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Food neophobia across the life course: Pooling data from five national cross-sectional surveys in Ireland

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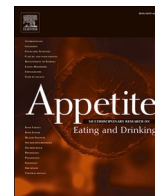
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Food neophobia across the life course: Pooling data from five national cross-sectional surveys in Ireland

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ABSTRACT

Food neophobia describes a reluctance to eat novel foods. Levels of food neophobia vary throughout life and are thought to peak in childhood. However, the trajectory of food neophobia across the life course is not fully clear. Using data from five national cross-sectional surveys in Ireland we explored levels of food neophobia in males and females aged 1–87 years. In addition, we assessed the influence of sociodemographic factors, breastfeeding and parental food neophobia on food neophobia. Food neophobia was measured using the Food Neophobia Scale in adults and adolescents and with the Children's Eating Behaviour Questionnaire in preschool and school aged children. A total of 3246 participants (female, 49.9%) were included. Food neophobia increased with age from 1 to ~6 years, then decreased until early adulthood where it remained stable until increasing with age in older adults (>54 years). In adults, lower education level, social class and rural residency were associated with higher food neophobia. When preschool and school aged children surveys were pooled (ages 1–12), higher food neophobia was seen in males, children with lower parental education and those who were not breastfed. Sociodemographic factors were not significantly associated with food neophobia in adolescents. Breastfeeding duration was negatively associated with food neophobia in children and adolescents and parental food neophobia was positively associated with child's food neophobia in preschool and school aged children. The influence of socioeconomic factors was more pronounced in adults than in children or adolescents. However, sociodemographic factors only explained a small proportion of the variation in food neophobia across all ages. Longitudinal studies are needed to understand how changes in age or socioeconomic circumstance influence food neophobia at an individual level.

1. Introduction

Humans, as with other omnivores, can acquire nutrients from a variety of sources. While this adaptability has allowed us to thrive in a wide range of environments, it poses a dilemma when deciding what to eat. Each potential food may provide a new source of nutrition but may also contain toxins (Rozin & Todd, 2016). Thus, humans must select enough variety to achieve adequate nutrition but remain cautious to avoid toxicity. This approach/avoidance conflict, popularly termed the 'omnivores dilemma', is thought to offer an evolutionary explanation for the food neophobia commonly observed in humans and other omnivorous animals (Rozin, 1990). Food neophobia is characterised by a reluctance to eat new or unfamiliar foods and is thought to have

developed as a protective mechanism against the ingestion of noxious substances. While food neophobia may have developed as an adaptive trait, nowadays, it is more often associated with maladaptive consequences, limiting dietary variety and quality (Cooke et al., 2003; Falciaglia et al., 2000; Hazley et al., 2022; Quick et al., 2014; Sarin et al., 2019).

Although the exact origins of food neophobia remains uncertain, its expression in humans varies greatly with age. During the first months of life, humans consume a single food, either breast milk or infant formula. After 3–6 months, solid foods are progressively introduced, providing the first opportunity for food rejection. Interestingly, despite all foods being new, infants under 18–20 months often readily accept new foods and only exhibit food neophobic behaviours at 20–24 months (Harris,

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2018; Nicklaus, 2009). At around 2 years, young children begin to recognize familiar and non-familiar foods but lack the experience to ascertain their safety. Moreover, this time of development coincides with a period of increased mobility, providing children with the ability to forage for food independently, increasing their risk of ingesting harmful substances. Thus, the onset of food neophobia may protect a child during this vulnerable period until the safety of new foods can be learned (Harris, 2018). It is commonly cited that food neophobia peaks in childhood between 2 and 6 years of age, after which it declines until reaching a relatively stable state in adolescence or early adulthood (Dovey et al., 2008; Lafraire et al., 2016). To date, most studies have assessed food neophobia across age groups rather than at each year. This has led to broad peak estimates and it remains unclear if food neophobia differs between children aged 2- and 6-years. In addition, a growing body of evidence suggests food neophobia increases again in older age (Meiselman et al., 2010; Siegrist et al., 2013; Tuorila et al., 2001), possibly due to higher concerns with food safety or increased levels of food disgust (Dovey et al., 2008; Hartmann & Siegrist, 2018). Thus, to better understand the influence of age on food neophobia levels, there is a need to assess the trajectory of food neophobia across the life course, including estimates of food neophobia at each age of childhood.

Like most complex traits, the degree of food neophobia observed between people varies across all ages. Some people will never exhibit food neophobic tendencies, whereas others will remain highly neophobic throughout life. What determines these differences is not fully understood but many intrinsic (e.g. genetic, sensory sensitivity, temperament traits) and extrinsic (e.g. food experiences, feeding practices, social facilitation) factors are thought to play a role (Cooke, 2018; Dovey et al., 2008; Lafraire et al., 2016).

Although humans exhibit some innate taste biases, such as a liking for sweet tastes (associated with energy) and an aversion towards bitter tastes (associated with toxins), food preferences are primarily learned through experiences (Birch, 1999). These experiences and their influence on food acceptance are thought to begin in utero, where the foetus is first exposed to flavour compounds from the mothers' diet through the amniotic fluid (Ventura & Worobey, 2013). Similarly, after birth, breast milk can expose neonates to a variety of flavour compounds that may influence food preferences later in life (Ventura & Worobey, 2013). These early exposures have also been shown to influence food neophobia levels (Cooke & Fildes, 2011). Some research suggests that breastfed children more readily accept new foods and have lower levels of food neophobia (Maier et al., 2008; Roßbach et al., 2016). However, not all studies have found significant effects (Cole et al., 2017).

Humans, particularly young children, rarely experience food selection in isolation. This social experience of eating is thought to have an important effect on the development of food preferences and overall food consumption (Birch, 1999; Herman, 2015). Unsurprisingly, social learning or social facilitation can also influence food neophobia (Blissett & Fogel, 2013; Lafraire et al., 2016). Evidence suggests that children accept new foods more readily when they observe familiar adult models consume the same food (Addressi et al., 2005). Whereas, when different foods are consumed, or when the model is present but does not eat, acceptance is not improved (Addressi et al., 2005). This modelling effect may partially explain why parental and child food neophobia are consistently correlated (Cooke, 2018), as higher displays of food rejection by the parent may be mimicked by the child. Another potential reason for such parent-child correlations is genetics, as food neophobia show high heritability (Cooke et al., 2007; Knaapila et al., 2007). In addition to parental modelling, the feeding practices of parents are also thought to influence food neophobia in children. Evidence suggests that controlling parental feeding practices that restrict food choices and pressure children to eat can create an emotionally unfavourable environment surrounding foods, leading to increased levels of food neophobia (Nicklaus & Monnery-Patris, 2018). Whereas practices that increase the familiarity of food through continual offering may lead to reductions in food neophobia (Nicklaus & Monnery-Patris, 2018).

Differences in food exposures may impact levels of food neophobia, with increased food experience resulting in lower neophobia (Dovey et al., 2008; Lafraire et al., 2016; Rabadán & Bernabéu, 2021). The foods people eat and are exposed to throughout their lives are strongly influenced by the cultures in which they grow up (Kittler et al., 2017). These cultural differences in food exposure likely explain the differences in food neophobia seen in both children and adults from different countries (Proserpio et al., 2020; Rabadán & Bernabéu, 2021). Similarly, socioeconomic status can have a significant effect on food choices. Evidence suggests people with lower socioeconomic status consume less varied diets than those with more economic means (Ahn et al., 2006; Darmon & Drewnowski, 2008). As a result of their limited food experiences, less affluent populations may exhibit higher levels of food neophobia. In adults, this appears to be the case, with consistent evidence linking lower education and socioeconomic status to higher levels of food neophobia (Meiselman et al., 2010; Tuorila et al., 2001; van den Heuvel et al., 2019). Interestingly, evidence in younger cohorts is less consistent. Some studies have linked lower parental education and rural residency with higher food neophobia in children and adolescence (Flight et al., 2003; Mustonen et al., 2012). However, most studies find food neophobia is not significantly related to socioeconomic and locational factors in children and adolescents (Cooke et al., 2006; Kozioł-Kozakowska et al., 2018; Kutbi et al., 2019; Roßbach et al., 2016).

This study aimed to explore levels of food neophobia across the life course and to examine the relationship between sociodemographic factors and food neophobia across all ages. Two additional objectives were to explore the influence of breastfeeding history on food neophobia in preschool children, school aged children and adolescents and parental food neophobia in preschool and school aged children.

2. Method

2.1. Survey populations

This analysis is based on data collected from five national cross-sectional nutrition surveys in adults, teenagers, school aged and preschool aged children in the Republic of Ireland: National Adult Nutrition Survey (NANS), National Teens' Food Survey (NTFS), National Children's Food Survey (NCFS), National Children's Food Survey II (NCFS II) and National Pre-School Nutrition Survey (NPNS). All surveys were carried out by the Irish Universities Nutrition Alliance (IUNA; www.iuna.net). A more detailed description of each surveys methods has been previously reported (IUNA, 2006, 2011a, 2011b, 2018; Rahill et al., 2019).

In summary, the NANS was conducted between 2008 and 2010 in 1500 adults aged 18–90 years (740 male, 760 females). Participants were recruited using a database held by Data Ireland (National Postal Service), which randomly selected people from 20 geographical clusters across Ireland. The NTFS was conducted between September 2005 and September 2006 in 441 teenagers aged 13–17 years (224 males, 217 females). Participants were recruited through thirty-two secondary schools located throughout the Republic of Ireland using the Department of Education and Science secondary school database. The NCFS and NCFS II were conducted between March 2003 and March 2004 in 594 children aged 5–12 years (293 males, 301 females) and between April 2017 and May 2018 in 600 children aged 5–12 years (300 boys, 300 girls), respectively. In both surveys, participants were recruited from twenty-eight primary schools, selected using the Department of Education and Science public school database. The NPNS was conducted between October 2010 and September 2011 in 500 pre-school children, aged 1–4 years (boys 251, girls 249). Participants were recruited using a database of children compiled by 'eumom' (an Irish parenting resource; www.eumom.ie) or from randomly selected childcare facilities distributed throughout the Republic of Ireland. Quota sampling was used in all surveys to recruit participants. The NANS, NTFS and NCFS were representative of the Irish population with respect to age, sex, social class and

location (urban/rural) when compared to the most recent Irish Census at the time of data collection (Central Statistics Office, 2003, 2007). In the NCFS II and NPNS, participants were representative with regard to age group, sex and residential location. However, the NCFS II contained a higher proportion of children of professional/managerial social class and a lower proportion of children from a semi-skilled/unskilled social class than the general population (Central Statistics Office, 2016) and the NPNS contained a higher proportion of children of professional/managerial social class and a lower proportion of children from a skilled manual social class than the general population (Central Statistics Office, 2007).

Ethical approval for each survey was obtained from University College Cork Clinical Research Ethics Committee of the Cork Teaching Hospitals and the Human Ethics Research Committee of University College Dublin. Written consent was obtained from all participants as well as their parents/guardians in the NTFS, NCFS, NCFS II and NPNS, in accordance with the Declaration of Helsinki.

2.2. Sociodemographic characteristics

Across all surveys, sociodemographic characteristics were collected by a Health and Lifestyle questionnaire developed by the IUNA research team. In the NANS, participants completed their own questionnaire and gathered information on participants social class, education level, smoking status and many other health and lifestyle characteristics. In the NTFS, NCFS, NCFS II and NPNS, parents of the participants completed the Health and Lifestyle questionnaire which gathered information on parental social class, education level and many other health and lifestyle characteristics. Where possible, both parents/guardians completed the questionnaire. Across all surveys, participants were classified into five social class groups (professional/managerial/technical, non-manual skilled, manual skilled, semi-skilled/unskilled, and students) based on their occupation using criteria outlined by the Central Statistics Office (CSO, 2002). In the NANS, social class was assigned to the higher occupational status of partners in married or cohabiting couples. In the NTFS, NCFS, NCFS II and NPNS, participants were assigned to the higher education level and social class when information on both parents/guardians was available. In the NPNS, NCFS and NCFS II, participants with primary parental education level and students social class made up less than 2% of the sample across each survey. Therefore, to increase the numbers in each variable, primary and intermediate were merged, and student and semi-skilled/unskilled were merged. No parents/guardians with primary education level or student social class were present in the NTFS.

2.3. Anthropometric measurements

Across all surveys, anthropometric measurements (height and weight) were taken by trained researchers during data collection visits. In the NANS and NCFS II, body mass was measured in duplicates to the nearest 0.1 kg using the Tanita BC-420MA Body Composition Analyzer (Tanita Corporation, Tokyo, Japan). In the NTFS, NCFS and NPNS body mass was measured in duplicates to the nearest 0.1 kg using the Seca 770 digital personal weighing scale. For all surveys, height was measured using the Leicester portable height measure to the nearest 0.1 cm. Body mass index (BMI) was calculated by dividing body mass (kg) by height (m^2). Adults were assigned to BMI categories according to the World Health Organisation cut-points for adults (WHO/Europe, 2021). Adolescents, children and preschool children (aged ≥ 2 years) were assigned to BMI categories using the International Obesity Task Force age- and sex-specific BMI charts for children aged 2–18 years (Cole et al., 2000).

2.4. Food neophobia

In the NANS and NTFS, food neophobia was assessed using the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992). The FNS is a ten-item

questionnaire with five food neophobic statements (e.g., “I don’t trust new foods”) and five food neophilic statements (e.g., “I will eat almost anything”). Each item is scored on a 7-point agreement scale, ranging from 1 = strongly disagree to 7 = strongly agree. All food neophilic statements were reversed scored so that higher scores indicated greater food neophobia. All items were summed to give a total FNS score. Out of the 1500 participants in the NANS, a sub-sample of 1263 completed a food choice behaviour questionnaire which included the FNS. Of those, a total of 1191 completed all 10 items of the FNS and were included in the final analysis. Of the 441 teenagers in the NTFS, 419 completed all 10-items of the FNS and were included in the final analysis.

In the NCFS, NCFS II and NPNS, food neophobia was assessed using the Children’s Eating Behaviour Questionnaire (CEBQ) completed by the parent/guardian of the participant (Wardle et al., 2001). The CEBQ includes a food fussiness construct made up of four food neophobia items (e.g. *My child refuses new foods at first*) and two food fussiness items (*My child is difficult to please with meals*). Each item is scored on a 5-point Likert scale, ranging from 1 = never to 5 = always. For the interests of this study, only the four food neophobia items were used. One item, “*My child enjoys tasting new foods*” was reverse scored and the four items were summed to give a total food neophobia score (FN-CEBQ). This approach has been previously reported with good internal reliability (Smith et al., 2017). In the NPNS and NCFS, parental food neophobia was measured using the FNS (Pliner & Hobden, 1992). To allow for comparisons across surveys, FNS and FN-CEBQ scores were standardised so that they reflect the percentage of the total score, giving both FN-CEBQ and FNS scores a potential range of 0–100. To date, there is no standardised approach to define food neophobia. As we were interested in making comparisons across all ages, we defined a novel criteria based on the standardised food neophobia scores. We created four groups, participants with scores ≤ 25 (≤ 8 FN-CEBQ; ≤ 25 FNS) were considered highly food neophilic, 24.99–49.99 (9–11 FN-CEBQ; 26–39 FNS) were mildly food neophilic, 50–74.99 (12–15 FN-CEBQ; 40–54 FNS) were mildly food neophobic and ≥ 75 (≥ 16 FN-CEBQ; ≥ 55 FNS) were highly food neophobic.

2.5. Breastfeeding history

In the NTFS, NCFS, NCFS II and NPNS, breastfeeding history was measured with two questions. Firstly, parents/guardians were asked “*Was the child breastfed?*” (Yes/No/Don’t know). Next, they were asked “*If yes, how long was the child breastfed for?*” and answers were provided in weeks. In the NPNS, breastfeeding duration was measured with an 8-point scale and was merged into a 6-point scale to increase the numbers across groups (0 = not breastfed, 1 = less than 2 weeks, 2 = 2–6 weeks, 3 = 6 weeks–3 months, 4 = 3–6 months, 5 = greater than 6 months). Participants who answered ‘Don’t know’ to the first question made up less than 1% of the sample across each survey and were excluded from all analyses relating to breastfeeding.

2.6. Statistical analysis

All statistical analyses were carried out using SPSS® for Windows™ statistical software package version 28 (SPSS Inc., Chicago, IL, USA). Internal consistency of the FNS and FN-CEBQ was assessed using Cronbach’s alpha. To compare standardised food neophobia scores across the life course, each age cohort was merged to give an age range of 1–87 years. As the NCFS and NCFS II were completed 15 years apart temporal differences in food neophobia were first assessed to determine if these two surveys could be merged. As participant characteristics differed significantly between surveys a one-way analysis of covariates (ANCOVA) with social class, parental education level and breastfeeding history as covariates was used to assess the difference in food neophobia scores between surveys. Because food neophobia scores were not significantly different between the NCFS and NCFS II ($F(1, 1140) = 3.041, P = 0.081$) and the distribution across ages appeared similar

(Supplementary Fig. 2) it was deemed appropriate to include both surveys in the final analysis. Multiple t-tests were used to compare standardised food neophobia scores across age groups. As food neophobia was measured using a different questionnaire in the NANS and NTFS than in the NCFS, NCFS II and NPNS, t-test's were only carried out between surveys using the same measure of food neophobia.

A one-way analysis of variance (ANOVA) with Gabriel *post hoc* test was used to compare differences in standardised food neophobia scores across sociodemographic factors and history of breastfeeding (Yes/No) in each age cohort. As breastfeeding duration was assessed using a non-ordinal scale in the NPNS, a one-way ANOVA was used to compare differences in food neophobia scores across breastfeeding duration categories. Homogeneity of variance was assessed using Levene's test. When the assumption of homogeneity of variance was broken ($P < 0.05$), a Brown-Forsythe ANOVA and Games-Howell *post hoc* test was used. Pearson's correlation and partial correlations, controlling for education level and social class, were used to assess the linear relationship between parental FNS and breastfeeding duration on children's food neophobia. Finally, to explore the sociodemographic determinants of food neophobia within each age cohort a multiple linear regression was used. As food neophobia, sociodemographic factors, BMI and breastfeeding history were measured in the same way in the NPNS, NCFS and NCFS II, a merged dataset was created (Preschool-Children) to assess the effects of sociodemographic characteristics and breastfeeding history using a larger sample size. Similarly, the NCFS and NCFS II were merged (NCFS-NCFS II) and the NPNS and NCFS were merged (NPNS-NCFS) to assess the influence of food neophobia on breastfeeding duration and parental food neophobia, respectively. A *P*-value of less than 0.05 was considered statistically significant for comparisons of standardised food neophobia scores across age groups. For all other analyses the standard criteria for statistical significance ($P < 0.05$) was adjusted for multiple comparisons using the Bonferroni correction.

3. Results

3.1. Participant characteristics and food neophobia scores

A total of 3246 participants aged 1–87 years were included in the final analysis (Table 1). Internal consistency measured by Cronbach's alpha was high across each cohort (Table 2). The frequency distribution for the FNS and FN-CEBQ standardised scores across each cohort can be seen in Supplementary Fig. 1.

3.2. Food neophobia across the life course

Fig. 1 displays the mean standardised food neophobia scores and the percentage classified into food neophobia groups across the life course. Food neophobia peaked in children at around 6 years of age with 68.5% exhibiting food neophobic tendencies (38.4% mildly neophobic and 30.1% highly neophobic). However, food neophobia scores were not significantly different between ages 6 and 7 (Supplementary Tables 3 and 4). After age 7, food neophobia decreased with age until reaching a trough at 25–34 years with only 26.5% of participants exhibiting food neophobic tendencies (21.5% mildly neophobic and 5.0% highly neophobic). However, food neophobia scores were not significantly different between ages 17 to 44. After approximately 54 years, food neophobia scores began to increase again with age.

3.3. Food neophobia and sociodemographic factors

The standardised food neophobia scores across sociodemographic characteristics and BMI category for each age cohort are shown in Table 3. When preschool children and school-aged children surveys were merged (Preschool-Children), males were found to have significantly higher food neophobia scores ($F(1, 1635) = 9.457, P = 0.002$). In addition, food neophobia was significantly higher among children with

Table 1

Participant characteristics of the National Pre-School Nutrition Survey (NPNS), National Children's Food Survey I and II (NCFS and NCFS II), National Teens' Food Survey (NTFS) and National Adults Nutrition Survey (NANS).

	NPNS n = 477	NCFS n = 574	NCFS II n = 585	NTFS n = 419	NANS n = 1191
	n (%)	n (%)	n (%)	n (%)	n (%)
Sex					
Male	240 (50.3)	286 (49.8)	293 (50.1)	215 (51.3)	590 (49.5)
Female	237 (49.7)	288 (50.2)	292 (49.9)	202 (48.2)	601 (50.5)
Age					
1-2	241 (50.5)	–	–	–	–
3-4	236 (49.5)	–	–	–	–
5-8	–	288 (50.2)	295 (50.4)	–	–
9-12	–	286 (49.8)	290 (49.6)	–	–
13-14	–	–	–	178 (42.5)	–
15-17	–	–	–	239 (57.0)	–
18–35	–	–	–	–	477 (40.1)
36–51	–	–	–	–	386 (32.4)
52–64	–	–	–	–	199 (16.7)
65+	–	–	–	–	129 (10.8)
Education Level					
Primary ^a	–	–	–	–	77 (6.5)
Intermediate	23 (4.8)	111 (19.3)	34 (5.8)	110 (26.3)	227 (19.1)
Secondary	62 (13.0)	129 (22.5)	44 (7.5)	90 (21.5)	290 (24.3)
Tertiary	392 (82.2)	330 (57.5)	505 (86.3)	211 (50.4)	588 (49.4)
Social Class					
Professional	296 (62.1)	297 (51.7)	388 (66.3)	216 (49.0)	553 (46.4)
Non-manual skilled	76 (15.9)	116 (20.2)	100 (17.1)	79 (17.9)	214 (18.0)
Manual skilled	71 (14.9)	88 (15.3)	52 (8.9)	85 (19.3)	152 (12.8)
Semi-skilled/ unskilled ^b	27 (5.7)	67 (11.7)	41 (7.0)	51 (11.6)	87 (7.3)
Student	–	–	–	–	144 (12.1)
Location					
Rural	230 (48.2)	316 (55.1)	258 (44.1)	206 (49.2)	383 (32.2)
Urban	247 (51.8)	258 (44.9)	327 (55.9)	211 (50.4)	808 (67.8)
BMI ^c					
Normal weight	289 (81.2)	437 (76.1)	474 (81.0)	337 (80.4)	438 (36.8)
Overweight	51 (14.3)	97 (16.9)	69 (11.8)	67 (16.0)	446 (37.4)
Obese	11 (3.1)	38 (6.6)	39 (6.7)	12 (2.9)	248 (20.8)
Breastfed					
Yes	319 (66.9)	269 (46.9)	364 (62.2)	169 (40.3)	–
No	158 (33.1)	301 (52.4)	219 (37.4)	235 (56.1)	–
Don't know	0 (0.0)	1 (0.2)	0 (0.0)	4 (0.9)	–

Some percentages don't add up to 100 due to missing values: NPNS, Social class, 6 (1.3%), BMI (>1 years), 5 (1.4%); NCFS: Education, 4 (0.6%), Social class, 6 (1.0%), BMI, 19 (3.3%), Breastfed, 3 (0.5%); NCFS II: Education, 2 (0.3%), Social class, 4 (0.7%), BMI, 3 (0.5%), Breastfed, 2 (0.3%); NTFS: Education, 8 (1.9%), Social class, 10 (2.4%), BMI, 1 (0.2%), Breastfed, 11 (2.6%); NANS:

Education level, 9 (0.8%), Social class, 40 (3.4%), BMI, 59 (4.9%). ^aPrimary was merged with intermediate in the NPNS, NCFS and NCFS II. ^bstudents were merged with semi-skilled/unskilled in the NPNS, NCFS, NCFS II. ^cIn the NANS, BMI categories were determined using WHO standards: normal weight, BMI <25.0 kg/m²; overweight, BMI = 25.0–29.9 kg/m²; obese, BMI ≥30.0 kg/m². In the NTFS, NCFS, NCFS II and NPNS, BMI categories were determined using the International Obesity Task Force age- and sex-specific BMI cut-offs for defining weight status in children aged 2–18 years (Cole et al., 2000). In the NPNS, BMI categories were only calculated for children age ≥2 years.

Table 2
Internal consistency and questionnaire used in each survey.

Survey	Questionnaire	Cronbach's α
NANS	FNS	0.908
NTFS	FNS	0.836
NCFS	CEBQ-FN	0.903
NCFS II	CEBQ-FN	0.921
NPNS	CEBQ-FN	0.889
Parental Food neophobia		
NCFS	FNS	0.843
NPNS	FNS	0.836

FNS, food neophobia scale. CEBQ-FN, Children's Eating Behaviour Questionnaire food neophobia questions.

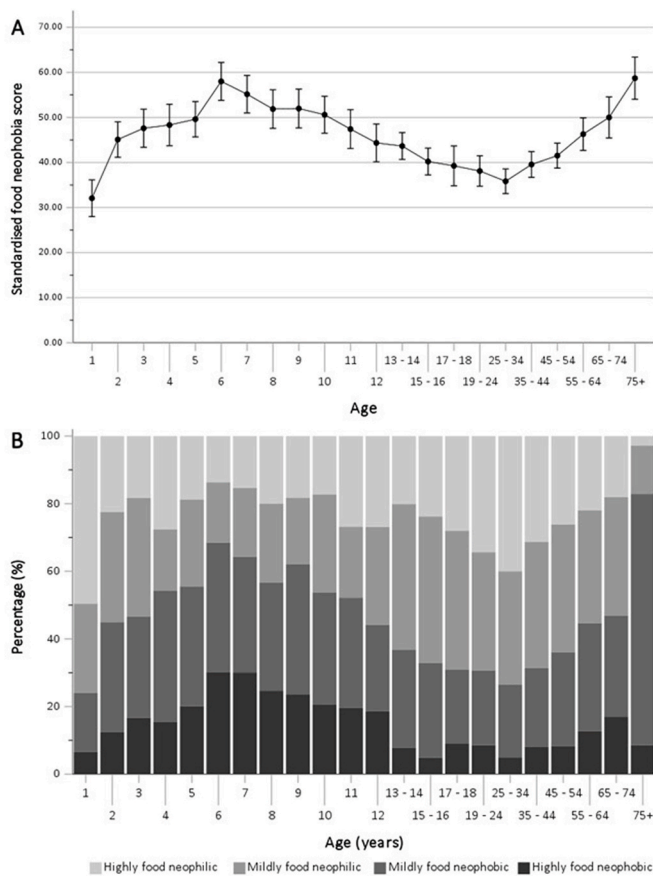


Fig. 1. A) Mean standardised food neophobia score (possible range 0–100) across the life course (ages 1 to 87). Error bars indicate 95% confidence intervals. B) Percentage of participants classified as highly food neophilic (food neophobia score <25), mildly food neophilic (food neophobia score, 25–49.99), mildly food neophobic (food neophobia score, 50–74.99), and highly food neophobic (food neophobia score ≥75) across the life course (ages 1 to 87).

parents with a primary/intermediate education level compared with parents with a secondary or tertiary education level ($F(2, 1629) = 7.375, P < 0.001$). In the NCFS, male children ($F(1, 573) = 7.236, P = 0.007$) and children of semi-skilled/unskilled/student social class ($F(3, 567) = 4.472, P = 0.004$) had significantly higher food neophobia. In the NCFS II, higher food neophobia scores were found in children with normal weight compared to children with obesity, although this was not significant after Bonferroni correction ($F(2, 581) = 3.336, P = 0.036$). In the NPNS and NTFS, food neophobia scores were not significantly different across all sociodemographic factors. In the NANS, higher food neophobia was observed in adults with primary education compared with intermediate and tertiary ($F(3, 1181) = 12.267, P < 0.001$) and in semi-skilled/unskilled social class compared to professional/managerial and student social classes ($F(4, 1149) = 6.402, P < 0.001$). In addition, adults living in urban areas showed lower food neophobia scores compared to those living in rural locations, although this was not significant after Bonferroni correction ($F(1, 1190) = 5.567, P = 0.018$). Food neophobia scores were not significantly different across sexes or BMI categories.

3.4. Breastfeeding and food neophobia

When preschool and school-aged children surveys were merged (Preschool-Children), food neophobia was significantly higher among non-breastfed participants compared to breastfed ($F(1, 1628) = 7.027, P = 0.008$; Table 3). Similarly, non-breastfed adolescents had significantly higher food neophobia compared to breastfed ($F(1, 405) = 7.974, P = 0.005$). Significant differences were not seen when the NPNS, NCFS and NCFS II were assessed separately. A small negative correlation was found between food neophobia and breastfeeding duration (weeks) when the NCFS and NCFS II were merged ($P = 0.003$) and in children in the NCFS ($P = 0.015$) and adolescents in the NTFS ($P = 0.006$) (Table 4). However, breastfeeding duration was not significantly associated with food neophobia in the NCFS II. After controlling for education level and social class, breastfeeding duration remained significantly associated with food neophobia when the NCFS and NCFS II were merged ($P = 0.013$) and in the NTFS ($P = 0.022$) but not in the NCFS ($P = 0.032$) after Bonferroni correction. In the NPNS, food neophobia scores were not significantly different across breastfeeding duration categories (Supplementary Table 11).

3.5. Parental and child food neophobia

Parental food neophobia was positively correlated with child's food neophobia in the NPNS and NCFS individually and when datasets were merged. These effects remained significant after adjusting for education level and social class (Table 4).

3.6. Multiple linear regression

The results from the multiple linear regression analysis can be seen in Table 5. When the NPNS, NCFS and NCFS II were merged (Preschool-Children), the multiple linear regression predicted only 1.6% of the variation in food neophobia. Age was negatively associated with food neophobia, although this was not significant after Bonferroni correction. In addition, females had significantly higher food neophobia compared to males and children with secondary and tertiary parental education levels had significantly lower food neophobia compared to those with primary/intermediate. The multiple linear regression predicted 6.3% of the variation in food neophobia scores in preschool children in the NPNS. Age was positively associated with food neophobia, and children with parents with secondary education had significantly lower food neophobia when compared to primary/intermediate. In the NCFS, the multiple linear regression predicted 3.1% of the variation in food neophobia scores. Children with semi-skilled/unskilled/student social class were found to have significantly higher food neophobia when compared

Table 3

Standardised food neophobia scores (possible range 0–100) across sociodemographic factors, BMI category and breastfeeding history in the NPNS, NCFS, NCFS II, NTFS, NANS and when the NPNS, NCFS and NCFS II were merged (Preschool-Children).

	NPNS		NCFS I		NCFS II		NTFS		NANS		Preschool-Children	
	mean (SD)	P-value	mean (SD)	P-value	mean (SD)	P-value	mean (SD)	P-value	mean (SD)	P-value	mean (SD)	P-value
Overall	43.2 (24.1)		53.0 (24.4)		49.4 (26.9)		41.6 (20.2)		41.1 (22.4)		48.8 (25.5)	
Sex												
Male	44.3 (23.9)	0.322	55.7 (23.8)	0.007	51.3 (27.4)	0.089	40.9 (20.4)	0.457	41.3 (23.0)	0.761	50.8 (25.6)	0.002
Female	42.1 (24.2)		50.3 (24.7)		47.5 (26.3)		42.4 (20.1)		40.9 (21.9)		46.9 (25.3)	
Education Level												
Primary	–	0.091	–	0.198	–	0.231	–	0.101	50.7a (21.1)	<0.001	–	–
Intermediate*	51.1 (22.9)		56.6 (25.9)		57.0 (29.1)		43.8 (21.2)		43.1 b (23.5)		55.9a (26.1)	<0.001
Secondary	38.6 (23.5)		51.2 (23.3)		48.0 (28.5)		43.8 (20.7)		44.0a,b (21.7)		47.3 b (24.9)	
Tertiary	43.5 (24.1)		52.5 (24.2)		49.0 (26.6)		39.5 (19.4)		37.5c (21.9)		48.2 b (25.4)	
Social Class												
Professional	43.3 (24.1)	0.327	50.1a (24.3)	0.004	49.0 (26.6)	0.690	40.6 (19.4)	0.120	39.2a (21.7)	<0.001	47.6 (25.5)	0.104
Non-manual skilled	45.5 (24.9)		52.96a,b (23.6)		50.6 (26.9)		38.3 (20.7)		44.5 b,c (23.0)		50.2 (24.8)	
Manual skilled	44.0 (23.6)		55.3a,b (24.9)		52.0 (27.4)		45.9 (17.3)		41.5a,b,c (22.9)		50.8 (25.1)	
Semi-skilled/unskilled*	35.2 (24.3)		61.6 b (24.1)		45.9 (29.2)		43.8 (25.7)		48.7c (21.3)		51.6 (28.2)	
Student	–		–		–		–		36.4a (22.0)		–	
Location												
Rural	43.2 (23.6)	0.977	53.4 (23.9)	0.672	48.7 (26.2)	0.616	42.3 (19.2)	0.534	43.3 (22.1)	0.018	47.0 (24.9)	0.843
Urban	43.2 (24.5)		52.5 (25.0)		49.9 (27.5)		41.0 (21.3)		40.0 (22.5)		48.7 (26.1)	
BMI [‡]												
Normal weight	46.8 (23.8)	0.806	53.4 (24.3)	0.511	50.4a (26.6)	0.036	41.6 (20.1)	0.688	39.0 (21.7)	0.079	50.6 (25.2)	0.207
Overweight	48.9 (21.5)		50.3 (24.6)		47.6a,b (28.6)		41.1 (21.0)		41.6 (22.7)		49.1 (25.2)	
Obese	44.9 (23.5)		53.5 (24.6)		39.1 b (25.5)		46.5 (22.7)		42.6 (22.2)		46.0 (25.5)	
Breastfed												
Yes	43.7 (25.0)	0.536	51.0 (24.2)	0.065	48.1 (26.6)	0.132	38.1 (20.4)	0.005	–		47.4 (25.5)	0.008
No	42.3 (22.1)		54.7 (24.4)		51.6 (27.3)		43.8 (20.0)		–		50.8 (25.3)	

*Primary was merged with intermediate in the NPNS, NCFS and NCFS II. †Students were merged with semi-skilled/unskilled in the NPNS, NCFS, NCFS II and Preschool-Children. ‡In the NANS, BMI categories were determined using WHO standards: normal weight, BMI < 25.0 kg/m²; overweight, BMI = 25.0–29.9 kg/m²; obese, BMI ≥ 30.0 kg/m². In the NTFS, NCFS, NCFS II, NPNS and Preschool-Children, BMI categories were determined using the International Obesity Task Force age- and sex-specific BMI cut-offs for defining weight status in children aged 2–18 years (Cole et al., 2000). In the NPNS and Preschool-Children, BMI categories were only calculated for children aged ≥ 2 years. ^{a,b,c}Different subscripts indicate significant differences ($P < 0.05$) between mean food neophobia scores. A P -value of <0.008 (0.05/6) was considered statistically significant after adjusting for multiple comparisons using the Bonferroni correction.

to professional/managerial social class. In addition, females were found to have lower food neophobia, however, this was not significant after Bonferroni correction. In the NCFS II, the multiple linear regression predicted 1.9% of the variation in food neophobia scores. Out of all variables assessed, only age was significantly associated with food neophobia. Younger children were found to have significantly lower food neophobia. Sociodemographic factors were not significantly associated with food neophobia in adolescents ($F(8, 406) = 1.619, P = 0.117$). In the NANS, the multiple linear regression predicted 7.1% of the variation in food neophobia scores. Age was positively associated with food neophobia. Tertiary education level and urban location were negatively associated with food neophobia when compared to primary education level and rural location, respectively. Non-manual skilled and semi-skilled/unskilled social classes were positively associated with food neophobia when compared to professional/managerial social class. However, only age remained significant after Bonferroni correction.

4. Discussion

4.1. Food neophobia across the life course

Our results indicate that food neophobia increases at two-time points across the life course, in childhood and older age. We observed a peak in childhood between ages 6 and 7. This is consistent with the higher end of the commonly cited estimate of between 2 and 6 years (Dovey et al., 2008; Lafraire et al., 2016) and may reflect the evolutionary protective effect of food neophobia. The onset of food neophobia is linked with the development of food categories (Harris, 2018; Lafraire et al., 2016). At 2 years of age, infants begin to recognize familiar and unfamiliar foods, but they lack the experience to determine their safety. In addition, as children age, they gain more independence and mobility, increasing their risk of consuming harmful foods. Thus, food neophobia may act as a protective mechanism against the consumption of hazardous foods during this vulnerable period (Rioux, 2019). After six or seven years this

Table 4

Pearson correlations and partial correlations between breastfeeding duration, parental food neophobia and child's food neophobia in the NPNS, NCFS, NCFS II, NTFS separately and when the NCFS and NCFS II (NCFS-NCFS II) and NPNS and NCFS (NPNS-NCFS) were merged.

Survey	Breastfeeding duration		Parental FNS	
	r	Partial correlation ^a	r	Partial correlation ^a
NTFS	-0.136**	-0.116*		
NCFS	-0.102*	-0.091*	0.278***	0.271***
NCFS II	-0.062	-0.052		
NPNS			0.148***	0.154***
NCFS-NCFS II	-0.086**	-0.074*		
NPNS-NCFS			0.258***	0.244***

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. ^apartial correlation controlled for education level and social class. A P -value of < 0.025 ($0.05/2$) was considered statistically significant after adjusting for multiple comparisons using the Bonferroni correction.

protection may be less warranted as children begin to develop heightened cognitive abilities and are better equipped to assess the safety of novel foods (Fallon et al., 1984; Rozin et al., 1986). Therefore, the alleviation of food neophobic behaviour may ensure adequate dietary variety to meet growing nutrient needs. Another suggested explanation for this decrease relates to the observation that with increased age comes increased food experiences and subsequently a larger repertoire of familiar food. Thus, decreasing food neophobia may simply reflect a reduction in new foods to reject (Cooke & Wardle, 2005).

In line with previous findings (Meiselman et al., 2010; Siegrist et al., 2013; Tuorila et al., 2001) we found food neophobia increased in older adults. Why older adults report higher food neophobia levels is not fully clear. Older adults tend to prefer familiar tastes, favouring more traditional meals over less familiar cuisines (Delaney & McCarthy, 2011). This might be because older adults avoid unfamiliar foods to reduce the risk of potential illness or discomfort. Older adults are more concerned with safety when choosing novel foods than younger adults (Bäckström et al., 2003). Moreover, older adults show higher levels of food disgust sensitivity (Egolf et al., 2018) and perceived food-related risks (Siegrist et al., 2020). However, food neophobia has only been linked with higher levels of food disgust (Hartmann & Siegrist, 2018), not food risk perception (Siegrist et al., 2020). Thus, in older adults, food neophobia

Table 5

Multiple linear regression for sociodemographic determinants of food neophobia in the NPNS, NCFS, NCFS II, NTFS and NANS and when the NPNS, NCFS and NCFS II were merged (Preschool-Children).

	NPNS		NCFS		NCFS II		NTFS		NANS		Preschool-Children	
	β	SE	β	SE	β	SE	β	SE	β	SE	β	SE
Sex (ref. Male)												
Female	-2.572	2.177	-5.140*	2.030	-3.242	2.220	0.664	1.996	-0.331	0.782	-3.527**	1.263
Age	5.286*	0.984	-0.769	0.448	-1.709***	0.487	-1.329	0.717	0.164***	0.029	0.541*	0.188
Education Level (ref. Primary ^a)												
Intermediate									-2.679	1.808		
Secondary	-13.489*	5.816	-2.520	3.284	-8.882	6.152	1.527	2.920	-0.413	1.812	-7.895**	2.626
Tertiary	-7.449	5.197	1.346	3.182	-8.617	4.893	-2.505	2.729	-4.167*	1.794	-5.882**	2.261
Social Class (ref. Professional)												
Non-manual skilled	0.682	3.038	3.887	2.810	1.824	3.037	-3.006	2.856	2.807*	1.087	2.163	1.719
Manual skilled	-0.996	3.139	5.424	3.281	2.124	4.036	3.767	2.875	0.388	1.356	2.112	1.999
Semi-skilled/unskilled ^b	-8.866	4.726	12.507***	3.737	-4.943	4.626	0.836	3.645	3.927*	1.613	1.988	2.463
Student									0.566	1.503		
Location (ref. Rural)												
Urban	0.358	2.212	-1.023	2.051	0.899	2.229	-0.916	2.008	-1.993*	0.821	-0.359	1.266

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. ^areference was primary and intermediate merged in the NPNS, NCFS, NCFS II and Preschool-Children and intermediate in the NTFS. ^bSemi-skilled/unskilled were merged with students in the NPNS, NCFS, NCFS II and Preschool-Children. NANS: $R^2 = 0.079$, R^2 adjusted = 0.071; $F(10, 1142) = 9.726$, $P < 0.001$. NTFS: $R^2 = 0.032$, R^2 adjusted = 0.012; $F(8, 406) = 1.619$, $P = 0.117$. NCFS: $R^2 = 0.044$, R^2 adjusted = 0.031; $F(8, 565) = 3.223$, $P = 0.001$. NCFS II: $R^2 = 0.033$, R^2 adjusted = 0.019; $F(8, 579) = 2.431$, $P = 0.014$. NPNS: $R^2 = 0.079$, R^2 adjusted = 0.063; $F(8, 470) = 4.949$, $P < 0.001$. Preschools-Children: $R^2 = 0.021$, R^2 adjusted = 0.016; $F(8, 1616) = 4.242$, $P < 0.001$.

A P -value of < 0.01 ($0.05/5$) was considered statistically significant after adjusting for multiple comparisons using the Bonferroni correction.

may be partly explained by higher levels of food disgust, but this may not necessarily mean that novel foods are viewed as more hazardous.

Another possibility is it may reflect a cohort effect due to generational differences in food exposure during earlier years of life. There is some suggestive evidence that levels of food neophobia have declined over time (Rabadán & Bernabéu, 2021), possibly due to an increase in food exposures caused by the globalisation of food markets. Thus, higher food neophobia in older adults may be a by-product of the less diverse food environments these cohorts grew up in. Unfortunately, due to the cross-sectional design, it is not possible to determine if the higher food neophobia seen in older adults is due to an increase with age or reveals an age cohort who developed higher levels of food neophobia that was fixed earlier in life. Longitudinal studies are needed to determine this relationship.

4.2. Sociodemographic factors and food neophobia

In adults, food neophobia did not differ across sexes. However, when preschool and school-aged children surveys were merged (Preschool-Children) and in the NCFS, higher food neophobia was seen among males. Evidence for sex differences in food neophobia is inconsistent. Some studies support the present findings suggesting higher levels of food neophobia among males (Koivisto Hursti & Sjöden, 1997; Koivisto & Sjöden, 1996; Moding & Stifter, 2016; Siegrist et al., 2013; Tuorila et al., 2001), whereas others find the opposite, showing higher levels in females (Frank & Van Der Klaauw, 1994; Maiz & Balluerka, 2016). However, most studies tend to find no difference (Cole et al., 2017; Dovey et al., 2008; Meiselman et al., 2010). Sex does appear to influence food preferences in children, with boys showing a higher preference for meat and fatty foods and girls preferring fruits and vegetables (Caine-Bish & Scheule, 2009; Cooke & Wardle, 2005). However, boys and girls tend not to differ in the number of foods tried (Cooke & Wardle, 2005). Thus, the results for sex differences are difficult to account for. It appears if such differences exist their effects are likely small and may be more visible in children than in adolescents or adults.

In adults, food neophobia was negatively associated with education level, social class and living in urban locations. These findings are consistent with previous studies across multiple countries (Rabadán & Bernabéu, 2021). Lower socioeconomic status, be it social class, education level or income, have been consistently linked with lower dietary variety and quality (Ahn et al., 2006; Darmon & Drewnowski, 2008).

This reduced variety may reduce food exposures to such a degree that it leads to an increase in food neophobia. Similarly, the variety of foods available to those living in rural environments is often lower than those living in urban settings (Layte et al., 2011). Therefore, much like socioeconomic factors, rural residents may experience lower food variety throughout life, leading to higher levels of food neophobia.

Interestingly, the influence of socioeconomic and locational factors on food neophobia in children and adolescents was less pronounced than in adults. When preschool and school-aged children surveys were merged food neophobia was significantly associated with parental education level but not social class. However, higher levels of food neophobia were observed in children with semi-skilled/unskilled/student social class in the NCFS. Much like adults, lower parental education levels and social class may be indirectly influencing food neophobia by reducing food exposure. One study found lower parental education level was associated with higher child's food neophobia and predicted a larger number of tasted foods (Mustonen et al., 2012). This suggests that parents with higher education levels may expose their children to a wider selection of foods, reducing their food neophobic tendencies. Interestingly, most studies to date have failed to identify significant differences in socioeconomic status (income) or educational level on food neophobia in children and adolescents (Cooke et al., 2006; Kozioł-Kozakowska et al., 2018; Kutbi et al., 2019; Roßbach et al., 2016). The effects of socioeconomic factors on food neophobia in children are likely small and therefore may be difficult to capture with small sample sizes. This may explain why significant differences in education level were only seen in the merged dataset as this variable may have been underpowered in individual surveys.

The impact of socioeconomic factors on food neophobia may have less effect on children and adolescents than adults because the food choices of children are predominantly dictated by their parents. This means the capacity of a child to seek or avoid new foods is often limited to what their parents purchase. Thus, although children of lower affluent families may experience less varied diets, they may also encounter fewer new foods, reducing their opportunity to exhibit food neophobic behaviours. It's also likely that the effects of socioeconomic deprivation on food neophobia build up over time, so that a visible increase in food neophobia may take many years to occur. Unfortunately, due to the cross-sectional design, it is not possible to determine if changes in socioeconomic circumstances could lead to a change in food neophobia. Longitudinal studies are required to determine this effect.

Across all surveys, only children in the NCFS showed a small negative association between food neophobia and obesity. Although this was not significant after Bonferroni correction. Evidence for food neophobia and weight status in children is mixed. However, most studies suggest food neophobia does not have a significant effect on BMI or obesity levels (Brown et al., 2016). Given the small number of children with obesity in the NCFS II ($n = 39$ (6.7%)), the strength of this relationship is uncertain.

4.3. Breastfeeding and food neophobia

Preschool-aged children, children and adolescents who were breastfed were found to have significantly lower levels of food neophobia. Similarly, breastfeeding duration was shown to have a significant small negative correlation with food neophobia in children and adolescents. This remained significant even after controlling for education level and social class. Breastmilk contains a wide variety of flavour compounds that change according to the mother diet, whereas infant formula provides a fixed array of compounds throughout the feeding period. Some evidence suggests that breastfeeding may increase a child's willingness to accept certain foods such as fruits and vegetables, potentially reducing food neophobia (Harris & Coulthard, 2016). However, previous research linking breastfeeding to food neophobia is varied. Although some studies have linked breastfeeding duration with lower food neophobia (Maier et al., 2008; Roßbach et al., 2016), most

research has failed to find significant effects (Cole et al., 2017). Given the complexity of food neophobia development, the influence of breastfeeding is likely small, if at all. This small effect size may make it difficult to capture in smaller sample sizes and may explain why significant differences in food neophobia between breastfed and non-breastfed children were only seen when preschool and school-aged children surveys were merged.

4.4. Parental and child food neophobia

Our results confirm previous findings that parental food neophobia is positively correlated with child food neophobia (Cooke, 2018). One obvious explanation for this relationship is heritability. Food neophobia shows high heritability with estimates ranging between 58% and 78% (Cooke, 2018). Alternative explanations may relate to parental feeding practices that stem from food neophobic behaviours. Food neophobic parents, who likely restrict their own food choices, may also limit the variety of foods they offer their children (Kaar et al., 2016; Tan & Holub, 2012). This may reduce the child's repertoire of familiar foods, increasing food neophobia. Food neophobia has also been linked to social modelling (Hobden & Pliner, 1995). Thus, food neophobic parents may present more examples of food rejection, leading children to imitate similar behaviours.

Unfortunately, data on parental food neophobia was not available for the NTFS or NANS. However, previous research suggests that associations between parental food neophobia and child food neophobia persists into adolescence (Roßbach et al., 2016) and has even been observed between university-aged students and their parents (Elkins & Zickgraf, 2018). Interestingly, as with previous findings, the correlations we observed were modest. Therefore, while parental food neophobia is related to child food neophobia, it is not a strong predictor.

4.5. Limitations

This study has some limitations. As each survey was collected during different years it is unclear if the observed relationships would have been observed in data collected over the same period. In preschool and school-aged children, food neophobia was measured using 4-items from the CEBQ which was developed as a part of a measure for food fussiness (Wardle et al., 2001). Although it showed good internal reliability, this instrument has not been validated with an appropriate behaviour test (Damsbo-Svendsen et al., 2017). It is unclear if a validated measure of food neophobia, such as the Children's Food Neophobia Scale (CFNS) (Pliner, 1994) would have led to different results. In addition, CEBQ was developed for children aged 2–9 years. However, in the present study, children aged 10 to 12 were also assessed using the CEBQ. At these ages, children exhibit more food independence which may reduce the accuracy of parental assessments (Lauzon-Guillain et al., 2012). Because the CEBQ only included 4-items compared to the 10-items in the FNS the spread of possible scores was far greater among adults and adolescents than in children and preschool children. This meant it was not possible to conduct statistical tests across these surveys and limited the ability to make direct comparisons between the degree of food neophobia observed between these different age cohorts. Moreover, although the FNS and FN-CEBQ are measured on ordinal scales the current analysis assumed both scores act as interval scales and can therefore be analysed using parametric statistical tests. Although some authors have argued that parametric tests are appropriate for analysing ordinal scales (Norman, 2010), recent evidence suggest that certain constructs of the CEBQ may need adjusting prior to such analyses (Somarakis et al., 2022).

5. Conclusion

These results provide the first exploration into the trajectory of food neophobia across the life course. We provide evidence that food neophobia peaks at around 6 or 7 years of age, decreasing thereafter with

age to a plateau in early adulthood and increasing again in older age around 54 and 64 years. Although the proportions varied with age, we observed people with high levels of food neophobia across all ages. While our results provide some evidence that socioeconomic factors, location, breastfeeding and parental food neophobia influence food neophobia, these factors only explained a small proportion of the variation seen across all ages. Although other sociodemographic models in adults have explained slightly more variance (15%) than the present study (Siegrist et al., 2013), most of the individual difference in food neophobia remains unexplained. Given the negative impact food neophobia can have on food consumption, especially among children (Kral, 2018; Rabadán & Bernabéu, 2021), uncovering factors that influence its development may provide future targets for interventions. There is some evidence to suggest that repeat exposure and improved social modelling may help alleviate some food neophobic tendencies, however, this has been primarily studied in children (Lafraire et al., 2016; Nicklaus & Monnery-Patris, 2018). Moreover, it is unclear if such changes can occur in all people or if certain characteristics make someone more likely to change. While this cross-sectional study has provided new insight into the prevalence of food neophobia across the life course, longitudinal studies are needed to assess the influence of food neophobia at an individual level and how levels may change with age and socioeconomic circumstance.

Author contributions

DH conceived the current research questions, carried out the data analysis and wrote the first draft. JK and MS contributed to the design of the study, data analysis and study review. JW and BMN contributed to the design, execution and/or management of the NANS, NTFS, NCFS, NCFS II, and NPNS datasets and provided expert advice throughout. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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Ethical statement

Ethical approval for each survey was obtained from University College Cork Clinical Research Ethics Committee of the Cork Teaching Hospitals and the Human Ethics Research Committee of University College Dublin. Written consent was obtained from all participants as well as their parents/guardians in the NTFS, NCFS, NCFS II and NPNS, in accordance with the Declaration of Helsinki.

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2022.105941>.

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