

# Locally implemented prevention programs may reverse weight trajectories in half of children with overweight/obesity amid low child-staff ratios: Results from a four-year prospective study in France

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## Research article

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# Abstract

**Background** The aim of the present study was to prospectively assess 4-year changes in the weight status of children between school-based prevention programs locally implemented in French municipalities with the same organizational support, and focused on experiential learning interventions promoting healthy eating and physical activity.

**Methods** Using a body mass index chart established by the International Obesity Task Force, school nurses assessed first-grade children for weight status (normal, overweight, obesity) several weeks before the launch of each program in 2011, and 4 years later, together with the BMI z-score measuring overweight/obesity severity. Child-staff ratios (CSRs) by occupation (canteen service/extracurriculars) and training session (healthy eating/physical activity) were computed in each municipality.

**Results** During the 4-year follow-up period, weight status improved in half of the children with overweight/obesity, and worsened in 6.6% of children with over/normal weight. In children who remained overweight, the BMI z-score diminished over time. Estimates of the positive 4-year weight change increased with age and were significantly higher in low-to-moderate CSR multicomponent programs ( City3 and City4 ) compared to moderate CSR single-intervention programs (reference: City1 ). The high-to-moderate CSR multicomponent program ( City2 ) had a similar effect as the reference. The estimated negative weight change decreased with age.

**Conclusions** Training ancillary school staff to experiential-focused interventions for healthy eating and physical activity in locally implemented school-based programs contributed positively to preventing childhood obesity without interfering with educational activities. However, low CSRs seem to be pivotal for optimal outcomes, especially in schools in deprived areas.

## Contributions To The Literature

- School-based prevention programs may be effective in promoting healthy behavior
- But even sound evidenced-based interventions yield modest effects on behavior and adiposity measures
- This study prospectively investigated the relationship between weight outcomes and child-staff ratios in locally implemented school-based obesity prevention programs.
- Training local ancillary school staff on experiential healthy eating and physical activity interventions for children contributed positively to preventing childhood obesity without interfering in educational activities.
- Low child-staff ratios seem to be pivotal for optimal outcomes, especially in schools in deprived areas.

## Background

Obesity in childhood is difficult to reverse(1) and often persists into adulthood, causing many health problems(2). According to systematic reviews, school-based prevention programs may be effective in promoting healthy behavior(3, 4). They typically include educational, environmental, and social activities designed to improve dietary habits and reduce sedentary time in schoolchildren(5, 6). However, even sound evidenced-based interventions yield modest effects on behavior and adiposity measures(7, 8).

Insights from implementation studies may partly explain these mitigated outcomes. First, how authorities bring prevention programs into the school communities may dramatically influence local dynamics. In France, the Education, Health, and Territory (EST) program included the core principles of health-promoting schools, such as training and support of staff to develop school health policy, focus on school environment and adaptation to local context, community involvement, and development of health-related knowledge, skills, and competencies,(9) but decisions and approvals came from upper authorities, and this “top-down” approach created a reluctance to participate locally.(10) In addition, health education programs require teachers to acquire additional competencies(11) and to include health education in their curriculum.(12) However, teacher work is already described as increasing in complexity and intensity because of societal changes, reformed and increased work tasks, and multitasking.(13) Urgent unforeseen priorities, competing responsibilities, and high workload may also constitute barriers to successful implementation,(14) especially when training and activities seem complex or theoretical.(10)

The success of school-based prevention initiatives involves balancing evidence-based interventions with the flexibility to permit local educational communities to target their specific needs.(15) Fostering commitment entails giving local stakeholders the freedom to shape their own programs and providing training and materials to persons interacting with children,(16) which may include both teachers and ancillary staff.(10) Following these core principles, some associations provide organizational backbone support(17) to local communities in charge of the education and care of children. This alternative approach to downstream interventions may induce variation between locally implemented programs, warranting a thorough examination of the relationship between process and outcome indicators.(18)

The aim of the present study was to prospectively assess 4-year changes in the weight status of children between school-based prevention programs locally implemented with the same organizational support and focused on experiential learning interventions promoting healthy eating (HE) and physical activity (PA). Another objective was to investigate process indicators of each locally implemented program and assess the influence of process indicators, expressed as child-staff ratios by occupation/component, on these changes.

## Methods

### Intervention

The Vivons en Forme (VIF; “live healthy”) organization is a continuation of the obesity prevention scheme previously known as Epode,(19) a community-based prevention program aimed at promoting healthier lifestyles among children and their families, and involving municipal services in charge of child education

and care under the supervision of a local coordinator. However, compared to Epode, the non-governmental organization acting as a backbone structure changed its process in 2010, following four new pathways in order to improve program efficiency. First, the name of the program was changed in order to be better accepted by the local stakeholders, including families and children, removing the mention of obesity in the name of the interventions. Second, a full social marketing approach was included for each yearly implemented thematic.<sup>(20)</sup> Third, toolkit materials were pilot-tested in living labs to collect input from users and stakeholders before application in real-life settings, and in the participating cities.<sup>(21)</sup> Lastly, the implementation process was centered around local stakeholders, including but not limited to school staff, as well as participation and empowerment.<sup>(22)</sup> The principle aim was to foster self-efficacy and a long-lasting effect in local school staff newly involved in the field of prevention and health promotion. Local stakeholders have the freedom to shape their programs, and can request additional interventions during the course of the program. The basic underlying principle of this “choose-and-pick” approach was to foster staff involvement and sustainably change their interactions with children and parents. Each participating municipality applies for a minimal 5-year period, and their representatives have to regularly attend regional coordination meetings to receive up-to-date information on training sessions and tool upgrades.

### Study design and participant selection

To meet the study objectives, a prospective design was used. Only the four municipalities that systematically monitored schoolchildren’s weight status were invited to participate. In these municipalities, VIF counselors (an engineer in nutrition and public health, a sociologist, and the leading coordinator of the program) organized training sessions for the municipal staff in charge of canteen service and extracurricular activities (ECAs) in primary schools. Training sessions and toolkits integrated roadmaps for conducting interactive activities with the children and reinforce child-staff interactions via concrete experiences (Table 1). Brochures highlighting the beneficial effect of HE and PA for children were systematically provided to parents.<sup>(22)</sup> They included tips on how to help kids stay hydrated by drinking water, on breakfast preparation, food breaks (including fruits), avoiding snacking between meals, on treats and smart portion sizes, and how to easily cook healthy meals at low cost.

### Measures

School nurses used a body mass index (BMI) chart established by the International Obesity Task Force, which allows classification of children into weight categories<sup>(23)</sup> (i.e., underweight, normal weight, overweight, and obesity), to assess the weight status of first-grade children at the school premises several weeks before the launch of each program in 2011. Children wore light clothes and no shoes during the weighing sessions. In addition, BMI Z-scores were computed using BMI-for-age reference standards<sup>(24)</sup> in order to account for overweight/obesity severity. Baseline and follow-up weight status, with BMI z-scores, were matched for gender and age at inclusion, and whether children were schooled in a zone of priority education (zone d’éducation prioritaire, ZEP) was indicated. ZEP refers to schools in deprived, usually urban, settings that are earmarked for special state support. The decision to categorize a school

as a ZEP lies with the administrative authorities, who can release additional funding to finance special needs education. A follow-up weight assessment using the same methodology was performed among the same children in 2015. When it comes to the process evaluation, the number and occupation (canteen service or ECAs) of persons who attended training sessions between 2011 and 2015 were systematically recorded by thematic component (HE and/or PA).

### Data blinding and confidentiality

A study number was attributed to each municipality (City#) and each child in the database to ensure confidentiality. The final database was completed in 2016, but anonymized data were transmitted to researchers in charge of statistical analyses in 2018 due to the administrative authorization procedure in each participating city.

### Statistical analysis

Process indicators were expressed as number and occupation of school staff attending training sessions by thematic component in each municipality, and then converted into child-staff ratios (CSRs), the number of children for each trained staff member, by occupation and thematic session. Because an average ratio of 8 children per adult was found in early childhood education and care settings,<sup>(25)</sup> the CSR was classified as “low” if between 1 to 5 children per adult, “moderate” if 6–9 children per adult, and “high” if > 10 children per adult. Categorical data were expressed as numbers and percentages and compared using the chi-squared test. Numerical data were expressed as means and standard deviations (SDs) and compared by one-way analysis of variance or the non-parametric Wilcoxon comparison test. Outcome indicators were 4-year changes in weight status, which were considered “positive” if obesity changed to over/normal weight or if overweight changed to normal-weight, and “negative” if normal weight changed to overweight/obesity or if overweight changed to obesity. To investigate the influence of process indicators on weight changes, we entered the CSRs (low, moderate, high) by occupation (canteen service/ECA) and thematic component (HE/PA) as interaction terms in a logistic regression using positive 4-year weight change as the binary outcome (yes/no), with adjustments for age at inclusion, gender, and school area (deprived/non-deprived). The same statistical procedure was employed with negative 4-year weight change as a binary outcome in children characterized as over/normal weight at inclusion. Estimates were expressed as odd ratios (ORs) with 95% confidence intervals (CIs). Statistical analyses were performed using the SPSS statistical package, version 20 (SPSS, Chicago, Illinois, United States).

## Results

Of the 850 first-grade children schooled in these four municipalities, 23 (2.7%) were not enrolled or removed from the database based on parental request. In 2011, the 827 children included in the analyses (Table 2) were gender-balanced, with an average age of 6.4 years (SD = 0.79) and 59.3% schooled in deprived areas. The mean age was significantly higher in City1 compared to the other municipalities ( $p < 0.001$ ), whereas children schooled in deprived areas were significantly overrepresented in City4 (77.4%) and City1 (71.6%) compared to City3 (45.3%) and City2 (0%;  $p < 0.001$ ). The distributions of gender and weight status were similar between municipalities. Over the 4-year study period, City1 requested two

training sessions on HE for canteen service staff, whereas City2, City3, and City4 requested 3, 5, and 15 training sessions, respectively, on HE and PA, for staff in charge of the canteen, and those in charge of ECAs. CSRs are given in Table 3.

At including in 2011, 137 children met the criteria for overweight (16.6%) and 32 for obesity (3.9%; Table 4). Four year later, 101 children met the criteria for overweight (12.2%) and 31 for obesity (3.7%;  $p = 0.002$ ). In children who remained overweight ( $n = 58$ ), the BMI z-score decreased from 2.24 (0.48) to 2.04 (0.69;  $p = 0.014$ ), but it remained unchanged in children with obesity (4.51 (1.82) vs. 4.09 (1.49)). Weight status improved in half of the children with overweight/obesity (48.2% and 59.4%, respectively), with lower estimates in City1 (38%) and City2 (45.5%) and higher estimates in City3 (68.4%) and City4 (55.1%). Concomitantly, weight status worsened in 6.6% of children with over/normal weight (6.9% overweight and 5.2% normal weight).

When CSRs were entered as interaction terms in multivariate models, they yielded comparisons between the four participating municipalities, with City1 as the reference (moderate CSR single-component intervention). In the 169 children with overweight/obesity at inclusion (Table 5), the estimated positive 4-year weight change increased with age and was significantly higher in low-to-moderate CSR multicomponent interventions (City3 and City4) compared to the reference. The high-to-moderate CSR multicomponent program in City2 had a similar effect as the reference program in City1. In children with over/normal weight at inclusion ( $N = 795$ ), the estimated 4-year negative weight change decreased with age and was unrelated to the process indicators being studied.

## Discussion

During the 4-year follow-up period, weight status improved in half of the children characterized as overweight/obesity. In children who remained overweight, the BMI z-score diminished significantly over time, and being schooled in a deprived area had a negative, though not significant, influence.

The implementation mode under study was similar to traditional school-based prevention programs in that it provided training and materials to local stakeholders.(9) However, the VIF program provides tools previously tested in real life settings and address thematic content over a long period of time based on a comprehensive social marketing methodology.(26) In addition, the interventions avoided interference with teachers' curricula, enriching existing school environments/interactions rather than implementing unusual and potentially disruptive procedures,(10) and promoting experiential learning instead of lectures.(16) On the other hand, upstream discussions revealed that teachers had no particular interest in adding HE/PA to their curriculum despite the recommendations of health experts.(27) Imposing their participation may have jeopardized local dynamics.(10)

Yet, the data analyses elicited interesting insights. First, weight trajectories were reversed in half of children with overweight/obesity over 4 years, whereas negative weight changes were marginal. In addition, overweight severity diminished over time. This is all the more important as 16.6% of children were considered overweight and 3.9% obese in the participating municipalities, compared to 10.1% and

2.4% of French children aged 6–10 years.(28) These higher than national average estimates could be due to the high level of social deprivation in these locations,(29, 30) except for City2, where others factors could be at stake.(31) Second, multi-component programs are widely acknowledged to be more successful than single interventions.(32) However, moderate-to-high CSRs seem to have weakened this asset in City2, whereas the presence of low CSRs characterized the most effective programs. On average, weight trajectories were reversed among 6 in 10 children over a 4-year period in City3 and City4, compared to 4 in 10 in City 1 and City 2, and approximately 38% over a 9-year period at the national level.(28, 33) Many studies have investigated the relationship between CSRs and outcomes in childhood education and care, mostly on child cognitive and emotional development, but the first attempt to systematically review and meta-analyze this highly complex and heterogeneous literature revealed few, if any, relationships.(18) These process indicators are often overlooked in obesity prevention program evaluations,(7) and the reasons behind their variations at the local level warrant further examination. However, they seem pivotal in childhood obesity prevention programs, though their optimal values still remain to be determined. Finally, it seems that older age had a sound positive influence on 4-year weight changes, though the children were relatively close to one another in regards to age (mean 6.38 years, SD = 0.76). Minor differences in this life period could mark the transition between two milestones of cognitive development, but the complexity of developmental theories warrants caution.(34) If confirmed elsewhere, this result would advocate, at the very least, for including 2nd grade children in these programs.

The present study has limitations related, in part, to the implementation mode under examination. Avoiding prescriptive approaches may have contributed to fostering local dynamics, but also precluded comparisons between balanced interventions. Furthermore, interactions between parents, children, and municipal school staff in charge of PA and HE were targeted by the programs but not directly assessed in the study. In addition, the municipalities participating in the study may have differed from other cities in France, as they systemically monitor the weight status of schoolchildren under their supervision. Considering the present findings, low CSRs in childhood prevention programs could be even more important in deprived areas.(35) This proportionate universalism(36) warrants further examination in relation to parental involvement and other variables of interest.(31) Nevertheless, this prospective study has some methodological assets, as it relies on reliable estimates of weight status collected twice at a 4-year interval among the same children at primary schools from distant municipalities and compared, which avoided contamination.

## Conclusions

Training ancillary school staff to experiential-focused interventions in locally implemented school programs contributed positively to childhood obesity prevention without interfering in educational activities. However, low CSRs are pivotal for optimal outcomes, especially in deprived areas, and the reasons for variations warrant further investigation.

# Declarations

## Ethics approval and consent to participate

The study protocol was approved by the CNIL (*Commission Nationale Informatique et Libertés*), a governmental body in charge of checking compliance with ethical and individual data protection regulations in France. The CNIL fulfils the role of the Institutional Review Board in France for non-invasive research. Children's weight status and other variables were available from school medical service records, and analysed after anonymization without Institutional Review Board oversight, as legally permitted in France (Article L. 541-1 du code de l'éducation) and in the United States (<https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts/index.html>). The study's protocol was approved by local authorities in charge of children's education and care (municipal authorities, school directors, and school health services). Verbal consent was obtained from the parents, prior to commencing the study. They received written information on the study objectives, about their right to accept or refuse research participation, and how to withdraw the child from the study once it has started, if they wished to do so. School nurses asked for the child's permission before assessing weight status.

## Consent for publication

Not applicable

## Availability of data and materials

The dataset generated and analyzed during the current study is available in the Open Science Frame Network repository, <https://osf.io/bfd8r>

Competing interest: Agnes Lommez (AL), Gaëlle Boulic (GB), and Raphaëlle Chaillou (RC) work at the VIF association. Sandrine Raffin (SR) is working for the VIF coordinating team.

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Authors' contribution: SR, AL, GB, and RC contributed to the conception and design of the tools, trained the local stakeholders, and collected process indicators during interventions. BG suggested the study design, and AC performed the statistical analysis and wrote the first draft of the manuscript. AC, BG, and SR interpreted the data and drafted the final manuscript.. All authors read and approved the manuscript.

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## Tables

Table 1: Description of training and tools provided to local school staff between 2011 and 2015 by occupation and thematic component

Occupation	Extracurricular activities		School canteens
Component	Physical activity	Healthy Eating	Healthy Eating
Training session	10 activities designed to involve kids in active gaming at school	Focus on 5 activities: <ul style="list-style-type: none"> <li>• Food rhythms and snacking control</li> <li>• Morning snacking management</li> <li>• Fostering breakfast consumption</li> <li>• Healthy snacks, treat portions, and eating more fruits</li> <li>• Drink water everyday</li> </ul>	<ul style="list-style-type: none"> <li>• 48 tips for canteen cooks to cook tasteful vegetables</li> </ul> <p>For canteen staff and staff in charge of extracurricular activities during meal time and leisure centers</p> <ul style="list-style-type: none"> <li>• Portion size and indulging products</li> <li>• Eco-gestures (no waste)</li> <li>• Improving lunch-time break: time to experience more balanced eating habits</li> </ul>
Tools	<ul style="list-style-type: none"> <li>• Training booklet and various tools to implement active games</li> </ul>	<ul style="list-style-type: none"> <li>• For the staff: roadmaps to conduct interactive sessions with the children and brochure focusing on relevant food rhythms for children</li> <li>• For staff and children: posters reminding to avoid snacking between meals and to eat healthy food on break</li> <li>• For parents: dedicated booklets on how to manage treats and on drinking water</li> </ul>	<ul style="list-style-type: none"> <li>• For canteen staff: a training booklet to set up workshops, portion posters to remind them of the guidelines discovered during the training</li> <li>• For canteen cooks: a booklet with tips to cook vegetables and a brochure to answer their most common questions</li> <li>• For children: a charter of good conduct to experience pleasant canteen meals (noise, respect of others)</li> <li>• For parents: booklet with indication of portion sizes</li> </ul>

Table 2: Schoolchildren characteristics at inclusion (N=827)						
	Municipalities					
	All	<i>City1</i>	<i>City2</i>	<i>City3</i>	<i>City4</i>	
	N= 827	N= 236	N = 137	N = 95	N = 359	p-value
Sex						
Girls	404 (48.9)	115 (48.7)	70 (51.1)	47 (49.5)	172 (47.9)	NS
Boys	423 (51.1)	121 (51.3)	67 (48.9)	48 (50.5)	187 (52.1)	
Mean age, years (SD)	6.38 (0.76)	6.85 (0.47)	6.38 (0.75)	6.05 (0.93)	6.17 (0.84)	<0.001
School area						
Deprived	490 (59.3)	169 (71.6)	0 (0)	43 (45.3)	278 (77.4)	<0.001
Non-Deprived	337 (40.7)	67 (28.4)	137 (100)	52 (54.7)	81 (22.6)	
Weight status						
Normal	658 (79.6)	186 (78.8)	115 (83.9)	76 (80.0)	281 (78.3)	NS
Overweight	137 (16.6)	42 (17.8)	19 (13.9)	13 (13.7)	63 (17.5)	
Obese	32 (3.9)	8 (3.4)	3 (2.2)	6 (6.3)	15 (4.2)	

Note: NS = non-significant; SD = standard deviation

Table 3: Number of municipal staff trained (N) and child-staff ratios (CSRs) by occupation and thematic session attended in each participating municipality (N=4) between 2011 and 2015

		Municipalities							
French Region		North-central		Western		Eastern		Northern	
		<i>City1</i>		<i>City2</i>		<i>City3</i>		<i>City4</i>	
		N	CSR	N	CSR	N	CSR	N	CSR
Healthy eating	Canteen	40	6:1	20	7:1	20	5:1	127	3:1
	ECA			12	12:1	30	4:1	79	5:1
Physical activity	ECA			25	6:1	30	4:1	63	6:1

Note: ECA= extracurricular activity; CSRs are expressed as number of children per adult.

Table 4: Baseline and 4-year weight status of schoolchildren according to weight status at inclusion (N=827)

	Inclusion	In-between changes †			Follow-up	p-value
	N (%)	None	Negative	Positive	N(%)	
Normal	658 (79.6)	624 (94.8)	34 (5.2)	0 (0)	695 (84.0)	0.002
Overweight	137 (16.6)	58 (42.3)	13 (9.5)	66 (48.2)	101 (12.2)	
Obesity	32 (3.9)	13 (40.6)	0 (0)	19 (59.4)	31 (3.7)	

† coded “positive” if obesity changed to overweight/normal or if overweight changed to normal; “negative” if normal changed to overweight/obesity or if overweight changed to obesity.

Table 5: Multivariate analysis of positive 4-year change in weight status according to child-staff ratios in children with overweight/obesity at inclusion (N=169)				
Child-Staff Ratio				
Occupation	Canteen service	ECA		OR [95% CI]
Training session	HE	HE	PA	
Municipalities				
<i>City4</i>	Low	Low	Moderate	<b>3.18 [1.37 – 7.38]</b>
<i>City3</i>	Low	Low	Low	<b>4.32 [1.28 – 14.5]</b>
<i>City2</i>	High	Moderate	Moderate	0.93 [0.28 – 3.12]
<i>City1</i>	Moderate			1
Child characteristics at inclusion				
Female sex				0.87 [0.46 – 1.67]
Age				<b>1.65 [1.04 – 2.60]</b>
Schooled in deprived area				0.45 [0.20 – 1.02]

Note: significant results are marked in bold. HE = healthy eating; PA = physical activity; ECA= extracurricular activity. The child-staff ratio is considered low if between 1 to 5 children per adult; moderate if between 9 and 6 children per adult; and high if >10 children per adult.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [STROBEchecklistcohort.docx](#)