INTRODUCTION

Successful obesity treatment in childhood has positive effects on several of obesity-related risks.\textsuperscript{1,2} It is well established that the success rate in paediatric obesity treatment is superior if the intervention is initiated at a young age.\textsuperscript{3,4}

The recommended treatment approach for paediatric obesity comprises behavioural lifestyle interventions targeting dietary and physical activity habits.\textsuperscript{5} It is important to involve the child’s family and network in order to establish a foundation of support that can be maintained throughout the intervention.\textsuperscript{5-7} Paediatric obesity is more common in lower socioeconomic status environments, but we...
have previously shown that this does not affect the possibility to adhere to treatment or to achieve good treatment results.8,9

Barriers to childhood obesity treatment among clinicians and families include limited knowledge, lack of motivation and difficulties in offering long-term treatment due to limited resources.10,11

In 2005, a treatment approach for childhood obesity was developed in Södertälje, a suburb of Stockholm, Sweden. The approach was structured and tailored towards patients younger than 13 years of age and has shown good treatment effect at the developing centre.9 In 2007, the Stockholm County Council decided to implement a plan of action as a new treatment approach for children with obesity at six paediatric clinics within the county.

This treatment is from here on called the action plan. This study aims to assess the treatment effect after 1 and 2 years in the clinics that have implemented the action plan in comparison to other paediatric clinics at the same level of care in order to provide a proof of concept for the action plan.

2 | METHODS

2.1 | Subjects

Included in this study were all children between 6 and 12.9 years of age who were referred to and started the explicit weight loss treatment programme described below during 1 January 2008-31 December 2014 in any of the six outpatient paediatric clinics in Stockholm County Council that have implemented the action plan.

The treatment model and the implementation consisted of four cornerstones; education of the treating staff, initial obesity treatment at groups of parents and children separately, continuous individualised treatment and regular coaching of the treating staff. These are thoroughly described below.

2.2 | Description of the treatment model

The treatment started with group activities for parents and children separately followed by individual meetings with the child and parents together. At treatment initiation, parents were invited to participate in group sessions once weekly for seven weeks. These sessions were 90 minutes in the afternoon or evening and were aimed to increase parents’ awareness regarding their role in their child’s weight development and to help parents support lifestyle changes regarding physical activity and diet through positive reinforcement. The optimal group size was estimated to be 20-25 families with at least one parent from each family participating in order to benefit from interaction during the discussions. A summary of the themes for the seven weeks is presented in Table 1. The group sessions included structured discussions where the parents got to exchange thoughts and experiences. If language barriers were present, an interpreter was consulted, which is free of charge in the Swedish healthcare system.

Key notes

- This study investigated the possibility to implement a childhood obesity treatment model and if the treatment effect was improved compared to usual care.
- The treatment model included education and support for the treating staff and group activities for parents and children separately followed by individual sessions.
- The treatment model was possible to implement with superior effect compared to usual care.

In parallel with the parental group sessions, children participated in educational and physical activities with emphasis on giving the children positive experiences. Both the parental and child group sessions followed the same themes (Table 1), but the information was tailored and delivered differently to parents and children, respectively.

After the group sessions, all families continued with individual treatment including visits to a medical doctor one to two times per year, visits to a nurse four to five times per year and for those who required, visits to a dietician and/or physiotherapist.

The visits lasted 30-60 minutes and included height and weight measurements as well as discussions about lifestyle progression and weight development.

The treatment model encouraged the treatment team to offer an empowering attitude during visits, seeking motivation for and giving advice about the child’s lifestyle changes to both the children and the parents.

2.3 | Description of the implementation

The implementation of the action plan consisted of an initial 2-day education in paediatric obesity and in how to create an empowering atmosphere during the group sessions. Further, workshops were held twice a semester for the continuous supervision of the clinical staff regarding how to deliver knowledge, how to be empowering, and how to help parents set the frames for their child’s diet and physical activity. The clinics had continuous opportunity to contact and get support from a coaching team. This was provided by a nurse who was part of the development of the treatment model and by a paediatrician.

Ethical approval was obtained from the Ethics Committee in Stockholm, Sweden (No. 2014/1422-31/2).

2.4 | Control group

The control group was children (n = 3012) receiving obesity treatment at outpatient paediatric clinics (n = 46) from different parts of Sweden that have not implemented the model. Treatment of
childhood obesity in Sweden comprises behavioural lifestyle modification, and may be delivered differently, for example to the whole family or parents only. Data were retrieved from The Swedish Childhood Obesity Register BORIS, and the same dates of treatment initiation and the same inclusion and exclusion criteria were applied. The register prospectively collects data and is aimed to be a clinical support and to advance the quality, knowledge and research of the treatment. The paediatric clinic where the treatment model was developed was excluded from the control group.

### 2.5 Definitions

The main outcome in the current study was treatment effects described assessed in three different ways: change in the BMI standard deviation scores (SDS), proportion of children reaching a clinically relevant weight loss specified as a loss of ≥0.25 BMI SDS units and children changing weight status (severe obesity, obesity, overweight and normal weight). Annual follow-up visits were defined to be 9-15 months (year one) and 18-30 months (year two) after treatment initiation. Age at the start of treatment is an important predictor of treatment outcome. Individuals’ ages were categorised into 6-7.9 years, 8-10.9 years and 11-12.9 years.

### 2.6 Data handling and statistics

Data were retrieved from BORIS and a review of medical records. Descriptive data are presented as proportions, standard deviations

| Week | Topic | Content |
|------|-------|---------|
| 1    | Introduction | As a start to the group activities, all children and parents come to an introductory meeting there they get to meet all of the team members at the outpatient clinic. |
| 2    | Changing habits through positive reinforcement | The hereditary and environmental aspects of obesity, focusing on how the solution is about changing habits—and that it requires effort! |
| 3    | Meal order—when, where and why we eat | The importance of a balanced supply of energy intake and sleep patterns for weight management. |
| 4    | Diet | Food and their components that we need and what kind of foods are good and healthy. |
| 5    | Treats to save for special occasions | Nowadays, temptations are all around us, and it is possible to ingest unhealthy amounts of calories from sodas, sweets and snacks. What is a fair amount and who is responsible for limit setting? |
| 6    | Physical activity | The importance of physical activity. Several aspects are brought up, such as short- and long-term duration and everyday physical activities, for example taking the stairs or walking instead of taking the car or bus. |
| 7    | Long-term planning | Consequences of obesity. Treatment and changing habits are long-term works. |
| Extra | Grocery shopping | At some time after week three, an educational grocery store walk together with a dietician takes place. During this practice, the dietician shows healthy alternatives and what labelling to look for and responds to the parent’s questions. |

#### TABLE 1 Themes brought up during the seven weekly group sessions

Four categories of attendance in group sessions were created: completed group sessions attended at least four out of seven, not completed group sessions attended less than four out of seven, declined to attend group sessions and not offered group sessions. Reasons for not being offered group sessions involved language barriers and logistic issues. These families received individual obesity treatment.

Blood sample data, including fasting glucose and insulin, total cholesterol, triglycerides, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol and alanine aminotransferase, were extracted from BORIS. All analyses were performed by accredited laboratories and paediatric-specific cut-offs were applied. To evaluate blood pressure in children a sex, age and height-adjusted reference from the National High Blood Pressure Education Program Working Group was applied. High blood pressure was defined as the 95th percentile or above.

Parental weight and height were self-reported and categorised based on BMI as normal weight (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²) and obesity (≥30.0 kg/m²).
During the seven years of inclusion, a total of 1334 children were referred to paediatric centres that have implemented the action plan. Boys started treatment at an older age compared with girls at 9.4 years vs 9.1 years, respectively (P = .006). Descriptive data are found in Table 2.

### 3.1 | Attendance

In the evaluated population, 538/1334 (40.3%) had completed all visits (initial, year one and year two). In addition, 245/1334 (18.4%) had data from the initial visit and year one, and 212/1334 (5.9%) had data from the initial visit and year two. The lost to follow-up subjects 338/1334 (25.3%) had a similar sex distribution (P = .26), heredity for obesity (P = .26), but they were three months older (P = .027) and had 0.07 units lower BMI SDS at treatment initiation (P = .048).

The proportion of families that completed group sessions or not was 396/1334 (29.7%) versus 113/1334 (8.5%), respectively, 370/1334 (27.7%) declined to participate, and 455/1334 (34.1%) were not offered to attend group sessions.

### 3.2 | Treatment results

One-year data are based on 783 patients, and the corresponding number for the 2-year follow-up is 750 patients.

### 3.3 | Change in BMI SDS

Children aged 6-7.9 years reduced their degree of obesity after two years by 0.14 BMI SDS units more compared with children 8.0-10.9 years (crude t test P < .001). Children aged 8.0-10.9 years decreased their BMI SDS 0.13 units more after 2 years compared with patients aged 11.0-12.9 years (P = .0005). There were no statistical sex differences from initial treatment visit to year one (P = .19) or year two (P = .95). Children who started treatment with a more severe degree of obesity achieved a greater reduction in BMI SDS.

The treatment effect differed both after one (P = .02) and 2 years (P = .0002) of treatment dependent on attendance in group sessions.

Post hoc analyses revealed that the group who completed the group sessions showed a greater decrease in BMI SDS after 2 years compared with those not offered to attend group sessions (−0.36 vs −0.22, respectively, P < .0001). However, the group who declined to participate in the group sessions had a greater decrease than those not offered to attend group sessions (−0.34 vs −0.22 units, respectively, P = .002). The group not offered to attend group sessions did not further improve their weight development between year one and year two, see Table 3. In analyses adjusted for sex, age group, attendance in group sessions and weight status, all variables except for sex remained as statistically significant predictors of treatment outcome until year two, Table S1.

### 3.4 | Clinically relevant change in BMI SDS

Age and degree of obesity at start of treatment affected the probability of reaching a clinically relevant reduction of 0.25 units or more in BMI SDS at follow-up year two (both P < .0001). The overall difference between the groups attending group sessions was non-significant (P = .053), but post hoc analyses revealed that the group who completed the group sessions showed a significantly higher proportion of children reaching a clinically relevant reduction compared to those not offered to attend group sessions (55.0% vs 43.2%, respectively, P = .007). There were no significant sex differences (P = .28), see Figure 1. In analyses adjusted for sex, age group, attendance in group sessions and weight status, age and degree of obesity remained as statistically significant predictors of reaching a clinically relevant reduction until year two, Table S2.

### 3.5 | Change in weight status

A proportion of 51.6% (n = 111/215) of the children who started their treatment with severe obesity improved their weight status after two years of treatment. Forty percent of the patients with obesity at treatment initiation were no longer diagnosed with obesity after 2 years of treatment. A small group of patients 48/750 (6.4%) were treated despite the fact that they did not meet the criterion for obesity at treatment initiation. For this group, treatment was unsuccessful since 12/48 (25.0%) developed obesity during the treatment period, see Figure 2.

### 3.6 | Comparison with the control group

Compared to the control group (n = 3,012), the children treated according to the action plan had similar mean (SD) BMI SDS at the start of treatment, to 2.7 ± 0.4 versus 2.7 ± 0.4 (P = .099). Proportion between the sexes was also similar 48.1% girls vs 47.5% (P = .71). But the intervention group was on average two months younger (P = .006). The treatment effect was significantly greater for children treated at the clinics that have implemented the action...
plan, Figure 3. The proportion of girls reaching a clinically relevant change in BMI SDS of −0.25 after 2 years was similar between the groups (P = .68), whereas boys in the intervention group reached a clinically relevant reduction to a higher extent 210/404 (52.0%) vs 290/705 (41.1%), P = .0004. The youngest age group benefited from the treatment in both groups, but the intervention group to a greater extent, where 173/253 (68.4%) reached a clinically relevant reduction in BMI SDS compared with 209/387 (54.0%) in the control group (P = .0003). The proportion of patients in the older age groups reaching a reduction in the degree of obesity by 0.25 BMI SDS units did not differ between groups (data not shown).

### 3.7 Blood pressure and biomarkers

Blood pressure was measured in 1110/1334 (83.2%) of the participants at the initial treatment visit. Of these, 234/1110 (21.1%) had systolic and 4/1110 (3.6%) had diastolic hypertensive levels. At Year 2, 198/750 (26.4%) had registered blood pressure. The proportion with systolic hypertensive levels decreased significantly to 22/198 (11.1%) (P = .001), while diastolic hypertensive levels decreased non-significantly to 5/198 (2.5%) (P = .58).

At treatment initiation, total cholesterol was reported for 70.2% of the patients, whereas fasting insulin level was reported for 54.0% of the patients. At year one and year two, the proportion of patients with reported biomarkers decreased.

An improvement in lipid profile and an impairment in glucose-insulin homeostasis was observed. These results should, however, be interpreted with caution due to a mismatch of subjects over the years with metabolic data. Nevertheless, a change in degree of obesity was associated with a change in low-density lipoprotein cholesterol (P = .03), high-density lipoprotein cholesterol (P = .01) and alanine aminotransferase (P = .006), see Table 4.

### 4 DISCUSSION

In this 2-year follow-up of an implementation of a structured multidisciplinary treatment model of childhood obesity, we can show that the intervention was possible to implement and that treated children therein reduced their degree of obesity to a greater extent compared with a control group. The implemented treatment model had greatest effect in younger children and among those with more severe obesity.
Even though the children in the control group in the present study had a smaller effect of obesity treatment corresponding to 0.08 BMI SDS units, the total effect on weight loss was not of considerable magnitude. In a large review from 2018, the average difference in degree of obesity between two groups with different obesity treatment approaches was shown to be 0.04 BMI SDS units.20 Hence, the magnitude of the difference between the groups in the present study was small, but slightly greater than previous findings.20 Further, the continuous effect of obesity treatment indicates that children who remains in treatment over 2 years generally benefits from it. Even though we cannot disentangle which mediating factors that further improved treatment outcome among the children within the intervention, there are some factors we believe might play an important role. Targeting parents in childhood obesity treatment has previously been shown to be a long-term fortunate approach.21,22 The implementation of the action plan included a thorough education of caregivers on childhood obesity treatment and the model. Education of healthcare providers and parents is an important cornerstone in the treatment of paediatric obesity.23 The education and extensive material on how to create a safe and empowering environment could have increased the staff’s awareness of tools that can be used and created a feeling of confidence in how a structured treatment can be delivered. An additional profitable factor might be the coaching team’s availability for questions and support during the treatment of childhood obesity. Thus, the beneficial effect of the treatment could be due to the structure and approach that the model offers, but we cannot exclude that it might also be due to more educated and engaged staff.

The intense initial treatment programme can be perceived as fairly time consuming and requires that families have the logistical

| TABLE 3 | Mean change (standard deviation) in BMI SDS score from the first visit presented by sex, attendance in group sessions, age group and weight status at baseline |
|---------|-------------------------------------------------|
|         | Change year one n = 783 | Change year two n = 750 |
| Sex     |                                 |                           |
| Girls   | -0.25 (0.34) P = .19           | -0.31 (0.42) P = .95      |
| Boys    | -0.22 (0.28)                 | -0.31 (0.38)              |
| Age group |                                |                           |
| 6.0-7.9 y | -0.34 (0.37) P < .0001         | -0.43 (0.37) P < .0001    |
| 8.0-10.9 y | -0.21 (0.26)             | -0.29 (0.38)               |
| 11.0-12.9 y | -0.15 (0.29)          | -0.15 (0.42)              |
| Weight status |                                |                           |
| Overweight | -0.16 (0.33) P < .0001        | -0.12 (0.43) P < .0001    |
| Obesity   | -0.21 (0.29)                 | -0.28 (0.39)              |
| Severe obesity | -0.32 (0.35)         | -0.42 (0.37)              |
| Attendance in group sessions | | |
| Completed | -0.28 (0.32) P = .023        | -0.36 (0.41) P = .0002    |
| Not completed | -0.26 (0.32)          | -0.31 (0.33)              |
| Declined to attend | -0.19 (0.28)      | -0.34 (0.40)              |
| Not offered | -0.22 (0.33)           | -0.22 (0.39)              |

Note: P values present group differences (analysis of variance).

| FIGURE 1 | Proportion of patients with a clinically relevant decrease of 0.25 BMI SDS units or more at Year 2. P values are calculated with chi-square tests or analysis of variance |
opportunity to participate. The intensity of obesity treatment is an important predictor for treatment outcome,\(^{24}\) and thus the initial intensity of the treatment model might have contributed to a greater effect after the first year compared with the second year. Findholt and colleagues\(^{10}\) found that travelling to healthcare centres might be a barrier for many families to participating in obesity treatment. The locations of the paediatric clinics in this setting were near the families’ home, which have been suggested to contribute to a greater possibility to attend treatment.\(^{25}\) However, we found a substantial decrease of BMI SDS in the families who declined to attend the group sessions and the ones not offered the group sessions. The reasons for this could be that these families chose the treatment option that best suited their ability, possibilities and needs. As in all clinical settings that treat paediatric obesity patients, loss to follow-up occurred. Nevertheless, nearly 60% of the children enrolled in this evaluation had 2-year follow-up data.

In the group who started treatment with severe obesity, almost 50% remained at the same weight status 2 years after treatment initiation. Nevertheless, approximately 65% lost more than 0.25 BMI SDS units, which has been shown to have positive effects on cardio-metabolic factors.\(^{13,14}\) Therefore, despite that the weight status was remained, it may not necessarily be viewed as treatment failure. This is in line with previous studies that have not been able to identify severe obesity as a risk for treatment failure.\(^{3}\)

Usually treating clinics only accept to treat children diagnosed with obesity. The overweight group consist thereby most likely of children in special needs, such as strong heredity for obesity, related comorbidities or siblings with obesity. With this in mind, the poor treatment outcome for the group with overweight at treatment initiation could be explained by the fact that they are most likely being at a great risk of developing obesity. It is nowadays well known that younger children succeed in obesity treatment to a greater extent than adolescents.\(^{3,4}\) In this study, we also saw a greater treatment effect in the youngest children, although this study only evaluated children up to 13 years of age. This implies that children with obesity need to be identified at younger ages in order to start more promising obesity treatment.

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4.1 | Strength and limitations

The strengths of this study are the large number of patients, the duration of treatment in an ordinary real-life condition and the matched control group. A limitation of this evaluation could be that the experiences and knowledge of the clinical staff and the treated families were not obtained. However, this evaluation was designed
to primarily show treatment results from a real-life condition without staff and families being affected by study questionnaires or similar. Other interesting aspects would have been to evaluate the cost-benefit of the implemented action plan, psycho-social factors and parental neglect, but the data were not available.

5 | CONCLUSION

The plan of action for the treatment of childhood obesity implemented by Stockholm Count Council in paediatric outpatient clinics showed encouraging results. The treatment consisted of initial group activities for parents and children separately followed by individual meetings with children and parents together. This approach, together with well-educated staff supported by a coaching team, seems to be an important factor in this structured multidisciplinary treatment model of childhood obesity. The implementation of the treatment approach was feasible, and a better treatment response was achieved after one and two years compared with a control group. The results from this multicenter study, together with earlier publication, provide proof of concept for the treatment model.

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CONFICT OF INTEREST

The authors have no conflicts of interest to declare.

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| TABLE 4 | Number of children with data reported on blood pressure and biomarkers, mean and standard deviation (SD), and proportion of patients with pathological values |
|---------------------------------|---------------------------------|---------------------------------|
| Initial treatment visit         | Year one                        | Year two                        |
| n                               | Mean (SD)                       | Pathology (%)                   | n                               | Mean (SD)                       | Pathology (%)                   | n                               | Mean (SD)                       | Pathology (%)                   |
| Systolic blood pressure (mm Hg) | 1110                            | 111.0 (13.3) 21.1               | 202                             | 111.7 (11.5) 13.4               | 198                             | 114.1 (10.5) 11.1               |
| Diastolic blood pressure (mm Hg)| 1110                            | 64.2 (8.4) 3.6                  | 202                             | 63.9 (8.4) 3.0                  | 198                             | 65.7 (9.0) 2.5                  |
| Glucose (mmol/L)                | 898                             | 4.88 (0.40) 0.6                 | 212                             | 4.94 (0.45) 0.5                 | 241                             | 5.06 (0.54) 2.5                 |
| HbA1C (mmol/mol)                | 797                             | 34.9 (3.2) 10.5                 | 199                             | 34.0 (4.2) 8.5                  | 234                             | 34.4 (3.6) 11.5                 |
| Total cholesterol (mmol/L)      | 936                             | 4.33 (0.78) 12.9                | 223                             | 4.23 (0.81) 12.6                | 252                             | 4.22 (0.69) 7.9                 |
| Triglycerides (mmol/L)          | 929                             | 0.90 (0.60) 16.6                | 128                             | 0.94 (0.51) 26.6                | 151                             | 0.94 (0.49) 13.9                |
| LDL-cholesterol (mmol/L)        | 805                             | 2.63 (0.73) 14.4                | 204                             | 2.58 (0.73) 10.3                | 228                             | 2.50 (2.63) 9.2                 |
| HDL-cholesterol (mmol/L)        | 819                             | 1.29 (0.32) 23.4                | 210                             | 1.29 (0.33) 23.3                | 238                             | 1.29 (0.32) 23.5                |
| ALT (µkat/L)                    | 931                             | 0.51 (0.19) 5.8                 | 220                             | 0.50 (0.20) 5.9                 | 239                             | 0.48 (0.17) 7.5                 |
| Insulin (mIE/L)                 | 721                             | 13.1 (8.3) 182                  | 182                             | 16.0 (9.8) 203                  | 16.7 (10.3)                     |

Note: High blood pressure was defined as the 95th percentile or above for sex, age and height. Impaired fasting glycemia was defined by fasting glucose levels of 6.1-6.9 mmol/L. The cut-off for pre-diabetes based on HbA1c was defined as 39 mmol/mol. Hypertriglyceridemia was defined for children younger than 10 y of age as triglycerides greater than 1.13 mmol/L and for children 10 y and older as triglycerides greater than 1.45 mmol/L, increased LDL-cholesterol concentrations greater than 3.36 mmol/L, and low HDL-cholesterol levels less than 1.04 mmol/L. Elevated ALT was defined as ≥0.748 µkat/L for girls and ≥0.850 µkat/L for boys.

Abbreviations: ALT, alanine aminotransferase; HbA1C, haemoglobin A1c; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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