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Prediction of Food Sensitization in Children with Atopic Dermatitis Based on Disease Severity and Epidermal Layer Impairment

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Keywords
Atopic dermatitis · Food sensitization · Transepidermal water loss · Stratum corneum hydration · Paediatrics

Abstract
Introduction: Atopic dermatitis (AD) is characterized by an impaired epidermal barrier, which could be associated with sensitization to food allergens (FAs) and/or inhaled allergens and contribute to the severity of AD. However, no clinical guidance has been established for evaluations of food sensitization (FS) in AD patients. This study investigated how AD severity and epidermal barrier impairment are associated with FS and factors that can predict FS in children with AD. ***Methods:*** This cross-sectional study included 100 children (12–60 months) diagnosed with AD. AD severity was determined using the Scoring Atopic Dermatitis (SCORAD) index. FS was evaluated by measuring serum-specific IgE antibodies against 31 FAs using an immunoblotting method. Epidermal barrier impairment was assessed by measuring transepidermal water loss (TEWL) and stratum corneum hydration (SCH) levels. ***Results:*** 90% of participants were sensitized to at least one tested FA, with cow's milk, egg white, beef, almond, egg yolk, and peanut being the most common. Children with moderate-severe AD had lower SCH levels than those with mild AD. Children with AD who were sensitized to >10 FAs had significantly higher TEWL and lower SCH levels, compared with those sensitized to 1–4 FAs and 5–10 FAs. The SCORAD score and SCH level in lesional skin provided moderately predictive value for sensitization to FAs in children with AD. ***Conclusion:*** FS is common in children with AD and closely associate with AD severity as well as epidermal barrier impairment. Evaluations of FS should be considered for children with moderate to severe AD and/or low SCH levels.

Plain Language Summary
The study has revealed notable associations between food sensitizations (FSs) and the disease severity as well as epidermal barrier impairment in children with atopic dermatitis (AD). Specifically, the findings indicate that children with AD who were sensitized to higher numbers of food allergens (FAs) had higher SCORAD scores and greater epidermal barrier impairment. In addition, SCORAD score and stratum

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corneum hydration (SCH) levels at lesional skin could be predictive factors for FS in children with AD. The findings of this study suggest that clinicians should consider screening for food sensitization in children with moderate-severe AD and/or low SCH levels at lesional skins.

Introduction

Atopic dermatitis (AD), characterised by itchy eczema skin lesions, is one of the most common allergic diseases in children with the age less than 5 years [1]. T helper 2 (Th2) response is an important pathological mechanism of AD, which leads to sensitization to food allergens (FAs) and aeroallergens [2, 3]. Previous studies from Europe and America showed that 91% of children with AD were sensitized to at least one FA [4]. Nevertheless, the profile of sensitized FAs among children with AD in Europe and America could differ from the profile among children in Southeast Asia.

Stratum corneum hydration (SCH) and trans-epidermal water loss (TEWL) are two important measures of the epidermal integrity [5]. Decreased SCH and increased TEWL indicate an impaired epidermal barrier, which facilitates the penetration of FAs into the skin, where they are captured and presented by antigen-presenting cells, leading to food sensitization (FS) [5, 6]. The Scoring Atopic Dermatitis (SCORAD) score is a useful tool for assessment of AD severity; SCORAD results are positively associated with allergen sensitization [7]. In this study, we hypothesized that sensitization to FAs was associated with AD severity and epidermal layer impairment in children with AD. Accordingly, we evaluated the associations of FS with TEWL, SCH, and SCORAD scores. We then explored factors that could predict FS in children with AD.

Materials and Methods

Patients

In this cross-sectional study, we recruited 100 children (age 12–60 months) diagnosed with AD at the Allergy and Clinical Immunology Unit of the University Medical Center at Ho Chi Minh City, Vietnam. We excluded patients with the following comorbidities: itchy vulgaris, scabies, seborrhoeic dermatitis, contact dermatitis, T-cell lymphoma, psoriasis, photosensitive dermatitis, and erythroderma. Study subjects were asked to stop using moisturizers at least 3 h prior to enrolment. The guardians of all study participants provided written informed consent for enrolment. This study was approved by the Institutional Review Board Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (IRB-VN01002/IORG0008603/FWA00023448).

Measurement of TEWL and SCH Levels

We measured TEWL and SCH using the GPSkin Barrier Pro® device (Gpower Inc., South Korea), in accordance with the manufacturer's instructions. TEWL and SCH levels were measured in triplicate at the volar forearm area; mean levels were used for statistical analysis. The lesional skin regions selected for measurement of TEWL and SCH were prioritised in the following order: forearms, arms, legs, and thighs.

Measurement of Serum IgE Antibodies to FAs

Serum IgE antibodies against 31 FAs were measured by immunoblotting using the EUROLINE Atopy "Venezuela" kit (EUROIMMUN, Lubeck, Germany, kit ID 3704-1601-1E) in accordance with the manufacturer's instructions. A participant was assumed to have a FS if they had a positive serum IgE antibody result (>0.35 IU/mL) to at least one tested FA.

Statistical Analysis

Independent samples *t* tests were used to compare mean levels among study groups. Receiver operating characteristic (ROC) curves were established to determine cut-off points for TEWL level, SCH level, and SCORAD score in terms of predicting FS. Stata 14.0 (StataCorp) was used for statistical analysis. $p < 0.05$ was considered statistically significant.

Results

Patients's Clinical Characteristics

There were 54 male (54%) and 46 female (46%) patients (mean age, 25.9 ± 13.1 months). The age of AD onset ranged from 1 month to 48 months (median: 3; interquartile range: 2–11.5 months). The mean SCORAD score was 31.1 ± 16.9. Most participants (60%) had moderate-severe AD, with a SCORAD score >25. Thirty-three participants (33%) with AD had a family history of AD (Table 1).

Serum IgE to FAs in Children with AD

90/100 study subjects (90%) were sensitized to at least one tested FA. The most prevalent sensitized food was cow's milk protein: any cow's milk proteins (60%), including β-lactoglobulin (44%), α-lactalbumin (37%), and casein (15%); followed by egg white (49%), beef (31%), almond (27%), egg yolk (26%), peanut (26%), goat's milk (24%), and rice (19%), shown in Figure 1.

FA Co-Sensitization in Children with AD

The prevalences of co-sensitization to tested FAs among children with AD are shown in Table 2. The most prevalent co-sensitization profile in the study population

Table 1. Clinical characteristics of study subjects

Clinical characteristics	Total (*n* = 100)
Gender (male)[1]	54 (54)
Age, months (mean±SD)	25.9±13.1
Age of onset, months median (IQR) min–max	3 (2–11.5) 1–48
Mean SCORAD score (mean±SD)	31.1±16.9
AD severity[1]	
Mild (SCORAD <25)	40 (40)
Moderate-severe (SCORAD ≥25)	60 (60)
Family history of AD[1]	33 (33)
Personal history of atopy[1]	
Urticaria	13 (13)
Allergic rhinitis	9 (9)
Asthma	6 (6)

n presented sample size. AD, atopic dermatitis; IQR, interquartile range; SCORAD, Scoring Atopic Dermatitis; SD, standard deviation.

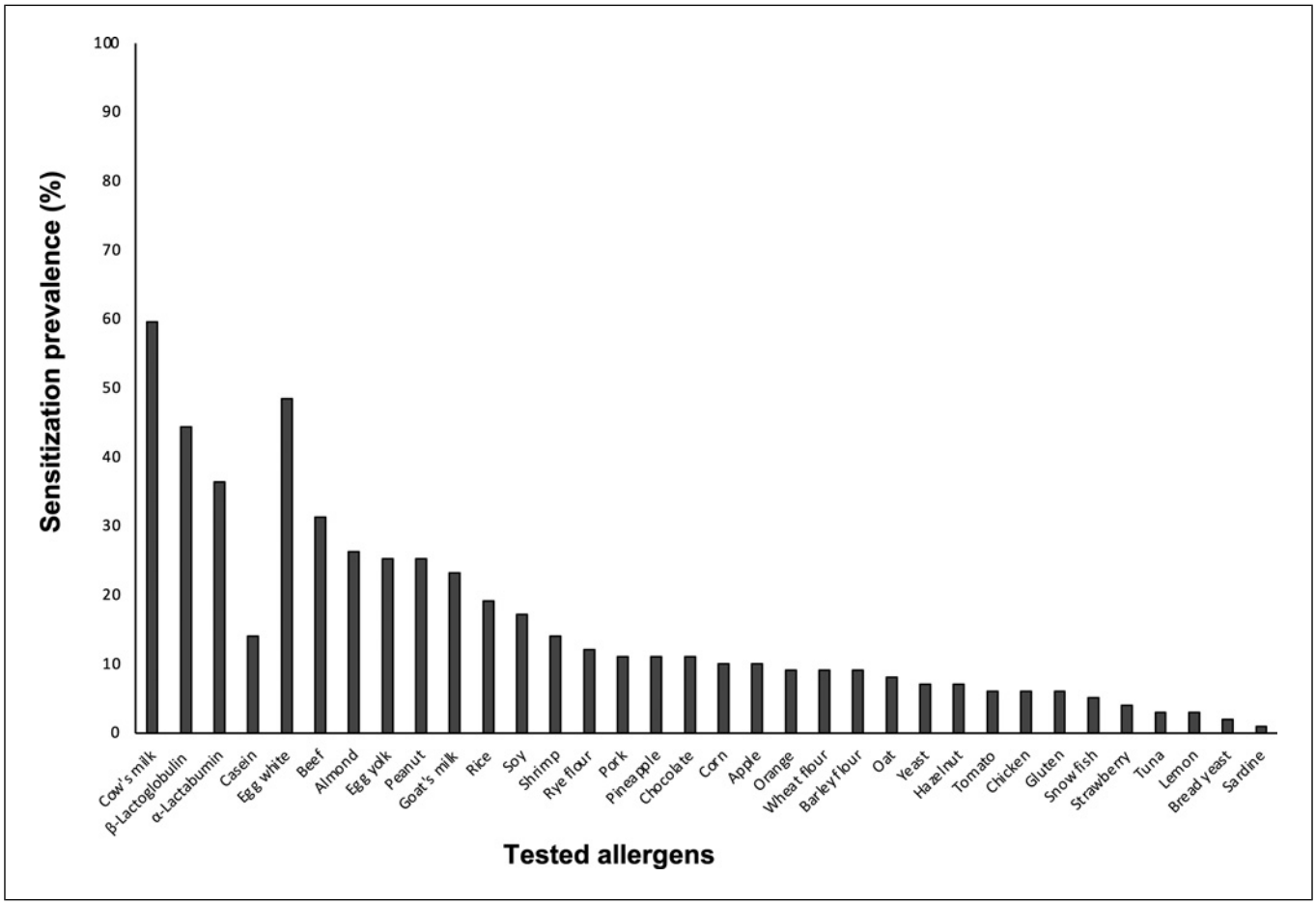

Fig. 1. Prevalence of sensitization to FAs in the study subjects.

Table 2. Co-sensitization to FAs

FAs	Egg white	Cow's milk	β-lactoglobulin	α-lactalbumin	Beef	Almond	Peanut	Egg yolk	Goat's milk	Rice
Egg white (n = 49)		35 (71.4)	27 (55.1)	25 (51.0)	21 (42.9)	20 (40.8)	21 (42.9)	24 (49)	19 (38.8)	15 (30.6)
Cow's milk (n = 60)	35 (58.3)		43 (71.7)	37 (61.7)	28 (46.7)	19 (31.7)	19 (31.7)	18 (30)	22 (36.7)	12 (20)
β-lactoglobulin (n = 44)	27 (61.4)	43 (97.7)		26 (59.1)	22 (50)	15 (34.1)	14 (31.8)	13 (29.5)	18 (40.9)	11 (25)
α-lactalbumin (n = 37)	25 (67.6)	37 (100)	26 (70.3)		21 (56.8)	15 (40.5)	14 (37.8)	14 (37.8)	20 (54.1)	10 (27.0)
Beef (n = 31)	21 (67.7)	28 (90.3)	22 (71)	21 (67.7)		14 (45.2)	11 (35.5)	14 (45.2)	17 (54.8)	10 (32.3)
Almond (n = 27)	20 (74.1)	19 (70.4)	15 (55.6)	15 (55.6)	14 (51.9)		16 (59.3)	17 (63)	15 (55.6)	13 (48.2)
Peanut (n = 26)	21 (80.8)	19 (73.1)	14 (53.8)	14 (53.8)	11 (42.3)	16 (61.5)		15 (59.7)	12 (46.1)	9 (34.6)
Egg yolk (n = 26)	24 (92.3)	18 (69.2)	13 (50)	14 (53.8)	14 (53.9)	17 (65.4)	15 (57.7)		14 (53.9)	11 (42.3)
Goat's milk (n = 24)	19 (79.2)	22 (91.7)	18 (75)	20 (83.3)	17 (70.8)	15 (62.5)	12 (50)	14 (58.3)		9 (37.5)
Rice (n = 19)	15 (78.9)	12 (63.2)	11 (57.9)	10 (52.6)	10 (52.6)	13 (68.4)	9 (47.4)	11 (57.9)	9 (47.4)	

n is the number of children with AD who were sensitised to each type of food allergen. Data were presented as frequency and prevalence (%).

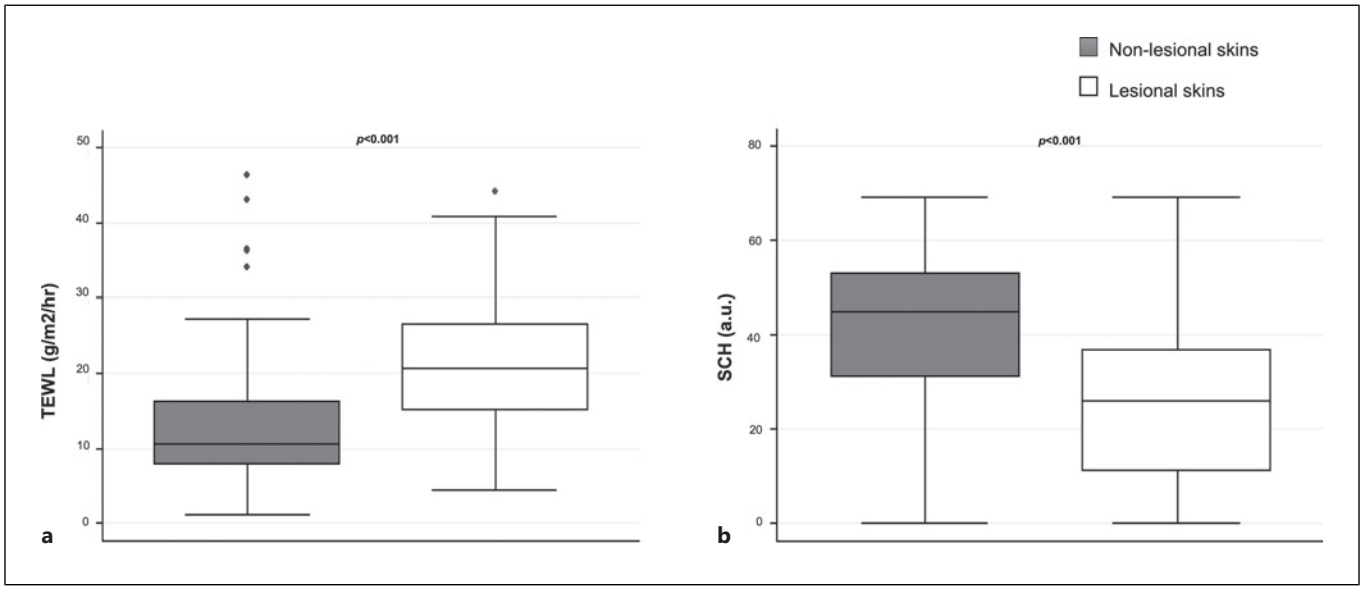

Fig. 2. a Transepidermal water loss (TEWL). **b** Stratum corneum hydration (SCH) in non-lesional and lesional skins in patients with AD. p values were obtained using independent sample t test.

involved cow's milk and egg white (35% of patients). This finding was present in 71.4% of children who were sensitized to egg white and 58.3% of children who were sensitized to cow's milk. The prevalence of co-sensitization to cow's milk and beef was 28%; this finding was present in 90.3% of children sensitized to beef and 46.7% of children sensitized to cow's milk. The prevalence of co-sensitization to egg white and egg yolk was 24%; this finding was present in 92.3% of children sensitized to egg yolk and 49% of children sensitized to egg white. The prevalence of co-sensitization to cow's milk and goat's milk was 22%; this finding was present in 91.7% of children sensitized to goat's milk and 36.7% of children sensitized to cow's milk.

SCH and TEWL Levels

In lesional skins, TEWL levels (20.7 ± 8.6 g/m^2/h) were significantly higher and SCH levels (25.7 ± 18.2 a.u.) were significantly lower than those in non-lesional skins (13.3 ± 8.7 g/m^2/h and 41.9 ± 15.1 a.u, respectively, p <

Table 3. Comparison of TEWL and SCH levels in children with mild versus moderate-severe AD

	Mild (n = 39)	Moderate-severe (n = 58)	p value
TEWL, g/m^2/h (mean±SD)			
Non-lesional skin	11.9±7.4	14.3±9.4	0.184
Lesional skin	18.8±9.0	21.9±8.1	0.08
SCH (a.u.) (mean±SD)			
Non-lesional skin	47.7±11.3	38.0±16.1	<**0.001**
Lesional skin	34.4±18.5	19.8±15.6	<**0.001**

h, hour; SD, standard deviation. p values were obtained by using independent sample t test.

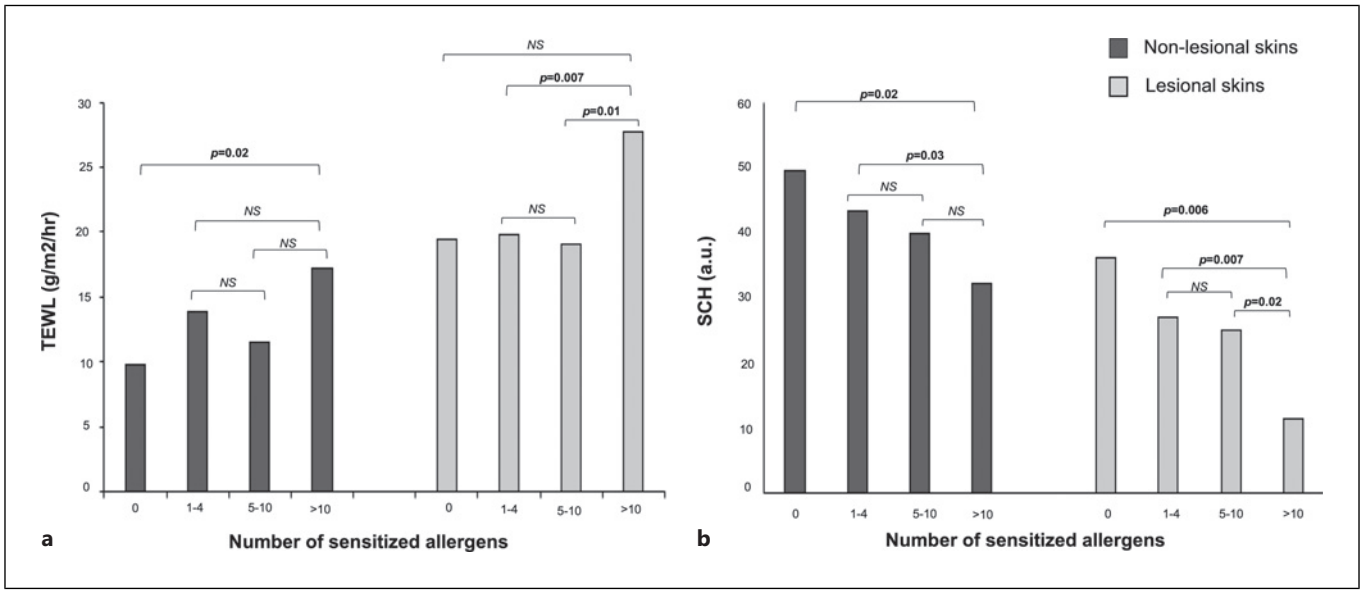

Fig. 3. Comparison of transepidermal water loss (TEWL) (**a**) and stratum corneum hydration (SCH) (**b**) according to the number of sensitized allergens in non-lesional and lesional skins. p-values were obtained by using independent sample t test.

0.001 for both), shown in Figure 2. In lesional or non-lesional skin, SCH levels were significantly lower in children with moderate-severe AD (38.0 ± 16.1 and 19.8 ± 15.6, respectively) than in children with mild AD (47.7 ± 11.3 and 34.4 ± 18.5, respectively; $p < 0.001$ for both) (Table 3). Although TEWL levels in children with moderate-severe AD tended to be higher than those in children with mild AD, the differences were not statistically significant.

Associations between FS and TEWL/SCH Levels

We compared the levels of TEWL and SCH among 4 study groups: children with AD and no FS ("non-sensitizers"), children sensitized to 1–4 FAs, 5–10 FAs, and >10 FAs. Children with AD who were sensitized to more FAs had higher TEWL and lower SCH levels, compared with those sensitized to fewer FAs or non-sensitizers, regardless of non-lesional/lesional skin areas ($p < 0.05$), shown in Figure 3.

Associations between FS and AD Severity

The number of sensitized FAs was positively associated with the SCORAD score in this study. Specifically, children with AD and sensitization to more FAs had higher SCORAD scores. The highest mean SCORAD score (51.4 ± 18.8) was observed in children sensitized to >10 FAs, whereas the lowest mean SCORAD score (22.9 ± 9.7) was observed in non-sensitized children with AD, shown in Figure 4. Additionally, compared with non-sensitized children, children with AD who were

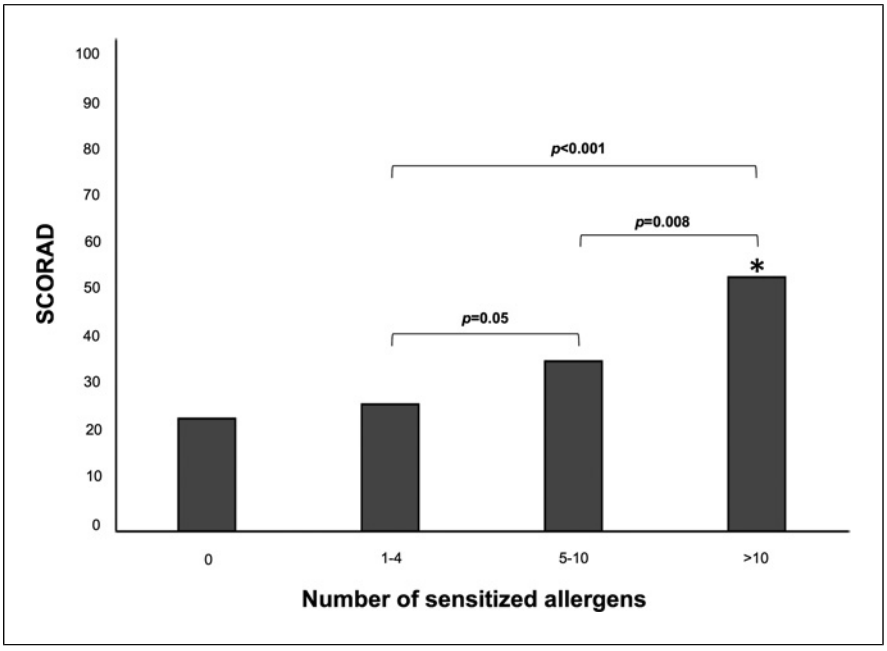

Fig. 4. Comparison of SCORAD scores according to number of sensitized allergens. *$p < 0.005$ compared with non-sensitizers. p values were obtained by using independent sample t test.

sensitized to egg, casein, goat's milk, beef, pork, chicken, rye flour, rice, soybean, corn, peanut, almond, apple, or strawberry had significantly higher SCORAD scores (Table S1).

Prediction of FS according to SCORAD Scores, TEWL Levels, and SCH Levels

We used ROC curves to determine the area under the curve (AUC), sensitivity, and specificity of cut-off points for SCORAD score, TEWL, and SCH level in predicting sensitization to the following common allergens: cow's milk, egg, almond, peanut, and goat's milk, shown in Table 4 and Figures 5–7. The SCORAD score was a good predictor of sensitization to egg yolk (AUC = 0.75, $p < 0.001$), beef (AUC = 0.71, $p = 0.001$), almond (AUC = 0.82, $p < 0.001$), peanut (AUC = 0.81, $p < 0.001$), and goat's milk (AUC = 0.74, $p < 0.001$) in children with AD. Additionally, the SCORAD score was moderately able to predict sensitization to cow's milk (AUC = 0.63, $p = 0.02$) and egg white (AUC = 0.68, $p = 0.001$). Generally, the SCH level in children with lesional skin had good predictive value for sensitization to peanut (AUC = 0.73, $p < 0.05$) and goat's milk (AUC = 0.72, $p < 0.05$), moderately predictive value for sensitization to cow's milk (AUC = 0.62, $p = 0.03$), egg white (AUC = 0.65, $p = 0.009$), egg yolk (AUC = 0.64, $p = 0.04$), almond (AUC = 0.63, $p = 0.05$), and beef (AUC = 0.66, $p = 0.01$). However, the TEWL level had low predictive value for FS in children with AD.

Discussion

In the present study, we found that most of children with AD were sensitized to at least 1 FAs, and those who were sensitized to a greater number of FAs had more severe AD phenotypes and greater epidermal integrity impairment. Moreover, SCORAD score and SCH level could predict FS in children with AD.

Most children with AD (90%) in the present study were sensitized to at least one of the tested FAs; this prevalence was higher than those reported by Moghtaderi et al. [8] (51%) and Yuenyongviwat et al. [9] (60%). However, those studies investigated smaller numbers of FAs (20 and 8 allergens, respectively), compared with our study [8, 9]. Additionally, other studies in children aged <15 years showed that the prevalence of FS ranged from 30% to 40% [10, 11], below the prevalence in our study. This difference may have occurred because FS is more frequent in young children and can be outgrown. In another study, the prevalence of FS in children with AD ranged from 20% to 80% [12]. According to previous reports, the prevalence of FS and food allergy among the children in different communities were much lower than that reported in AD children. Suaini et al. [13] found that among Asian children, prevalence of food allergy was 1.1% in Singapore and 15% in Australia. Another study in China showed that parent-reported FA and doctor-diagnosed FA prevalence in children were 6.2% and 3.3%, respectively [14]. In Vietnam, Le et al. [15] found

Table 4. SCORAD scores, TEWL levels, and SCH levels predicting FS in children with AD according to sensitised allergens

	AUC	Cut-off	Sensitivity	Specificity	*p* value
Cow's milk					
SCORAD	0.63	29.1	60.5	59.7	**0.02**
SCH non-lesional skin	0.59	49	43.6	74.3	0.13
SCH lesional skin	0.62	19	69.4	42.9	**0.03**
TEWL non-lesional skin	0.57	14.6	45.7	74.2	0.73
TEWL lesional skin	0.50	19	57.1	46.8	0.70
Egg white					
SCORAD	0.68	34.2	51.0	86.3	**0.001**
SCH non-lesional skin	0.61	38	70.0	46.8	**0.04**
SCH lesional skin	0.65	22	70.0	55.3	**0.009**
TEWL non-lesional skin	0.61	12.6	55.3	68.0	0.08
TEWL lesional skin	0.59	18.2	68.1	52.0	0.12
Egg yolk					
SCORAD	0.75	34.3	61.5	79.7	<**0.001**
SCH non-lesional skin	0.60	47	46.6	58.3	0.08
SCH lesional skin	0.64	15	75.3	45.8	**0.04**
TEWL non-lesional skin	0.60	12	62.5	60.3	0.35
TEWL lesional skin	0.55	23	45.8	65.8	0.56
Beef					
SCORAD	0.71	30.3	67.7	69.6	**0.001**
SCH non-lesional skin	0.69	34	78.3	50.0	**0.002**
SCH lesional skin	0.66	19	72.5	53.6	**0.01**
TEWL non-lesional skin	0.59	12	60.7	60.9	0.49
TEWL lesional skin	0.53	22	50.0	60.9	0.47
Almond					
SCORAD	0.82	30.1	81.5	71.2	<**0.001**
SCH non-lesional skin	0.63	45	55.6	64.0	0.09
SCH lesional skin	0.63	25	56.9	56.0	**0.05**
TEWL non-lesional skin	0.52	13	56.0	63.9	0.89
TEWL lesional skin	0.60	25.3	48.0	75.0	0.13
Peanut					
SCORAD	0.81	34.3	73.1	83.8	<**0.001**
SCH non-lesional skin	0.70	38	68.5	58.3	**0.007**
SCH lesional skin	0.73	20	69.9	66.7	<**0.001**
TEWL non-lesional skin	0.50	10.5	52.1	54.2	0.77
TEWL lesional skin	0.64	26.5	45.8	80.8	0.06
Goat's milk					
SCORAD	0.74	30.1	70.8	65.8	<**0.001**
SCH non-lesional skin	0.67	46	46.1	76.2	**0.008**
SCH lesional skin	0.72	19	71.1	57.1	**0.001**
TEWL non-lesional skin	0.53	13	52.4	61.8	0.82
TEWL lesional skin	0.55	25.3	42.9	72.4	0.32

AD, atopic dermatitis; AUC, area under the curve; FS, food sensitization; SCORAD, Scoring Atopic Dermatitis; SCH, stratum corneum hydration; TEWL, transepidermal water loss.

that the prevalence of self-reported FA and doctor-diagnosed FA among children were 5.0–9.8%. These findings suggest that FS is more common than previously reported in children with AD, particularly among such children aged <5 years. Additionally, the number of FAs investigated in each study and the ethnicity of the study population could affect FS prevalence.

We found that cow's milk protein (60%) was the most commonly sensitized FA, followed by egg white (49%), beef (31%), almond (27%), egg yolk (26%), and peanut (26%). Similar results were reported by Moghtaderi et al. [8]. Another study also showed that egg, cow's milk, and peanut were the most prevalent allergens in children with AD who were sensitized to FA [16].

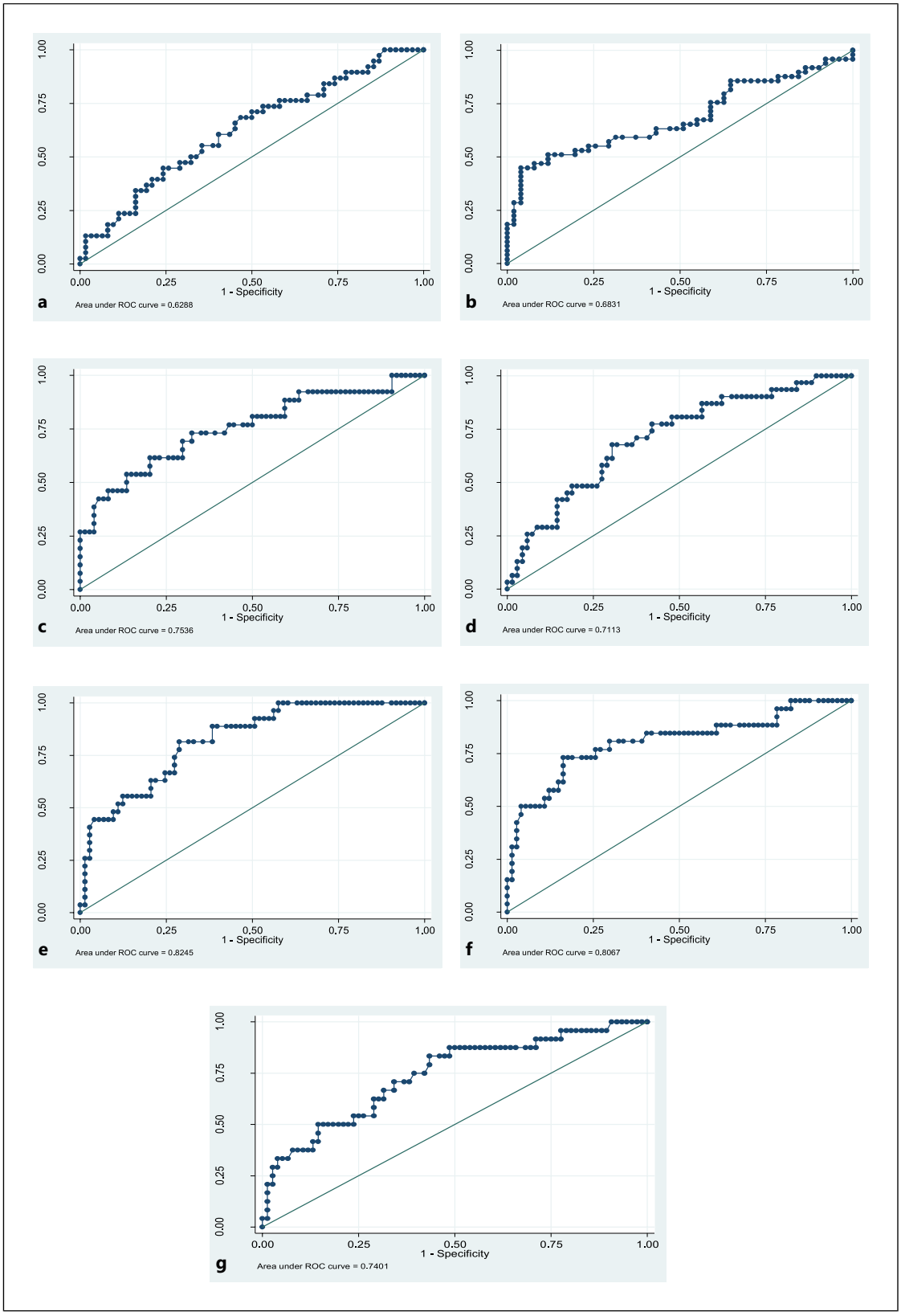

Fig. 5. SCORAD scores predicting FS in children with AD according to sensitized allergens. **a** Cow's milk. **b** Egg white. **c** Egg yolk. **d** Beef. **e** Almond. **f** Peanut. **g** Goat's milk.

However, a study in an American population showed that egg and peanut were the most prevalent FAs [17]. The profile of FS in the Southeast Asia could be different from the trends observed in the Western world. Yuenyongviwat et al. [9] conducted a research in Thailand and reported that approximately 30% of children experienced sensitization to egg yolk during their first year of life. Differences in commonly sensitized FAs among studies could be related to differences in ethnicity, age, local food customs, and dietary habits among study populations. In Vietnam and other Asian countries, cow's milk proteins and egg appear to be the most common FAs in children.

We also examined features of co-sensitization among the tested FAs and found that egg white and beef had the highest prevalence of co-sensitization, such that 71.4% of children sensitized to egg white were also sensitized to beef; 58.3% of children sensitized to beef were also sensitized to egg white. This prevalence was higher than that reported previously, which showed that 28.5% of AD children who were sensitized to egg white also exhibited beef sensitization. The prevalence of co-sensitization to cow's milk and cow's milk protein ranged from 75% to 91.7% in children with AD who were sensitized to goat's milk. Therefore, in clinical practice, caution should be exercised when introducing cow's milk to AD children who have had allergic reactions to beef and/or goat's milk. Cow's milk and goat's milk contain homologues allergenic proteins, such as casein and whey, which can lead to cross-reactivity. Evidence shows that milk proteins from various ruminant species exhibit cross-reactivity [18, 19]. Pork and beef share homologues allergenic proteins; therefore, cross-reactivity between pork and beef allergies may occur [20, 21]. Additionally, children with AD who were sensitized to egg yolk demonstrated a high prevalence (92.3%) of sensitization to egg white; consequently, caution should be exercised when introducing egg white to children with AD who have had allergic reactions to egg yolk.

To our knowledge, this is the first study in Vietnam to evaluate the association between FS and epidermal layer impairment. We found that in children with AD, lesional skin had significantly higher TEWL levels, and lower SCH levels compared with non-lesional skin. Additionally, participants with moderate-severe AD had significantly higher TEWL levels and lower SCH levels in lesional skin, compared with participants who had mild AD. These findings were consistent with the results of Montero-Vilchez et al. [22], who showed that impaired skin barrier function in the lesional skin was associated with AD severity.

The damaged epidermal barrier (indicated by increased TEWL levels and decreased SCH levels) in patients with AD could enhance FA penetration and induce FS. Subsequent exposure to FAs via damaged skin could trigger an inflammatory response, leading to enhancement of AD severity [2]. In the present study, patients with higher TEWL levels and lower SCH levels were sensitized to more FAs. We found that the number of sensitized FAs was positively associated with AD severity as determined by SCORAD scores. Compared with non-sensitizers, children with AD who were sensitized to FAs such as egg, cow's and goat's milk proteins, beef, pork, chicken, rice, and others (online suppl. Table S1; for all online suppl. material, see https://doi.org/10.1159/000533492) had more severe AD. This was consistent with the findings of Wolkerstorfer et al. [23]. Other studies showed strong associations among FS, food allergies, and the severity and chronicity of AD [8, 24]. Consequently, those findings indicate that FS could be associated with epidermal barrier impairment and subsequently AD severity in children. Although these findings suggest a clear association between FS and epidermal barrier impairment, the causative relationship between these factors cannot be determined using data from cross-sectional studies.

There is currently no clinical guidance regarding the appropriate time to evaluate FA in patients with AD. The results of previous studies have suggested that FS is associated with severe and persistent AD [25]. In the present study, we analysed the ROC curves of SCORAD scores, as well as the utilities of SCH and TEWL levels, in terms of predicting FS in the study subjects. We found that SCORAD scores and SCH levels in lesional skin had moderate predictive value for sensitization to cow's milk, egg, almond, beef, peanut, and goat's milk in children with AD. SCORAD scores and SCH levels in lesional skin had the highest predictive value for sensitization to peanut and the lowest predictive value for sensitization to cow's milk. However, TEWL levels were not useful for predicting FS in the present study. The SCORAD assessment and the measurements of TEWL and SCH levels are easy, non-invasive procedures that are safe for children. Our findings suggest that clinicians should consider assessing FS in children with moderate-severe AD and/or low SCH levels in lesional skin.

The limitations of the present study include the inability to perform a follow-up assessment because of the cross-sectional design. Secondly, we did not perform an oral food challenge test to determine food allergies. Third, the age range of our study participants was also limited because we did not include children

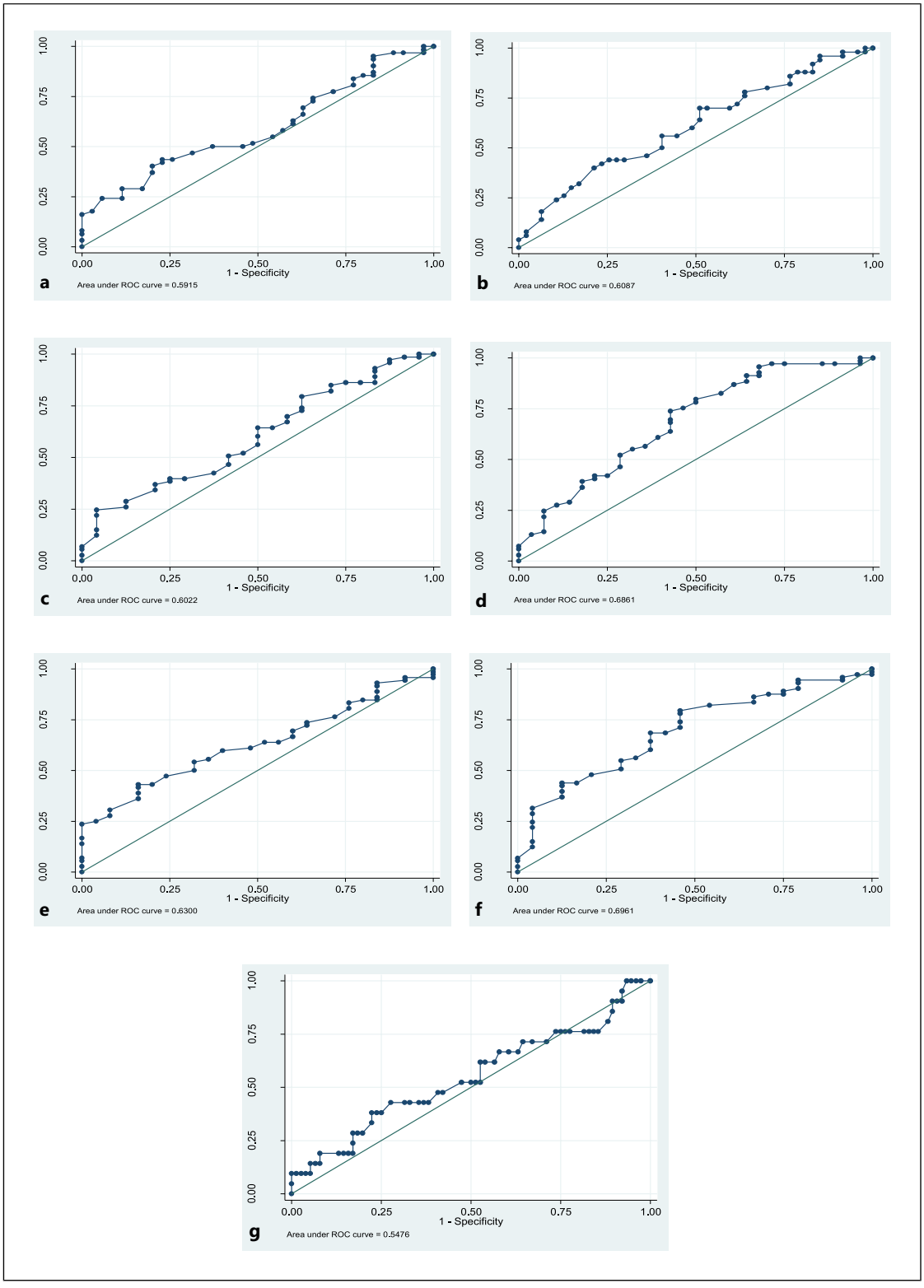

Fig. 6. SCH levels non-lesional skins predicting FS in children with AD according to sensitized allergens. **a** Cow's milk. **b** Egg white. **c** Egg yolk. **d** Beef. **e** Almond. **f** Peanut. **g** Goat's milk.

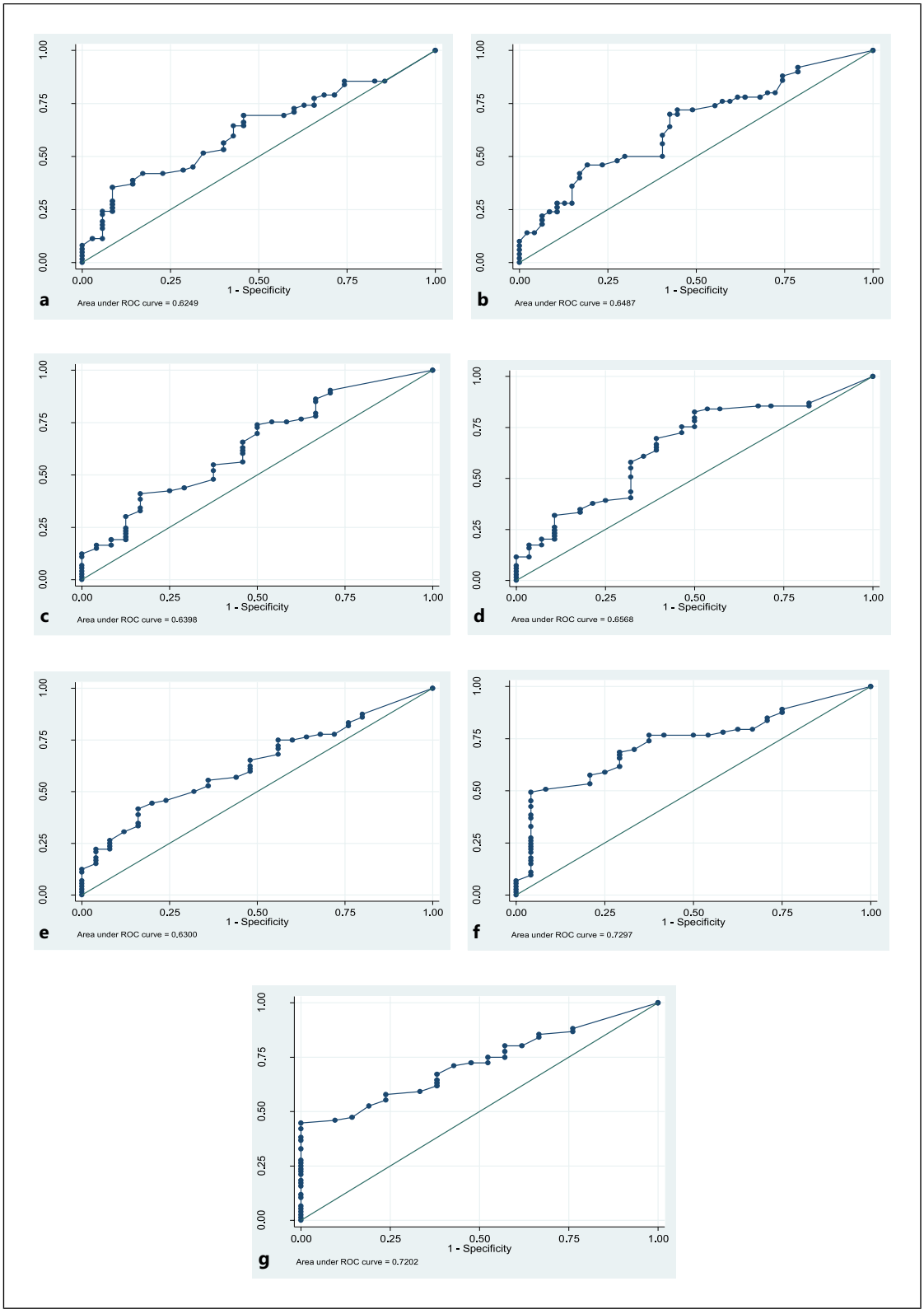

Fig. 7. Stratum corneum hydration (SCH) levels lesional skins predicting FS in children with AD according to sensitized allergens. **a** Cow's milk. **b** Egg white. **c** Egg yolk. **d** Beef. **e** Almond. **f** Peanut. **g** Goat's milk.

aged <1 year. Thus, the study results are not representative of children with the highest prevalence of AD (i.e., children aged <6 months). Finally, the present study only aimed to investigate the predicting factors for FS in children with AD using SCORAD, TEWL, and SCH levels. Consequently, we did not evaluate the sensitization to inhaled allergens. Nonetheless, the study conducted by Trinh et al. [26] showed a high prevalence of sensitization to *Dermatophagoides pteronyssinus* (59.2%), *Dermatophagoides farinae* (42.9%), and *Blomica tropicalis* (42.9%) in patients with AD living in southern Vietnam. The allergen sensitization in children tends to shift from FAs to inhaled allergens when they grow up. Therefore, future studies should include both food and inhaled allergens to provide a general picture of allergen sensitization in children with AD.

In conclusion, FS is common in children with AD and closely associate with AD severity as well as epidermal barrier impairment. Evaluations of FS should be considered for children with moderate to severe AD and/or low SCH levels.

Statement of Ethics

The guardians of all study participants provided written informed consent for enrolment. This study was approved by the Institutional Review Board Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (IRB-VN01002/IORG0008603/FWA00023448).

Conflict of Interest Statement

The authors have no conflict of interest to declare.

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Author Contributions

Nguyen Le Huong Tran: conceptualization; methodology; data curation; formal analysis; investigation; writing – original draft preparation; writing – review and editing. Nhung Thi My Ly: conceptualization; project administration; supervision; writing – original draft preparation; writing – review and editing. Hoang Kim Tu Trinh: project administration; writing – review and editing. Minh Kieu Le: investigation; writing – review and editing. Niem Van Thanh Vo: investigation; writing – review and editing. Duy Le Pham: conceptualization; formal analysis; investigation; methodology; validation; project administration; supervision; writing – original draft preparation; writing – review and editing, and acceptance for submission.

Data Availability Statement

All data generated or analysed during this study are included in this article and its supplementary material files. Further enquiries can be directed to the corresponding author.

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