve the evidence-base of effective interventions, particularly in non-industrialised countries.

A first step would be to include in the design of any planned intervention or initiative some measures of effectiveness. The development of clear methodological guidelines and standard tools would also be useful to increase confidence in programme evaluations and to allow valid comparison of interventions. This would involve for example developing a series of standard measures of fruit and vegetable intake (appropriate for various climate, culture and level of urbanization) and tools to measure predictors of intake (that is, knowledge, attitude, social support). These measures should ideally be as simple as possible to encourage their use when the intervention, and not research, is the primary objective.

Standardising the measurement of fruit and vegetable intake is a particularly important issue. The studies reviewed used a wide range of data collection methods, from a single-question food-frequency estimate, to multiple-item food frequency questionnaires, 24-hour recalls, or several days’ food diary. In the United States, several «5 a day» studies used the same food-frequency questionnaire. This questionnaire may not be generalizable to other regions, but simple validated tools could be adapted to different cultural contexts. Whatever tools are used, any programme evaluation should aim to be explicit about the definition of fruit, vegetables and juices that are counted, and of realistic portion sizes. Estimates should exclude potatoes and limit the amount of fruit juices counted.
Another important issue to increase confidence in programme evaluation is to include in all study reports a much better description of the methods used. This should include information on measurement tools, response rates, randomization method (if used), precise details of the intervention, training of individuals involved with intervention delivery, blinding of outcome assessors, and existence of ongoing reinforcement or maintenance interventions, and generalizability of the findings.

All evaluations should ideally have a control or comparison group, although it is accepted that this is unrealistic for national programmes. Randomized controlled trials are still the «gold-standard» for assessing the effectiveness of interventions, and are the best method for reducing bias. However, although such trials can be used in developing countries, the financial costs involved and lack of expertise in some cases, limit their use (38). Yet it is feasible and good practice to incorporate a control group into the evaluation. This should enable unequivocal findings about the change an intervention has made in the target population independent of any other interventions that may contaminate the results.

As study methods improve, intervention designs may need to address other important issues, including: the potential use of validated biochemical markers of fruit and vegetable intake and novel methods of measuring dietary consumption to address concerns about measurement bias; in-depth assessment of the effectiveness of specific components of interventions and how these effects vary in different countries, particularly in developing countries; the examination of factors that prevent relapse; the assessment of the long-term effectiveness of the interventions in terms of health outcomes, although the time required may not be feasible, and the estimation of what constitutes clinically meaningful changes in intake; and the measurement of the cost-effectiveness of interventions to identify which interventions would be best suited for a particular country or a region's needs and how best to allocate scarce resources.

CONCLUSIONS

The results of this review of the literature indicate that small increases in fruit and vegetable intake are possible in population subgroups, and that these can be achieved by a variety of approaches in both children and adults. Clearly, effective interventions for fruit and vegetable promotion will need to include a range of approaches: individual-level interventions, population-level prevention strategies and «upstream» macro-level policy and environmental interventions. Although more work needs to be done to improve the design and methods of such interventions, these encouraging results and evidence for the health benefits of dietary fruit and vegetable intake suggest that national governments should continue to develop policies to improve nutrition which have a strong emphasis on fruit and vegetable intake. If they are to be relevant in all regions of the world such policies should take into account the range of economic, social and environmental factors that influence food availability and an individual's ability to make healthy choices in each country and world region.

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