Online asthma management for children is cost-effective

To the Editor:

eHealth interventions have been proposed as an appealing method to improve health outcomes and reduce healthcare costs [1–3]. However, the development of an eHealth intervention is associated with high costs and this investment needs to be balanced by increased clinical effectiveness and related cost savings. Unfortunately, solid evidence for the effectiveness of eHealth with regard to health improvement is still limited [2–5], as is evidence regarding cost-effectiveness. This causes uncertainty about the effectiveness of eHealth and constitutes a barrier towards successful implementation in daily practice [6, 7]. Thus, it is necessary to assess both effectiveness and cost-effectiveness to convince colleagues and policymakers of its added value.

We assessed the cost-effectiveness of online asthma care for children alongside a randomised controlled trial (RCT) to evaluate the effectiveness of this eHealth intervention on health improvement [8]. In this RCT, 210 asthmatic children were randomly allocated into two groups of asthma management. In the usual care (UC) group, care consisted of routine 4-monthly outpatient visits where asthma control was assessed with an asthma control test (ACT)/children's asthma control test (C-ACT) [9]. Alternatively, in the virtual asthma clinic (VAC) group, outpatient visits were reduced by 50% and asthma control was monitored online with monthly web-based ACT/C-ACT tests. In the VAC group, children had more symptom-free days per month and their ACT/C-ACT scores were more improved. As such, this RCT proved that routine outpatient visits can partly be replaced by online asthma management using the VAC.

We carried out an *a priori* defined cost-effectiveness analysis with the hypothesis that online management *via* the VAC is cost-effective. Standard cost questionnaires were completed by the parents every 4 months to assess costs from both a healthcare and a societal perspective. Healthcare (or direct) costs included all costs related to medical conditions, prescribed medication and intervention costs (including development of the VAC and estimated hosting and licence costs). Societal (or indirect) costs consisted of the loss of productivity, travel costs for any medical condition and parking expenses. The costs were based on the Dutch guideline for cost analyses [10] although if prices were not available other sources were used. Prices were converted to the 2014 level using the Dutch consumer price index [11].

Mean incremental costs were weighted against the mean incremental effects in terms of asthma-related quality of life (QoL) and asthma control. Uncertainty boundaries of 95% for the incremental cost-effectiveness ratio (ICER) were determined nonparametrically using bootstrap analyses. In this bootstrap simulation, 1000 random samples of cost–effect pairs were selected with replacement. Results from the simulation were presented graphically in a scatter plot in which each dot signifies the ICER of one iteration of the bootstrap stimulation. Two validated questionnaires were used to assess QoL at 0, 8 and 16 months: the Paediatric Asthma Caregiver's Quality of Life Questionnaire (PACQLQ) to assess QoL in the caregivers of young children (6–12 years) and the Paediatric Asthma Quality of Life Questionnaire (PAQLQ) for teenagers (12–16 years) [12, 13]. Asthma control was measured by ACT/C-ACT as described above for the RCT. Differences in cost were assessed with a nonparametric Mann–Whitney U-test. The changes from baseline in ACT/C-ACT and PACQLQ/PAQLQ were analysed using linear mixed models.

After 16 months, asthma control in young children (C-ACT) was higher in the VAC group with a mean (95% CI) difference of 1.17 (0.09–2.25) points (p=0.03) [8]. In the group of teenagers, no significant difference in ACT score between treatment arms was observed with a mean (95% CI) difference of 0.88 (−0.41–2.16) points. In addition, a 50% reduction in the number of outpatient visits did not have any relevant influence on PACQLQ and PAQLQ results (data not presented; p=0.95 and 0.84, respectively).

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Both direct and indirect costs per patient were significantly lower in the VAC group than in the UC group (median VAC €726.52/median UC €875.86 ($p=0.01$) and median VAC €102.79/median UC €124.56 ($p=0.02$), respectively). This resulted in lower total costs from a societal perspective (direct plus indirect costs) for VAC compared to UC (median VAC €889.77/median UC €1081.47 ($p=0.014$)). There were no significant differences in the following healthcare and societal costs: GP consultations, paediatrician consultations, other specialists, physiotherapists, consultations by phone, Emergency Room visits, hospital admissions and loss of productivity (data not presented). Online asthma management was associated with lower costs because of fewer outpatient clinic visits (median VAC €237.09/median UC €385.15 ($p<0.000$)) and lower travel expenses (median VAC €94.09/median UC €120.15 ($p=0.003$)).

In young children, the VAC resulted in both improved health outcomes and cost savings in 99% of the 1000 bootstrapped replications with a mean cost saving of €352 per patient (95th percentiles: €67 and €652) (figure 1a). In teenagers, considerable cost savings were realised in 90% of the bootstrapped replications with mean savings of €852 per patient (95th percentiles: €–294 and €2584) (figure 1b). Asthma control was similar in both groups and the percentage of bootstrapped replications that resulted in both improved health outcomes and cost savings was 74%. Similar results were found for the cost-effectiveness planes concerning QoL and cost (figures 1c and 1d). QoL was maintained whereas cost savings were realised for online care in both age groups.

In summary, we have demonstrated the cost-effectiveness of online asthma management for children with a 50% reduction in the number of routine outpatient visits compared with UC. In young children, online care results in both improved health outcomes and substantial cost savings. In teenagers, UC and online care are equally effective with respect to clinical outcome but considerable cost-savings are realised with online care. This cost-effectiveness analysis supports implementation of online asthma management from

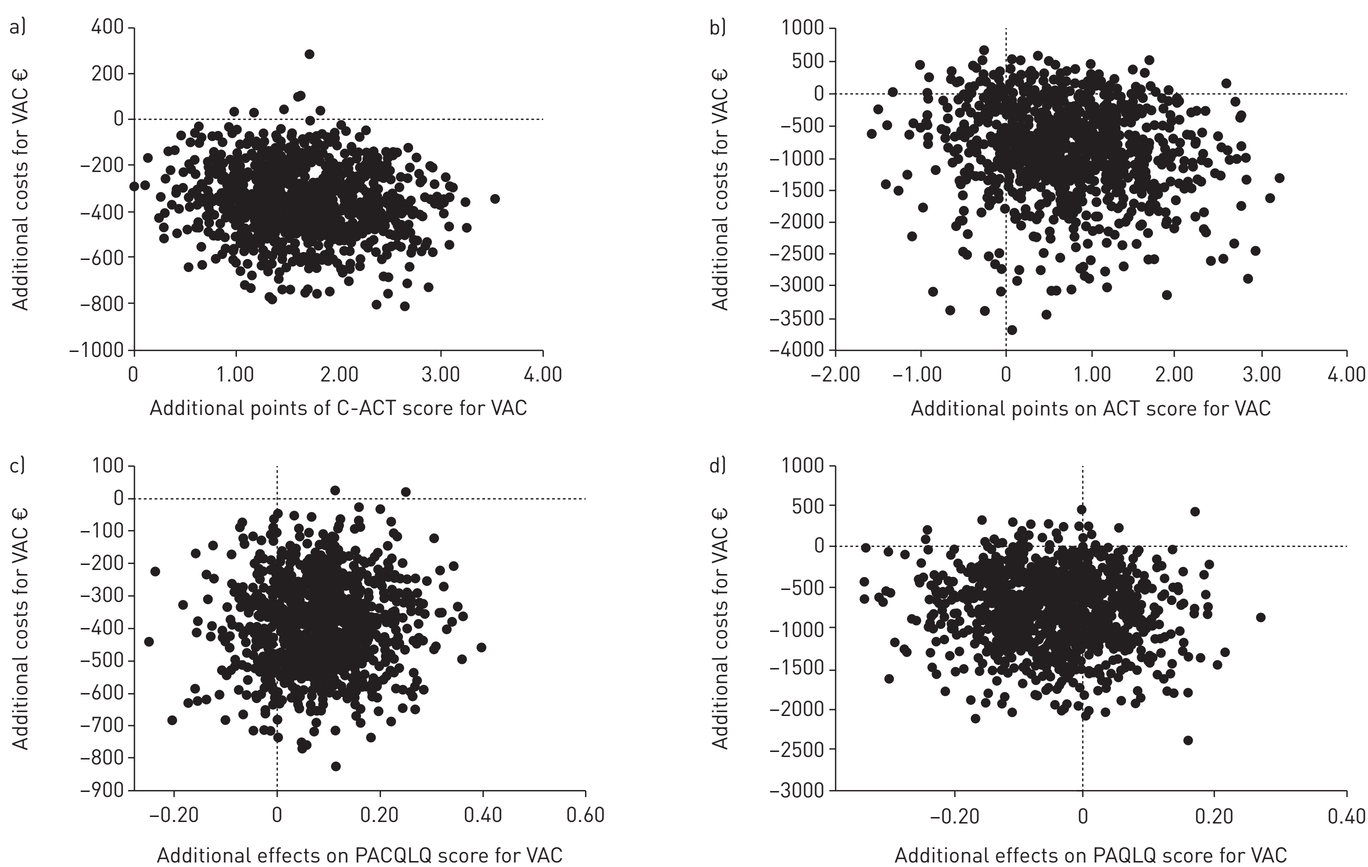

FIGURE 1 Cost-effectiveness planes showing the cost-effectiveness of a virtual asthma clinic (VAC) compared with usual care (1000 bootstrapped estimates). Dots represent the societal costs (direct plus indirect costs) plotted against asthma control for a) young children (6–11 years; asthma control measured by C-ACT) and b) teenagers (12–16 years; asthma control measured by ACT) or against quality of life for c) caregivers of young children (quality of life measured by PACQLQ) and d) teenagers (quality of life measured by PAQLQ). The South-East quadrants in a, b, and c indicate that the VAC dominates usual care (*i.e.* effectiveness is higher and costs are lower); however, the lower quadrants in d indicate that while costs are lower, effectiveness is the same. C-ACT: children's asthma control test; ACT: asthma control test; PACQLQ: Paediatric Asthma Caregiver's Quality of Life Questionnaire; PAQLQ: Paediatric Asthma Quality of Life Questionnaire.

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a health economics perspective. While evidence on the clinical effectiveness of eHealth is accumulating, the evidence of its cost-effectiveness remains scarce [3, 14]. The main limitations on the economic evaluation of eHealth are the lack of RCTs and the absence of quality data and appropriate measures [14, 15]. In addition, most eHealth interventions are used in addition to standard care, in contrast to our study where eHealth partly replaces UC. National implementation of the VAC has the potential to effect costs savings of €10.7 million per year (including both direct and indirect costs) based on the ±30 000 children with asthma treated by paediatricians in The Netherlands. Online paediatric asthma care in other countries may result in substantial cost savings as well, especially when healthcare costs are higher or travel distances are larger. One could argue that the frequency of routine visits in real life differs from the fixed protocol in the RCT and that some patients should be seen less frequently and others more frequently. A general approach to individual patients is not desirable and the focus of healthcare is shifting from the volume of services delivered to added patient value. It is important to tailor healthcare to individual patient's wishes, in agreement with the doctor's needs. This is one of the strengths of the VAC: it reflects a development towards "personalised eHealth". Additionally, it is a nice example of value-based healthcare: achieving high value for patients with care adapted to the individual, while reducing costs by replacing infrequent traditional outpatient visits by more frequent online monitoring, which is both more efficient and more patient friendly.

We conclude that the VAC for children is an effective and cost-effective eHealth intervention to improve asthma care. Introducing this intervention as part of current asthma management is an attractive and very realistic option to optimise monitoring strategies in a more personalised way. The next step is implementation and routine use of this intervention in daily practice.

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