Objective: To determine which factors predict development of chronic suppurative otitis media (CSOM) in children.

Design: Case-control study, with univariate and multivariate logistic regression analysis applied to determine which factors independently predict CSOM.

Subjects: Prognostic factors for CSOM were identified in (1) 100 children with CSOM and 161 controls aged 1 to 12 years and (2) 83 children who developed CSOM in the presence of a tympanostomy tube and 136 children with tympanostomy tubes who did not develop CSOM.

Results: Independent predictors for CSOM were previous tympanostomy tube insertion (odds ratio [OR], 121.4 [95% confidence interval [CI], 38.9-379.3]); having had more than 3 upper respiratory tract infections in the past 6 months (OR, 12.2 [95% CI, 3.5-42.3]); having parents with a low education level (OR, 14.1 [95% CI, 2.9-68.6]); and having older siblings (OR, 4.4 [95% CI, 1.6-12.6]). Independent predictors for CSOM after tympanostomy tube insertion were having experienced more than 3 episodes of otitis media in the past year (OR, 4.9 [95% CI, 2.2-11.0]); attending day care (OR, 3.6 [95% CI, 1.7-7.8]); and having older siblings (OR, 2.6 [95% CI, 1.2-5.5]).

Conclusions: Treatment with tympanostomy tubes is the most important prognostic factor for CSOM in children. In children who are being treated with tympanostomy tubes for persistent middle ear effusion, the most important prognostic factor for CSOM is a history of recurrent episodes of acute otitis media. This information should be taken into consideration and discussed with parents when considering insertion of tympanostomy tubes in children.

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CHRONIC SUPPURATIVE OTITIS MEDIA (CSOM) IS DEFINED AS A CHRONIC INFLAMMATION OF THE MIDDLE EAR AND TUBA MUCOSA IN WHICH THE TYPANIC MEMBRANE IS INTACT AND DISCHARGE IS PRESENT. THIS CONDITION CAN OCCUR IN THE PRESENCE OF A TYPANIC MEMBRANE PERFORATION OR AFTER A TYPANOSTOMY TUBE INSERTION. DESPITE IMPROVEMENTS IN GENERAL PATIENT HEALTH AND IN THEIR ACCESS TO OTOLARYNGOLOGIC PEDIATRIC CARE, MANAGEMENT OF CSOM REMAINS A CHALLENGE.

There is no consensus regarding the most effective treatment for CSOM, and both medical and surgical therapies have substantial failure rates. Therefore, prevention or early treatment of CSOM is important. This requires knowledge of factors that predict CSOM in children. Such data are scarce. Since it is thought that CSOM begins with an episode of otitis media (OM), it is likely that prognostic factors for OM also play a role in the development of CSOM. These include intrinsic factors such as race, age, previous upper respiratory tract infections (URTIs) and/or acute OM, educational level of the parents, and extrinsic (environmental) factors such as parental smoking, day-care attendance, and bottle vs breastfeeding. Herein, we report the results of our study of prognostic factors for OM in children with CSOM, in healthy controls and in children treated with tympanostomy tubes for persistent middle ear effusion.

METHODS

PATIENTS AND CONTROLS

The patient group of our case-control study consisted of children aged 1 to 12 years with a documented history of at least 3 months of continuous otorrhea through either a tympanic membrane perforation or a tympanostomy tube. They were referred to the department of Pediatric Otorhinolaryngology of the University Medical Center Utrecht between February 2003 and June 2003 to participate in a study on the
Table 1. Univariate Analysis of Potential Prognostic Factors for Chronic Suppurative Otitis Media (CSOM) in Patients With CSOM and Healthy Controls

<table>
<thead>
<tr>
<th>Potential Prognostic Factors</th>
<th>Patients With CSOM (n = 100)</th>
<th>Healthy Controls (n = 161)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt;4 y</td>
<td>49 (49)</td>
<td>71 (44)</td>
<td>1.2 (0.7-2.0)</td>
</tr>
<tr>
<td>Male sex</td>
<td>55 (55)</td>
<td>78 (49)</td>
<td>1.3 (0.8-2.1)</td>
</tr>
<tr>
<td>Previous OM episodes</td>
<td>68 (68)</td>
<td>61 (38)</td>
<td>3.6 (2.1-5.9)</td>
</tr>
<tr>
<td>OM in first year of life</td>
<td>27 (40)</td>
<td>35 (22)</td>
<td>2.3 (1.2-4.2)</td>
</tr>
<tr>
<td>&gt;3 OM episodes in year before study entry</td>
<td>24 (36)</td>
<td>12 (8)</td>
<td>6.8 (3.1-14.8)</td>
</tr>
<tr>
<td>Parental history of OM</td>
<td>42 (43)</td>
<td>79 (53)</td>
<td>0.7 (0.4-1.1)</td>
</tr>
<tr>
<td>Previous tympanostomy tube insertion</td>
<td>58 (58)</td>
<td>15 (9)</td>
<td>13.4 (6.9-26.1)</td>
</tr>
<tr>
<td>&gt;2 Siblings</td>
<td>13 (13)</td>
<td>10 (6)</td>
<td>2.3 (1.0-5.4)</td>
</tr>
<tr>
<td>Older siblings</td>
<td>73 (73)</td>
<td>64 (40)</td>
<td>4.1 (2.4-7.1)</td>
</tr>
<tr>
<td>Parent(s) smoked</td>
<td>29 (29)</td>
<td>19 (12)</td>
<td>3.1 (1.6-5.8)</td>
</tr>
<tr>
<td>&gt;10 Cigarettes/d</td>
<td>16 (16)</td>
<td>7 (4)</td>
<td>4.5 (1.8-11.5)</td>
</tr>
<tr>
<td>Low education level of mother</td>
<td>19 (19)</td>
<td>9 (6)</td>
<td>4.0 (1.7-9.3)</td>
</tr>
<tr>
<td>Birth weight &lt;2500 g</td>
<td>15 (15)</td>
<td>8 (5)</td>
<td>3.4 (1.4-8.3)</td>
</tr>
<tr>
<td>Breastfed for &gt;3 mo</td>
<td>34 (34)</td>
<td>82 (51)</td>
<td>0.5 (0.3-0.8)</td>
</tr>
<tr>
<td>Atopy</td>
<td>39 (39)</td>
<td>46 (29)</td>
<td>1.5 (0.9-2.6)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OM, otitis media; OR, odds ratio; URTI, upper respiratory tract infection (rhinitis, cough, and/or sore throat).

*Unless otherwise noted, data are reported as number (percentage) of subjects.

The effectiveness of prolonged treatment with sulfamethoxazole-trimethoprim. Exclusion criteria for this study were (1) cholestearoma, (2) known immune deficiency other than for IgA or IgG subclass deficiency, (3) Down syndrome, (4) craniofacial anomalies, (5) cystic fibrosis, (6) primary ciliary dyskinesia, (7) allergy to sulfamethoxazole-trimethoprim, and (8) continuous use of antibiotics for more than 6 weeks in the past 6 months.

Prognostic factors in the patient group were compared with those in 2 control groups.

The first control group consisted of “healthy” children recruited at 2 day care centers and a primary school in the vicinity of Utrecht. Between November 2003 and January 2004, parents were asked to fill in a questionnaire with information on possible prognostic factors for CSOM. Of the 400 questionnaires distributed, 163 were filled out and returned to the study center.

The second control group consisted of children treated with tympanostomy tubes for persistent OM with effusion between December 1999 and July 2002. They participated in a prospective cohort study on the immune status and eustachian tube function in children with recurrent OM with effusion. Exclusion and inclusion criteria have been described in detail elsewhere. Baseline information on prognostic factors for OM was collected at study entry. None of the participants developed CSOM during follow-up. Distribution of prognostic factors in this control group with tympanostomy tubes without CSOM was compared with children in the patient group who developed CSOM in the presence of a tympanostomy tube.

### PROGNOSTIC FACTORS

The following potential prognostic factors for CSOM were studied in the group of children with CSOM and in the healthy controls: age (<4 vs ≥4 years), sex (male vs female), previous OM episodes (yes vs no), OM in first year of life (yes vs no), recurrent OM episodes in the year before study entry (>3 vs ≤3 episodes), parental history of OM (yes vs no), recurrent URTIs (rhinitis, cough, and/or sore throat) in the 6 months before study entry (>3 vs ≤3 episodes), previous tympanostomy tube insertion (yes vs no), siblings (>2 vs ≤2 siblings), older siblings (yes vs no), smoking in the household (yes vs no and >10 vs ≤10 cigarettes per day), educational level of the mother (low vs average or above average), birth weight (<2500 g vs ≥2500 g), gestational age (<37 weeks vs ≥37 weeks), having been breastfed (>3 vs ≤3 months), and atopy (yes vs no).

For the comparison between the children who developed CSOM in the presence of a tympanostomy tube and the controls with tympanostomy tubes without CSOM, the same factors were studied except for URTIs, previous tympanostomy tube insertion, educational level of the mother, birth weight, and atopy, since these factors were not measured in the controls. Prognostic factors associated with day care, however, were added: attending day care (yes vs no and >2 vs ≤2 days per week) and group size (>10 vs ≤10 children per group).

### STATISTICAL ANALYSIS

The association between each of the factors and the outcome measures (CSOM and CSOM in the presence of tympanostomy tubes) was determined by applying univariate logistic regression analysis. Results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs).

Predictors that were univariately associated with the outcome (P < 0.10) were included in multivariable logistic regression analyses. The predictive accuracy of the models was estimated by their reliability (goodness of fit) using Hosmer-Lemeshow statistics that evaluate the correspondence between a model’s predicted probabilities and the observed frequencies over groups spanning the entire range of probabilities. The prognostic value of the models was evaluated using the c-index. This index has a theoretical range of 0.5 (no prognostic value) to 1.0 (maximum prognostic value). The c-index is equal to the area under the receiver operating curve. All analyses were performed using SPSS statistical software, version 12.0 (SPSS Inc, Chicago, Ill).

### RESULTS

Of the 100 patients with CSOM, 83 children had developed CSOM in the presence of tympanostomy tubes and 17 in the presence of a tympanic membrane perforation. One hundred sixty-three children served as healthy controls, and 136 as the control group with tympanostomy tubes without CSOM. Characteristics of these children are reported in Table 1 and Table 2.

### PROGNOSTIC FACTORS FOR CSOM IN AN OTHERWISE HEALTHY POPULATION

Independent predictors for CSOM were previous tympanostomy tube insertion (OR, 121.4 [95% CI, 38.9-379.3]); having had more than 3 URTIs in the past 6 months (OR, 12.2 [95% CI, 3.5-42.3]); having older siblings (OR, 4.4 [95% CI, 1.6-12.6]); and having parents with a low education level (OR, 14.1 [95% CI, 2.9-68.6]). The goodness-of-fit test indicated an acceptable agreement between observed and predicted probabilities.
fit of the multivariate model ($P = .94$), and the c-index was 0.98 (Table 3).

**COMMENT**

This is the first study to our knowledge to identify independent predictive factors for CSOM. In otherwise healthy children, previous tympanostomy tube insertion, having older siblings, more than 3 URTIs in the past 6 months, and a low education level of the mother were independent predictors for CSOM. The prognostic value of the model, as indicated by the c-index, was very high, indicating that clinicians can reliably use this information to predict CSOM in children.

So far, only Fliss et al.8 have compared risk factors for CSOM in a population of 88 children with CSOM (12 with tympanostomy tubes and 76 with perforations) and in 76 healthy controls. They found that a history of acute OM, a parental history of chronic OM, and crowded conditions (larger families and large day care centers) were risk factors for CSOM. However, they did not study whether these factors were independently associated with CSOM.

Since most of our CSOM group had chronic otitis media in the presence of tympanostomy tubes, we also studied which factors predict CSOM in children treated with tympanostomy tubes for persistent OM with effusion. Attending day care, having older siblings, but most of all having experienced more than 3 acute OM episodes in the past year were independent predictors for CSOM in these children. Apparently, children treated with tympanostomy tubes because of persistent middle ear effusion have an increased risk of CSOM when they are also prone to recurrent acute OM episodes.20

Since we performed a case-control study, the proportion of patients with CSOM (a relatively rare condition) is much higher than in the general population. Therefore, the ORs provided cannot be used to calculate absolute risks for CSOM. However, the ORs do indicate which factors predict CSOM in children with and without tympanostomy tubes.

In conclusion, treatment with tympanostomy tubes is the most important prognostic factor for CSOM in children. In children who are being treated with tympanostomy tubes for persistent middle ear effusion, this is a history of recurrent episodes of acute OM. This information should be taken into consideration and discussed with parents when considering insertion of tympanostomy tubes in children.

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Author Contributions: Dr van der Veen had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: van der Veen, Schilder, Verhoeff, and Rovers. Acquisition of data: van der Veen, van Heerbeek, Verhoeff, and Zielhuis. Analysis and interpretation of data: van der Veen, Schilder, Zielhuis, and Rovers. Drafting of the manuscript: van der Veen. Critical revision of the manuscript for important intellectual content: van der Veen, Schilder, van Heerbeek, Verhoeff, Zielhuis, and Rovers. Statistical analysis: Rovers. Obtained funding: Schilder. Administrative, technical, and material support: van der Veen, van Heerbeek, Verhoeff, and Zielhuis. Study supervision: Schilder and Rovers. Financial Disclosure: None reported. Funding/Support: This study was funded by a grant from the Health Care Insurance Council, the Netherlands (project 01235). Acknowledgment: We thank P. M. van Eden for conscientious secretarial support.

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