

Original Article

Increased Rates of Peanut and Tree Nut Aspiration as a Possible Consequence of Allergy Prevention by Early Introduction

James Leung, MBBS, MSc^a, John Ainsworth, MBBS, FRACP^{b,c}, Rachel Peters, MPH, PhD^{d,e},

Sam Mehr, MBBS, FRACP^{b,c,d}, Joanne Smart, PhD, FRACP^{b,c,d}, and Elizabeth Rose, MBBS, FRACS^a Melbourne and Richmond, VIC, Australia

What is already known about this topic? Studies and guidelines on allergy prevention are encouraging early ingestion of allergens to prevent food allergy. Peanuts and tree nuts are choking hazards for infants and young children.

What does this article add to our knowledge? We noted a rise in food aspiration in young children since the publication of the Learning Early About Peanut allergy study.

How does this study impact current management guidelines? The observation suggests that earlier introduction of hard foods for prevention purposes could be driving increased aspiration, and there is therefore an urgent need to educate parents and carers about safe solid food introduction in children.

BACKGROUND: Pediatric airway foreign bodies (FBs) are a surgical emergency, and peanuts and tree nuts (PN/TNs) can pose a significant aspiration risk in young children. In 2015, the Learning Early About Peanut allergy (LEAP) trial established that early introduction of peanuts in high-risk infants reduced the risk of developing a peanut allergy. Infant feeding guidelines were subsequently modified to actively encourage the introduction of allergenic foods for all infants. The impact of this shift in feeding advice on the incidence of PN/TN inhalation has not been previously studied.

OBJECTIVE: To determine the incidence of PN/TN inhalation presentations to a quaternary pediatric hospital between 2008 and 2018.

METHODS: A retrospective cohort study of children who were diagnosed with an airway FB by rigid bronchoscopy.

RESULTS: There were 200 cases of FB inhalation (35% PN/TN, 34% other foods, and 31% inorganic material). There was a rise in the total incidence of FB inhalation over the study period (incidence ratio rate [IRR], 1.09; $P < .001$). The rise was due to PN/TN (IRR, 1.16; $P < .002$) and other food inhalation (IRR, 1.12; $P = .01$), with no significant increase in inorganic FB aspiration (IRR, 1; $P = .94$). Between pre-LEAP (2008-2014) and post-LEAP (2015-2018) periods, there was a trebling, doubling, and no increase in the rate of PN/TN, other food, and inorganic FB inhalation, respectively.

CONCLUSIONS: Since the publication of the LEAP study, there has been a rise in PN/TN and other hard solid food inhalation at our institution. This study highlights the urgent need to engage the public to promote safe introduction of hard foods in young children. © 2021 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2021;■:■-■)

Key words: Airway; Aspiration; Foreign body; Inhalation; LEAP; Nut; Peanut; Pediatrics; Tree nut

^aPaediatric Otolaryngology Head and Neck Surgery Unit, The Royal Children's Hospital, Parkville, Melbourne, VIC, Australia

^bPaediatric Allergy and Immunology Unit, The Royal Children's Hospital, Parkville, Melbourne, VIC, Australia

^cEpworth Allergy Specialists & Centre for Paediatric Allergies, Epworth Hospital, Richmond, VIC, Australia

^dMurdoch Children's Research Institute, Parkville, Melbourne, VIC, Australia

^eDepartment of Paediatrics, The University of Melbourne, Parkville, VIC, Australia
This research was conducted at the Royal Children's Hospital, 50 Flemington Road, Parkville, Melbourne, VIC 3052, Australia.

Conflict of interest: R. L. Peters holds an Australian National Health & Medical Research Council award. The rest of the authors declare that they have no relevant conflicts of interest.

Received for publication August 25, 2020; revised March 26, 2021; accepted for publication March 29, 2021.

Available online ■■

Corresponding author: James Leung, MBBS, MSc, Paediatric Otolaryngology Head and Neck Surgery Unit, The Royal Children's Hospital, 50 Flemington Rd, Parkville, Melbourne, VIC 3052, Australia. E-mail: j_leung1@hotmail.com.

2213-2198

© 2021 American Academy of Allergy, Asthma & Immunology

<https://doi.org/10.1016/j.jaip.2021.03.052>

INTRODUCTION

Pediatric airway foreign bodies (FBs) are a surgical emergency because they can lead to significant complications including pneumonia, bronchiectasis, abscess formation, and airway obstruction causing death.¹ Whole or crushed peanuts and tree nuts (PN/TNs) pose a particularly significant aspiration risk in young children because children lack the adequate dentition and oromotor skills to safely handle small and hard food types.² In February of 2015, the Learning Early About Peanut allergy (LEAP) trial was published, and established that early introduction of peanuts before age 12 months reduced the risk of developing a peanut allergy in infants with moderate to severe eczema and/or IgE-mediated egg allergy.³ This finding was

Abbreviations used

ASCIA- Australasian Society for Clinical Immunology & Allergy

FB- foreign body

IR- incidence rate

IRR- incidence ratio rate

LEAP- Learning Early About Peanut allergy

PN/TN- peanut and tree nut

supported by the Enquiring About Tolerance study, albeit on a per-protocol basis.⁴ In response to these findings, allergy and immunology societies across the world, including the Australasian Society of Clinical Immunology and Allergy (ASCIA), updated their infant feeding guidelines to actively encourage the introduction of allergenic foods in all infants.⁵ The impact of these studies and subsequent modification of infant feeding guidelines resulted in a change in Australian infant feeding behavior, with the rate of peanut introduction in the first year of life increasing from 28% of infants between 2007 and 2011 to 89% by 2018.⁶ The impact of this shift in feeding behavior on the incidence of PN/TN inhalation has not been studied.

We aimed to determine the incidence of PN/TN inhalation presentations to a quaternary pediatric hospital from 2008 to 2018, and to investigate whether the rate of PN/TN inhalation in children increased following the publication of the LEAP trial in 2015.

METHODS

This retrospective cohort study was conducted at the Royal Children's Hospital, Melbourne, Australia. It included all pediatric patients, younger than 18 years, admitted to the Royal Children's Hospital who were diagnosed with an airway FB by rigid bronchoscopy between January 2008 and December 2018. This study was approved by the Royal Children's Hospital Human Research Ethics Committee (QA/54390/RCHM-2018-151085).

Study subjects were identified using 2 Australian Medicare Benefits Schedule surgical billing codes: 41895 (bronchus, removal of foreign body in) or 41886 (trachea, removal of foreign body in). Once subjects had been identified, data were extracted from their electronic medical record (Epic Systems Corporation, Verona, Wis). Demographic data, clinical and radiological features at the time of presentation, intraoperative findings, and postoperative complications were recorded.

Information collected included age, sex, history of an acute coughing or choking episode, refractory cough and/or wheeze, patient acknowledgment of FB aspiration, respiratory distress, need for intensive care unit admission, operative duration, type of FB, site of FB impaction, need for a second rigid bronchoscopy, antibiotic and corticosteroid use at discharge, the need for readmission, and mortality.

Subjects were grouped into type of inhaled FBs: PN/TNs, other foods, or inorganic material. Peanuts and tree nuts were grouped together because they are recognized as analogous "allergenic" foods to be introduced into infants' diets, and are texturally comparable as small, hard foods that pose similar risks when aspirated by young children. Sites of FB impaction were classified into either upper airways (proximal to the carina), right lung subsites (inclusive of and distal to right main bronchus), or left lung subsites (inclusive of and distal to left main bronchus).

Rigid bronchoscopy is currently the criterion standard for the diagnosis and retrieval of pediatric airway FBs, and is used as first-line surgical management at our institution.⁷ Flexible bronchoscopy is occasionally used in conjunction with rigid bronchoscopy to aid in the diagnosis of airway FBs and the exclusion of airway FBs in the distal bronchial tree.

An acute choking or coughing episode was defined as a reported witnessed or unwitnessed episode of coughing or choking in direct relation to the ingestion of an FB suggestive of aspiration. A refractory cough or wheeze was defined as a patient who had a persistent cough or wheeze for longer than 4 weeks in which all other diagnoses were excluded and/or already treated.⁸

The need for a second rigid bronchoscopy under general anesthetic was primarily warranted in those subjects who had persistent features of a possible retained airway FB despite already having had a rigid bronchoscopy. This may have been due to numerous factors including a slow recovery outside of clinical expectations, or a predetermined second bronchoscopy being warranted because of an unfavorable clinical situation during the initial bronchoscopy.

Readmission was defined as the need for subsequent inpatient admission for a complication secondary to FB aspiration. Complications included secondary respiratory tract infection or respiratory distress.

Statistical analysis

Demographic and clinical characteristics of study patients were compared across the FB subgroups (PN/TNs, other foods, and inorganic material) using a χ^2 test for categorical variables and the nonparametric Kruskal-Wallis equality-of-populations rank test for continuous variables.

The incidence rate was calculated as the number of new cases of FB inhalation per year divided by the total population of Victorian children at risk in the same time period. The number of children at risk per year was estimated as the total population of Victorian children as reported by the Australian Bureau of Statistics.⁹ The comparison of incidence and trends of FB inhalation over time was assessed using Poisson regression, presented as incidence rate ratios (IRRs) with corresponding 95% CIs. The goodness-of-fit χ^2 test was used to assess whether the Poisson model form fit our data; all *P* values for these tests were greater than .1 (data not shown), which indicates that the Poisson model fit the observed data reasonably well. Overall and age-specific incidence rates were presented and stratified by FB type. Subjects were divided into 3 age groups: 0 to younger than 3 years, 3 years to younger than 5 years, and 5 years or older to younger than 18 years. These age groups were determined first by the Australian National Health & Medical Research Council infant feeding guidelines, which recommend that whole PN/TNs should not be given to children younger than 3 years,¹⁰ and second by other global national guidelines, namely in the United Kingdom and New Zealand, that recommend that whole PN/TNs should not be given to children younger than 5 years.^{11,12}

RESULTS

There were 200 cases of FB inhalation between 2008 and 2018. Eleven cases of FB inhalation were excluded from the analysis, because the type of FB was not specified (*n* = 5) or could not be categorized into 1 of the 3 subgroups (grape twig [*n* = 1], grass seeds [*n* = 1], insect [*n* = 1], and plant material [*n* = 3]). The median age of presentation was 21 months (interquartile range, 15-35), 63% were males, and 14% required an intensive care unit admission. No death from FB inhalation

TABLE I. Demographic and clinical characteristics of children presenting with FB inhalation (n = 189)

Characteristic	PN/TN (n = 66), %	Other food (n = 65), %	Inorganic (n = 58), %	P value
Demographic				
Sex (male)	58	63	67	.54
Age (mo), median (IQR)	21 (15-26)	20 (15-32)	26 (13-125)	.27
Treatment/surgical history				
Operative time (min), median (IQR)	38 (23-54)	33 (20-51)	30 (22-49)	.29
Days of admission, median (IQR)	1.0 (0.7- 1.9)	0.8 (0.7-1.1)	0.8 (0.2-1.3)	.05
Flexible bronchoscopy	15	6	9	.21
Need for second rigid bronchoscopy	11	5	7	.42
ICU admission	12	3	12	.12
Antibiotics on discharge	27	17	21	.35
Steroids on discharge	8	3	3	.41
Readmission	8	5	0	.11
Clinical history				
Coughing/choking episodes	92	92	74	.003
Child acknowledgment	0	0	17	<.001
Refractory wheeze/cough	27	22	17	.40
Respiratory distress	15	12	19	.59
Physical examination				
Wheeze	67	71	47	.014
Cough	50	54	31	.03
Decreased air entry	45	60	14	<.001
Stridor	11	11	29	.006
Increased work of breathing	39	40	31	.52
Visual findings on X-ray				
Gas trapping	48	52	24	.003
FB visible on X-ray	2	2	36	<.001
Atelectasis	12	6	3	.16
Consolidation	12	8	5	.37
Site of FB				
Right only	48	56	43	<.001
Left only	38	34	24	
Left and right	8	3	0	
Upper	6	6	33	
≥2 sites	15	14	0	.009

ICU, Intensive care unit; IQR, interquartile range.

Bold values indicate statistical significant ($P < .05$).

was recorded. There were no differences between the groups with respect to median age of presentation or sex distribution (Table I).

The FB subgroups were 35% PN/TNs, 34% other foods, and 31% inorganic material. The most common food FBs were tree nuts (n = 39), peanut (n = 27; 3 were from crunchy peanut butter spread and the rest whole or crushed peanut), carrot (n = 22), and apple (n = 9). Tree nuts included almonds (n = 13), pistachios (n = 8), walnuts (n = 5), cashews (n = 5), hazelnuts (n = 1), and nuts-not otherwise specified (n = 7) (Table II).

Children who aspirated PN/TNs or other foods were more likely than those with inorganic FB aspiration to have had an acute coughing/choking episode, examination features of cough, wheeze, and decreased air entry, radiological features of gas trapping, and multiple sites of lodgment ($P < .05$ for all analyses; Table I).

Children who aspirated inorganic FBs were more likely to present with a history acknowledging FB aspiration, and have clinical features suggestive of upper airway obstruction (such as

stridor). Inorganic FBs were more likely to be radiopaque on chest X-ray, and found in the upper airway ($P < .05$ for all analyses; Table I).

There was a significant rise in the total incidence of FB inhalation over the study period (IRR, 1.09; 95% CI, 1.04-1.15; $P < .001$) (Figure 1, A; see Table E1 in this article's Online Repository at www.jaci-inpractice.org). The rise in FB inhalation was largely due to PN/TNs (IRR, 1.16; 95% CI, 1.07-1.26; $P < .001$) and other food inhalation (IRR, 1.12; 95% CI, 1.04-1.22; $P = .005$), whereas there was no significant increase in inorganic FB aspiration over the study period (IRR, 1; 95% CI, 0.92-1.09; $P = .97$) (Figure 1, A; Table E1). Age stratification identified that the rise in FB aspiration occurred primarily in children younger than 3 years, with a statistically significant increase in both PN/TN inhalation (IRR, 1.14; 95% CI, 1.04-1.24; $P = .002$) and other food inhalation (IRR, 1.12; 95% CI, 1.02-1.23; $P = .014$) (Figure 1, B and C; see Table E2 in this article's Online Repository at www.jaci-inpractice.org). The rise in the incidence of PN/TN inhalation was most significant in children

TABLE II. Type and number of airway FBs

PN/TN		Other food		Inorganic	
Type	n	Type	n	Type	n
Peanut	27	Carrot	22	Plastic	17
Almond	13	Apple	9	Pin	11
Pistachio	8	Popcorn	5	Stone	6
Nut, NOS	7	Chicken	4	Lego	5
Cashew	5	Bone (fish/chicken)	3	Metallic	4
Walnut	5	Corn	2	Pen parts	3
Hazelnut	1	Food, NOS	2	Tooth	3
		Meat	2	Wood	3
		Seeds	2	Crayon	1
		Baked bean	1	Earring	1
		Biscuit	1	LED light	1
		Bread	1	Pendant	1
		Broadbean	1	Rubber	1
		Chickpea	1	Seashell	1
		Gooseberry	1		
		Grape	1		
		Lentil	1		
		Mandarin pip	1		
		Pea	1		
		Prune	1		
		Pumpkin seed	1		
		Sausage	1		
		Toast	1		

NOS, Not otherwise specified.

aged between 2 years and younger than 3 years (IRR, 1.29; 95% CI, 1.09-1.51; $P = .002$), compared with those children aged between 1 year and younger than 2 years (IRR, 1.07; 95% CI, 0.97-1.19; $P = .18$) and younger than 1 year (IRR, 1.02; 95% CI, 0.71-1.46; $P = .92$) (Figure 2; see Table E3 in this article's Online Repository at www.jaci-inpractice.org). Outside of the 0- to 3-year age group, the incidence rate of airway FB inhalation across all subgroups remained stable throughout the study period, indicating that the rise in airway FB aspiration was an age-specific morbidity (Figure 1, B-D; see Table E2). No child older than 5 years had a nut inhalation episode during the study period (Figure 1, B; see Table E2).

The rise in rate of PN/TN inhalation commenced after 2015, and persisted thereafter, with a trebling of the incidence rate from 2008 to 2014 (pre-LEAP averaged incidence rate [IR] of 2.54 per million person years vs post-LEAP averaged IR of 8.07 per million person years) (Figure 1, A; Table E1). This is compared with a doubling of the rate to other foods (pre-LEAP averaged IR of 3.34 per million person years vs post-LEAP averaged IR of 6.59 per million person years), and no increase in the rate to inorganic material (pre-LEAP averaged IR of 4.10 per million person years vs post-LEAP averaged IR of 4.20 per million person years) (Figure 1, A; Table E1). The most dramatic increase was seen in children younger than 3 years to nuts (pre-LEAP averaged IR 14.54 per million person years vs post-LEAP averaged IR 41.59 per million person years) and other foods (pre-LEAP averaged IR 13.9 per million person years vs post-LEAP averaged IR 30.2 per million person years) (Figure 1, B and C; see Table E2).

DISCUSSION

We found an increase in PN/TN inhalation presentations in children presenting to our institution since the publication of the LEAP trial in 2015. This increase was predominantly observed in children younger than 3 years (particularly in those aged between 2 years and <3 years), with no occurrences of PN/TN aspiration observed in children older than 5 years. To our knowledge, this is the first study to explore the potential morbidities associated with the early introduction of PN/TN in the post-LEAP allergy era.

The LEAP allergy trial demonstrated that the early introduction of peanuts was an effective strategy in reducing peanut allergy in high-risk atopic infants.³ Before this trial, infant feeding guidelines in 2000 recommended that high-risk infants should avoid peanuts until the age of 3 years.¹³ Infant feeding guidelines were subsequently updated in 2008 and stated that there was insufficient evidence to support the idea that delaying or avoiding the introduction of potentially allergenic foods was an effective strategy to prevent food allergy.^{13,14} Despite this change in guidelines, Tey et al¹⁵ demonstrated only a small increase in infant peanut consumption following this revision. Our study did show an increase in the IR of PN/TN aspiration in children aged between 1 year and younger than 2 years from 2008 to 2010 compared with 2011 to 2014. This could represent a reflexive, but ultimately unsustainable, response to the changes made in the 2008 guidelines, culminating in increased exposure of PN/TNs in young children, and as such, a rise in PN/TN inhalation.

Post-LEAP, however, there was a subsequent paradigm shift in allergy and immunology guidelines to encourage the early introduction of peanuts in high-risk infants, which was extrapolated to all PN/TNs in general and other allergenic foods, and to the general population.^{5,16} In the post-LEAP era, we found a significant increase in PN/TN and other food inhalation, and exclusively in children 0 to 3 years old. However, there was no increase in inorganic FB inhalation, which remained static throughout the study period.

We suspect that the rapid rise in PN/TN inhalation since 2015 is multifactorial. These factors include the early adoption of the LEAP trial recommendations publicized through the mainstream media rather than via infant feeding guidelines, the wider extrapolation of the LEAP trial findings to include other potentially allergenic foods (ie, tree nuts), the lack of explicit safety recommendations in infant feeding guidelines with regard to hazardous food in children older than 1 year, and the inherent anatomical and developmental inadequacies in young children to handle small and hard foods.

The publication of the LEAP trial in early 2015 garnered immense attention from mainstream media. The findings were broadly and rapidly publicized, and it is possible this accelerated the promotion of early PN/TN introduction, before any alteration of infant feeding guidelines. This is supported by our findings of a trebling of PN/TN inhalation from 2014 to 2015, whereas ASCIA infant feeding guidelines were modified only in 2016. Potentially, the updated ASCIA infant feeding guidelines in 2016 then reinforced the message of the importance of early PN/TN introduction. Furthermore, although strictly speaking the LEAP trial recommendations were about early peanut introduction, we suspect these recommendations were extrapolated and expanded to include tree nuts, because they were likely to be considered as analogous allergenic food groups by the general public. Given that the public health message received the

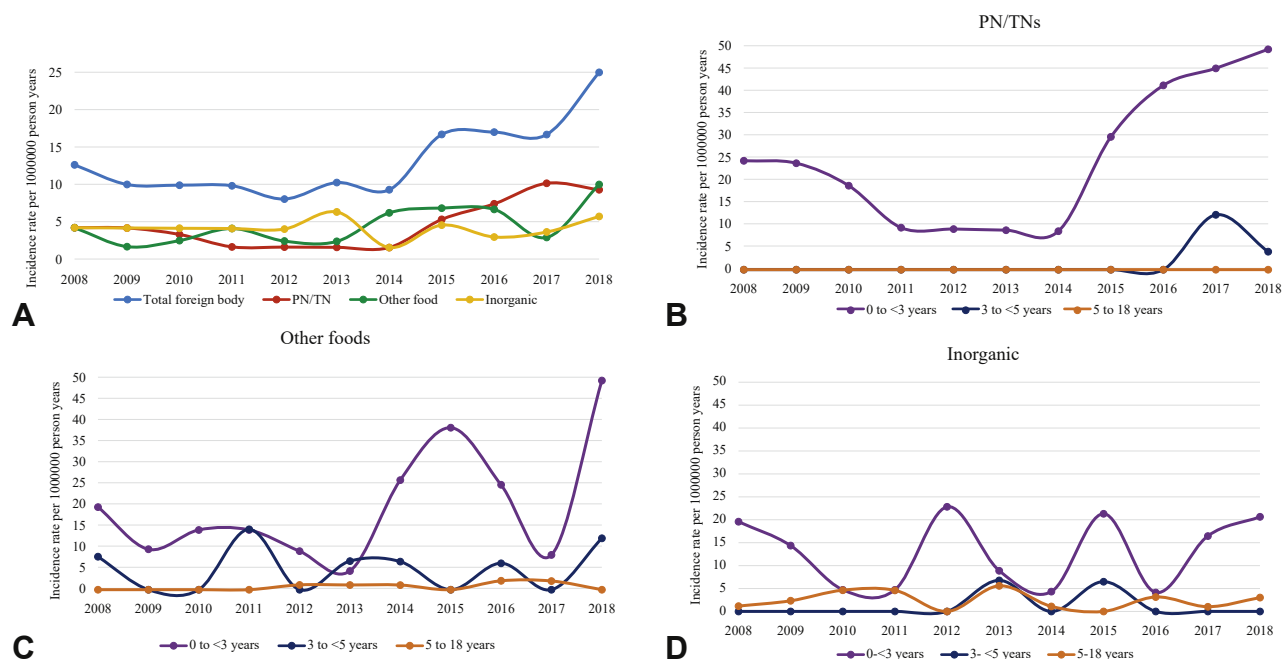


FIGURE 1. Incidence of airway FBs from 2008 to 2018. (A) Airway FBs divided into food type subgroups. Total FB: IRR, 1.09 (95% CI, 1.04-1.15; $P < .001$); PN/TN: IRR, 1.16 (95% CI, 1.07-1.26; $P < .001$); Other food: IRR, 1.12 (95% CI, 1.04-1.22; $P < .005$); Inorganic: IRR, 1.00 (95% CI, 0.92-1.09; $P = .97$). (B) PN/TN FBs divided into age subgroups. PN/TNs, 0 to younger than 3 years: IRR, 1.14 (95% CI, 1.04-1.24; $P = .002$); 3 to younger than 5 years: IRR, 2.29 (95% CI, 0.97-5.41; $P = .06$). (C) Other food FBs divided into age subgroups. Other foods, 0 to younger than 3 years: IRR, 1.12 (95% CI, 1.02-1.23; $P = .014$); 3 to younger than 5 years: IRR, 1.04 (95% CI, 0.83-1.30; $P = .74$); 5 to 18 years: IRR, 1.22 (95% CI, 0.94-1.60; $P = 0.14$). (D) Inorganic FBs divided into age subgroups. Inorganic, 0 to younger than 3 years: IRR, 1.02 (95% CI, 0.92-1.14; $P = .7$); 3 to younger than 5 years: IRR, 1.08 (95% CI, 0.69-1.70; $P = .74$); 5 to 18 years: IRR, 0.97 (95% CI, 0.85-1.10; $P = .62$).

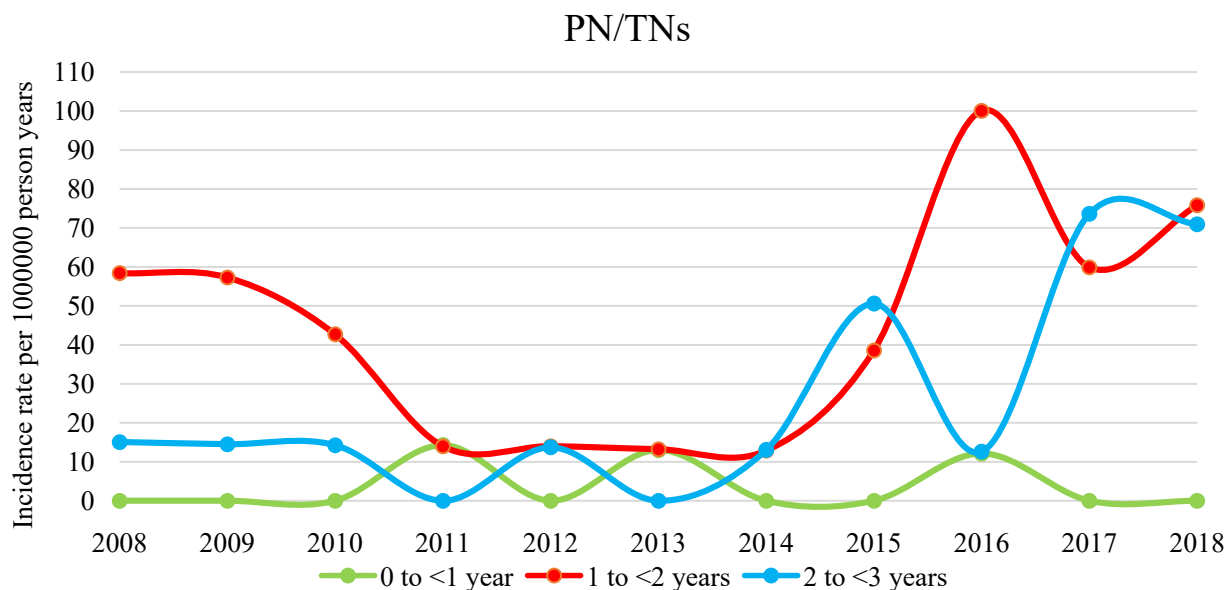


FIGURE 2. Incidence of PN/TN airway FBs divided into age groups: 0 to younger than 1 year, 1 to younger than 2 years, and 2 to younger than 3 years from 2008 to 2018. PN/TNs, 0 to younger than 1 year: IRR, 1.02 (95% CI, 0.71-1.46; $P = .92$); 1 to younger than 2 years: IRR, 1.07 (95% CI, 0.97-1.19; $P = .18$); 2 to younger than 3 years: IRR, 1.29 (95% CI, 1.09-1.51; $P = .002$).

bulk of its traction via the mainstream media, there was also likely insufficient emphasis placed on the safe introduction of

PN/TNs in older children. Current ASCIA feeding guidelines do provide information on the safe introduction of PN/TNs and the

avoidance of hard foods, such as apples and carrots, in children younger than 12 months. Indeed, in our cohort, we saw no significant increase in nut or other foods inhalation in children younger than 12 months. However, there are no clear recommendations for infants beyond 12 months as to the form in which PN/TNs should be provided, and indeed many guidelines generalize that children by 12 months should be tolerating the same food and even the same texture as the rest of the family.^{5,17,18} In Australia, the current recommendation is that whole PN/TNs should not be given to infants before age 3 years; however, it seems that this explicit safety instruction has not been appreciated or consistently communicated to the general public.¹⁰ This is likely to be a contributing factor to the rise in PN/TN aspiration that was observed in our study in children aged between 0 and 3 years, but primarily after age 12 months.

There are inherent anatomical and neurological factors that place infants and young children at particular risk of FB inhalation. These include immature dentition, inadequate oromotor skills, and unique pediatric laryngeal anatomy.² In terms of dentition, young children lack molar teeth and thus they have a limited capacity to masticate food.¹⁹ Children require at least 2 molars per quadrant to be able to appropriately grind hard foods. Eruption of the second primary molars occurs at 27 months on average, which means that children younger than 2 years cannot safely ingest whole or crushed nuts on the basis of dentition alone.²⁰ Furthermore, Wilson and Green²¹ showed that rotatory chew pattern, which is the hallmark of mature mastication and required in the ability to handle hard foods, was not evident in children at 30 months.²¹ It is possible that this lack of effective rotatory mastication, despite likely having adequate dentition, accounts for high rates of PN/TN inhalation in children aged between 2 and 3 years. Anatomically, the relatively high position of the pediatric larynx within the aerodigestive tract makes children younger than 5 years susceptible to FB inhalation.²² Younger children also have a higher respiratory rate compared with older children, which means that they have a higher baseline risk of aspiration.¹⁹ Nut inhalation in children can be associated with significant complications for several reasons. Nuts tend to be rich in oil and more likely to produce a local inflammatory response and granulation formation within the respiratory tract.²³⁻²⁵ The local effects of nuts on respiratory mucosa mean that they are more likely to cause secondary infection and can be more technically challenging to remove endoscopically. Furthermore, nuts are radiolucent on X-ray and may remain unnoticed until they cause respiratory complications such as pneumonia, bronchiectasis, or abscess formation.^{22,26}

Although there was a rise in other food FB inhalation during the post-LEAP era, the magnitude of the rise in PN/TNs inhalation was greater. It is possible that the findings of the LEAP trial had the effect of promoting the early introduction of a broad variety of solid foods in infants' diets. ASCIA infant feeding advice information suggests that solid foods could be introduced between age 4 and 6 months, and that these solids could be the same as the family would normally eat.⁵ Parental anxiety to take advantage of a time-limited "window" to prevent food allergy may have led to the inadvertent exposure of texturally unsafe foods such as raw carrot and apple (the 2 most common inhaled foods after PN/TNs) at a younger age, resulting in the observed increased incidence of other food inhalation.

Limitations of this study include the limited availability of data since the publication of the LEAP trial compared with data

available before 2015. Given this is a single-centered study, it is possible that our results underestimate the true rate of PN/TN inhalation in young children. Further multicenter studies should be conducted both to confirm our findings and to capture the true scale of this morbidity on a broader population level.

Current ASCIA infant feeding guidelines explicitly state that PN/TNs should be given in a smooth paste or butter form. In addition, we suggest that further emphasis needs to be placed on the safe introduction of PN/TNs to infants and young children (particularly those <3 years), and that this safety message is broadly communicated to the general public via a targeted public health campaign. We recommend that (a) whole or crushed PN/TNs, which includes crunchy peanut butter, should never be given to children younger than 5 years due to developmental immaturity, (b) to younger than 5 years, peanuts or tree nuts should be given only in a smooth paste, powder, or butter form, and (c) hard foods such as apple or carrots should be finely grated or cooked until soft.

CONCLUSIONS

Our findings highlight the urgent need to engage the public to promote safe solid food introduction in young children, particularly in this era where early PN/TN introduction is being actively encouraged.

REFERENCES

1. Foltran F, Ballali S, Rodriguez H, Sebastian van As AB, Passali D, Gulati A, et al. Inhaled foreign bodies in children: a global perspective on their epidemiological, clinical, and preventive aspects. *Pediatr Pulmonol* 2013;48:344-51.
2. Morley RE, Ludemann JP, Moxham JP, Kozak FK, Riding KH. Foreign body aspiration in infants and toddlers: recent trends in British Columbia. *J Otolaryngol* 2004;33:37-41.
3. Du Toit G, Roberts G, Sayre PH, Bahnsen HT, Radulovic S, Santos AF, et al. Randomized trial of peanut consumption in infants at risk for peanut allergy. *N Engl J Med* 2015;372:803-13.
4. Perkin MR, Logan K, Tseng A, Raji B, Ayis S, Peacock J, et al. Randomized trial of introduction of allergenic foods in breast-fed infants. *N Engl J Med* 2016;374:1733-43.
5. Australasian Society of Clinical Immunology and Allergy (ASCIA). ASCIA Guidelines for infant feeding and allergy prevention; 2016.
6. Soriano VX, Peters RL, Ponsonby A-L, Dharmage SC, Perrett KP, Field MJ, et al. Earlier ingestion of peanut after changes to infant feeding guidelines: the EarlyNuts study. *J Allergy Clin Immunol* 2019;144:1327-1335.e5.
7. Paradis TJ, Dixon J, Tieu BH. The role of bronchoscopy in the diagnosis of airway disease. *J Thorac Dis* 2016;8:3826-37.
8. Chang AB, Glomb WB. Guidelines for evaluating chronic cough in pediatrics: ACCP evidence-based clinical practice guidelines. *Chest* 2006;129:260S-83S.
9. Australian Bureau of Statistics. Regional population by age and sex, Australia, 2018. 2019. Available from: <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3235.02018?OpenDocument>. Accessed July 5, 2020.
10. National Health and Medical Research Council. Infant feeding guidelines: information for health workers. Canberra: National Health and Medical Research Council; 2012. Available from: <https://www.nhmrc.gov.au/sites/default/files/images/literature-review-infant-feeding-guidelines.pdf>. Accessed April 26, 2020.
11. National Health Service, UNICEF UK. Introducing solid foods: giving your baby a better start in life. 2015. Available from: <https://www.unicef.org.uk/babyfriendly/wp-content/uploads/sites/2/2008/02/Start4Life-Introducing-Solid-Foods-2015.pdf>. Accessed April 26, 2020.
12. New Zealand, Ministry of Health. Food and nutrition guidelines for healthy infants and toddlers (aged 0-2): a background paper. Wellington, New Zealand: Ministry of Health; 2012.
13. Kleinman RE. American Academy of Pediatrics recommendations for complementary feeding. *Pediatrics* 2000;106:1274.
14. Australasian Society of Clinical Immunology and Allergy (ASCIA). ASCIA Guidelines for infant feeding and allergy prevention; 2010 [Internet].

15. Tey D, Allen KJ, Peters RL, Koplin JJ, Tang MLK, Gurrin LC, et al. Population response to change in infant feeding guidelines for allergy prevention. *J Allergy Clin Immunol* 2014;133:476-84.
16. Fleischer DM, Sicherer S, Greenhawt M, Campbell D, Chan E, Muraro A, et al. Consensus communication on early peanut introduction and the prevention of peanut allergy in high-risk infants. *J Allergy Clin Immunol* 2015;136:258-61.
17. Feeding your baby: 1–2 years. Available from: <https://www.unicef.org/parenting/food-nutrition/feeding-your-baby-1-2-years>. Accessed April 26, 2020.
18. Raising Children Network. Introducing solids: why, when, what and how. Available from: <https://raisingchildren.net.au/babies/breastfeeding-bottle-feeding-solids/solids-drinks/introducing-solids>. Accessed April 26, 2020.
19. Gregori D, Scarinzi C, Morra B, Salerni L, Berchiulla P, Snidero S, et al. Ingested foreign bodies causing complications and requiring hospitalization in European children: results from the ESFBI study. *Pediatr Int* 2010;52:26-32.
20. Nelson SJ, Ash MM. Wheeler's dental anatomy, physiology, and occlusion. Philadelphia: W.B. Saunders; 2003.
21. Wilson EM, Green JR. The development of jaw motion for mastication. *Early Hum Dev* 2009;85:303-11.
22. Gang W, Zhengxia P, Hongbo L, Yonggang L, Jiangtao D, Shengde W, et al. Diagnosis and treatment of tracheobronchial foreign bodies in 1024 children. *J Pediatr Surg* 2012;47:2004-10.
23. Xu Y, Feng R-L, Jiang L, Ren H-B, Li Q. Correlative factors for the location of tracheobronchial foreign bodies in infants and children. *J Thorac Dis* 2018;10:1037-42.
24. Huang Z, Zhou A, Zhang J, Xie L, Li Q. Risk factors for granuloma formation in children induced by tracheobronchial foreign bodies. *Int J Pediatr Otorhinolaryngol* 2015;79:2394-7.
25. Barbato A, Novello A, Tormena F, Corner P. Problems with the retrieval of long-standing inhaled foreign bodies in children. *Monaldi Arch Chest Dis Arch Monaldi Mal Torace* 1996;51:419-20.
26. Sirmali M, Türlüt H, Kisacik E, Findik G, Kaya S, Taştepe I. The relationship between time of admittance and complications in paediatric tracheobronchial foreign body aspiration. *Acta Chir Belg* 2005;105:631-4.

ONLINE REPOSITORY

TABLE E1. Incidence of airway FBs (per million person years) from 2008 to 2018

Year	Total FB	PN/TN	Other food	Inorganic
2008	12.60	4.20	4.20	4.20
2009	9.98	4.16	1.66	4.16
2010	9.89	3.30	2.47	4.12
2011	9.81	1.64	4.09	4.09
2012	8.03	1.61	2.41	4.02
2013	10.24	1.58	2.36	6.30
2014	9.27	1.55	6.18	1.55
2015	16.67	5.30	6.82	4.55
2016	16.99	7.39	6.65	2.95
2017	16.67	10.15	2.90	3.62
2018	24.97	9.27	9.99	5.71
IRR (95% CI)	1.09 (1.04-1.15)	1.16 (1.07-1.26)	1.12 (1.04-1.22)	1.00 (0.92-1.09)
<i>P</i> value	<.001	<.001	.005	.97

Bold values indicate statistical significant ($P < .05$).

TABLE E2. Incidence of airway FBs (per million person years) divided into age and food type subgroups from 2008 to 2018

Year	0-<3 y			3-<5 y			5-18 y		
	PN/TN	Other food	Inorganic	PN/TN	Other food	Inorganic	PN/TN	Other food	Inorganic
2008	24.46	19.57	19.57	0	7.80	0	0	0	1.17
2009	23.92	9.57	14.35	0	0	0	0	0	2.32
2010	18.87	14.16	4.72	0	0	0	0	0	4.62
2011	9.43	14.15	4.72	0	14.30	0	0	0	4.59
2012	9.13	9.13	22.83	0	0	0	0	1.13	0
2013	8.87	4.44	8.87	0	6.77	6.77	0	1.12	5.58
2014	8.65	25.96	4.33	0	6.65	0	0	1.10	1.09
2015	29.83	38.35	21.31	0	0	6.49	0	0	0
2016	41.40	24.84	4.14	0	6.26	0	0	2.10	3.15
2017	45.24	8.23	16.45	18.41	0	0	0	2.05	1.03
2018	49.51	49.51	20.63	6.08	12.16	0	0	0	3.02
IRR (95% CI)	1.14 (1.04-1.24)	1.12 (1.02-1.23)	1.02 (0.92-1.14)	2.29 (0.97-5.41)	1.04 (0.83-1.30)	1.08 (0.69-1.70)	0	1.22 (0.94-1.60)	0.97 (0.85-1.10)
<i>P</i> value	.002	.014	.7	.06	.74	.74	0	.14	.62

Bold values indicate statistical significant ($P < .05$).

TABLE E3. Incidence of PN/TN airway FBs (per million person years) divided into age groups: 0-<1 y, 1-<2 y, and 2-<3 y from 2008 to 2018

Year	0-<1 y	1-<2 y	2-<3 y
2008	0	58.40	15.08
2009	0	57.30	14.51
2010	0	42.70	14.26
2011	14.27	13.99	0
2012	0	14.01	13.72
2013	13.02	13.23	0
2014	0	12.87	13.04
2015	0	38.58	50.59
2016	12.14	100.08	12.62
2017	0	59.91	73.65
2018	0	75.80	70.95
IRR (95%CI)	1.02 (0.71-1.46)	1.07 (0.97-1.19)	1.29 (1.09-1.51)
<i>P</i> value	.92	.18	.002

Bold values indicate statistical significant ($P < .05$).