



The stress of food allergy issues in daily life

Rana L. Peniamina, Miranda Miroso, Philip Bremer & Tamlin S. Conner

To cite this article: Rana L. Peniamina, Miranda Miroso, Philip Bremer & Tamlin S. Conner (2016): The stress of food allergy issues in daily life, *Psychology & Health*, DOI: [10.1080/08870446.2016.1143945](https://doi.org/10.1080/08870446.2016.1143945)

To link to this article: <http://dx.doi.org/10.1080/08870446.2016.1143945>



View supplementary material [↗](#)



Accepted author version posted online: 20 Jan 2016.
Published online: 25 Feb 2016.



Submit your article to this journal [↗](#)



Article views: 36



View related articles [↗](#)



View Crossmark data [↗](#)

The stress of food allergy issues in daily life

Rana L. Peniamina^a, Miranda Miroso^a, Philip Bremer^a and Tamlin S. Conner^{b*}

^aDepartment of Food Science, University of Otago, Dunedin, New Zealand; ^bDepartment of Psychology, University of Otago, Dunedin, New Zealand

(Received 14 October 2015; accepted 14 January 2016)

Objective: Food allergies are a growing health concern, but their implications for daily psychological functioning are unknown. This micro-longitudinal study investigated the daily frequency of food allergy issues and how this related to experiences of stress, mood and physical energy.

Design: One hundred and eight adults with physician-diagnosed food allergies completed an initial Internet survey followed by a 2-week Internet daily diary survey.

Main outcome measures: The initial survey collected socio-demographic and food allergy information. The daily survey collected information about the participants' experiences of stress, mood, physical energy and food allergy issues during that day.

Results: Commonly experienced allergy issues included negative physical symptoms, higher food prices, anxiety about safety of food, trouble maintaining a healthy diet and anxiety/stress at social occasions. Furthermore, multilevel modelling analyses showed that stress and negative mood were significantly higher on days with more allergy issues. Older adults experienced lower positive mood and physical energy on days with more issues.

Conclusion: This is the first study to incorporate near to real-time tracking to examine the frequency of food allergy issues and the implications for daily psychological functioning. Targeting the issues we identified could reduce stress in patients with food allergies and improve their overall quality of life.

Keywords: food allergy; stress; mood; allergy issues; daily diary; hierarchical linear modelling

Introduction

Food allergies are a growing concern in the public health domain. The prevalence of food allergies has increased over the past 10 years along with the incidence of emergency department visits and hospital admissions for food-induced anaphylaxis (Sampson, 2014). Based on a review of prevalence studies, Immunoglobulin E (IgE)-mediated food allergies (reactions involving IgE antibodies, e.g. peanut, treenut, cow's milk) are estimated to affect 2–10% of the population (Sicherer, 2011). Less is known about the prevalence of non-IgE-mediated food allergies (immune reactions that do not involve IgE antibodies) (Jyonouchi, 2012) apart from coeliac disease (an adverse immune reaction to ingested gluten), which is reported to affect 1% of the overall population (Reilly & Green, 2012).

*Corresponding author. Email: tconner@psy.otago.ac.nz

The physical effects of food allergies are well understood. Food allergy symptoms can include reactions of the skin (e.g. hives, eczema), gastrointestinal system (e.g. nausea, diarrhoea, and vomiting), respiratory system (e.g. shortness of breath, wheezing) and cardiovascular system (e.g. palpitations, low blood pressure). IgE-mediated food allergies are associated with immediate symptoms (onset within minutes to 2h) while non-IgE-mediated food allergies are associated with delayed symptoms (onset within hours or days). The most severe form of IgE-mediated food allergy results in anaphylaxis, a life-threatening systemic allergic reaction requiring emergency treatment with epinephrine. While IgE- and non-IgE-mediated food allergies differ in terms of the immune mechanisms involved and the typical symptoms experienced, qualitative research suggests that these sub-groups of food allergy patients experience similar allergen management issues in their daily lives (Peniamina, Bremer, Conner, & Miroso, 2014).

The psychological effects of food allergies are less well understood, although published research suggests that food allergies may impact health-related quality of life. The results of a cross-sectional health-related quality of life survey showed that three areas of health-related quality of life (social functioning, vitality, and general health) were poorer for adults with food allergies compared with the general population (Flokstra-de Blok et al., 2010). In another cross-sectional survey, Voordouw and colleagues (2010) found higher direct health care costs, indirect costs (loss of time and lost income), and intangible costs (self-perceived health and well-being) in households with food allergy compared to those without food allergy. Qualitative and cross-sectional survey data also suggests that daily frustrations resulting from food allergy management are a 'constant' source of stress for patients with food allergies, which can undermine their quality of life (Cummings, Knibb, King, & Lucas, 2010; Marklund, Ahlstedt, & Nordström, 2007; Peniamina et al., 2014). However, the frequency and perceived impact of food allergy management issues and their association with quality of life have not been investigated in the context of daily life.

Issues associated with food allergy management include a constant need for vigilance, trouble finding suitable foods, increased costs, and social implications, just to name a few (Goossens et al., 2011; Peniamina et al., 2014). Although adults living with food allergies may differ in the types of issues they experience (Peniamina et al., 2014), experiencing these issues on a day-to-day basis may impact their daily quality of life through increased stress, poorer mood, and reduced physical energy. Stress and mood are key daily indicators of subjective well-being, which is important to individual quality of life (Glatzer, Camfield, Møller, & Rojas, 2015). Physical energy is a concept similar to vitality, which Floksta-de Blok and colleagues (2010) found was impaired in adults with food allergies.

Research to date has not assessed the naturalistic relationship between food allergy management and daily experiences of stress, mood and energy over time in real-world settings. Although cross-sectional surveys and qualitative interviews such as those used in published food allergy research provide a starting point for understanding the psychological concomitants of living with food allergy issues, other approaches are needed to assess the naturally occurring relationships between patients' allergy experiences and their psychological states in daily life. Such data can only be obtained by tracking allergy issues and testing their associations with psychological sequelae over time across consecutive days (Mehl & Conner, 2012; Shiffman, Stone, & Hufford, 2008; Stone,

Shiffman, Atienza, & Nebeling, 2007). Daily diary methods involve collection of data in 'near to real time' and encompass many similar advantages to real-time methods. While daily diary methods involve a degree of retrospection across the day, and therefore possible recall bias, they are less demanding than true real-time methods such as experience sampling or ecological momentary assessment (EMA) (Schwarz, 2007). In addition, certain types of data (e.g. reporting the occurrence of specific events) are less bias-prone and therefore better suited to daily diary methods compared to other types of data (e.g. reporting how often a frequent and ordinary event occurred). Unlike cross-sectional surveys, daily diary methods can also assess the within- and between-person associations between predictors and outcomes.

Understanding how allergy issues are related to daily changes in quality of life – particularly stress and negative mood – is important given the personal and social costs of impairment in these states. Increased daily stress and/or negative mood resulting from food allergy management could have implications for short- and long-term health outcomes of people with food allergies. For example, both stress and negative mood are associated with increased levels of stress hormones (Smyth et al., 1998; van Eck, Berkhof, Nicolson, & Sulon, 1996). Continual activation of the body's stress response associated with chronic daily stress has been linked to an increased risk of infections (due to inhibition of the immune system), and the development of insulin resistance disorders, cardiovascular disease and mental health problems such as anxiety or depression (Cacioppo et al., 1998; Cohen, Janicki-Deverts, & Miller, 2007; Sapolsky, 2004). Stress can also cause imbalances in the immune system that can further increase susceptibility to allergic responses (Elenkov, 2002). In addition to the individual costs of food allergies, there may also be societal costs in terms of lost work productivity (Voordouw et al., 2010) and increased costs to the health care system due to more frequent engagement of health care services (Patel, Holdford, Edwards, & Carroll, 2011).

The primary aim of the current study was to use daily diary methods to quantify the most common food allergy issues that people experience in their daily lives, and to test the between-person and within-person relationships between the number of food allergy issues and experiences of stress, mood and physical energy on a daily basis. This approach provided a quantitative extension to qualitative health research that identified issues people with food allergies face (Peniamina et al., 2014) and improves upon previous cross-sectional research by tracking the dynamic covariation between allergy issues and psychological states in naturalistic settings. To our knowledge, no study has ever used daily diary methods to investigate the links between psychological well-being and food allergy issues in daily life. We hypothesised that food allergy issues occur frequently in the daily lives of adults with food allergies and contribute to impairments in daily stress, mood and physical energy levels.

Another primary aim was to test whether patients' socio-demographic characteristics (e.g. age, gender, income level) and their food allergy characteristics (e.g. symptom severity, number and type of food allergies) moderated the frequency and impact of food allergy issues. Socio-demographic and food allergy characteristics may affect how food allergies are experienced and therefore influence quality of life. For example, it was expected that individuals/families with a lower income might report more issues related to food and medical costs. In addition, because some food allergens are more commonly found in staple foods than others, the type of food allergy might influence stress related to allergen avoidance. Other socio-demographic and food allergy

characteristics (e.g. age, gender, symptom severity and number of food allergies) have each been linked to differences in reported quality of life (Flokstra-de Blok et al., 2009, 2010; Goossens et al., 2011; Hallert, Sandlund, & Broqvist, 2003).

A secondary aim was to test for possible carry-over (lagged) associations of allergy issues onto next day quality of life and vice versa. This was included to see whether the associations were time-limited and restricted to the same day, or whether there were possible carry-over patterns onto the next day that could potentially indicate the direction of associations found. Although exploratory, these lagged analyses reflect our desire to capitalise on the richness of this micro-longitudinal data-set.

Method

Participant recruitment

Participants were recruited by placing advertising flyers at prominent locations (e.g. doctor's clinic noticeboards, supermarkets, libraries, universities, hospitals), through social media (advertising on Facebook), and by newspaper advertising. For the purpose of this study, food allergy was defined as a reproducible adverse reaction caused by an immune-mediated response to a food or food component. This definition is based on the World Health Organization definition of food allergy, and includes both IgE-mediated food allergies and non-IgE-mediated food allergies (e.g. coeliac disease) (World Health Organisation International Food Safety Authorities Network [INFOSAN], 2006). Participants aged 18 years or older were included in the study if they self-reported a medically diagnosed food allergy. Reported symptoms, type of doctor who made the diagnosis and method/s of diagnosis were used to confirm if participants fit the inclusion criteria for food allergy diagnosis. This study was approved by the Department of Food Science and the Department of Psychology ethics committees prior to commencement of the study. Informed consent was obtained from the participants prior to their participation.

Measures

The measures included an initial online survey followed by daily online surveys. The initial survey collected a range of socio-demographic information (e.g. age, gender, ethnicity, type of household, income and education) and information about the participants' food allergies (e.g. food allergy type, symptoms, diagnostic methods used, doctor/s involved in diagnosis and time since diagnosis) (see Table 1). The daily survey was designed to be accessed online on a daily basis over 14 consecutive days. In the first section of the daily survey, participants rated their stress, mood and physical energy in terms of how they felt 'that day.' The stress measure was based on a single-item measure validated by Elo, Leppänen, and Jahkola (2003). Participants rated their stress that day on a five-point scale from 1 (*not at all*) to 5 (*very much*). Negative mood items (sad, anxious, irritable), positive mood items (content, happy, enthusiastic), and physical energy items (run-down, energetic) were rated on a five-point scale from 1 (*not at all*) to 5 (*extremely*), and averaged for each day (using reverse scoring for the 'run-down' item). Reliabilities were .54 for the negative mood scale and .70 for the positive mood scale (multilevel reliability procedures based on Nezlek, 2012).¹ Reliability for the physical energy items was not computed because it was only a two-item scale; however, the items were highly correlated at the daily level ($B = -.499$, $SE = .044$, $p < .001$).

Table 1. Socio-demographic and food allergy information of the study participants.

Characteristic	Frequency (%)
Ethnicity	
NZ European	92
Māori	11
Other European	12
Other ^a	7
Type of household	
Couple, no children at home	36
Family with children at home	33
Single parent with children at home	8
Group of adults (shared accommodation)	22
Adult living alone	6
Other ^b	3
Income (NZ\$)	
≤ 25,000	24
25,001–40,000	8
40,001–60,000	20
60,001–80,000	18
80,001–100,000	11
100,001–150,000	15
> 150,000	12
Education (highest qualification)	
High school	19
Polytechnic certificate or diploma	15
Trade qualification	3
Bachelor's degree	41
Postgraduate diploma	12
Masters or PhD degree	18
Type of food	
Gluten	59
Peanut	23
Cow's milk	18
Shellfish/seafood	18
Treenut	17
Egg	14
Fruit/vegetables ^c	12
Wheat	11
Soya	8
Other ^d	10
Number of allergen foods	
1	68
2	21
3 or more ^e	19
Type of symptoms	
Anaphylaxis	26
Gastrointestinal	85
Respiratory	32
Skin	58
Other ^f	30

(Continued)

Table 1. (Continued).

Characteristic	Frequency (%)
Method/s used in diagnosis	
Blood tests	71
Biopsy	44
Skin prick testing	34
Medical history	34
Elimination diet/food challenge	29
Anaphylactic reaction after eating allergen	3
Allergy diagnosed by	
Gastroenterologist	41
General practitioner	37
Allergy specialist/immunologist	28
Other specialist ^g	2

^aOther ethnicities: Indian, South American, Native American, African American, Australian, Canadian, American.
^bOther households: temporarily staying with parents, couple living with adult child and partner, hall of residence.
^cFruit/vegetables: avocado ($n = 5$), kiwifruit ($n = 4$), banana ($n = 3$), tomato ($n = 2$), citrus fruit, lychee, tamarillo, pineapple, capsicum, corn, carrot, spinach.
^dOther foods: sesame ($n = 2$), chicken, beef, rice, broad beans, chickpeas, cocoa, peppermint, guar gum, spirulina.
^eIncluded participants who were allergic to three foods ($n = 7$), four foods ($n = 6$), five foods ($n = 4$), and nine foods ($n = 1$).
^fOther symptoms: fatigue, headache/migraine, depression, dizziness, hotness/sweating, blurred vision, drowsiness, anxiety, confusion, lack of concentration, memory loss, oedema, oral allergy, mouth ulcers, anaemia, weight loss, leg pain, joint problems.
^gOther specialists: dermatologist, specialist not specified.

In the second section of the daily survey, participants were asked whether they experienced any food allergy issues that day (yes/no). If yes, this was followed by a list of 25 food allergy issues (including ‘other’) for participants to select from. This list of food allergy issues was based on the results of focus group research that investigated the issues experienced by adults with food allergies (Peniamina et al., 2014). The list included issues related to allergen-free eating, financial cost, time cost, personal cost, external influences, physical effects and mental well-being issues (a full list of the issues can be found in Supplemental Material 2, Table S-2). The total number of issues per day for each participant served as a measure of his/her daily allergy issues. In the third section, participants were asked to select up to three issues that had the most impact on their life that day. Participants further rated each of these issues in terms of the perceived severity (i.e. how stressful that issue was for them), and the perceived impact it had on their ability to complete normal daily tasks.

Data collection

Participants accessed the study from a website. After answering several eligibility questions (about allergy diagnosis, age and availability), they were asked to complete the initial online survey prior to signing up for a two-week period during which daily surveys would be completed. A two-week period was used for the daily surveys to allow for the experience of a broad range of issues (including two weekends) while keeping participant burden to a minimum. Participants were given options of several upcoming

two-week periods, all of which started on a Monday. They were then asked to complete the daily survey each day, which was accessible between 6 pm and 2 am during their chosen two-week period. A reminder email was sent out on the day of the first daily survey, and text reminders were sent out each evening during the two-week period. The majority of surveys were typically completed between 8 and 10 pm. The data were collected between January and July 2013. Participants were entered in a prize draw (one prize of NZ\$200 and eight prizes of NZ\$100) as thanks for their participation and were given the option to receive an individualised report of the study results.

Statistical analysis

Descriptive analyses were conducted on the 25 allergy issues from the daily surveys to determine the frequency of allergy-related issues, including the number and type of issues experienced, and the proportion of participants affected. Perceived severity and impact ratings were also examined descriptively to determine which issues were perceived as high stress and/or impact.

Inferential analyses were conducted using multilevel modelling to determine the between and within-person relationships between the number of food allergy issues and reports of daily stress, mood and physical energy. The hierarchical linear modelling programme was used for all models (HLM 7 student version, Raudenbush, Bryk, & Congdon, 2011). More details about the multilevel models can be found in Supplementary Material 1. Between-person multilevel models tested whether individuals who experienced more (vs. fewer) food allergy issues on average also experienced more stress, poorer mood and less energy on average. The average number of allergy issues served as the level-2 predictor (grand centred) and stress served as the level-1 outcome. Separate models were run for negative mood, positive mood and physical energy as the other outcomes. Within-person multilevel models tested whether on days with more (vs. fewer) food allergy issues, individuals experienced more stress, poorer mood, and less energy. The number of allergy issues served as the level-1 predictor (group centred) and stress served as the level-1 outcome. Again, separate models were run for negative mood, positive mood and physical energy as the other outcomes. This approach took into account the nested nature of the data with reports of food allergy issues experienced, daily stress, negative mood, positive mood and physical energy (at level-1) nested within individuals (at level-2).

Additional models were then run to determine whether level-2 predictors (age, gender, income level, symptom severity, number of food allergies and type of food allergy, each tested separately, continuous measures grand-mean centred) moderated the within-person associations between number of allergy issues per day and the outcomes (stress, negative mood, positive mood and physical energy). Significant moderators were probed to determine the relationship between allergy issues and the outcome at different levels of the socio-demographic or food allergy characteristic.

Lastly, lagged analyses were run for the within-person associations (without level-2 predictors) to determine if the number of allergy issues carried over onto next-day psychological states controlling for same day psychological states. For completeness, these analyses were also completed in reverse (i.e. to determine if psychological states carried over onto next-day higher allergy issues, controlling for same day number of allergy issues).

Results

Participants

A total of 131 participants started the study. Of these, one was excluded because he/she did not fit the inclusion criteria for food allergy diagnosis and 22 were excluded because they completed fewer than five daily surveys. The data inclusion cut-off was set at 30% of daily surveys (a minimum of five out of 14 possible surveys) because this would allow enough data to compute frequency estimates for the allergy related issues and to conduct the lagged analyses. Inclusion criteria of 25–50% of reports are common in diary research (Conner & Lehmen, 2012) and prior research suggests that including people with one third or more reports balances inclusiveness while maintaining data quality (Delespaul, 1995). The majority of excluded participants did not complete any daily surveys ($n = 12$) or completed only one daily survey ($n = 5$). Excluded individuals did not differ from included individuals on any of the study variables (socio-demographic and food allergy characteristics). The remaining 108 participants (15% male, 85% female) completed on average 11 (range 5–14; $SD = 2.5$) daily surveys during the two-week period, yielding a total of 1144 diary records.

The participants' mean age was 40.2 (range 18–87). Socio-demographic information (ethnicity, type of household, income, education) and food allergy information (food allergy type, symptoms, diagnostic methods used, doctors involved in diagnosis) for the final sample of 108 participants is shown in Table 1. The sample included participants with a range of food allergies and symptoms. Several participants ($n = 19$) reported allergies to three or more foods. Based on the food allergy information (food/s allergic to, diagnostic methods, symptoms) provided by participants, it was estimated that the sample consisted of participants with an IgE-mediated food allergy (41%), non-IgE-mediated food allergy (50% total; 36% biopsy-diagnosed coeliac), or a combination of IgE- and non-IgE-mediated food allergy (8% total; 5% biopsy-diagnosed coeliac with additional IgE-mediated food allergy). Most of the participants ($n = 79$) were diagnosed using a combination of at least two methods (e.g. medical history or food challenge combined with skin prick testing and/or blood tests). Most participants with an allergy to gluten had coeliac disease diagnosed by biopsy ($n = 44$), with the remainder diagnosed by blood tests combined with food challenge and/or medical history ($n = 10$) or by blood tests ($n = 5$).

Descriptive results and most frequent allergy issues

Participants experienced two food allergy issues per reported day on average (range 0–14; $M = 2.06$; $SD = 2.35$). Across the two-week reporting period, participants experienced issues on an average of nearly 50% of reported days (range 0–100%, $M = 49.5\%$; $SD = 29.7\%$ of days). The average daily stress, positive mood, negative mood and physical energy reported by participants in this study were 2.0 ($SD = 1.0$, range 1.0–5.0), 3.2 ($SD = .8$, range 1.0–5.0), 1.7 ($SD = .7$, range 1.0–5.0) and 3.2 ($SD = .9$, range 1.0–5.0), respectively. Of the daily diary reports in which participants reported any food allergy issues, 66% corresponded with some stress (daily stress rating of two or more) and 30% corresponded with moderate to high stress (daily stress rating of 3–5), compared with 52% and 22% of daily diary reports with no issues, respectively. Participants who reported an average of one or more issues per day ($n = 69$)

reported some stress on 68% of reported days, and moderate to high stress on 34% of reported days. Participants who reported an average of two or more issues per day ($n = 36$) reported some stress on 75% of reported days and moderate to high stress on 37% of reported days.

Some issues were reported by a higher proportion of the participants and more frequently than other issues. Table 2 shows a list of the top 10 issues experienced by a substantial proportion of participants. The most common issues included those related to food choice (e.g. problems finding suitable foods, no food available), cost of allergen free food, food allergy reactions (e.g. physical symptoms) and social activities (e.g. stress during social occasions). The mean perceived severity and perceived impact ratings showed that, on average, these commonly experienced issues were rated as moderately stressful ($M = 2.8$, range 2.2–3.0, $SD = .25$) and as having moderate impact on daily tasks ($M = 2.3$, range = 2.1–2.7, $SD = .20$). Of these top 10 issues, six issues were identified as particularly stressful for participants (i.e. mean perceived severity rating of 2.9 or higher, marked with asterisk in Table 2), with the most stressful being extra financial cost (food). A complete list of all the issues and their perceived severity and impact ratings can be found in Supplementary Material 2 (Table S-2). Based on the proportion of participants affected, the frequency of reporting, and the mean perceived severity, these issues are a likely source of moderate daily stress.

Multilevel model results

Between-person multilevel models showed that participants who reported more daily food allergy issues also reported higher average daily stress ($B = .120$, $SE = .021$, $p < .001$), a more negative daily mood ($B = .063$, $SE = .017$, $p < .001$), and lower daily physical energy levels ($B = -.080$, $SE = .018$, $p < .001$), but no differences in positive mood ($B = -.034$, $SE = .026$, $p = .183$). Between-person variation in the number of food allergy issues explained 26.5% of the variation in average daily stress, 10.6% in average daily negative mood, and 10.3% in average physical energy.

Within-person multilevel models showed that on days that participants experienced more food allergy issues, they also reported higher stress ($B = .072$, $SE = .013$, $p < .001$) and a more negative mood ($B = .028$, $SE = .009$, $p = .002$). Daily stress was .072 points higher and negative mood was .028 points higher with each additional allergy issue experienced. Daily variation in the number of food allergy issues explained 4.5% of the variance in daily stress and 3.5% of the variance in daily negative mood. Within-person multilevel models also showed a strong within-day yoking between daily stress and reports of more allergy symptoms ($B = .517$, $SE = .117$, $p < .001$). Within-person multilevel models showed no relationships between allergy issues and either positive mood ($B = .003$, $SE = .010$, $p = .800$) or physical energy ($B = -.016$, $SE = .012$, $p = .178$). To ensure that the allergy issues that involved stress and/or anxiety (e.g. feeling anxious or stressed when participating in social occasions involving food) were not inflating the observed associations, separate analyses were run after removing these items. Removal of these allergy issues from the analyses did not change the reported associations.

However, age significantly moderated the associations between allergy issues and both positive mood (age $B = -.0018$, $SE = .0006$, $p = .004$) and physical energy (age $B = -.0014$, $SE = .0007$, $p = .039$). Models of these associations were tested for people

Table 2. The top 10 food allergy issues experienced by participants, the proportion of participants affected, frequency reported, perceived severity and perceived impact on daily tasks.

Issue	Proportion of participants (%) ^a	Frequency (%) ^b	Perceived severity	Perceived impact on daily tasks
Problems finding suitable foods to eat when away from home	65.7	15.3	2.5	2.1
Extra financial cost due to higher food prices for safe food*	63.0	17.0	3.0	2.3
Having to take risks by eating foods that may contain allergens	57.4	13.4	2.6	2.1
Loss of time due to extra time spent sourcing safe food	52.8	12.4	2.2	2.1
Physical symptoms of food allergy*	49.1	17.4	2.9	2.7
Feeling anxious about whether food is safe to eat*	48.1	11.8	2.9	2.3
Having to go hungry/not eat because there is no safe food available	46.3	9.7	2.7	2.6
Feeling anxious or stressed when participating in social occasions involving food*	41.7	7.9	2.9	2.3
Problems with finding suitable foods to purchase when grocery shopping*	39.8	5.7	2.9	2.3
Trouble with maintaining a healthy, nutritionally balanced diet as a result of my food allergy*	35.2	11.6	2.9	2.4

Notes: The top 10 issues were identified by ranking issues by the proportion of participants affected and then by the frequency with which an issue was reported. A comparison of the issues at the top of these two tables revealed an overlap between top issues based on proportion of participants and top issues based on frequency. The first six issues were the same in each table, although not necessarily in the same order. Including a further two issues from each table created our top 10 issues. These top 10 issues were experienced by at least 40% of participants or on at least 10% of days reported.

^aProportion of participants: proportion of participants who reported experiencing this issue at least once during the two-week reporting period.

^bFrequency %: how often the issue was reported, as a percentage of total daily reports (reports with issue selected/1144 × 100).

*Issues identified as particularly stressful, on average.

at age 70, 55, 40, 25 (corresponding to +2, +1, 0, and -1 SDs in age), which showed that relative to younger ages, older adults experienced stronger reductions in positive mood (age 70, $B(SE) = -.051(.021)$, $p = .017$; age 55, $B(SE) = -.024(.013)$, $p = .076$; age 40, $B(SE) = .003(.009)$, $p = .709$; age 25, $B(SE) = .031(.013)$, $p = .019$) and greater decreases in energy (age 70, $B(SE) = -.058(.019)$, $p = .002$; age 55, $B(SE) = -.036(.011)$, $p = .002$; age 40, $B(SE) = -.014(.011)$, $p = .203$; age 25, $B(SE) = .008(.019)$, $p = .687$) on days with more allergy issues. Age did not moderate the within-person associations between allergy issues and stress ($B = -.001$, $SE = .001$, $p = .548$) or negative mood ($B = .001$, $SE = .001$, $p = .087$).

Participants who reported allergies to three or more foods experienced lower positive mood ($B = -.029$, $SE = .011$, $p = .010$) on days with more allergy issues while participants with allergies to one ($B = .011$, $SE = .012$, $p = .384$) or two foods ($B = .007$, $SE = .032$, $p = .836$) did not. Number of food allergies did not moderate the

within-person associations between allergy issues and stress, negative mood, or physical energy. A comparison between food allergy type groups (gluten/wheat allergy; peanut/treenut allergy; shellfish/seafood allergy; cow's milk allergy; other allergy) showed that the relationship between the number of allergy issues and stress was lower for participants who reported a shellfish or seafood allergy compared to participants with gluten or wheat allergy ($\chi^2 = 4.26$, $p = .037$). No other demographic factors (gender, income level, symptom severity) moderated these within-person patterns.

Lagged analyses found no significant cross-day lagged relationships. The number of allergy issues did not predict changes in next-day psychological states (stress, mood and energy) nor did psychological states predict changes in the next-day number of reported allergy issues.

Discussion

This is the first study to intensively track the experience of allergy related issues in adults living with food allergies. Based on our analysis of the proportion of participants affected, frequency of allergen issues, and the perceived severity and impact ratings, the current study descriptively identified several key issues having the most impact on adults with food allergies. These included issues related to allergen-free eating (lack of suitable allergen-free food, risk-taking), cost (social limitations, financial cost of food, loss of time) and well-being (recurring physical symptoms, nutritional health, stress/anxiety).

Some of the top issues identified quantitatively in the current study were similar to the top issues identified by Goossens et al. (2011) using a validated food allergy quality of life questionnaire. For example, problems finding suitable foods, anxiety about safety of food and anxiety/stress at social occasions were common to both studies. Constant alertness, vigilance, and labelling issues identified by Goossens and colleagues (2011) are likely to contribute to the loss of time due to extra time spent sourcing safe food issue identified in the current study. However, the food allergy quality of life questionnaire used by Goossens and colleagues (2011) did not include any questions about the effect of food allergy symptoms (only the fear of having a reaction and how discouraged they feel during a reaction), nor the cost of allergen-free food products, both of which were important issues in the current study.

Adults with food allergies who reported more allergy issues, on average, also reported higher average stress, a more negative mood, and lower physical energy. In fact, between-person variation in reported allergy issues accounted for a large percentage of the variance in average stress (27%), negative mood (11%), and energy (10%). These results support previous findings from cross-sectional research indicating a lower health-related quality of life and general well-being among individuals with a food allergy (Flokstra-de Blok et al., 2010; Voordouw et al., 2010) and extend current knowledge by quantifying the per cent variance in daily general stress, mood, and energy accounted for by the experience of allergy issues. In addition, the results indicate that allergy issues contribute more to daily stress than to mood or energy, and were unrelated to positive mood.

Adults with food allergies also experienced greater stress and negative mood on days with more food allergy issues, compared to days with fewer allergy issues. While it would be expected that food allergy issues would increase food allergy-related stress, these results show a broader connection linking the experience of food allergy issues to

general feelings of daily stress. Thus, there appears to be spill-over from allergy issues into general feelings of stress at the end of the day. This is the first study to show that allergy issues are linked at a within-person level to increases in general stress and negative mood on a day-to-day basis. These findings warrant investigation into how food allergy affects general stress levels and its associated physical concomitants (e.g. blood pressure, cortisol, poorer daily functioning).

Within-person variation in reported allergy issues accounted for a small to moderate percentage of the variance in daily changes in stress (5%), and negative mood (4%). These changes equate to a Cohen's d effect size of .43 and .38, respectively (using the r to d online effect size converter http://www.psychometrica.de/effect_size.html). An effect size around .2 is a small effect whereas an effect size around .4 is considered a medium or moderate effect (Cohen, 1988). This suggests that daily allergy issues had a moderate relationship to general daily stress. Whether these increases in stress are clinically significant is difficult to know. Few studies report effect sizes for within-person patterns (between 2 and 5% of variance, Eckenrode, 1984; Kamarck et al., 1998), and although studies have linked daily stressors to major health outcomes like cardiovascular disease (Kamarck et al., 2005), it is not known what level of daily stress is needed before negative effects are seen. We would not be surprised, however, if even low levels of stress could result in negative consequences if the daily stressors were chronic enough. There is growing awareness that a build-up of daily hassles, even if they seem small, can have a long-term impact on health outcomes (Odgers & Jaffee, 2013).

The relationships between food allergy issues and both stress and negative mood were linear, meaning that each increase in number of food allergy issues was linked with an increase in stress and negative mood in a dose-response fashion. We found no evidence for curvilinear patterns in the results which we tested in tertiary analyses (not reported). These results support previous findings that food allergy management is linked to lower health-related quality of life (Flokstra-de Blok et al., 2010) and extend current knowledge by confirming the presence of dynamic daily relationships among allergy issues and psychological states on a day-to-day basis.

Considering that the participants in this study experienced an average of two issues per day and 30% of reports with allergy issues corresponded with moderate to high general stress (compared with 22% of reports with no allergy issues), it is possible that some adults with food allergies are at risk of experiencing chronic elevated stress and negative mood. There is a growing appreciation that accumulating daily stressors are more important for longer term health outcomes than major life events (DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982; Odgers & Jaffee, 2013). Given that both daily stress and negative mood have been linked to an increased circulation of stress hormones (Smyth et al., 1998; van Eck et al., 1996), and that daily stressors are known to disrupt the cortisol awakening response (Gartland, O'Connor, Lawton, & Bristow, 2014), some adults with food allergies may be at risk of long-term health complications. Future research should investigate whether adults with food allergies experience clinically significant levels of chronic stress and which sub-groups are at a higher risk. Based on the current results, it appears individuals who experience more allergy issues would be at the greatest risk. Adults with food allergies also risk exacerbating their allergic reactions as stress has been linked to worsening of allergic reaction symptoms (Dave, Xiang, Rehm, & Marshall, Jr., 2011; Wright, Cohen, & Cohen, 2005). In addition to the relationship between overall number of allergy issues and stress, our results

showed a relationship between reported allergy symptoms and end of day general stress ($B = .517$, $SE = .117$, $p < .001$). Future research should investigate this potential bi-directional relationship between allergic symptoms and general daily stress.

The only demographic characteristic that moderated allergy experiences was age. Although age was not related to the number of issues ($B = .004$, $p = .746$), or their stress reactivity to issues, late middle age and older adults (55+, and 70+ years old) reported relatively less energy and less positive mood on days with more allergy issues, compared to younger adults. This age-related difference for energy is consistent with other research suggesting that energy declines with age, and is more affected by daily activities with age (Avlund, 2010; Mirowsky & Ross, 1999). Thus, among older adults, allergy issues might be another factor contributing to reduced energy at the end of the day. The age-related difference for positive mood is somewhat surprising given prior research indicating a reduction in emotional reactivity to stressors with age (Lawton, Kleban, Rajagopal, & Dean, 1992; Röcke, Li, & Smith, 2009; Scheibe & Carstensen, 2010). One possibility is that for older people, their positive mood is more affected by energy levels. However, when we controlled for energy levels, the age related differences in positive mood remained. Differences between older adults and young adults indicate that approaches to help adults with food allergies better manage their condition may need to be tailored differently for different age groups.

For the most part, the relationship between allergy issues and daily stress did not depend on the type of food allergy. The one exception was that participants with a shellfish/seafood allergy had comparatively less stress on days with more allergy issues compared to participants with a gluten or wheat allergy. It could be that shellfish/seafood allergies are relatively easier to manage than other types of allergies. Shellfish/seafood is less likely to be an ingredient or potential cross-contaminant in processed staple food products compared to wheat or gluten. This means that issues such as problems finding suitable foods, having to take risks, cost of allergen free foods, anxiety about safety of food and physical symptoms of food allergy may have been less common and less psychologically challenging for participants with a shellfish/seafood allergy compared to the participants with gluten or wheat allergy.

Strengths and limitations

A strength of this study was including adults with a physician-diagnosed allergy rather than a self-assessed allergy. However, this strict criterion made it difficult to recruit a larger number of participants for this research. Adults with food allergies experience difficulties accessing specialists or general practitioners who are experienced in recognising and testing for food allergies (Peniamina et al., 2014), which will limit the number of doctor-diagnosed adults with food allergies. For this reason, it was also not possible to limit participants to those diagnosed by oral food challenge (the gold standard for food allergy diagnosis). While it is possible that including participants whose diagnosis was not confirmed by oral food challenge introduced some bias, we do not believe it is likely. No diagnosis procedure is without error but most participants reported being diagnosed using a combination of at least two methods, which improves the likelihood of accurate diagnosis. As men are less likely to seek health care for symptoms, this reduces the number of available doctor-diagnosed men even further (Galdas, Cheater, & Marshall, 2005). In addition, men are less likely to participate in research compared to

women (Patel, Doku, & Tennakoon, 2003). A higher number of male participants would have allowed for better gender comparisons. Recruitment of a wider range of ethnicities would have allowed for a comparison between some of the major ethnic groups.

The current research had several limitations. Although allergy issues and psychological states were measured in 'near to real-time' using a best-practice daily diary approach, this association is still correlational and does not prove a causal relationship. While it is likely that food allergy issues are contributing to daily stress and mood outcomes, it may also be argued that participants were more likely to report more issues if they felt stressed or were experiencing a more negative mood given the link between negative mood and higher symptom reporting (Cohen et al., 1995). However, Cohen and associates (1995) also found that while trait negative mood was found to be associated with higher symptom reporting irrespective of objective disease, the associations between state negative mood and higher symptom reporting could be primarily explained by increased underlying illness. The within-person associations we found between negative mood and allergy issues relate to fluctuations in daily mood (i.e. state negative mood) therefore, based on the findings of Cohen and associates (1995), are more likely to reflect an increase in the incidence of allergy issues. In addition, the daily diaries provided clear descriptions of a range of issues for participants to choose from rather than asking participants to recall and quantify issue frequency, thus reducing the likelihood of over-reporting.

Further research using an EMA approach to assess stress, mood and number of issues experienced at set times during the day (e.g. morning, noon and evening) or to assess stress and mood immediately after food allergy issues are experienced (i.e. event contingent sampling) is recommended to improve the understanding of the associations identified in the current study. However, the daily diary approach used in this research was a necessary first step to determine if associations exist between allergy issues and daily functioning. By using this approach, it was possible to test for associations between the experience of allergy issues and several aspects of daily functioning (e.g. stress, mood, physical energy), while also gaining an improved understanding of the frequency and type of issues experienced in daily life. The number of questions required to achieve this meant EMA was not an appropriate method for this study. The current findings provide a basis for the development of an EMA study with fewer questions to minimise participant burden.

The reliability values for the shortened three- and two-item scales used to measure daily negative mood, positive mood and physical energy were less than ideal. Although our use of shortened scales reduced participant burden, the lower reliability of the scales could weaken the study results. However, we are not too concerned about this given that our scale items were highly correlated at the within-person level, and we found similar results when analysing the scale items separately. This suggests that our items were tapping the same underlying construct. The use of validated scales with more items would likely increase participant burden to an unacceptable level. Future research needs to address the need for short-item scales that are validated for use with daily diary and EMA research.

Conclusion

This study identified a clear link between food allergy issues and higher daily stress as well as a worse negative mood. These findings suggest that experiencing frequent allergy issues could have implications for day-to-day psychological functioning and increase the risk of stress-related health complications. Further research using EMA to determine temporal sequencing is needed to confirm this. These results indicate that the psychological, social, and physical functioning of adults with food allergies may be improved using interventions targeting the prevention of food allergy issues and/or access to training in stress management techniques (e.g. cognitive-behavioural stress management). Interventions targeting the prevention of issues should aim to reduce the cost and improve the availability of allergen free food products, reduce the risk of accidental exposure, improve public understanding of food allergy and provide access to nutritional advice with food allergy trained dieticians. Older adults also experienced lower positive mood and physical energy on days with more food allergy issues, while younger adults did not. This suggests additional interventions tailored specifically for older adults may be useful. Food allergies should be considered a growing health concern in the field of health psychology. The current findings indicate that the management of this chronic condition has potential implications for the physical and psychological health and well-being of this growing population.

Acknowledgements

The authors thank Hadyn Youens of the University of Otago for the programming of the study website and online surveys.

Disclosure statement

The authors declare no conflicts of interest.

Supplemental data

Supplemental data for this article can be accessed here: <http://10.1080/08870446.2016.1143945>

Note

1. Reliability values between .5 and .7 are common for three-item scales. Although more items would have increased reliability, a minimum number of items were chosen to keep the daily survey short. The items combined into the scales were all highly correlated with each other at the within-person level (Negative Mood; sad and anxious, $B = .266$, $SE = .034$, $p < .001$; sad and irritable, $B = .326$, $SE = .035$, $p < .001$, anxious and irritable $B = .337$, $SE = .041$, $p < .001$; Positive Mood; content and happy $B = .619$, $SE = .038$, $p < .001$; content and enthusiastic $B = .549$, $SE = .034$, $p < .001$, happy and enthusiastic $B = .485$, $SE = .027$, $p < .001$).

References

- Avlund, K. (2010). Fatigue in older adults: An early indicator of the aging process? *Aging Clinical and Experimental Research*, 22, 100–115. doi:[10.1007/BF03324782](https://doi.org/10.1007/BF03324782)

- Cacioppo, J. T., Berntson, G. G., Malarkey, W. B., Kiecolt-Glaser, J. K., Sheridan, J. F., Poehlmann, K. M., Burleson, M. H., Ernst, J. M., Hawkley, L. C. & Glaser, R. (1998). Autonomic, neuroendocrine, and immune responses to psychological stress: The reactivity hypothesis. *Annals of the New York Academy of Sciences*, 840, 664–673. doi:[10.1111/j.1749-6632.1998.tb09605.x](https://doi.org/10.1111/j.1749-6632.1998.tb09605.x)
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.
- Cohen, S., Doyle, W. J., Skoner, D. P., Fireman, P., Gwaltney, Jr., J. M., & Newsom, J. T. (1995). State and trait negative affect as predictors of objective and subjective symptoms of respiratory viral infections. *Journal of Personality and Social Psychology*, 68, 159–169.
- Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, 298, 1685–1687. doi:[10.1001/jama.298.14.1685](https://doi.org/10.1001/jama.298.14.1685)
- Conner, T. S., & Lehman, B. (2012). Getting started: Launching a study in daily life. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 89–107). New York, NY: Guilford Press.
- Cummings, A. J., Knibb, R. C., King, R. M., & Lucas, J. S. (2010). The psychosocial impact of food allergy and food hypersensitivity in children, adolescents and their families: A review. *Allergy*, 65, 933–945. doi:[10.1111/j.1398-9995.2010.02342.x](https://doi.org/10.1111/j.1398-9995.2010.02342.x)
- Dave, N. D., Xiang, L., Rehm, K. E., & Marshall, Jr., G. D. (2011). Stress and allergic diseases. *Immunology and Allergy Clinics of North America*, 31, 55–68. doi:[10.1016/j.iac.2010.09.009](https://doi.org/10.1016/j.iac.2010.09.009)
- Delespaul, P. A. E. G. (1995). *Assessing schizophrenia in daily life: The experience sampling method*. Maastricht: IPSEr.
- DeLongis, A., Coyne, J. C., Dakof, G., Folkman, S., & Lazarus, R. S. (1982). Relationship of daily hassles, uplifts, and major life events to health status. *Health Psychology*, 1, 119–136. doi:[10.1037/0278-6133.1.2.119](https://doi.org/10.1037/0278-6133.1.2.119)
- Eckenrode, J. (1984). Impact of chronic and acute stressors on daily reports of mood. *Journal of Personality and Social Psychology*, 46, 907–918. doi:[10.1037/0022-3514.46.4.907](https://doi.org/10.1037/0022-3514.46.4.907)
- Elenkov, I. J. (2002). Systemic stress-induced Th2 shift and its clinical implications. In A. Clow & F. Hucklebridge (Eds.), *Neurobiology of the immune system* (pp. 163–186). San Diego, CA: Academic Press.
- Elo, A. L., Leppänen, A., & Jahkola, A. (2003). Validity of a single-item measure of stress symptoms. *Scandinavian Journal of Work, Environment & Health*, 29, 444–451. doi:[10.5271/sjweh.752](https://doi.org/10.5271/sjweh.752)
- Flokstra-de Blok, B. M. J., Dubois, A. E. J., Vlieg-Boerstra, B. J., Oude Elberink, J. N. G., Raat, H., DunnGalvin, A., ... Duiverman, E. J. (2010). Health-related quality of life of food allergic patients: Comparison with the general population and other diseases. *Allergy*, 65, 238–244. doi:[10.1111/j.1398-9995.2009.02121.x](https://doi.org/10.1111/j.1398-9995.2009.02121.x)
- Flokstra-de Blok, B. M. J., Van der Meulen, G. N., DunnGalvin, A., Vlieg-Boerstra, B. J., Oude Elberink, J. N. G., Duiverman, E. J., ... Dubois, A. E. J. (2009). Development and validation of the food allergy quality of life questionnaire – Adult form. *Allergy*, 64, 1209–1217. doi:[10.1111/j.1398-9995.2009.01968.x](https://doi.org/10.1111/j.1398-9995.2009.01968.x)
- Galdas, P. M., Cheater, F., & Marshall, P. (2005). Men and health help-seeking behaviour: Literature review. *Journal of Advanced Nursing*, 49, 616–623. doi:[10.1111/j.1365-2648.2004.03331.x](https://doi.org/10.1111/j.1365-2648.2004.03331.x)
- Gartland, N., O'Connor, D. B., Lawton, R., & Bristow, M. (2014). Exploring day-to-day dynamics of daily stressor appraisals, physical symptoms and the cortisol awakening response. *Psychoneuroendocrinology*, 50, 130–138. doi:[10.1016/j.psyneuen.2014.08.006](https://doi.org/10.1016/j.psyneuen.2014.08.006)
- Glatzer, W., Camfield, L., Möller, V., & Rojas, M. (Eds.). (2015). *Global handbook of quality of Life*. Dordrecht: Springer.
- Goossens, N. J., Flokstra-de Blok, B. M. J., Vlieg-Boerstra, B. J., Duiverman, E. J., Weiss, C. C., Furlong, T. J., & Dubois, A. E. J. (2011). Online version of the food allergy quality of life questionnaire – Adult form: Validity, feasibility and cross-cultural comparison. *Clinical & Experimental Allergy*, 41, 574–581. doi:[10.1111/j.1365-2222.2011.03711.x](https://doi.org/10.1111/j.1365-2222.2011.03711.x)

- Hallert, C., Sandlund, O., & Broqvist, M. (2003). Perceptions of health-related quality of life of men and women living with coeliac disease. *Scandinavian Journal of Caring Sciences*, 17, 301–307. doi:[10.1046/j.1471-6712.2003.00228.x](https://doi.org/10.1046/j.1471-6712.2003.00228.x)
- Jyonouchi, H. (2012). Non-IgE mediated food allergy – Update of recent progress in mucosal immunity. *Inflammation & Allergy-Drug Targets*, 11, 382–396. doi:[10.2174/187152812803250971](https://doi.org/10.2174/187152812803250971)
- Kamarck, T. W., Schwartz, J. E., Shiffman, S., Muldoon, M. F., Sutton-Tyrrell, K., & Janicki, D. L. (2005). Psychosocial stress and cardiovascular risk: What is the role of daily experience? *Journal of Personality*, 73, 1749–1774. doi:[10.1111/j.0022-3506.2005.00365.x](https://doi.org/10.1111/j.0022-3506.2005.00365.x)
- Kamarck, T. W., Shiffman, S. M., Smithline, L., Goodie, J. L., Paty, J. A., Gnys, M., & Jong, J. Y.-K. (1998). Effects of task strain, social conflict, and emotional activation on ambulatory cardiovascular activity: Daily life consequences of recurring stress in a multiethnic adult sample. *Health Psychology*, 17, 17–29.
- Lawton, M. P., Kleban, M. H., Rajagopal, D., & Dean, J. (1992). Dimensions of affective experience in three age groups. *Psychology and Aging*, 7, 171–184. doi:[10.1037/0882-7974.7.2.171](https://doi.org/10.1037/0882-7974.7.2.171)
- Marklund, B., Ahlstedt, S., & Nordström, G. (2007). Food hypersensitivity and quality of life. *Current Opinion in Allergy and Clinical Immunology*, 7, 279–287. doi:[10.1097/aci.0-b013e32814a569b](https://doi.org/10.1097/aci.0-b013e32814a569b)
- Mehl, M. R., & Conner, T. S. (Eds.). (2012). *Handbook of research methods for studying daily life*. New York, NY: Guilford Press.
- Mirowsky, J., & Ross, C. E. (1999). Well-being across the life course. In T. L. Scheid & T. N. Brown (Eds.), *A handbook for the study of mental health* (2nd ed.) pp. 328–347. New York, NY: Cambridge University Press.
- Nezlek, J. B. (2012). Multilevel modelling analyses of diary-style data. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 357–383). New York, NY: Guilford Press.
- Odgers, C. L., & Jaffee, S. R. (2013). Routine versus catastrophic influences on the developing child. *Annual Review of Public Health*, 34, 29–48. doi:[10.1146/annurev-publhealth-031912-114447](https://doi.org/10.1146/annurev-publhealth-031912-114447)
- Patel, D. A., Holdford, D. A., Edwards, E., & Carroll, N. V. (2011). Estimating the economic burden of food-induced allergic reactions and anaphylaxis in the United States. *Journal of Allergy and Clinical Immunology*, 128, 110–115. doi:[10.1016/j.jaci.2011.03.013](https://doi.org/10.1016/j.jaci.2011.03.013)
- Patel, M. X., Doku, V., & Tennakoon, L. (2003). Challenges in recruitment of research participants. *Advances in Psychiatric Treatment*, 9, 229–238. doi:[10.1192/apt.9.3.229](https://doi.org/10.1192/apt.9.3.229)
- Peniamina, R. L., Bremer, P., Conner, T. S., & Miroso, M. (2014). Understanding the needs of food-allergic adults. *Qualitative Health Research*, 24, 933–945. doi:[10.1177/1049732314539733](https://doi.org/10.1177/1049732314539733)
- Raudenbush, S. W., Bryk, A. S., & Congdon, R. (2011). *HLM 7 for windows (computer software, student version)*. Skokie, IL: Scientific Software International.
- Reilly, N., & Green, P. R. (2012). Epidemiology and clinical presentations of celiac disease. *Seminars in Immunopathology*, 34, 473–478. doi:[10.1007/s00281-012-0311-2](https://doi.org/10.1007/s00281-012-0311-2)
- Röcke, C., Li, S.-C., & Smith, J. (2009). Intraindividual variability in positive and negative affect over 45 days: Do older adults fluctuate less than young adults? *Psychology and Aging*, 24, 863–878. doi:[10.1037/a0016276](https://doi.org/10.1037/a0016276)
- Sampson, H. A. (2013). Anaphylaxis and food allergy. In D. D. Metcalfe, H. A. Sampson, R. A. Simon, & G. Lack (Eds.), *Food allergy* (5th ed. pp. 178–191). Chichester: Wiley.
- Sapolsky, R. M. (2004). *Why zebras don't get ulcers* (3rd ed.). New York, NY: Times Books.
- Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: Recent findings and future trends. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 65B(2): 135–144. doi:[10.1093/geronb/gbp132](https://doi.org/10.1093/geronb/gbp132)
- Schwarz, N. (2007). Retrospective and concurrent self-reports: The rationale for real-time data capture. In A. A. Stone, S. Shiffman, A. A. Atienza, & L. Nebeling (Eds.), *The science of*

- real-time data capture: Self-reports in health research* (pp. 11–26). New York, NY: Oxford University Press.
- Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4, 1–32. doi:10.1146/annurev.clinpsy.3.022806.091415
- Sicherer, S. H. (2011). Epidemiology of food allergy. *Journal of Allergy and Clinical Immunology*, 127, 594–602. doi:10.1016/j.jaci.2010.11.044
- Smyth, J., Ockenfels, M. C., Porter, L., Kirschbaum, C., Hellhammer, D. H., & Stone, A. A. (1998). Stressors and mood measured on a momentary basis are associated with salivary cortisol secretion. *Psychoneuroendocrinology*, 23, 353–370. doi:10.1016/s0306-4530(98)00008-0
- Stone, A. A., Shiffman, S., Atienza, A. A., & Nebeling, L. (Eds.). (2007). *The science of real-time data capture: Self-reports in health research*. Oxford: Oxford University Press.
- Van Eck, M., Berkhof, H., Nicolson, N., & Sulon, J. (1996). The effects of perceived stress, traits, mood states, and stressful daily events on salivary cortisol. *Psychosomatic Medicine*, 58, 447–458. doi:10.1097/00006842-199609000-00007
- Voordouw, J., Fox, M., Cornelisse-Vermaat, J., Antonides, G., Mugford, M., & Frewer, L. (2010). Household costs associated with food allergy: An exploratory study. *British Food Journal*, 112, 1205–1215. doi:10.1108/00070701011088197
- World Health Organisation International Food Safety Authorities Network. (2006). INFOSAN Information Note No. 3/2006: Food allergies. Retrieved April 29, 2011, from http://www.who.int/foodsafety/fs_management/No_03_allergy_June06_en.pdf
- Wright, R. J., Cohen, R. T., & Cohen, S. (2005). The impact of stress on the development and expression of atopy. *Current Opinion in Allergy and Clinical Immunology*, 5, 23–29. doi:10.1097/00130832-200502000-00006

SUPPLEMENTARY MATERIAL 2

The stress of food allergy issues in daily life

Table S-2. A full list of daily allergy issues, proportion of participants affected, frequency of reporting, and their mean perceived severity/impact scores. Issues are ranked from the most (to the least) commonly experienced based on the proportion of participants who reported the issue at least once during the two week period.

Issue	Proportion of participants (%) ^a	Frequency (%) ^b	Perceived severity (mean)	Perceived impact (mean)
Problems finding suitable foods to eat when away from home	65.7	15.3	2.5	2.1
Extra financial cost due to higher food prices for safe food	63.0	17.0	3.0	2.3
Having to take risks by eating foods that may contain allergens	57.4	13.4	2.6	2.1
Loss of time due to extra time spent sourcing safe food	52.8	12.4	2.2	2.1
Physical symptoms of food allergy	49.1	17.4	2.9	2.7
Feeling anxious about whether food is safe to eat	48.1	11.8	2.9	2.3
Having to go hungry/not eat because there is no safe food available	46.3	9.7	2.7	2.6
Feeling anxious or stressed when	41.7	7.9	2.9	2.3

participating in social occasions				
involving food				
Problems with finding suitable foods	39.8	5.7	2.9	2.3
to purchase when grocery shopping				
Loss of time due to extra time spent	38.9	9.8	2.2	2.5
preparing meals				
Feeling embarrassed as a result of	38.0	7.4	2.8	2.0
my food allergy				
Avoiding participation in social	37.0	5.8	2.3	2.4
occasions because of food allergy				
Feeling anxious about potentially	37.0	8.0	2.7	2.1
having an allergic reaction				
Loss of time due to extra time spent	37.0	8.6	1.8	2.1
organizing food				
Problems finding a restaurant or café	36.1	4.3	2.6	2.3
that can provide an allergen free				
meal				
Lack of understanding from others	35.2	8.0	3.1	2.6
in relation to my food allergy				
Trouble with maintaining a healthy,	35.2	11.6	2.9	2.4
nutritionally balanced diet as a result				
of my food allergy				
Feeling inadequate or defective as a	24.1	4.9	3.1	2.7
result of my food allergy				
Being excluded from social	22.2	2.9	2.6	2.9

occasions because of food allergy				
Difficulties travelling with food allergies	21.3	3.7	2.9	2.7
Missing out on foods because of the cost of allergen free products	20.4	5.1	3.3	2.8
Feeling anxious about how people will react if I reveal my food allergy	18.5	2.9	2.6	1.9
Extra financial cost due to medical expenses resulting from the food allergy	15.7	2.7	2.7	2.2
People being uncooperative or unkind towards me because of my food allergy	7.4	1.1	3.5	3.5
Other issues	33.3	5.6	2.3	2.0

^aProportion of participants = proportion of participants who reported experiencing this issue at least once during the two-week reporting period. ^bFrequency % = how often the issue was reported, as a percentage of total daily reports (reports with issue selected/1144 x 100).

SUPPLEMENTARY MATERIAL 1

The stress of food allergy issues in daily life

Hierarchical Linear Modelling

Overview

Multilevel models were run to examine the associations between food allergy issues experienced and the outcomes (stress, negative mood, positive mood, and physical energy). This approach took into account the nested nature of the data with reports of food allergy issues experienced, daily stress, negative mood, positive mood, and physical energy (at level-1) nested within individuals (at level-2). Multilevel regression models were run using the Hierarchical Linear Modelling Program version 7 (Raudenbush, Bryk, & Congdon, 2011) for each outcome separately (stress, negative mood, positive mood, and physical energy).

Between-Person Analyses

In each model, the level-1 outcome (e.g. daily stress: DSTRESS) was predicted by the average number of daily food allergy issues at level-2 (ISSDM). The level-1 and level-2 equations were as follows:

Level-1 Model

$$\text{DSTRESS} = B_0 + r$$

Level-2 Model

$$B_0 = G_{00} + G_{01} * (\text{ISSDM}) + U_0$$

where DSTRESS was the outcome; B_0 was each individual's average stress. G_{00} was the mean daily stress for participants at the mean number of issues, and G_{01} indicated whether mean daily stress varied as a function of mean number of issues. ISSDM was grand-mean centred. This process was repeated for positive mood, negative mood, and physical energy as

separate level-1 outcomes. A significant G_{01} coefficient indicated that individuals who experienced more daily issues, on average, also experienced differences in daily stress (or mood, energy). Between-person effect size estimates were computed using the proportion of reduction in variance strategy described on page 149 of Raudenbush & Bryk (2002). Specifically, the change in variance between the unconditional model (e.g., for stress: level-1 $DSTRESS = B_0 + r$, level-2 $B_0 = G_{00} + U_0$) and the model with the predictor added (e.g., level-1 $DSTRESS = B_0 + r$, level-2 $B_0 = G_{00} + G_{01}*(ISSDM) + U_0$) was used to calculate effect size using the equation shown below:

(Variance for unconditional model – variance for model with predictor)

$$\text{Variance for unconditional model} \quad \quad \quad \times 100$$

Within-Person Analyses

In each model, the outcome (e.g. daily stress: $DSTRESS$) was predicted by the number of food allergy issues experienced ($ISSPDAY$). The level-1 and level-2 equations were as follows:

Level-1 Model

$$DSTRESS = B_0 + B_1 * (ISSPDAY) + r$$

Level-2 Model

$$B_0 = G_{00} + U_0$$

$$B_1 = G_{10} + U_1$$

where $DSTRESS$ was the outcome; B_0 was each individual's stress at their mean number of issues per day; and B_1 was each individual's change in stress when number of issues increased above the mean. $ISSPDAY$ was group-mean centred. There were no predictors at level-2 in this equation. G_{00} was the mean stress at mean number of issues; and, G_{10} was the

mean change in stress when issues increased above the mean. This process was repeated for positive mood, negative mood, and physical energy as separate outcomes. A significant G_{10} coefficient indicated that individuals experienced changes in stress (or mood, energy) on days with more (vs fewer) food allergy issues. Within-person effect size estimates were computed using the proportion of reduction in variance strategy described on page 149 of Raudenbush & Bryk (2002). Specifically, the change in variance between the unconditional model (e.g., for stress: $DSTRESS = B_0 + r$) and the model with the predictor added (e.g., $DSTRESS = B_0 + B_1 * (ISSPDAY) + r$) was used to calculate effect size using the equation shown below:

(Variance for unconditional model – variance for model with predictor)

$$\text{Variance for unconditional model} \quad \quad \quad \times 100$$

Next, a set of analyses was run to examine whether socio-demographic and allergen-related factors (age, gender, income level, symptom severity, number of food allergies, and type of food allergy) moderated the level-1 relationships between food allergy issues per day and the outcomes (stress, negative mood, positive mood, and physical energy). The level-1 models were the same as in the analyses above; the level-2 models included a series of predictors that were entered and tested separately (age, gender, income level, symptom severity, number of food allergies, and type of food allergy). All continuous measures were grand-mean centred. An example equation with age as the level-2 moderator is shown below:

Level-1 Model

$$DSTRESS = B_0 + B_1 * (ISSPDAY) + r$$

Level-2 Model

$$B_0 = G_{00} + G_{01} * (AGE) + U_0$$

$$B_1 = G_{10} + G_{11} * (AGE) + U_1$$

Age was centred around the grand mean. G_{00} was the mean daily stress at mean number of issues for participants at the mean age (age 40); G_{01} indicated whether mean daily stress at the mean number of issues varied as a function of age; G_{10} was the change in stress when issues increased above the mean for participants at the mean age (age 40); and G_{11} was the change in the within-person relationship between daily stress and number of issues attributable to age. A significant G_{11} coefficient indicated significant moderation. In subsequent models, the AGE variable was recentred at -1, + 1, + 2 standard deviations, and the G_{10} coefficients examined to determine the significance of the within-person relationships for participants of different ages. A similar procedure was followed for the income level, which was also a continuous predictor and centred around the grand mean.

Gender was entered as an uncentred level-2 predictor (0 = male; 1 = female). G_{00} was the mean daily stress at mean number of issues for male participants; G_{01} indicated whether mean daily stress at the mean number of issues differed for female participants; G_{10} was the change in stress when issues increased above the mean for male participants; and G_{11} indicated whether the within-person relationship between daily stress and number of issues differed for female participants compared to male participants. Again, a significant G_{11} coefficient indicated significant moderation by gender. A similar procedure was followed for allergy severity, which was also a categorical and uncentred predictor (0 = participants without anaphylaxis, 1 = participants with anaphylaxis).

Number of food allergies was first grouped into three categories (1, 2, 3+ allergies) and dummy coded (dummy 1: 1 allergy = 1, all others = 0; dummy 2: 2 allergies = 1, all others = 0; dummy 3: 3+ allergies = 1, all others = 0). The level-2 intercept was dropped from the equation:

Level-1 Model

$$\text{DSTRESS} = B_0 + B_1 * (\text{ISSPDAY}) + r$$

Level-2 Model

$$B_0 = G_{01}*(\text{Dummy 1}) + G_{02}*(\text{Dummy 2}) + G_{03}*(\text{Dummy 3}) + U_0$$

$$B_1 = G_{11}*(\text{Dummy 1}) + G_{12}*(\text{Dummy 2}) + G_{13}*(\text{Dummy 3}) + U_1$$

where $G_{11} - G_{13}$ indicated the within-person relationship between allergy issues and stress (or mood or physical energy) for each group (those with 1, 2, or 3+ allergies, respectively). The multivariate hypothesis testing option was then used to compare differences between coefficients ($G_{11} - G_{13}$).

Similarly, type of food allergy was grouped into five categories and dummy coded (dummy 1: gluten/wheat allergy = 1, no gluten/wheat allergy = 0; dummy 2: peanut/treenut allergy = 1, no peanut/treenut allergy = 0; dummy 3: shellfish/seafood allergy = 1, no shellfish/seafood allergy = 0; dummy 4: Cow's milk allergy = 1, no cow's milk allergy = 0; dummy 5: Other allergy = 1, no other allergy = 0). Following the same modelling as above, the level-2 intercept was dropped from the equation and the multivariate hypothesis testing option was used to compare differences between coefficients ($G_{11} - G_{15}$).

Lagged Analyses

Where t refers to time (day of report), lagged analyses tested first whether the number of allergy issues reported on one day (level-1, t predictor) predicted changes in each next-day psychological state (stress, mood, or energy) (level-1, $t+1$ outcome) while controlling for the previous day psychological state (level-1 t covariate). An example equation with next-day stress (STRESS2) as the level-1 outcome is shown below:

Level-1 Model

$$\text{STRESS2} = B_0 + B_1*(\text{DSTRESS}) + B_2*(\text{ISSPDAY}) + r$$

Level-2 Model

$$B_0 = G_{00} + U_0$$

$$B_1 = G_{10} + U_1$$

$$B_2 = G_{20} + U_2$$

Level-1 predictors and covariates were group-mean centred. A significant G_{20} coefficient indicated a significant association between number of reported issues and next-day psychological state.

After this, we reversed the direction of prediction and tested whether each psychological state on one day (level-1, t predictor) predicted changes in next-day reporting of allergy issues (level-1, $t+1$ outcome) while controlling for previous day reporting of allergy issues (level-1, t covariate). An example equation with stress (DSTRESS) as the level-1 predictor is shown below:

Level-1 Model

$$\text{ISSDAY2} = B_0 + B_1 * (\text{DSTRESS}) + B_2 * (\text{ISSPDAY}) + r$$

Level-2 Model

$$B_0 = G_{00} + U_0$$

$$B_1 = G_{10} + U_1$$

$$B_2 = G_{20} + U_2$$

Level-1 predictors and covariates were group-mean centred. A significant G_{20} coefficient indicated a significant association between psychological state and next-day number of reported issues.

References

- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: SAGE Publications.
- Raudenbush, S. W., Bryk, A. S., & Congdon, R. (2011). HLM 7 for Windows (Computer software, student version). Skokie, IL: Scientific Software International, Inc.