### Objective:
To compare the costs associated with 2 clinical strategies in children with recurrent upper respiratory tract infections (URTIs): immediate adenoidectomy vs an initial watchful waiting strategy.

### Design:
A cost-minimization analysis from a societal perspective including both direct and indirect costs, alongside an open randomized controlled trial with a 2-year follow-up.

### Setting:
Multicenter study, including 11 general and 2 university hospitals in the Netherlands.

### Patients:
The study population comprised 111 children aged 1 through 6 years, selected for adenoidectomy for recurrent URTIs according to current clinical practice.

### Intervention:
A strategy of immediate adenoidectomy with or without myringotomy or a strategy of initial watchful waiting.

### Main Outcomes Measures:
Difference in median costs during the 2-year follow-up.

### Results:
The median total of direct and indirect costs in the adenoidectomy and watchful waiting group were €1385 (US $1995) and €844 (US $1216) per patient, respectively. The extra costs in the adenoidectomy group are primarily attributable to surgery and visits to the otorhinolaryngologist. Other costs did not differ significantly between the groups.

### Conclusions:
In children selected for adenoidectomy for recurrent URTIs, immediate adenoidectomy results in an increase in costs, whereas it confers no clinical benefit over an initial watchful waiting strategy.

### Trial Registration:
trialregister.nl Identifier: NTR968; isrctn.org Identifier: ISRCTN03720485

### Author Affiliations:
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**Adenoidectomy is one of the most commonly performed surgical procedures in children in Western countries. Indications for adenoidectomy include recurrent or chronic nasal discharge, recurrent episodes of acute otitis media, persistent otitis media with effusion, and symptoms of upper airway obstruction. In most cases, children undergo surgery for a combination of nasal and middle ear symptoms. In 2009, in the Netherlands, 15 179 children (16.3 per 1000) aged 0 to 4 years and 5573 children (5.5 per 1000) aged 5 to 9 years underwent adenoidectomy. In 60% of these children, recurrent upper respiratory tract infection (URTI) was the indication for surgery. In 2006, in the United States, 129 540 children (1.76 per 1000) up to the age of 18 years underwent adenoidectomy. In 12% of these children, the operation was performed because of chronic infections. In both countries the figures remained stable over the past decade. In a recent randomized controlled trial, we compared 2 common clinical strategies in children with recurrent URTIs: immediate adenoidectomy vs initial watchful waiting. We found no relevant differences between both strategies in the incidence of URTIs and middle ear problems or health-related quality of life. We concluded that immediate adenoidectomy confers no clinical benefits over an initial watchful waiting strategy.**
pated benefits and risks and personal preference. Costs should be part of this decision process as well.7 So far, no information is available on the costs involved with immediate adenoidecotomy or initial watchful waiting in children with recurrent URTIs. This is relevant because in both strategies costs may be considerable. Besides costs related to immediate or delayed surgery, there are those related to physician visits, use of medication for URTIs, and indirect costs, eg, related to parental absence from work. We set out to compare the costs associated with both strategies.

METHODS

STUDY DESIGN

A cost-minimization study was carried out alongside an open multicenter randomized controlled trial investigating the effectiveness of adenoidecotomy in children with recurrent URTIs. The study was approved by the medical ethics committee of the University Medical Center Utrecht. The design of the study has been reported previously.5 In short, between April 2007 and October 2010, otolaryngologists from 11 general and 2 academic hospitals in the Netherlands referred children aged 1 through 6 years selected for adenoidecotomy for recurrent URTIs to the trial center. Children with previous adenoidecotomy or adenotonsillectomy, as well as those with tympanostomy tubes present or an indication for insertion of tympanostomy tubes in combination with adenoidecotomy, were excluded from the study. Children with Down syndrome or craniofacial malformation were also excluded. Children, whose parents gave informed consent, were randomly assigned to either (1) adenoidecotomy with or without myringotomy within 6 weeks, or (2) an initial watchful waiting strategy. For this purpose we used a computerized minimization strategy, ie, a method of ensuring balance between prognostic factors in small samples. Treatment allocation was concealed until formal informed consent was obtained and the child was included in the trial.

FOLLOW-UP

During the 2-year follow-up parents kept a diary, including specific symptoms of URTIs, middle ear complaints, and absence from day care or school because of URTI. They also measured their child’s temperature every day with a validated tympanic membrane thermometer.8 Parallel to these clinical symptoms, parents recorded resources used in the diary, such as physician visits, medication, hospital admissions, and surgical interventions, as well as out-of-pocket expenses for over-the-counter drugs, babysitting, and traveling to medical appointments. Costs reported in the diary were costs made specifically for the participating child because of URTIs. The study physician (M.T.A.V.D.A) collected the diary data during the scheduled follow-up visits at 3, 6, 12, 18, and 24 months. Where relevant, diary entries were verified by data from the medical records.

During follow-up, parents, family physicians, and otolaryngologists of the participating children were encouraged to manage episodes of URTIs according to their regular practice, including antibiotics and ear-nose-throat surgery.

OUTCOME MEASURES

The primary outcome measure of this cost-minimization study was the difference in median costs between the 2 strategies during the full 2 years of follow-up. To study short-term effects, the secondary outcome was the difference in median costs in the first year of follow-up. These costs included both direct and indirect costs and were estimated at patient level in euros for 2009.

COSTS

For out-of-pocket expenses the actual amount of money indicated in the diary was used. For the other expenses, the number of resources used (eg, physician visits) was multiplied by the corresponding cost price. Cost prices were estimated from a societal perspective according to the guidelines for economic evaluation in health care research. Costs of surgery were retrieved from available data from a previous cost study.7 Costs of diagnostic tests were retrieved from the Dutch diagnostic formulary.10 Costs of medication were derived from the Dutch Formulary,10 and a pharmacist’s fee was added.11 Costs of over-the-counter drugs and alternative medicines were based on average retail prices. Costs of consulting a family physician or medical specialist, day case surgery, and other procedures and hospitalizations were based on current Dutch guidelines for pharmacoeconomic evaluation.11 Indirect costs to society associated with work absence from the parents were estimated using the friction cost method.12 Costs associated with absence of professional day care were estimated as the compensation for professional day care as provided by the government. Costs for informal babysitting were estimated using standard rates of the Dutch National Institute for Family Finance Information (NIBUD).13 According to the guidelines for economic evaluation in health care research, euros were converted to US dollars using the exchange rate of December 31, 2009 (€1 = US $1.4406).14

ANALYSIS

We used a short time horizon for all analyses and therefore took no time preference or discount rate into account. Differences in costs were compared between both randomization groups. When relevant, differences were tested by nonparametric Mann-Whitney tests, since costs always have a skewed distribution. Uncertainty was addressed by means of bootstrapping,15 for which we replicated the trial 1000 times using random replacement samples. All analyses were performed on an intention-to-treat basis because we aimed to compare the costs of 2 strategies (adenoidectomy vs initial watchful waiting [the latter may include surgery later during follow-up]). Sensitivity analyses were conducted by (1) excluding the children in the initial watchful waiting group who underwent ear-nose-throat surgery during follow-up (per-protocol analysis) or (2) by counting these children in the adenoidecotomy group (as-treated analysis) to analyze if the results were influenced by the crossovers.

RESULTS

STUDY GROUPS

In total, 111 children were enrolled in the study between April 2007 and April 2009; 54 were allocated to adenoidecotomy within 6 weeks and 57 were allocated to an initial watchful waiting strategy. The mean age was 36 months in the adenoidecotomy group and 38 months in the watchful waiting group. The median number of episodes of URTIs in the previous year was 10 in the adenoidecotomy group and 9 in the watchful waiting group. The median follow-up duration was 24 months in both...
groups. Overall, 11 children were lost to follow-up for nonmedical reasons (4 from the adenoidectomy group and 7 from the watchful waiting group). All children allocated to adenoidectomy underwent adenoidectomy within 6 weeks: 48 underwent adenoidectomy alone and 6 underwent adenoidectomy combined with myringotomy. During follow-up, 7 children (13%) allocated to adenoidectomy underwent tonsillectomy and revision adenoidectomy and 3 (6%) had tympanostomy tubes inserted. During the course of the trial, of the children allocated to initial watchful waiting, 17 (30%) underwent adenoidectomy (4 children underwent adenoidectomy combined with myringotomy and 2 children underwent adenoidectomy and had tympanostomy tubes inserted; 1 child underwent adenoidectomy in the first year of follow-up and revision adenoidectomy with tympanostomy tubes in the second year of follow-up; and 1 child underwent adenoidectomy in the first 6 months of follow-up and tonsillectomy in the 6 months thereafter) and 6 children (11%) underwent adenotonsillectomy (1 child underwent adenotonsillectomy combined with myringotomy).

COSTS

Table 1 gives a detailed overview of the most relevant cost estimates. The median costs per patient during the 2-year follow-up period were €1,385 (interquartile range [IQR], €806–€2,386) (US $1,995; IQR, $1,162–$3,437) in the adenoidectomy group and €844 (IQR, €416–€1,994) (US $1,215; IQR, $600–$2,873) in the watchful waiting group, ie, an immediate surgical strategy costs €541 (US $779) more than an initial watchful waiting strategy (Table 2). Bootstrapping yielded the same results, which means that there is no uncertainty regarding the median costs. Children in the adenoidectomy group had higher median costs related to surgery (48% more) than children in the watchful waiting group. Other costs, such as those of visits to the family physician, over-the-counter drugs, and parental leave of absence did not differ significantly between the groups. The median costs during the first year of follow-up were €959 (IQR, €632–€1,658) (US $1,382; IQR, $911–$2,388) in the adenoidectomy group and €505 (IQR, €105–€1,194) (US $728; IQR, $151–$1,720) in the watchful waiting group (Table 2). Again, bootstrapping yielded the same results.

SENSITIVITY ANALYSIS

Per-protocol analysis resulted in a difference in median cost between the adenoidectomy and initial watchful waiting group of €778 (US $1,121) during the 2-year follow-up (P < .001). As-treated analysis resulted in a difference in median costs between the 2 groups of €777 (US $1,119) during the 2-year follow-up (P < .001) (Table 3).

COMMENT

This study shows that in children selected for adenoidectomy for recurrent URTIs, an immediate surgical strategy costs €541 (US $799) more than an initial watchful waiting strategy during 2 years of follow-up. This is an increase of 64%, whereas immediate surgery confers no clinical benefit over an initial watchful waiting strategy. The extra costs are related to surgery and visits to the otorhinolaryngologist. Other costs did not differ significantly between the groups.

The results of our study are in agreement with 3 other studies that reported higher costs for surgical strategies in children with URTIs, ie, adenotonsillectomy in children with mild to moderate throat infections and tympanostomy tubes in children with otitis media with effusion.16,17 To our knowledge, this is the first economic evaluation of adenoidectomy in children with recurrent URTIs.

The major strength of our study is that we measured costs prospectively alongside a randomized controlled trial and used a societal perspective that included all relevant costs.

Some potential limitations should also be taken into consideration. First, 23 children (40%) from the initial watchful waiting group underwent adenoidectomy during the course of the trial. We performed an intention-to-treat analysis as our primary analysis because our aim was to determine the clinical benefit over an initial watchful waiting strategy. The results of our study are in agreement with 3 other studies that reported higher costs for surgical strategies in children with URTIs, ie, adenotonsillectomy in children with mild to moderate throat infections and tympanostomy tubes in children with otitis media with effusion.16,17 To our knowledge, this is the first economic evaluation of adenoidectomy in children with recurrent URTIs.

The major strength of our study is that we measured costs prospectively alongside a randomized controlled trial and used a societal perspective that included all relevant costs.
was to compare clinical strategies and not to compare adenoidectomy vs no adenoidectomy per se. To investigate whether the crossovers influenced our results, we performed 2 sensitivity analyses: a per-protocol and an as-treated analysis. It should be noted that the sensitivity analyses could suffer from confounding because the baseline comparability of prognosis achieved through randomization, which is the main strength of a randomized controlled trial, may be lost. Interestingly, the per-protocol and as-treated analyses did not change the clinical results, confirming the lack of benefit following adenoidectomy. However, the differences in costs were substantially higher, €778 (US $1121) and €777 (US $1119) after 1 and 2 years of follow-up, respectively. This larger negative economic effect can be explained by the fact that in the sensitivity analyses children with higher costs (mostly because of surgery) were excluded from the watchful waiting group.

Second, we originally planned this study as a cost-effectiveness study, dividing the difference in costs by the difference in effects. Because our trial showed comparable clinical effectiveness of an immediate surgical strategy and an initial watchful waiting strategy in children with recurrent URTIs, we decided to perform a cost-minimization study, comparing the costs of both strategies.

Third, for those who did not keep the diaries, we could only include the available expense information, ie, physician visits and costs for (additional) surgery. Because

### Table 2. Median Costs in Euros and US Dollars During the 2-Year Follow-up and During the First Year of Follow-up

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cost, Median (IQR), €</th>
<th>Adenoidectomy (n = 54)</th>
<th>Watchful Waiting (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>During the 2-Year Follow-up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery and hospitalization</td>
<td>336.54 (336.54-599.35)</td>
<td>0.00 (0.00-379.01)</td>
<td></td>
</tr>
<tr>
<td>Prescribed medication</td>
<td>8.55 (0.72-30.35)</td>
<td>6.64 (0.00-21.50)</td>
<td></td>
</tr>
<tr>
<td>OTC drugs and CAM</td>
<td>8.36 (2.36-28.98)</td>
<td>12.41 (2.03-36.78)</td>
<td></td>
</tr>
<tr>
<td>Consultation with ORL</td>
<td>61.40 (0.00-122.80)</td>
<td>0.00 (0.00-107.45)</td>
<td></td>
</tr>
<tr>
<td>Consultation with other specialist</td>
<td>0.00 (0.00-63.53)</td>
<td>0.00 (0.00-57.62)</td>
<td></td>
</tr>
<tr>
<td>Consultation with family physician</td>
<td>72.96 (18.24-117.09)</td>
<td>72.96 (20.79-172.01)</td>
<td></td>
</tr>
<tr>
<td>Absence of day care</td>
<td>0.00 (0.00-0.00)</td>
<td>0.00 (0.00-0.00)</td>
<td></td>
</tr>
<tr>
<td>Parental leave of absence</td>
<td>359.90 (53.99-899.75)</td>
<td>251.93 (0.00-701.81)</td>
<td></td>
</tr>
<tr>
<td>Babysitting</td>
<td>0.00 (0.00-47.03)</td>
<td>0.00 (0.00-45.60)</td>
<td></td>
</tr>
<tr>
<td>Other costs (including travel costs)</td>
<td>80.40 (24.58-171.45)</td>
<td>80.40 (26.09-201.62)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1384.84 (806.48-2385.51)</td>
<td>843.56 (416.40-1994.03)</td>
<td></td>
</tr>
<tr>
<td>Euros</td>
<td>1995.00 (1161.82-3436.57)</td>
<td>1215.23 (599.87-2872.60)</td>
<td></td>
</tr>
<tr>
<td><strong>During the First Year of Follow-up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery and hospitalization</td>
<td>336.54 (336.54-336.54)</td>
<td>0.00 (0.00-336.54)</td>
<td></td>
</tr>
<tr>
<td>Prescribed medication</td>
<td>6.47 (0.07-16.48)</td>
<td>3.36 (0.00-13.23)</td>
<td></td>
</tr>
<tr>
<td>OTC drugs and CAM</td>
<td>5.27 (0.97-18.17)</td>
<td>8.81 (1.19-29.48)</td>
<td></td>
</tr>
<tr>
<td>Consultation with ORL</td>
<td>61.40 (0.00-69.08)</td>
<td>0.00 (0.00-61.40)</td>
<td></td>
</tr>
<tr>
<td>Consultation with other specialist</td>
<td>0.00 (0.00-57.62)</td>
<td>0.00 (0.00-47.30)</td>
<td></td>
</tr>
<tr>
<td>Consultation with family physician</td>
<td>31.38 (0.00-62.47)</td>
<td>31.38 (5.30-93.95)</td>
<td></td>
</tr>
<tr>
<td>Absence of day care</td>
<td>0.00 (0.00-0.00)</td>
<td>0.00 (0.00-0.00)</td>
<td></td>
</tr>
<tr>
<td>Parental leave of absence</td>
<td>287.92 (0.00-863.76)</td>
<td>0.00 (0.00-431.88)</td>
<td></td>
</tr>
<tr>
<td>Babysitting</td>
<td>0.00 (0.00-45.60)</td>
<td>0.00 (0.00-17.10)</td>
<td></td>
</tr>
<tr>
<td>Other costs (including travel costs)</td>
<td>47.66 (19.17-81.50)</td>
<td>41.58 (7.80-121.98)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>959.24 (632.12-1657.80)</td>
<td>505.40 (104.68-1193.66)</td>
<td></td>
</tr>
<tr>
<td>Euros</td>
<td>1381.88 (910.63-2388.23)</td>
<td>728.08 (150.80-1719.59)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CAM, complementary and alternative medication; IQR, interquartile range; ORL, otorhinolaryngologist; OTC, over-the-counter.

### Table 3. Sensitivity Analyses on Total Costs in Euros and US Dollars During the 2-Year Follow-up

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cost, Median (IQR), €</th>
<th>Excluding crossovers</th>
<th>Analyzing crossovers as treated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excluding crossovers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euros</td>
<td>1384.84 (806.48-2385.51)</td>
<td>1384.84 (806.48-2385.51)</td>
<td>1383.54 (756.97-2276.46)</td>
</tr>
<tr>
<td>US dollars</td>
<td>1995.00 (1161.79-3436.57)</td>
<td>1995.00 (1161.79-3436.57)</td>
<td>1993.13 (1090.49-3279.47)</td>
</tr>
<tr>
<td><strong>Median Difference in Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euros</td>
<td>778.23</td>
<td>776.93</td>
<td>776.93</td>
</tr>
<tr>
<td>US dollars</td>
<td>1121.12</td>
<td>1119.25</td>
<td>1119.25</td>
</tr>
</tbody>
</table>

Abbreviation: IQR, interquartile range.
the loss to follow-up was very low (10%) and equally distributed over the 2 groups, we do not think that missing cost data would have changed our results.

Fourth, generalizing the results of economic evaluations to other countries might be challenging owing to differences in health care systems and prices. Although the absolute (differences in) costs might indeed not be generalizable, the ratio between the costs in the adenoidectomy and the watchful waiting group will remain applicable to other countries, ie, we expect that in other countries adenoidectomy is also approximately 1.5 times more costly than watchful waiting.

Finally, we indexed costs of surgery from a previous costing study because recent cost figures could not be extracted from the current Dutch “Diagnosis Treatment Combination” system (DBC-system) introduced in 2005. This system is based on diagnostic classifications rather than on an internationally recognized therapeutic classification system. A DBC can be defined as a predefined average package of care with, in most cases, a fixed price depending on the diagnosis. By using the indexed costs from our previous costing study, instead of a DBC price, our cost prices and final results are comparable to those of previous and future economic evaluations.

In conclusion, in children selected for adenoidectomy for recurrent URTIs, immediate adenoidectomy results in an increase in costs, whereas it confers no clinical benefit over an initial watchful waiting strategy.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Hoes, Schilder, and Rovers.

Acquisition of data: Boonacker, van den Aardweg, and Broos.

Analysis and interpretation of data: Boonacker, Schilder, and Rovers.

Drafting of the manuscript: Boonacker and Broos.

Critical revision of the manuscript for important intellectual content: Boonacker, van den Aardweg, Hoes, Schilder, and Rovers.

Statistical analysis: Boonacker and Rovers.

Obtained funding: Schilder and Rovers.

Administrative, technical, and material support: van den Aardweg.

Study supervision: Hoes, Schilder, and Rovers.

Conflict of Interest Disclosures: Dr Schilders and Rovers received honoraria from GlaxoSmithKline for participation in expert meetings, a workshop, and educational activities on otitis media. They also received a grant for a study on the microbiology of otitis media from GlaxoSmithKline.

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Previous Presentation: The results described in this article were presented at the 11th International Congress of the European Society of Pediatric Otorhinolaryngology (ESPO2012); May 21, 2012; Amsterdam, the Netherlands.

Additional Contributions: Ardine de Wit, PhD, provided advice regarding the design of the study.

REFERENCES


