

# Highly-integrated programs for the prevention of obesity and overweight in children and adolescents: results from a systematic review and meta-analysis

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## Abstract

**Background.** Since overweight and obesity has become epidemic in children and adolescents, the aim of this study was to determine the role of highly-integrated programs in preventing and reducing prevalence of children and adolescent obesity and overweight, even evaluating if this approach has properly been effective in communities with different determinants as in the Pacific Area.

**Methods.** According to PRISMA guidelines, a systematic review of literature was conducted and a meta-analysis was performed to compare obese/overweight prevalence between the intervention and the control group.

**Results.** We identified 23 studies describing 14 programs. For 11 out of 14 programs, obese/overweight prevalence changing from baseline were definable and meta-analysis of them showed a significant change of obese/overweight prevalence (-0.03; 95% CI = -0.04 to -0.01;  $P < 0.0001$ ). Secondary outcomes as dietary (such as vegetable intake, carbonated beverages, fruit juice, drinks, healthful food consumption), physical activity and TV-time-spent was analyzed in many of the studies to define community readiness and behavioral changes. Macro-interventions, based on what was observed in our systematic review have a high potential to reach the entire population.

**Conclusion.** Adoption of coordinated cross-sectoral, multi-component and multi-stakeholder initiatives to oppose obesity remains a challenge, but it is also desirable as one of the possible solutions to this major public health issue.

## Key words

- pediatric obesity
- prevention and control
- systematic review

## INTRODUCTION

In the last decades, the number of overweight and obese children and adolescents has dramatically increased, presenting a major public health issue [1-3]. This has been a well-known challenge in high-income countries since the second half of the last century, but current data are suggesting that this epidemic is actually global [2, 4, 5]. A special focus of the WHO also highlights the dimension of this phenomenon in the South Pacific [4].

Changes in cultural and economic behaviors are main causes for the overweight and obesity epidemic. In fact, 21<sup>st</sup>-century societies propose a less active lifestyle, avoiding “time-wasting” physical activities such as walking to work or to school, and an unhealthy but of-

ten more economic and tasteful high-calorie diet. This background directly affects children and adolescents by suggesting negative models in an oversensitive stage of life, increasing risk for a favorable metabolic status tracking obesity and overweight into adulthood and, consequently, for chronic diseases and comorbidities associated [2, 6]. Aside from medical problems, it is also a high risk for failing social goals: obese and overweight young people have been shown to have less satisfying social relationships, more school absences and poor scholar outcomes, representing a vicious circle leading to lower levels of education and salaries, which are themselves risk factors for adult obesity and overweight [6].

This scenario suggests that preventive programs

against obesity and overweight with a new population-focused approach to be effective and reproducible in different communities are needed. The prevention of childhood obesity and overweight needs to be tightly and highly integrated with other efforts in order to control all major noncommunicable disease (NCD) risk factors (such as unhealthy diet, low physical activity, tobacco use, alcohol intake etc.) [7, 8]. These integration efforts require interventions at all levels of society, from communities through to governments, private and nongovernmental organizations, public institutions, etc. In fact, NCD risk factors are rooted in the framework of society and influenced by many areas of national policy [9].

Since behaviors are strictly influenced and linked to the community in which they occur, new preventive programs were addressed not only to passively limit caloric intake but to actively empower people through awareness of healthy lifestyle and community involvement. This integrated approach, in which community is widely involved to reach the objective and to build enduring positive behaviors was first used in the early '90s in substance abuse settings [10], but it was only in the last few years that this approach has been implemented and studied to manage large communities facing widespread unhealthy behaviors. Commitment of social and political institutions, policy makers, schools and families to highly-integrated interventions according a real multi-stakeholder approach, where each of them cooperate to build awareness of healthy behaviors, seems to be the way to positively influences community's habits and to be applied as a structured scheme in different social and cultural settings.

Actions to prevent obesity and overweight in children and adolescents need to be taken in multiple settings, incorporate a variety of approaches and involve a wide range of stakeholders. Different interventions are required at different levels: at an individual level in schools and community settings to obtain behavioral change and at sector level within agriculture, food manufacturing, education, transportation, urban planning etc. to provide systemic changes [11]. At the beginning, each intervention may have few effects if considered alone but it can represent a significant component of an overall strategy [9]. New organizational efforts are possible in order to face obesity and overweight in children and adolescents, but it's necessary to focus: 1) on multi-component approaches, addressing eating behaviors and energy balance, physical activity, inactivity; 2) on multi-level efforts, targeting individual children, families, groups, primary care providers, and community youth-serving organizations; 3) on multiple settings interventions for primary care clinics, community centers, and homes, in a more integrated and synergic way [1, 12, 13]. Furthermore, it is crucial to elaborate schemes that can fit both in developed and developing countries where communities and social determinants of obesity are different: programs have to be addressed also to manage these differences [14-16].

The aim of our study was to determine if highly-integrated programs exist for the prevention of obesity and overweight in children and adolescents and if they are able to reduce the prevalence of obesity and overweight

in these populations. Beside this, we also evaluated if this approach has properly been effective in communities with different social, cultural, and maybe genetic determinants as in the Pacific Area.

## MATERIALS AND METHODS

A systematic review and a meta-analysis were conducted and reported according to PRISMA guidelines for meta-analyses and systematic reviews [17].

### *Search strategy and study selection*

A literature search was performed by accessing PubMed, Web of Knowledge and Scopus databases to identify obesity and overweight prevention programs targeting children and adolescent. Search terms such as "prevention and control", "childhood obesity", "coordinated programme", "community based", "integrated approach" were used.

Our search was restricted to English language studies published before 31<sup>st</sup> December 2015. Studies were considered eligible if they investigated highly-integrated prevention programs, subjects involved were under 18 years, programs were actually been active and at least one outcome was investigated using a statistical method. Guidelines, systematic reviews and studies about obesity and overweight diagnosis and treatment were excluded.

Two reviewers independently screened titles and identified abstracts of relevant titles. Full texts of potential citations were subsequently obtained and independently screened by the two reviewers for inclusion. Disagreements were resolved through discussion. In addition, a snowball method was also used to screen for additional studies.

### *Data extraction and analysis*

From each study data about name of the prevention program, first author's last name, year of publication, study period, Country, study population, study aims, outcome evaluated and key findings were extracted. For each outcome, quantitative data were extracted if available.

Two reviewers conducted all data extraction independently and disagreements were resolved through discussion. The same reviewers evaluated also the risk of bias of the included studies with the Cochrane Collaboration's risk of bias tool [18].

Among the clinical outcomes evaluated, meta-analysis was performed to compare obese/overweight prevalence between the intervention and the control group which quantitative data were exhaustively reported for 11 different programs. Obese/overweight prevalence, as considered in meta-analysis guidelines [19], were computed as change from baseline instead of final values to avoid that differences in baseline prevalence between intervention and control groups may distort the analysis. Because of the significant heterogeneity expected among the studies performed in different settings, the random effects model was employed using the DerSimonian and Laird's method.

Heterogeneity was quantified using the Cochran Q test and  $I^2$  statistics and meta-regression against study

location, subject mean age and quality of study was undertaken to identify between-study predictors of effect size and to investigate the source of heterogeneity within the included studies.

Sensitivity analyses were conducted by excluding one study at a time from the meta-analysis to determine whether the results of the meta-analysis were influenced by individual studies and whether risk estimates and heterogeneity were substantially modified.

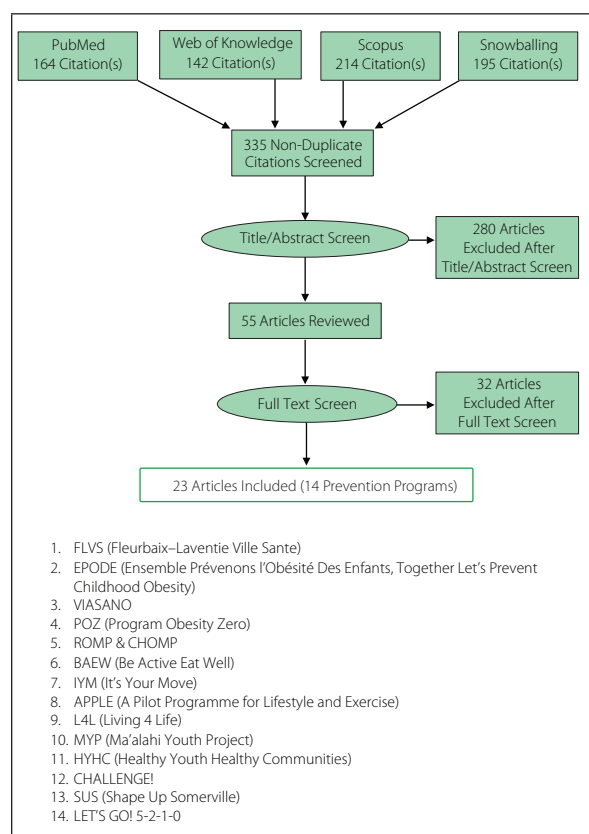
The presence of publication bias was assessed using the Egger's test [20].

All analyses were carried out using Review Manager, version 5.2.7 for Mac (The Nordic Cochrane Centre, Copenhagen, Denmark) and Stata, version 13.1 for Mac (StataCorp, College Station TX, USA).

## RESULTS

### Characteristics of the studies

We identified a total number of 164, 142 and 214 studies through PubMed, Web of Knowledge and Scopus databases search and 195 additional references by snowballing. After removing the duplicates, 335 studies were left. Carefully reading titles and abstract, 55 full text articles were assessed for eligibility. By not fulfilling the inclusion criteria, 32 articles were excluded leaving 23 studies describing 14 programs to be included in our analysis [15, 21-42]. *Figure 1* depicts the process of literature search and study selection.



**Figure 1**  
Flowchart depicting literature search and study selection.

The publication years of the studies were ranged from 2006 [37] until the most recent one, from 2015 [22]. The intervention period varies from 6 months [23] to 12 years [21]. The programs included in our review were carried out:

- 4 in Europe: Fleurbaix-Laventie Ville Sante – FLVS [21], Ensemble Prévenons l'Obésité Des Enfants – EPODE [14,15], VIASANO [22] and Program Obesity Zero – POZ [23].
- 3 in the USA: Shape Up Somerville – SUS [24-26], Challenge! [27], Let's Go! 5-2-1-0 [28].
- 7 in Oceania: Be Active Eat Well – BAEW [29-32], Romp & Chomp [33, 34], It's Your Move – IYM [35, 36], A Pilot Programme for Lifestyle and Exercise – APPLE [37-39], Living 4 Life - L4L [40], Healthy Youth Healthy Communities – HYHC [41] and Ma'alahi Youth Project – MYP [42, 43]. BAEW, Romp & Chomp and IYM are based on an Australian National Programme called "Sentinel Site for Obesity Prevention"; instead the projects IYM, L4L, HYHC, MYP are part of the supranational Pacific OPIC (Obesity Prevention In Communities) collaboration [16, 44, 45].

The main features of selected studies are reported in the Supplementary Materials available online.

There were several outcomes examined throughout the studies. Many investigated the effect of highly-integrated prevention programs on obese/overweight prevalence and BMI/BMIz. Other anthropometric measures and modifications in healthy behaviors were also assessed in a fewer number of studies.

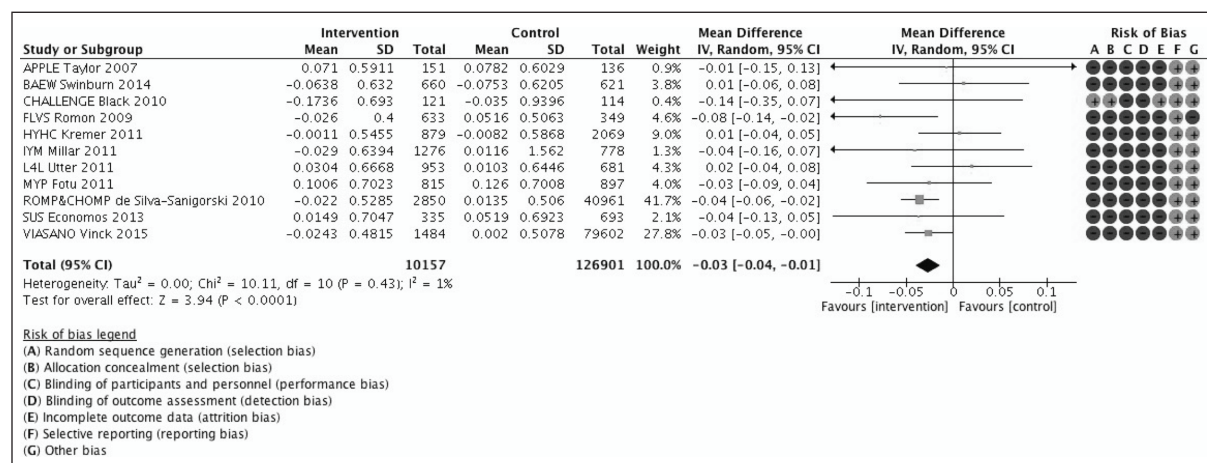
We used the Cochrane Collaboration's risk of bias tool [18] to assess the risk of bias in the included studies. None of the studies showed reporting bias due to selective outcome reporting. However, due to the nature of the intervention, blinding of participants and personnel, as well as blinding of outcome assessments, was not employed in any of the included studies, and a random study model was employed only by one program [27]. For these reasons, the body of evidence in our review was generally characterized by a low level of quality.

### Effects of highly-integrated programs on obese/overweight prevalence

For 11 out of 14 programs, quantitative data needed to calculate obese/overweight prevalence (as changes from baseline) were available. Meta-analysis of them showed a significant difference of the variation in obese/overweight prevalence between participants of highly-integrated prevention programs and controls  $-0.03$  (95% CI =  $-0.04$  to  $-0.01$ ;  $P < 0.0001$ ) (*Figure 2*).

Although we expected significant heterogeneity among the studies because of the different settings, heterogeneity quantified with  $I^2$  statistics (1%) and Cochrane Q test ( $P = 0.43$ ) was low. Meta-regression did not show any significant correlation between study location, subject mean age, or quality of study and effect size estimated (*Table 1*).

Sensitivity analysis showed the stability of the overall effect sizes with the withdrawal of any of the study from the analysis. Publication bias was not evident from reviews of the funnel plot or Egger's test.

**Figure 2**

Meta-analysis of the effect of highly-integrated prevention programs on variation in obese/overweight prevalence.

### Effects of highly-integrated programs on other outcomes

Beside zBMI or BMI most of the studies defined secondary outcomes to evaluate community readiness and behavioral changes in intervention schools, children and families. Many studies evaluated and focused on dietary, physical activity and TV-time-spent [25, 26, 37-40]. In some studies policies on healthy lifestyle and community awareness of healthy behaviors was evaluated to define community readiness to change and impact of highly-integrated approaches. No secondary outcomes have been evaluated in the EPODE study, which only describes methodology of highly integrated intervention and anthropometric outcomes [14, 15].

**Diet.** - APPLE Intervention recorded significantly fewer children consuming carbonated beverages, fruit juice or drinks. In this study children were also observed consuming higher servings of fruit, whereas no intervention effect was observed for vegetable intake [37, 38]. Also Romp & Chomp [33, 14], Challenge! [27] and HYHC [41] studies were able to determine a significant reduction of total calories intake or in reducing unhealthy food consumption among children and adolescents. Romp & Chomp showed a significantly lower intake of unhealthy food and a significant increase in healthful food consumption [33, 14]. In the Challenge! study the intervention effect was marginally significant in reducing the consumption of total energy and total dietary fat [27]. In Healthy Youth Healthy Communities (HYHC) [41] some promising shifts for both the intervention and comparison groups on several behaviors have been noticed and a significant difference be-

tween groups in terms of daily intake of vegetables was highlighted. Though SUS [25, 26] and POZ [23] studies showed differences between intervention and control groups in healthy dietary behaviors, these were not statistically significant. The Be Active Eat Well (BAEW) study [29-32] has been able to identify a significant relationship between changes in child zBMI and changes in sweet drink consumption. In the Living 4 Life (L4L) study [40], a parental survey showed improvements in child adherence to eating more servings of fruits and vegetables each day and limiting consumption of sugary drinks each day. Results indicated a positive association between the program and message awareness and message exposure in multiple settings.

**Physical activity.** - APPLE showed a significant impact on increasing time spent in physical activity at the first-year follow-up [38, 39]. In IYM [35] the proportion of adolescent students in the intervention group who actively travelled to school increased while the proportion in the comparison group decreased. In the POZ study [23] the majority of children were not registered in a sports club at baseline. After the intervention, five percent of these children registered in a sports club and data also indicates an increase in vigorous activity in the intervention group. SUS [25, 26] showed a significant increase in the number of organized sports and physical activities. By contrast, the Challenge study [27] did not reach any significant result on activity behaviors even if intervention group increased physical activity.

**TV-time-spent.** - TV-time-spent has been evaluated, collaterally or uniquely, in different studies. A significant positive healthful change in time spent watching TV was observed in HYHC [41], POZ [23], Romp & Chomp [33, 34], SUS [25, 26], and BAEW [29-32]. In BAEW study, screen time usage was also shown to be significantly linked to zBMI [29-32].

**Community readiness to change.** - Highly integrated programs aim to deeply influence community behavior empowering community building capabilities and many studies evaluated children, adolescents and families awareness regarding healthy living issues and about perception of healthy policies. In the Living 4

**Table 1**  
Meta-regression results

| Independent variable | Coefficient (95% confidence interval) | P value |
|----------------------|---------------------------------------|---------|
| Study location       | 0.021 (-0.029-0.071)                  | 0.37    |
| Mean age             | 0.002 (-0.003-0.007)                  | 0.38    |
| Quality of study     | -0.004 (-0.051-0.043)                 | 0.84    |



Life (L4L) study [40], positive changes of school policies that improved quality of food and beverages were observed, as well as changes of adolescent student perceptions of the school environment and breakfast consumption. In Romp & Chomp study [33, 34], parents showed to have been enhancing their knowledge about healthy life behaviors during the intervention period. The study also highlighted that there were significantly more policy elements promoting healthy eating in the intervention group policies. POZ analysis of the children's knowledge concerning healthy diet and nutrition indicated that from baseline measurements, dietary knowledge increased after 6 months from the beginning of intervention [23]. Let's Go [28] parent-survey data showed statistically significant increases in the proportion of parents reporting awareness and children and adolescents adherence of the Let's Go! program's recommendations. In HYHC [41] intervention group school environment perception improved only for few measures, and then non-significantly.

## DISCUSSION

This study can be considered as a comprehensive overview of cross-sectoral, multi-component and multi-stakeholder initiatives to face obesity and overweight in children and adolescents, in a global perspective. The present analysis has followed a strength methodology and has been aimed at evaluating not only the effects of highly-integrated programs on overweight and obese prevalence among children and adolescents, but also the effects on other outcomes such as individual healthy lifestyles and community behaviors.

The studies included in this review described 14 "highly integrated" community prevention programs, all facing children and adolescents overweight and obesity. These programs refer to multi-component and multi-setting approaches, showing a significant difference of the variation in overweight and obese prevalence between participants and controls, even if the environment where these interventions are implemented strongly determines their effectiveness. For example, school-based prevention programs seem to be more effective when larger and more coordinated is the student engagement [46, 47]. Furthermore, the coordination of targeted activities needs to run in parallel with the provision of right services, functional facilities and learning opportunities [48]. It has been described that also in the same setting difference among policies can have different impact on the habit of the students and their obesity and overweight level. Regarding school food policies, for example, schools that provide a canteen service compared to schools that do not provide such service, or schools that ask for a fee for meals and schools that provide it for free, can lead to different outcomes in terms of children and adolescents overweight and obesity [49, 50]. In the same way, interventions to increase bicycle use in cities where there are bike lanes with traffic rules for cyclists differ from interventions in cities in which cycling is not supported by the urban planning or by regulations [9]. These differences can be considered as a key determinant of the health status of the population. It is clear that effective strategies to ad-

dress obesity and overweight need to take into account the abovementioned differences in policy implementation as well as cultural differences. Indeed, despite overweight and obesity represent a major public health issue due to their medical and social implications [2, 6], in some cultures, such as in the case of Tonga [42, 43], high levels of obesity are acceptable, or even considered desirable since seen as a sign of well-being, while other cultures – especially today – express a strong prejudice against obese and overweight people, both children and adults, as a consequence of the growing awareness of the risks attributable to obesity. Moreover, not all cultures support physical activity of young people in the same way, especially for girls [51].

Considering the factors that can impact on children and adolescents health is a fundamental exercise that needs to be systematized and analyzed to effectively produce results. Also for this reason, the production of evidence to prevent obesity and overweight and the development of strategies for improving dietary habits and physical activity is growing rapidly. The intervention strategies can play a role at the level of individuals, families, local and small communities or settings, such as schools or work environments (micro interventions), and their impact is certainly more widely described than the macro intervention targeted on the general population, such as the adjustment of prices or the promotion of consumption of certain food categories. Interventions in micro-settings, more suitable for controlled trials, limit the available information on which health policies can be assumed, because the arising evidence is often limited to a too narrow range, not transferable to other contexts, and is often lacking in sustainability. Instead, based on what has been observed in this systematic review and considering lessons from other areas of prevention such as tobacco and alcohol consumption preventive approaches, the macro-interventions have a high potential to have an impact on the entire population [52]. Anyway, more actions based on structured approaches and new evidences are needed to understand how to make preventive interventions more effective, to slow down and reverse the overweight and obesity epidemic in place, as well as to counteract the occurrence of NCDs. Considering the importance of school, as previously stated, the approach to take into account are not merely educational measures, but combinations of policies and regulations as part of a coordinated strategy for public health. Programs to prevent obesity and overweight, especially in children and adolescents, should be comprehensive and broad, based on the integration of diet, motivation, healthy attitudes for increasing self-esteem and emphasizing healthy behaviors and activities to drastically increase population awareness of the individual and social impacts arising from obesity and overweight, rather than idealizing weight or physical appearance.

Large scale health related lifestyle changes are needed, even if their effects can be measurable or noticeable after lot of time. Now more than ever is strategic to implement "multi-stakeholder" long-term plans in all age groups, with a particular emphasis on the developmental age (childhood and adolescence). These ap-

proaches have to involve institutions, public and private sectors (such as those involved in the food chain) in joint actions in different sectors (agriculture, financial, commercial, urban, education and sports) and in different contexts (school, business, family or associations) to amend significantly and permanently lifestyle choices and behaviors [53].

### Limits

Results reported from the studies identified in this review should be viewed with caution for the low level of quality of the studies. Moreover, the impact of the intervention was assessed by comparing it with what happened in the control group. Given that children in the control groups were full aware of study aims, and were assessed for height, weight, and dietary intake and/or physical activity levels, this assessment could itself have had an impact on the children's diet and physical activity patterns in the same direction as the intervention. Thus, any comparison of the impact of an intervention with such controls is likely to underestimate the effect.

### CONCLUSIONS

Overweight and obesity is no longer a syndrome of wealthy societies. As a matter of fact, it is becoming just as dominant in developing countries and countries with economies in transition. Therefore, this phenomenon should be viewed properly in the globalization process [2, 4, 5, 54]. New organizational efforts are needed in order to face children and adolescents obesity and overweight, but it is necessary to take into account lessons learnt, taking advantage from the newest biological, clinical and social research. In line with these consideration, as reported above, the academic, social and political commitment has to be focused: 1) on multi-component approaches (taking into account eating behaviors and energy balance, physical activity, inactivity); 2) on multi-level efforts (targeting individual children, families, groups, primary care providers, and community youth-serving organizations); 3) on multiple settings interventions (primary care clinics, community centers, and homes) in a more integrated and synergic

way. Namely, the multi-multi-multi approach (MMM approach) [1, 12, 13]. In fact, the whole is greater than the sum of its single parts and the MMM approach, as suggested by Robinson *et al.*, is potentially declinable into real world, by using infrastructure and resources that already exist in many communities [12]. As described in this analysis, all the gaps in fighting childhood obesity and overweight can only be addressed with a multi tiers strategic commitment intended as a "governance chain" among community leaders, health professionals, schools, youth community organizations, the Healthcare authorities covering these community needs, Local Authorities such as municipality, counties, regional governments but, above all, the children, adolescents and their families with a shared perspective and common clear goals [55]. In fact, the community-based approach of programs, as described in our review, characterized by highly-integrated social, behavioral and environmental interventions, realized through coordination activities involving a staff with clear common goals, has been proven to obtain positive changes. These public health effective strategies to tackle obesity must consider cultural differences.

The adoption of coordinated cross-sectoral, multi-component and multi-stakeholder initiatives to oppose obesity and overweight in children and adolescents remains a challenge, but it is also desirable as one of the possible solutions to this major public health issue. The initiatives should be undertaken not only at a national level, but also at regional, local and especially supranational level and should be tailored to the needs of the population and the cultural and regulatory context.

### Conflict of interest statement

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the review.

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