Public Health Impact of Various Risk Factors for Acute Otitis Media in Northern Finland

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The aim of this study was to assess the excess risk attributable to alterable risk factors for acute otitis media in Finnish children, including day care attendance, parental smoking, and a short duration of breastfeeding. Data on a population-based cohort of 2,512 children were gathered from medical records and questionnaires from 1985 to 1988. Excess (attributable) fractions for the risk factors were calculated among 825 children (target population) followed for 2 years, from a dynamic logistic model fitted to the entire cohort (estimation data). In theory, one child out of every five affected in the exposed population would have escaped otitis media completely if he/she had been moved from nursery day care to home care, and two out of every five affected could have escaped recurrent episodes in this way. The corresponding figures for family day care were lower: one and two children out of every six affected, respectively. Cessation of parental smoking and breastfeeding would have smaller effects. The impacts were more modest in the whole population. Nevertheless, approximately 14% of all of the otitis media episodes would have been avoided if all of the children had been cared for at home. These figures are hypothetical, since it is unlikely that use of day care outside the home can be avoided altogether, but they offer further evidence of the notable role of day care attendance as a risk factor for otitis media. Am J Epidemiol 1996; 143:1149-56.

attributable fraction; child; day care; epidemiologic methods; otitis media; risk factors

In addition to the morbidity, potential complications, and adverse developmental effects caused by recurrent episodes of otitis media among children, these episodes entail major financial costs to the community in the form of medical visits, medication use, operations, and parental time taken off from work (1). Several risk factors for recurrent otitis media have been identified (2–5), and intervention in these factors through changes in health and social policy could, in principle, be an effective and safe means of prevention. However, little is known about the magnitude of the effect that changing the prevalences of the various risk factors would have at the population level.

The excess fraction (attributable fraction) expresses the proportion of the occurrence of an illness in an exposed population that can theoretically be prevented by eliminating the exposure (6). This measure may be calculated for a combined population of exposed and unexposed individuals as well, in which case both the relative effect and the frequency of the exposure are considered (population excess fraction).

The problem in the case of acute otitis media is that the risk factors have interrelations, and the effect of any one of them greatly depends on the values of other determinants (4, 7). Day care, for example, is more common among children with few siblings; simultaneously, the effect of day care depends on the number of siblings (7). If children were moved out of nursery day care to be cared for at home, the impact in the population might thus differ from what would be expected from the crude average risk ratios only. Therefore, when the risk of acute otitis media is to be estimated, one should allow for modification of the effects of the risk factors by the values of other determinants.

The present investigation was carried out to estimate the excess fractions of the primary risk factors for acute otitis media, both among the exposed and in a whole child population, in Northern Finland, using estimated odds ratios from a dynamic logistic regression model for the occurrence of acute otitis media.
MATERIALS AND METHODS

Source population

During the years 1985–1988, the two northernmost provinces of Finland had over 600,000 inhabitants. The health care system in the area is universal and provides equal access to medical and hospital services for everyone, because it is based on a general health insurance scheme. Primary medical care is free of charge, the fees of private practitioners are partly refunded, and fees for hospital consultations are low. Most parents in the area take their children to a health center for regular examinations at 3, 6, 12, 18, and 24 months of age, and children’s ears and hearing are screened at these times. During every visit to a health center, hospital, or private practitioner for illness, the ears are routinely examined by pneumatic otoscopy, and tympanocentesis is often performed in primary care. Antibiotics are always prescribed for acute otitis media, and standard checkup visits are scheduled at 2-week intervals after diagnosis until the ears are regarded as having healed (8). Measures such as antimicrobial prophylaxis or tympanostomy tube insertion are recommended for children considered otitis-prone.

Study population

All of the pregnant women in the area whose estimated date of delivery was between July 1, 1985, and June 30, 1986, were enrolled in a research program investigating both the fetal period and the later development and illnesses of their children. Altogether, 9,478 children were born to these women (99 percent of all children born in the area during the above period). From this birth cohort, a sample of 2,512 children from 10 local government districts was drawn by a two-stage random cluster method (9) to form the present study population.

Data collection

Data on infections and treatment were collected by one of the authors (O.-P. A.) retrospectively from all possible medical records in the area, including primary health care centers, hospitals, and private practitioners. Subtraction of the date of birth from the date of out-migration from the area (if any) or the time of data collection, whichever was earlier, gave an observation time for each child. The mean observation time was 653 days (22 months). Among those children who were followed for a minimum of 12 months from birth, the mean observation times in the various risk factor groups were as follows: 683, 709, and 712 days for those cared for at home, in family day care, and at a day nursery, respectively; 690 and 698 days for children with nonsmoking and smoking parents, respectively; and 690 and 704 days for children who had been breastfed for at least 2 months or not, respectively.

When each child reached the age of 2 years, the parents were sent a self-administered questionnaire on possible risk factors and other background data. The overall response rate was 87 percent. Of the 40 variables on which data were gathered, the following factors, previously found to be significant risk factors for acute otitis media (4), were utilized here: 1) atopic manifestations based on both parental information and medical records (atopic dermatitis, food allergy, asthma, allergic rhinitis, wheezy bronchitis); 2) duration of breastfeeding (at least partial breastfeeding, regardless of supplementation); 3) number of siblings at the age of 2 years; 4) postnatal smoking habits of both parents (numbers of cigarettes smoked per day and whether smoking took place inside the home or outdoors); and 5) type and initiation date of day care (home care, family day care, or day nursery). Under Finnish regulations, the maximum number of children permitted in a family day care center is four, and the maximum number allowed in a day nursery is 12. All children under 3 years of age are placed in the same group, separate from the older children in the nursery.

Definition of acute otitis media

A disease reported in the records was regarded as acute otitis media on the basis of both acute symptoms (earache, fever, irritability, respiratory symptoms, restless sleep, etc.) and pneumootoscopic signs (distinct redness and outward bulging or reduced mobility of the eardrum). At least one of the acute symptoms and at least one of the pneumootoscopic findings was required for a diagnosis. When a tympanostomy tube or perforation was present, otorrhea, if accompanied by acute symptoms, was classified as acute otitis media.

Statistical methods

The risk factors were selected on the basis of previous research (4, 7). A dynamic or regressive (10) logistic model was constructed in which the child’s life up to 24 months of age was analyzed in 1-month periods by recording values for the risk factors for each period separately. The logit of the monthly risk of contracting acute otitis media was specified to be linearly dependent on model terms describing the child’s risk factor values at the beginning of the month and the observed history of previous episodes of acute otitis media up to the month under consideration. The risk factors were classified as either fixed (atopy, number of siblings at the age of 2 years, parental smoking, sex) or time-dependent (age, breastfeeding,
day care, prior episodes, season). The model was fitted to all of the 2,411 children whose observation times were known and exceeded 1 month (estimation data). Details on the modeling approach have been presented elsewhere (11).

Altogether, 968 children were followed up to the age of 24 months. In 825 of these cases, complete risk factor data were available, and these children formed the target population for the excess fraction calculations. The model-based excess fraction estimates for the alterable variables (nursery and family day care, parental smoking, and early weaning from breastfeeding) were calculated using the estimated odds ratios from the estimation data and the risk factor prevalences from the target population, by a modification of the method of Greenland and Drescher (12). The calculations were performed with the GLIM (Numerical Algorithms Group Ltd., Oxford, England) and SAS (SAS Institute, Inc., Cary, North Carolina) software packages.

Ethical approval

The research protocol was approved by the Finnish Ministry of Health and Social Welfare and by the Ethical Committee of the Faculty of Medicine, University of Oulu, Oulu, Finland.

RESULTS

The overall odds ratio (OR) estimates associated with the alterable risk factors for acute otitis media obtained from the population of 2,411 children were as follows: for family day care versus home care, OR = 1.5 (95 percent confidence interval (CI) 1.3–1.7); for nursery day care versus home care, OR = 2.1 (95 percent CI 1.8–2.3); for breastfeeding versus bottle-feeding among children over 3 months of age, OR = 0.9 (95 percent CI 0.8–1.0); and for parental smoking, OR = 1.2 (95 percent CI 1.1–1.3).

In the target population of the 825 children whose risk factor distribution was used in excess fraction estimation, 777 (94 percent) had been taken to a physician for acute otitis media or respiratory infection, resulting in a total of 4,342 visits to a health care facility. The mean number of acute care visits per episode of acute otitis media was approximately the same in all risk factor groups (table 1). The proportion of children whose parents had consulted a private practitioner at least once was greater among children attending day care outside the home than in those being cared for at home.

These 825 children had suffered a total of 1,658 episodes of acute otitis media, as defined by clinical signs; in 695 (42 percent) of the episodes, tympanocentesis revealed the presence of effusion. This gave a cumulative incidence of first episodes of 74 percent and an overall incidence density of 1.0 episodes per child-year up to age 24 months. The distribution of the numbers of episodes in various risk factor groups is given in table 1. The number of children who had at least three episodes was 268, and only two of them received antimicrobial prophylaxis.

### TABLE 1. Characteristics of various subpopulations defined by risk factors for acute otitis media among children aged birth to 2 years, northern Finland, 1985–1988

<table>
<thead>
<tr>
<th>Subpopulation</th>
<th>Total</th>
<th>0</th>
<th>1–2</th>
<th>≥3</th>
<th>Consultation rate*</th>
<th>Use of a private physician †</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Breastfeeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breastfed infants (age ≥3 months)</td>
<td>735</td>
<td>89</td>
<td>199</td>
<td>27</td>
<td>311</td>
<td>42</td>
</tr>
<tr>
<td>Weaned early (age &lt;3 months)</td>
<td>90</td>
<td>11</td>
<td>18</td>
<td>20</td>
<td>29</td>
<td>32</td>
</tr>
<tr>
<td>Day care</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cared for at home</td>
<td>407</td>
<td>49</td>
<td>127</td>
<td>31</td>
<td>170</td>
<td>42</td>
</tr>
<tr>
<td>Attending family day care</td>
<td>255</td>
<td>31</td>
<td>56</td>
<td>22</td>
<td>107</td>
<td>42</td>
</tr>
<tr>
<td>Attending nursery day care</td>
<td>163</td>
<td>20</td>
<td>34</td>
<td>21</td>
<td>63</td>
<td>39</td>
</tr>
<tr>
<td>No. of siblings (at age 2 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>217</td>
<td>26</td>
<td>61</td>
<td>28</td>
<td>85</td>
<td>39</td>
</tr>
<tr>
<td>≥1</td>
<td>608</td>
<td>74</td>
<td>156</td>
<td>26</td>
<td>255</td>
<td>42</td>
</tr>
<tr>
<td>Parental smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsmoking parents</td>
<td>696</td>
<td>84</td>
<td>186</td>
<td>27</td>
<td>288</td>
<td>41</td>
</tr>
<tr>
<td>Smoking parents</td>
<td>129</td>
<td>16</td>
<td>31</td>
<td>24</td>
<td>52</td>
<td>40</td>
</tr>
<tr>
<td>All infants</td>
<td>825</td>
<td>100</td>
<td>217</td>
<td>26</td>
<td>340</td>
<td>41</td>
</tr>
</tbody>
</table>

* Mean number of acute care visits during one acute episode.
† Number and proportion of all children with ≥1 episode whose parents consulted a private physician.

Am J Epidemiol Vol. 143, No. 11, 1996
The distributions and mutual associations of the risk factors in the target population are displayed in table 2. The most closely interrelated variables were 1) parental smoking and a short duration of breastfeeding; 2) day care attendance and having no siblings; and 3) day care attendance and parental smoking.

**Excess fractions**

The estimated excess risks attributable to the four factors in the exposed subsets of the target population of 825 children are shown by age in figures 1-4. Dividing the differences between the plots of hypothetical and current values by the current values gives the excess fraction estimates for the exposed population when the results are subtracted from 100.

Nursery day care had the strongest effect at the population level (figure 1). Its effect started at the age of 9 months, when children commonly began to attend day care outside the home. The influence on recurrent episodes became evident later, during the second year of life. If the children had been cared for at home instead of at a day nursery during the first 2 years of life, 19 percent (95 percent CI 15–24) of the children with at least one episode would have avoided experiencing the first episode, and 42 percent (95 percent CI 35–49) of the otitis-prone children would have avoided recurrent episodes (≥3). The corresponding figures for family day care were somewhat lower: 16 percent (95 percent CI 11–20) and 30 percent (95 percent CI 21–38), respectively (figure 2). This difference was also evident in the total numbers of episodes for the two modes of day care: The reduction was 117 episodes (33 percent of all episodes) among the 163 children in nursery day care and 96 episodes (21 percent of all episodes) among the 255 children in family day care.

Parental smoking had a more modest effect which started soon after the child's birth (figure 3). An estimated 3 percent (95 percent CI 0.5 to 10) and 22 percent (95 percent CI 11–34) of the children with one episode and recurrent episodes, respectively, would have escaped the first and recurrent episodes if the parents had stopped smoking. The number of episodes avoided in 129 families with parents who smoked would have been 47 (17 percent of all of the episodes).

The protective effect of breastfeeding after 3 months was weak. In the hypothetical situation of all of the infants' being weaned at the age of 3 months (figure 4), only 3 percent (95 percent CI 1.5) and 6 percent (95 percent CI 0–12) more children would have experienced their first episode or recurrent episodes, respectively. The corresponding increase in episodes would have been 25 (2 percent of all episodes).

The population excess fraction for the first episode in the entire mixed population of exposed and unexposed children (i.e., when the distribution of exposure is considered as well) was 4 percent for nursery day care, 5 percent for family day care, and 0.4 percent for parental smoking. The corresponding figures for recurrent episodes were 11 percent for nursery day care, 10 percent for family day care, and 4 percent for parental smoking.

**DISCUSSION**

A clinically significant proportion of acute otitis media in this population could have been prevented, in

### Table 2. Prevalence of various risk factors for acute otitis media in subpopulations defined by other variables, northern Finland, 1985–1988

<table>
<thead>
<tr>
<th>Subpopulation</th>
<th>Total</th>
<th>&lt;3 months breastfeeding</th>
<th>Family day care</th>
<th>Nursery day care</th>
<th>≥1 sibling</th>
<th>Parents who smoked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No. %</td>
<td>No. %</td>
<td>No. %</td>
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<tr>
<td><strong>Breastfeeding</strong></td>
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<td></td>
</tr>
<tr>
<td>Breastfed infants (age ≥3 months)</td>
<td>735</td>
<td></td>
<td>232 32</td>
<td>143 19</td>
<td>544 74</td>
<td>109 15</td>
</tr>
<tr>
<td>Weaned early (age &lt;3 months)</td>
<td>90</td>
<td></td>
<td>23 26</td>
<td>20 22</td>
<td>64 71</td>
<td>20 22</td>
</tr>
<tr>
<td><strong>Day care</strong></td>
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<td></td>
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<tr>
<td>Cared for at home</td>
<td>407</td>
<td>47 12</td>
<td>334 82</td>
<td>54 13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending family day care</td>
<td>255</td>
<td>23 9</td>
<td>163 64</td>
<td>46 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending nursery day care</td>
<td>163</td>
<td>20 12</td>
<td>111 68</td>
<td>29 18</td>
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<tr>
<td>No. of siblings (at age 2 years)</td>
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<tr>
<td>0</td>
<td>217</td>
<td>26 12</td>
<td>92 42</td>
<td>52 24</td>
<td>39 18</td>
<td></td>
</tr>
<tr>
<td>≥1</td>
<td>608</td>
<td>64 10</td>
<td>163 27</td>
<td>111 18</td>
<td>90 15</td>
<td></td>
</tr>
<tr>
<td><strong>Parental smoking</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Nonsmoking parents</td>
<td>696</td>
<td>70 10</td>
<td>209 30</td>
<td>134 19</td>
<td>518 74</td>
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<tr>
<td>Smoking parents</td>
<td>129</td>
<td>20 15</td>
<td>48 36</td>
<td>29 22</td>
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<tr>
<td><strong>All infants</strong></td>
<td>825</td>
<td>90 11</td>
<td>255 31</td>
<td>163 20</td>
<td>608 74</td>
<td>129 16</td>
</tr>
</tbody>
</table>

Am J Epidemiol Vol. 143, No. 11, 1996
Risk Factors for Otitis Media

FIGURE 1. Fitted proportions of children with no episodes of acute otitis media (OM) and no recurrent episodes (defined as ≥3 episodes), by age, in a subset of 163 children attending nursery day care and in the hypothetical situation where all of these children were being cared for at home, northern Finland, 1985–1988.

FIGURE 2. Fitted proportions of children with no episodes of acute otitis media (OM) and no recurrent episodes (defined as ≥3 episodes), by age, in a subset of 255 children attending family day care and in the hypothetical situation where all of these children were being cared for at home, northern Finland, 1985–1988.

principle, by changing the distribution of the key risk factors. Day care attendance had the strongest effect. If our model is valid, these results would imply that of those children attending a nursery, one out of every five children affected would have escaped otitis media altogether if he/she had been moved to home care, and two out of every five children would have avoided fulfilling the criterion for an otitis-prone child. The corresponding figures for family day care were slightly lower: one child and two children out of every six affected, respectively. The fairly similar results obtained in family day care and nursery day care are...
understandable in view of the small difference in the maximum permitted group size—four children versus 12 children, respectively. These figures are hypothetical, since eliminating day care outside the home is impossible in modern society, but they offer further evidence of the notable role of day care attendance as a risk factor for otitis media.

Cessation of parental smoking would have only a modest protective impact on the appearance of the first acute episode, but it would have a more profound

Am J Epidemiol Vol. 143, No. 11, 1996
effect on otitis-proneness. One child out of every five children affected in families with smoking parents would avoid becoming otitis-prone if their parents stopped smoking. Strong measures to restrict smoking have already been taken in Finland in the form of heavy taxation, and the present results provide one further justification for this measure.

Breastfeeding seems not to have any major effect after 3 months of age, since the increase in acute otitis media would have been insignificant even if all of the mothers had stopped breastfeeding at that point in time. Moreover, because it is difficult to influence the duration of breastfeeding, this variable does not offer much potential in terms of prevention at the population level.

Although changes in the risk factor levels would have had a significant effect among the exposed children in this study, the impact would have been more modest in the total population, since only the exposed children would have been affected. The effect related to both parental smoking and short duration of breastfeeding would have been insignificant, but moving children from nursery day care to home care would have kept approximately 20 percent of them from becoming otitis-prone. According to a recent meta-analysis, this is somewhat less than what can be accomplished by antimicrobial prophylaxis (13).

When interpreting our results, the strengths and possible weaknesses of this study’s design and methods should be considered. Our study population was a random sample of a well-defined geographic birth cohort. The rate of response to the questionnaire on risk factors was rather high, and gathering of infection data up to the individual censoring time was virtually complete. Some selection bias due to nonresponse and to unequal observation times may have been present. However, a life table approach was used in fitting the dynamic logistic model to the whole population, hence utilizing all available outcome information. On the other hand, the subset of 825 children for whom complete follow-up data up to age 2 years were available was fairly comparable with the entire study population in terms of the distributions of the fixed risk factors (11). This was as expected, because the timing of outcome data collection or outmigration, which determined the individual observation time, was basically independent of the outcome. There was only slight variation in the mean observation times for the subgroups and the risk factors.

Questionnaire-based gathering of risk factor data may involve misclassification bias. Because the questionnaire was administered less than 2 years after the major events characterizing exposure took place (e.g., cessation of breastfeeding, initiation of day care outside the home—these being memorable occasions for most parents), it is likely that no notable recall bias exists as such. On the other hand, when asked, people may tend to exaggerate the duration of breastfeeding and underreport their smoking, because of the perceived social desirability of these behaviors. Since the questionnaire data were gathered when the child was 2 years old, the observed history of acute otitis media episodes may have influenced parental responses, leading to some differential misclassification. However, we think that this would not have changed our conclusion qualitatively.

The criteria for acute otitis media used here, calling for both acute symptoms and pneumatic otoscopic findings, may still have entailed inaccuracies, since the data were collected retrospectively and the diagnostic abilities of the physicians could not be assessed in advance. The estimates of both cumulative incidence and acute incidence agreed remarkably well with those reached by two specialists elsewhere in Finland (14). In addition, effusion was demonstrated by tympanocentesis in almost half of the episodes. Theoretically, this disease misclassification is probably nondifferential and should therefore moderate the associations. Because the associations detected here were quite strong, significant error is unlikely.

Only the symptomatic form of otitis media was studied here, but since our purpose was to ascertain the reasons for recurrent episodes that require treatment and cause morbidity, complications, and economic cost, rather than the possible consequences of otitis media, this restriction did not pose a problem. Moreover, the mean consultation rate per acute episode, which reflects both the severity of episodes and the readiness of parents to seek medical attention, was similar for the various groups of risk factors examined. On the other hand, children attending day care had been seen by private practitioners more often than those being cared for at home, and this could have had a slight effect on the figures presented.

Contrary to the currently popular practice in epidemiologic research, we did not use odds ratios as the end product of our statistical analysis. Among the many problems of interpretation which make odds ratios inferior to risk differences or risk ratios (15) is the fact that an odds ratio is a particularly poor estimate of the risk ratio (“relative risk”) when the baseline risk of the outcome is very high (such as the risk of having at least one episode of acute otitis media prior to 2 years of age). Following the advice of Greenland (15), we used the odds ratios from logistic modeling only as an intermediate tool for estimating a more meaningful epidemiologic measure, the excess fraction.
In principle, the excess fraction provides an informative measure of the public health implications of the effect of a particular risk factor, because it combines both the varying effect of the risk factor on the incidence of the disease in various subgroups (7) and the prevalence of the factor in the target population. In spite of extensive epidemiologic research into risk factors for acute otitis media, we were able to find only one article which assessed the excess or attributable fraction associated with day care (16) and only two articles which discussed that for parental smoking (17, 18). The differences in study design, type of population, data collection, and statistical analysis were such that the results presented in these papers cannot be directly compared with ours.

The regression model used here, the dynamic logistic model, has several benefits in comparison with conventional methods. It yields more realistic risk estimates, since the time-dependent nature of some of the exposures and of the episodes themselves is considered. When the population excess fractions were calculated, the effects of other risk factors were assumed to alter accordingly, which is again more reasonable. Thus, the estimated excess fraction for recurrent episodes due to nursery care provided by the present model was higher than that derived from the crude data: 42 percent versus 34 percent, respectively.

In conclusion, this population-based study from Finland suggests that a significant proportion of recurrent episodes of acute otitis media is attributable to the current practice of placing young children in day care outside the home, providing additional evidence for the notable role of day care attendance as a risk factor for otitis media. Similar results would probably be obtained in other Western societies, but the present data cannot be directly generalized to other countries. Nevertheless, they do offer one way of approaching the complex problem of preventing recurrent otitis media.

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