Thumb-Sucking, Nail-Biting, and Atopic Sensitization, Asthma, and Hay Fever

Stephanie J. Lynch,[a] Malcolm R. Sears, MB,[b] Robert J. Hancox, MD[a]

abstract

BACKGROUND: The hygiene hypothesis suggests that early-life exposure to microbial organisms reduces the risk of developing allergies. Thumb-sucking and nail-biting are common childhood habits that may increase microbial exposures. We tested the hypothesis that children who suck their thumbs or bite their nails have a lower risk of developing atopy, asthma, and hay fever in a population-based birth cohort followed to adulthood.

METHODS: Parents reported children's thumb-sucking and nail-biting habits when their children were ages 5, 7, 9, and 11 years. Atopic sensitization was defined as a positive skin-prick test ($\geq$2-mm weal) to $\geq$1 common allergen at 13 and 32 years. Associations between thumb-sucking and nail-biting in childhood, and atopic sensitization, asthma, and hay fever at these ages were assessed by using logistic regression with adjustments for sex and other potential confounding factors: parental atopy, breastfeeding, pet ownership, household crowding, socioeconomic status, and parental smoking.

RESULTS: Thirty-one percent of children were frequent thumb-suckers or nail-biters at $\geq$1 of the ages. These children had a lower risk of atopic sensitization at age 13 years (odds ratio 0.67, 95% confidence interval 0.48–0.92, P = .013) and age 32 years (odds ratio 0.61, 95% confidence interval 0.46–0.81, P = .001). These associations persisted when adjusted for multiple confounding factors. Children who had both habits had a lower risk of atopic sensitization than those who had only 1. No associations were found for nail-biting, thumb-sucking, and asthma or hay fever at either age.

CONCLUSIONS: Children who suck their thumbs or bite their nails are less likely to have atopic sensitization in childhood and adulthood.

FREE

---

[a]Department of Preventive and Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand; and [b]Firestone Institute for Respiratory Health, Michael de Groote School of Medicine, McMaster University and St Joseph's Healthcare, Hamilton, ON, Canada.

Address correspondence to Robert J. Hancox, MD, Department of Preventive and Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand. E-mail: bob.hancox@otago.ac.nz

WHAT'S KNOWN ON THIS SUBJECT: The hygiene hypothesis suggests that childhood exposure to microbial organisms reduces the risk of developing allergic diseases. The effects of thumb-sucking and nail-biting habits are likely to increase microbial exposure, but their effects on allergic diseases are unknown.

WHAT THIS STUDY ADDS: Children who sucked their thumbs or bit their nails between ages 5 and 11 years were less likely to have atopic sensitization at age 13. This reduced risk persisted until adulthood. There was no association with asthma or hay fever.

ARTICLE

The "hygiene hypothesis" was suggested by Strachan[1] to explain why children from larger families and those with older siblings are less likely to develop hay fever. Strachan[1] hypothesized that this could be explained if "allergic diseases were prevented by infection in early childhood transmitted by unhygienic contact with older siblings, or acquired prenatally from a mother infected by contact with her older children." The hypothesis is supported by evidence showing that children who grow up in large families are at greater risk of coming into contact with more infections, promoting T helper (TH)-1 immune responses, whereas children from smaller families are more likely to have TH-2 type responses and a higher risk of atopy.[2] The hygiene hypothesis remains controversial, however, as it is unable to fully explain many associations, including the rise of allergies in "unhygienic" inner-city environments, and why probiotics are ineffective at preventing allergic diseases.[3]

Thumb-sucking and nail-biting are common oral habits among children, although the reported prevalence varies widely, from <1% to 25%.[4–7] These habits have the potential to increase the exposure to environmental microorganisms, and have been associated with the oral carriage of Enterobacteriaceae, such as *Escherichia coli* and intestinal parasite infections.[8–12] It seems likely that thumb-sucking and nail-biting would introduce a wide variety of microbes into the body, thus increasing the diversity of the child's microbiome. If the hygiene hypothesis is correct, it is plausible that this would influence the risk for allergies. There is currently no evidence as to whether thumb-sucking and nail-biting influence immune function or risk for allergy. A recent study found that infants whose mothers "cleaned" their pacifiers by sucking them clean were less likely to develop asthma and eczema.[13] They concluded that immune stimulation secondary to the exchange of maternal oral bacteria might protect against atopy. We hypothesized that the introduction of microbes by thumb-sucking and nail-biting would influence children's immune responses and reduce the risk of developing allergies.

We investigated the effect of thumb-sucking and nail-biting in childhood on the development of atopic sensitization, asthma, and hay fever among participants of the Dunedin Multidisciplinary Health and Development Study, a prospective longitudinal population-based birth cohort study followed to age 38 years.

METHODS

The Dunedin Multidisciplinary Health and Development Study is a population-based birth cohort study of 1037 participants (52% male participants) born in Dunedin in 1972–1973. Dunedin is a coastal city of ~120 000 inhabitants including the surrounding rural areas. The cohort represents the full range of socioeconomic status in the South Island of New Zealand, and the study participants are mostly of New Zealand European ethnicity. Follow-up assessments were completed at ages 3, 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, and 38 years. A full description of the study is reported elsewhere.[14] The Otago Ethics Committee approved the study, and written informed consent was obtained at each assessment.

Thumb-Sucking and Nail-Biting

When the study members were age 5, 7, 9, and 11 years, parents were asked about their child's thumb-sucking and nail-biting status. Parents were asked if the statements "frequently sucks their finger/ thumb" and "frequently bites their nails" applied to their child. They could choose from 3 responses: not at all, somewhat, or certainly. Children were considered to be frequent thumb-suckers or nail-biters if their parents reported that the oral habit in question "certainly" applied to them at least once.

Atopic Sensitization

Skin-prick testing was first undertaken at age 13 years on 70% (724 of 1031) of the study members. Allergens tested included house dust mite (*Dermatophagoides pteronyssinus*; Bencard, Brentford, UK), grass, cat, dog, horse, kapok, wool, *Aspergillus fumigatus, Alternaria, Penicillium,* and *Cladosporium* (Hollister-Stier, Spokane, WA). At age 32 years, skin-prick tests were repeated in 93% (946 of 1015) of the participants by using the same allergens, but obtained from a different manufacturer (ALK, supplied by Allergy Canada, Thornhill, Ontario, Canada), with the addition of cockroach. A positive response to a skin-prick test was defined by a wheal diameter at least 2 mm larger than the negative saline control. Atopic sensitization was defined as having ≥1 positive response to an allergen.[15]

Asthma and Hay Fever

Detailed respiratory assessments have been conducted since age 9 using previously developed questionnaires.[16] Participants were considered to have current asthma if they reported a diagnosis of asthma and had compatible symptoms or treatment in the previous 12 months.[17] Participants were considered to have current hay fever if this was reported at age 13 or 32 years.

Control Variables

A number of potential confounders known to be associated with atopic sensitization in this cohort were considered, including sex

and parental history.[18] The parent attending with the child at age 7 years was asked whether either parent had asthma or hay fever. This information was supplemented with information obtained from the study members themselves at age 18 years. If either parent had a history of atopy or asthma, the child was considered to have a parental history of atopy.[19] At age 3 years, the child's mother was asked about the initiation and duration of breastfeeding. In most cases this was verified from prospective visiting nurse records. Children were considered to be breastfed if breastfeeding continued for ≥4 weeks.[20] Cat and dog ownership from birth to age 9 years was reported from parental recall at age 9 years. Previous analyses of this cohort found that those exposed to both a cat and a dog during childhood had a lower risk of atopic sensitization; therefore, owning both animals was considered a potential confounder.[21] A sensitivity analysis included ownership of each animal separately. Parental smoking history was obtained from a parent when the child was aged 7, 9, and 11 years. At aged 13 years, the study members themselves were also asked about their parents' smoking status. Participants were regarded as being exposed to parental smoking if either parent smoked at any of these ages.[19] An index of household crowding was developed according to the total number of children in the house at the assessment at 3 years, divided by the number of rooms (excluding kitchens and bathrooms; R.J.H., unpublished data). The socioeconomic status (SES) of the families was classified on a 6-point scale based on the income and education levels associated with parental occupations using data from the New Zealand Census. The average of the families' SES over multiple assessments between birth and age 13 years was used for analysis.[22]

TABLE 1 Prevalence of Thumb-Sucking and Nail-Biting in Childhood, and Atopic Sensitization and Asthma at Ages 13 and 32 Years

	Girls n/n%	Boys n/n%	P
Thumb-sucking	97/492 (20)	90/521 (17)	.32
Nail-biting	98/492 (20)	90/521 (17)	.28
Any oral habit	164/492 (33)	153/521 (30)	.17
Atopic sensitization at age 13	132/349 (38)	196/375 (52)	.001
Asthma at age 13	35/355 (10)	60/380 (16)	.017
Hay fever at age 13	99/355 (28)	120/380 (32)	.27
Atopic sensitization at age 32	271/467 (58)	294/479 (61)	.29
Asthma at age 32	83/474 (18)	90/493 (18)	.76
Hay fever at age 32	197/473 (42)	181/495 (37)	.11

Statistical Analysis

Associations between thumb-sucking or nail-biting during childhood and atopic sensitization, asthma, and hay fever at age 13 years were assessed by using binary logistic regression. Atopic sensitization, asthma, or hay fever at age 13 years were the dependent variables, and the presence of either oral habit (thumb-sucking or nail-biting) status was the main predictor. Initial logistic regression analyses assessed whether the effects of oral habits differed between sexes by testing for sex-by-oral habit interactions. These were not significant and therefore both sexes were analyzed together, with an adjustment for sex. Further analyses also adjusted for parental atopy, breastfeeding, cat and dog ownership, parental smoking, household crowding, and socioeconomic status. To assess whether the oral habits had different effects on sensitization to different allergens, additional analyses were performed for the 3 most common sensitizing allergens in this cohort: house dust mite, grass, and cat.[15]

To assess whether any association between thumb-sucking or nail-biting and atopic sensitization, asthma, or hay fever persisted into adulthood, these analyses were repeated for age 32 years. Analyses were performed by using Stata 13 (Stata Corp, College Station, TX). *P* < .05 was considered statistically significant. Analyses used all available data.

RESULTS

Of 1013 children providing data, 317 (31%) had ≥1 oral habit: there was no significant sex difference in prevalence of these habits (Table 1).

Of the 724 children who had skin-prick tests at age 13 years, 328 (45%) showed atopic sensitization. The prevalence of sensitization was lower among children who had an oral habit (38%) compared with those who did not (49%) (*P* = .009). The lower risk of atopic sensitization was similar for thumb-sucking and nail-biting. Children with only 1 habit were less likely to be atopic (40%) than children with no habit at all (49%), but those with both habits had the lowest prevalence of sensitization (31%) (Fig 1). The trend in atopic sensitization across those with neither, 1, or both of these oral habits was statistically significant: *P* = .005.

The associations between oral habits and atopic sensitization remained significant in logistic regression analyses adjusting for sex, and after further adjustment for parental atopy, breastfeeding, cat and dog ownership, parental smoking, household crowding, and SES. Repeating the analyses examining cat and dog ownership separately did not materially affect the findings (data not shown). Further analyses of individual oral habits on their own showed a significant association between thumb-sucking and atopy at age 13 years. Nail-biting also was associated with lower risk of atopic

TABLE 2 Childhood Oral Habits and Atopic Sensitization

	Sex Adjusted			Multiply Adjusted		
	n	OR	(95% CI)	n	OR	(95% CI)
Age 13						
Thumb-sucking or nail-biting	724	0.67	(0.48–0.92)	674	0.64	(0.45–0.90)
Thumb-sucking	724	0.67	(0.70–1.83)	674	0.64	(0.42–0.97)
Nail-biting	724	0.68	(0.46–1.00)	674	0.70	(0.47–1.10)
Age 32						
Thumb-sucking or nail-biting	935	0.61	(0.46–0.81)	748	0.62	(0.45–0.86)
Thumb-sucking	935	0.69	(0.49–0.96)	748	0.69	(0.47–1.00)
Nail-biting	935	0.67	(0.48–0.94)	748	0.71	(0.49–1.02)

Analyses by logistic regression by using atopic sensitization as the dependent variable, and oral habit in childhood as the main predictor. Analyses are adjusted for sex alone, or multiply adjusted for sex, breastfeeding, parental atopy, parental smoking, household crowding, cat and dog ownership, and SES. The differences in n values are caused by missing data for outcome measures or covariates. CI, confidence interval.

**TABLE 3** Childhood Oral Habits and Sensitization to Specific Allergens

	Sex Adjusted			Multiply Adjusted		
	n	OR	(95% CI)	n	OR	(95% CI)
Age 13						
House dust mite	724	0.70	(0.49–1.00)	674	0.70	(0.49–1.02)
Grass	724	0.82	(0.58–1.15)	674	0.84	(0.58–1.21)
Cat	724	0.75	(0.46–1.22)	674	0.69	(0.42–1.16)
Age 32						
House dust mite	935	0.58	(0.44–0.77)	748	0.6	(0.44–0.83)
Grass	935	0.3	(0.55–0.96)	748	0.72	(0.52–1.00)
Cat	934	0.62	(0.43–0.90)	747	0.69	(0.46–1.04)

Analyses by logistic regression by using atopic sensitization as the dependent variable, and oral habit in childhood as the main predictor. Analyses are adjusted for sex alone, or multiply adjusted for sex, breastfeeding, parental atopy, parental smoking, household crowding, cat and dog ownership, and SES. The differences in n values are caused by missing data for outcome measures or covariates.

sensitization at age 13 years when adjusted for sex, but this was of borderline statistical significance when multiply adjusted (Table 2). Overall, children manifesting 1 or both of these oral habits had ~30% to 40% reduction in the risk of atopic sensitization across all analyses, whether statistically significant or of borderline significance.

Thumb-sucking and nail-biting also were associated with a lower prevalence of atopic sensitization in both sex-adjusted and multiply-adjusted analyses at age 32 years (Table 2). The pattern of findings was similar for both thumb-sucking and nail-biting when considered individually, but these associations were of borderline statistical significance in the multiply-adjusted analyses.

None of the associations between oral habits and atopic sensitization to specific allergens (house dust mite, cat, and grass) were
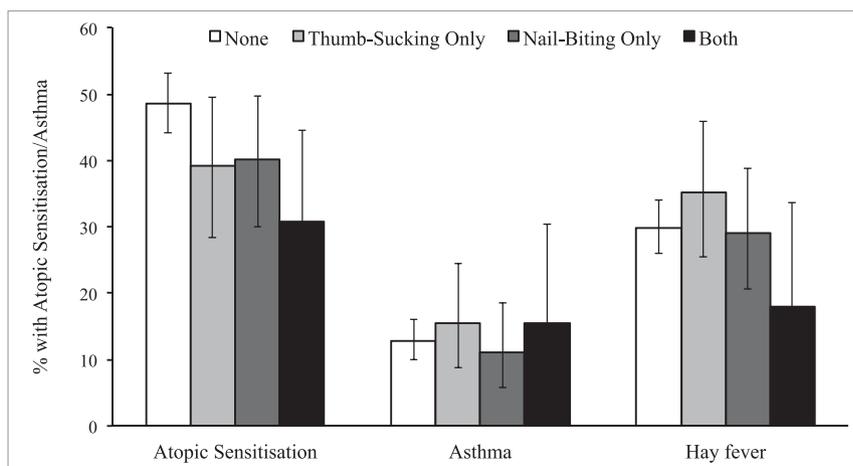
FIGURE 1
Prevalence of atopic sensitization and asthma in children aged 13 years with a history of thumb-sucking or nail-biting. Error bars show the 95% confidence intervals. The statistical significance of differences between oral habit categories from χ^2 tests are $P = .05$ for atopy, $P = .76$ for asthma, and $P = .27$ for hay fever.

statistically significant in sex-adjusted analyses at age 13, but all of these associations were significant at age 32 years. In the multiply-adjusted analyses, there were no significant associations

at age 13, whereas at age 32 the reduced odds of house dust mite sensitization remained significant but the associations with grass and cat sensitization were of borderline statistical significance (Table 3).

LYNCH et al

TABLE 4 Childhood Oral Habits and Asthma

	Sex Adjusted			Multiply Adjusted		
	n	OR	(95% CI)	n	OR	(95% CI)
Age 13						
Thumb-sucking or nail-biting	735	1.01	(0.68–1.71)	683	1.13	(0.70–1.84)
Thumb-sucking	735	1.34	(0.78–2.30)	683	1.40	(0.80–2.50)
Nail-biting	735	0.91	(0.52–1.60)	683	0.98	(0.55–1.78)
Age 32						
Thumb-sucking or nail-biting	955	1.14	(0.80–1.61)	760	1.34	(0.91–1.98)
Thumb-sucking	955	1.34	(0.90–2.00)	760	1.52	(0.96–2.40)
Nail-biting	955	1.16	(0.77–1.74)	760	1.30	(0.83–2.05)

Analyses by logistic regression by using asthma as the dependent variable, and oral habit in childhood as the main predictor. Analyses are adjusted for sex alone, or multiply adjusted for sex, breastfeeding, parental atopy, parental smoking, crowding, cat and dog ownership, and SES. The differences in n values are caused by missing data for outcome measures or covariates.

TABLE 5 Childhood Oral Habits and Hay Fever

	Sex Adjusted			Multiply Adjusted		
	n	OR	(95% CI)	n	OR	(95% CI)
Age 13						
Thumb-sucking or nail-biting	735	1.00	(0.71–1.40)	683	1.05	(0.73–1.51)
Thumb-sucking	735	1.03	(0.68–1.55)	683	1.07	(0.69–1.66)
Nail-biting	735	0.80	(0.53–1.21)	683	0.88	(0.56–1.36)
Age 32						
Thumb-sucking or nail-biting	956	0.97	(0.74–1.29)	761	1.12	(0.82–1.55)
Thumb-sucking	956	1.01	(0.72–1.41)	761	1.13	(0.77–1.65)
Nail-biting	956	0.84	(0.60–1.17)	761	0.91	(0.63–1.33)

Analyses by logistic regression by using hay fever as the dependent variable, and oral habit in childhood as the main predictor. Analyses are adjusted for sex alone, or multiply adjusted for sex, breastfeeding, parental atopy, parental smoking, crowding, cat and dog ownership, and SES. The differences in n values are caused by missing data for outcome measures or covariates.

Sensitivity analyses using a 3-mm cutpoint to define a positive skin-prick test showed a similar pattern of findings with a significant reduction in sensitization at both ages 13 and 32 (sex-adjusted odds ratios [ORs]: 0.63 [P = .007] and 0.56 [P < .001], respectively). Children who had sucked their thumbs or bit their nails in childhood had a lower total number positive skin-prick tests at age 13 than those who had not (Wilcoxon rank sum test: P = .0297) and the sum of weal sizes across all 11 skin-prick tests was also less among those who had an oral habit in childhood (P = .043). Similarly, by age 32 those who had sucked their thumbs or bit their nails had fewer positive skin-prick tests (P < .001) and the sum of all 12 weal sizes was lower than among those who had not (P < .001).

At age 13 years, 95 (12.9%) of 735 children were asthmatic and 219 (29.8%) of 735 children reported

current hay fever (Table 1). There was no evidence that oral habits in childhood were associated with asthma (13.3% vs 12.8% for those with and without oral habits respectively: P = .8) or hay fever (29.6% vs 29.9%: P = .9) at age 13 years. Nor was there a significant association with specific habits (Fig 1). There were no statistically significant associations between thumb-sucking and nail-biting and asthma or hay fever at ages 13 or 32 years in either sex-adjusted or multiply-adjusted analyses (Tables 4 and 5).

DISCUSSION

The findings from this study support our hypothesis that children who frequently suck their thumbs or bite their nails have a lower risk of developing atopic sensitization. Children who were reported to have either of these habits were

less likely to have positive skin-prick tests at age 13 years and this apparent protective effect persisted to age 32 years. These associations were independent of sex, a parental history of atopy, and a variety of environmental factors known to be associated with atopic sensitization within this cohort.

There also appeared to be a dose-response relationship for atopic sensitization at age 13: those who had both oral habits had a lower incidence of atopic sensitization than those who had only 1 (Fig 1). This dose-response was not apparent at age 32, however (not shown). When habits were assessed individually, it appeared that thumb-sucking and nail-biting had similar associations with reduced prevalence of atopic sensitization; however, when multiply-adjusted, nail-biting on its own did not reach statistical significance (Table 2). Post hoc analyses showed little evidence

that having these oral habits at >1 age was associated with a lower risk of allergic sensitization than at just 1 age. Nor did we find that the association was substantially different for different ages, with the exception that oral habits at age 11 appeared to have weaker associations with a reduced risk of sensitization.

By contrast, we did not find any association between thumb-sucking and nail-biting with asthma or hay fever at either age 13 or 32 years. The reasons for this inconsistency are unclear. Although asthma and hay fever are often associated with atopy, there are other contributing factors. Only approximately one-third of childhood asthma is attributable to atopy in this and other studies.[23] The development of asthma is less clearly linked to immune function than atopy.[24] In addition, both asthma and hay fever were based on reported diagnoses and symptoms and are therefore more subjective than the outcomes of skin-prick tests.

The findings of this study are consistent with those of the pacifier study by Hesselmar et al,[13] who found that children whose mothers sucked their pacifiers clean were less likely to develop allergies. Although the mechanism and age of exposure are different, both studies suggest that the immune response and risk of allergies may be influenced by exposure to oral bacteria or other microbes. It is known that the gut microbiome can alter the function of TH cell subsets and thereby influence TH-1 and TH-2 responses and the development of immune tolerance.[25] Our findings lend support to the hygiene hypothesis that avoiding oral environmental microbial exposures increases the risk for allergic sensitization to inhaled allergens.

Strengths of this study include multiple assessments of exposure in a large population-based cohort of children with a high rate of follow-up. We are able to adjust for a wide range of potential environmental and familial confounding factors. We have data on thumb-sucking and nail-biting habits only during primary school ages (5–11 years) and not for the preschool years and we do not know whether children had already developed atopic sensitization before information on these oral habits was gathered. However, it seems unlikely that childhood sensitization would influence subsequent thumb-sucking and nail-biting habits. Hence, we believe that the findings are unlikely to be explained by reverse causation. In addition, our primary outcome measure, atopic sensitization, was objectively assessed by skin-prick tests. Habit status, however, was based on parental reports and there will be some errors in these. Although only those who "certainly" sucked their thumbs or bit their nails frequently were considered to be exposed, some parents may have been unwilling to report that their child sucked his or her thumb, or bit his or her nails. The choice of answers provided to the parents, "not at all," "somewhat," and "certainly," are also open to interpretation by the individual. However, it seems unlikely that misreporting would be systematically different between parents whose children did or did not have atopic sensitization, and nondifferential reporting errors would tend to bias the associations toward the null value. A limitation is that at age 13 years, only 70% of the participants consented to skin-prick tests; however, those who were not tested at age 13 had a similar prevalence of atopic sensitization at age 32 years compared with those who were tested (56% vs 60% P = .22).[19]

Thumb-sucking and nail-biting are often seen as undesirable habits and are discouraged by many parents,[26] and numerous studies have assessed interventions to stop these habits.[27] There is some evidence that these habits are associated with dental malocclusion[28–30] and gingival injury,[31] and that they can also cause local hand infections.[32–34] Spontaneous correction of some oral malocclusions can occur if thumb-sucking habits are stopped before dental development progresses,[35,36] but there is limited research on the long-term effects of these habits on oral health. Our findings suggest that these habits also may have some beneficial effects: although we did not find an impact of these habits on asthma or hay fever, the reduction in atopic sensitization may have long-term health benefits. Further investigation of the long-term effects of these childhood habits is warranted.

To our knowledge this is the first study to explore the association between the effects of thumb-sucking and nail-biting and the prevalence of atopic sensitization and asthma. We found that there was a lower prevalence of atopic sensitization among teenagers and adults who had had these habits during childhood. These results contribute to the body of evidence supporting the hygiene hypothesis. Although we do not suggest that children should be encouraged to take up these oral habits, the findings suggest that thumb-sucking and nail-biting reduce the risk for developing sensitization to common aeroallergens.

ABBREVIATIONS

CI: confidence interval
OR: odds ratio
SES: socioeconomic status
TH: T helper

LYNCH et al

REFERENCES

1. Strachan DP. Hay fever, hygiene, and household size. *BMJ.* 1989;299(6710):1259–1260

2. Prokopakis E, Vardouniotis A, Kawauchi H, et al. The pathophysiology of the hygiene hypothesis. *Int J Pediatr Otorhinolaryngol.* 2013;77(7): 1065–1071

3. Matricardi PM. 99th Dahlem conference on infection, inflammation and chronic inflammatory disorders: controversial aspects of the 'hygiene hypothesis'. *Clin Exp Immunol.* 2010;160(1):98–105

4. Kharbanda OP, Sidhu SS, Sundaram K, Shukla DK. Oral habits in school going children of Delhi: a prevalence study. *J Indian Soc Pedod Prev Dent.* 2003;21(3):120–124

5. Foster LG. Nervous habits and stereotyped behaviors in preschool children. *J Am Acad Child Adolesc Psychiatry.* 1998;37(7):711–717

6. Rajchanovska D, Zafirova BI. Prevalence of nail biting among preschool children in Bitola. *J Spec Educ Rehab.* 2011;12(1-2):56–68

7. Garde JB, Suryavanshi RK, Jawale BA, Deshmukh V, Dadhe DP, Suryavanshi MK. An epidemiological study to know the prevalence of deleterious oral habits among 6 to 12 year old children. *J Int Oral Health.* 2014;6(1):39–43

8. Baydaş B, Uslu H, Yavuz I, Ceylan I, Dağsuyu İM. Effect of a chronic nail-biting habit on the oral carriage of Enterobacteriaceae. *Oral Microbiol Immunol.* 2007;22(1):1–4

9. Kamal FG, Bernard RA. Influence of nail biting and finger sucking habits on the oral carriage of Enterobacteriaceae. *Contemp Clin Dent.* 2015;6(2):211–214

10. Reddy S, Sanjai K, Kumaraswamy J, Papaiah L, Jeevan M. Oral carriage of Enterobacteriaceae among school children with chronic nail-biting habit. *J Oral Maxillofac Pathol.* 2013;17(2): 163–168

11. Bello J, Núñez FA, González OM, Fernández R, Almirall P, Escobedo AA. Risk factors for Giardia infection among hospitalized children in Cuba. *Ann Trop Med Parasitol.* 2011;105(1):57–64

12. Sah RB, Bhattarai S, Yadav S, Baral R, Jha N, Pokharel PK. A study of prevalence of intestinal parasites and associated risk factors among the school children of Itahari, Eastern Region of Nepal. *Trop Parasitol.* 2013;3(2):140–144

13. Hesselmar B, Sjöberg F, Saalman R, Åberg N, Adlerberth I, Wold AE. Pacifier cleaning practices and risk of allergy development. *Pediatrics.* 2013;131(6). Available at: www.pediatrics.org/cgi/content/full/131/6/e1829

14. Poulton R, Moffitt TE, Silva PA. The Dunedin Multidisciplinary Health and Development Study: overview of the first 40 years, with an eye to the future. *Soc Psychiatry Psychiatr Epidemiol.* 2015;50(5):679–693

15. Sears MR, Herbison GP, Holdaway MD, Hewitt CJ, Flannery EM, Silva PA. The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. *Clin Exp Allergy.* 1989;19(4):419–424

16. Sears MR, Greene JM, Willan AR, et al. A longitudinal, population-based, cohort study of childhood asthma followed to adulthood. *N Engl J Med.* 2003;349(15):1414–1422

17. Belsky DW, Shalev I, Sears MR, et al. Is chronic asthma associated with shorter leukocyte telomere length at midlife? *Am J Respir Crit Care Med.* 2014;190(4):384–391

18. Sears MR, Burrows B, Flannery EM, Herbison GP, Holdaway MD. Atopy in childhood. I. Gender and allergen related risks for development of hay fever and asthma. *Clin Exp Allergy.* 1993;23(11):941–948

19. Hancox RJ, Welch D, Poulton R, et al. Cigarette smoking and allergic sensitization: a 32-year population-based cohort study. *J Allergy Clin Immunol.* 2008;121(1):38–42.e3

20. Sears MR, Greene JM, Willan AR, et al. Long-term relation between breastfeeding and development of atopy and asthma in children and young adults: a longitudinal study. *Lancet.* 2002;360(9337):901–907

21. Mandhane PJ, Sears MR, Poulton R, et al. Cats and dogs and the risk of atopy in childhood and adulthood. *J Allergy Clin Immunol.* 2009;124(4):745–750.e4

22. Hancox RJ, Milne BJ, Taylor DR, et al. Relationship between socioeconomic status and asthma: a longitudinal cohort study. *Thorax.* 2004;59(5):376–380

23. Pearce N, Pekkanen J, Beasley R. How much asthma is really attributable to atopy? *Thorax.* 1999;54(3):268–272

24. Lambrecht BN, Hammad H. The immunology of asthma. *Nat Immunol.* 2015;16(1):45–56

25. Riiser A. The human microbiome, asthma, and allergy. *Allergy Asthma Clin Immunol.* 2015;11:35

26. healthychildren.org. Common childhood habits. 2015. Available at: https://www.healthychildren.org/English/family-life/family-dynamics/communication-discipline/Pages/Common-Childhood-Habits.aspx. Accessed February 5, 2016

27. Borrie FRP, Bearn DR, Innes NPT, Iheozor-Ejiofor Z. Interventions for the cessation of non-nutritive sucking habits in children. *Cochrane Database Syst Rev.* 2015;(3):CD008694

28. Omer MI, Abuaffan AH. Prevalence of oral habits and its effect in primary dentition among Sudanese preschool children in Khartoum City. *Ind J Dent Edu.* 2015;8(2):57–62

29. Kamdar RJ, Al-Shahrani I. Damaging oral habits. *J Int Oral Health*. 2015;7(4):85–87

30. Moimaz SA, Garbin AJ, Lima AM, Lolli LF, Saliba O, Garbin CA. Longitudinal study of habits leading to malocclusion development in childhood. *BMC Oral Health*. 2014;14:96

31. Alessandri Bonetti G, Incerti Parenti S, Zucchelli G. Onychophagia and postorthodontic isolated gingival recession: diagnosis and treatment. *Am J Orthod Dentofacial Orthop*. 2012;142(6):872–878

32. Harness N, Blazar PE. Causative microorganisms in surgically treated pediatric hand infections. *J Hand Surg Am*. 2005;30(6):1294–1297

33. Shafritz AB, Coppage JM. Acute and chronic paronychia of the hand. *J Am Acad Orthop Surg*. 2014;22(3):165–174

34. Singal A, Khanna D. Onychomycosis: diagnosis and management. *Indian J Dermatol Venereol Leprol*. 2011;77(6):659–672

35. Góis EG, Vale MP, Paiva SM, Abreu MH, Serra-Negra JM, Pordeus IA. Incidence of malocclusion between primary and mixed dentitions among Brazilian children. A 5-year longitudinal study. *Angle Orthod*. 2012;82(3):495–500

36. Dimberg L, Lennartsson B, Söderfeldt B, Bondemark L. Malocclusions in children at 3 and 7 years of age: a longitudinal study. *Eur J Orthod*. 2013;35(1):131–137

Thumb-Sucking, Nail-Biting, and Atopic Sensitization, Asthma, and Hay Fever
Stephanie J. Lynch, Malcolm R. Sears and Robert J. Hancox
Pediatrics originally published online July 11, 2016;

Updated Information & Services	including high resolution figures, can be found at: http://pediatrics.aappublications.org/content/early/2016/07/07/peds.2 016-0443
References	This article cites 35 articles, 4 of which you can access for free at: http://pediatrics.aappublications.org/content/early/2016/07/07/peds.2 016-0443#BIBL
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): **Allergy/Immunology** http://www.aappublications.org/cgi/collection/allergy:immunology_s ub **Asthma** http://www.aappublications.org/cgi/collection/asthma_sub
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.aappublications.org/site/misc/Permissions.xhtml
Reprints	Information about ordering reprints can be found online: http://www.aappublications.org/site/misc/reprints.xhtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Thumb-Sucking, Nail-Biting, and Atopic Sensitization, Asthma, and Hay Fever
Stephanie J. Lynch, Malcolm R. Sears and Robert J. Hancox
Pediatrics originally published online July 11, 2016;

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN®