



Water Exposure on the Hands in Adolescents: A Report from the BAMSE Cohort

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Water exposure on the skin of the hands has previously been studied in adults. The aim of this study was to investigate self-reported water exposure in adolescents in the BAMSE cohort in Stockholm, Sweden. A questionnaire including a question on daily water exposure on the hands was answered by 3,091 adolescents at age 16 years. Exposure >10 times/day was reported by 28.7% and >20 times/day by 3.1%; boys had somewhat higher exposure than girls ($p=0.03$). In a multivariate analysis, adolescents with dry skin reported higher exposure (adjusted odds ratio (OR_{adj}) 1.4; 95% CI 1.2–1.7), while no statistically significant exposure differences were found in relation to hand eczema or atopic dermatitis. Reported exposure may be considered as baseline exposure during a period of life with limited occupational and domestic duties.

Key words: atopic dermatitis; dry skin; hand eczema; risk factor; wet work.

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Water exposure on the hands in adults and wet work have been studied in a number of recent publications, with the primary focus on occupational exposure (1–10). Large differences in exposure have been shown previously in the adult general population in Sweden, with the highest exposure reported in jobs in the service sector, e.g. kitchen and restaurant work, cleaning and hairdressing (3, 4, 9). Water exposure correlates to the wider concept of “wet work” (3) and is one of several causative factors for hand eczema (11, 12). In Germany there is a regulation defining “wet work” as having wet hands for >2 h/day, or frequent daily hand washing, or wearing occlusive gloves for >2 h/day (13). Non-occupational water exposure in adults is also considerable (10). However, little is known about water exposure on adolescents' hands.

The present study is part of the epidemiological project BAMSE (Barn [children], Allergy, Milieu, Stockholm, Epidemiological survey) (14). In this project, lifestyle and environmental risk factors for the development of atopic dermatitis (AD), asthma and rhinitis are studied.

Results regarding the occurrence of hand eczema, the correlation between AD and hand eczema and the prevalence of contact allergy have been reported previously from the project (15–17). At follow-up at 16 years of age a question on frequency of daily water exposure on the hands was included.

The aim of the present study was to investigate the extent of self-reported water exposure on the hands in adolescents in a population-based cohort study.

MATERIALS AND METHODS

Study population

The BAMSE project includes a closed population-based birth cohort. The children were recruited consecutively at birth and followed up to 16 years of age (14). All children born between 1994 and 1996 in predefined areas of Stockholm, Sweden, were invited to participate. Seventy-five percent ($n=4,089$) of the eligible children were included (14). Data on environmental exposure and history of parental allergy were obtained shortly after birth (median age 2 months). Subsequently, parents answered questionnaires concerning manifestations of AD, asthma and rhino-conjunctivitis when the children were 1, 2, 4, 8, 12 and 16 years of age. At the follow-ups at ages 12 and 16 years the children also answered questionnaires. A question about water exposure on the hands was included in the questionnaire completed at 16 years of age, as were questions about hand eczema and dry skin (see below).

A total of 4,089 children was included in the original BAMSE cohort; retention through to age 16 years was 78% ($n=3,181$) (17). In the present study, the population is defined as all adolescents who answered the question on water exposure; in total 3,091 (97.2%), girls 1,573/3,091 (50.9%) and boys 1,518/3,091 (49.1%). Most (99%) were still attending school and 98% were living with at least one of their parents.

Definition of variables

Water exposure. The question used was: “How many times a day are your hands exposed to water?” There were 5 possible responses (not at all, 1–10 times, 11–20 times, 21–30 times, and >30 times).

Dry skin. “Have you during the past 12 months been bothered by dry skin?” (yes/no).

Hand eczema. For lifetime prevalence the question was: “Have you ever had hand eczema (itching eruptions, vesicles or itching rash)?” (yes/no), and for the 1-year period prevalence “Have you had hand eczema on any occasion during the past 12 months?” (yes/no) (15).

Atopic dermatitis. AD at age 1, 2 and 4 years: dry skin and itchy rash with a typical age-specific location for at least 2 weeks the year before follow-up and/or doctor's diagnosis of eczema since the last

follow-up. AD at age 8 and 16 years: dry skin in combination with itchy rash and typical localization the year before follow-up and/or doctor's diagnosis of eczema since the last follow-up. AD at age 12 years: dry skin in combination with itchy rash and typical localization the year before follow-up and/or doctor's diagnosis of eczema since the age of 10 years (16).

Occasional AD. Fulfilling the definition of AD at one or more follow-ups up to the age of 4 years, but not from 4 to 16 years, or vice versa (16).

Persistent AD. Fulfilling the definition of AD at one or more follow-ups up to the age of 4 years and at one or more follow-ups from 4 to 16 years (16).

Ethical approval

The study was approved by the Regional Ethics Review Board in Stockholm, Sweden. The principles of the Declaration of Helsinki were followed and all parents gave their written informed consent that their children were allowed to participate.

Statistical analysis

Groups were compared using Student's *t*-test for parametric data and the χ^2 -test or Fisher's exact test for non-parametric data. Differences were considered significant at $p < 0.05$.

A multivariate logistic regression analysis was used to examine a possible correlation between water exposure and sex, dry skin, hand eczema at age 16 years, AD ever, and AD at age 16 years. The logistic regression is presented as odds ratios (OR_{adj}) with 95% confidence intervals (95% CIs). Prior knowledge was used to choose the included variables. Each variable was adjusted for all the other variables in the analysis. Analyses were performed with STATA Statistical Software (release 11.1; Stata Corp, College Station, TX, USA). In **Fig. 1** data from a previous study are reproduced (with permission) (10).

RESULTS

Low exposure to water on the skin (0–10 times/day) was reported by 71.4%, exposure > 10 times/day by 28.7% and > 20 times/day by 3.1%. Boys reported somewhat higher exposure than girls ($p = 0.03$) (**Table I**).

Dry skin during the past 12 months was reported by 1,202 individuals (39%) and they reported more frequent

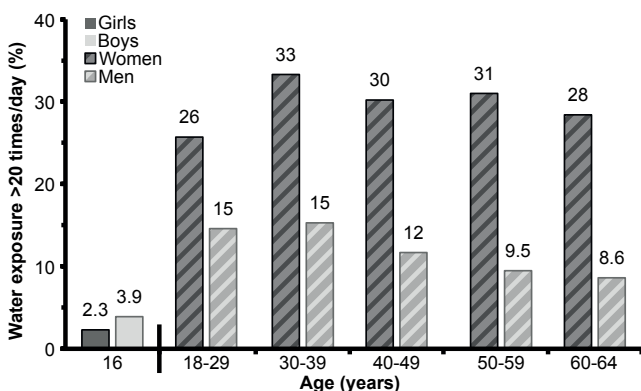


Fig. 1. Self-reported skin water exposure on the hands > 20 times/day. Data for girls and boys, age 16 years, from the present study, and previous data on adults from the Swedish National Environmental Health Survey 2007 (10, with permission).

Table I. Self-reported skin water exposure on the hands at age 16 years in relation to sex, dry skin, hand eczema, and atopic dermatitis (AD)

Characteristics	Water exposure (times/day)		
	0–10 (n = 2,206) % (n)	11–20 (n = 790) % (n)	> 20 (n = 95) % (n)
Girls ^a (n = 1,573)	72.7 (1,144)	25.0 (393)	2.3 (36)
Boys (n = 1,518)	70.0 (1,062)	26.2 (397)	3.9 (59)
Dry skin ^b (n = 1,202)	66.8 (803)	29.3 (352)	3.9 (47)
No dry skin (n = 1,872)	74.3 (1,391)	23.2 (434)	2.5 (47)
Hand eczema age 16 ^c (n = 152)	65.1 (99)	32.9 (50)	2.0 (3)
No hand eczema age 16 (n = 2,757)	71.8 (1,979)	25.1 (691)	3.2 (87)
AD ever ^d (n = 1,321)	71.3 (941)	25.8 (341)	3.0 (39)
AD at age 16 ^e (n = 339)	65.5 (222)	30.7 (104)	3.8 (13)
Occasional AD ^f (n = 837)	71.1 (595)	26.5 (222)	2.4 (20)
Persistent AD ^f (n = 484)	71.5 (346)	24.6 (119)	3.9 (19)
No AD (n = 1,770)	71.5 (1,265)	25.4 (449)	3.2 (56)

^aComparison girls vs. boys, $p = 0.03$; ^bcomparison dry skin vs. no dry skin, $p < 0.001$; ^ccomparison hand eczema at age 16 years vs. no hand eczema at age 16 years, $p = 0.1$; ^dcomparison AD ever vs. no AD, $p = 0.7$; ^ecomparison AD at age 16 years vs. no AD, $p = 0.2$; ^fcomparison occasional AD, persistent AD vs. no AD, $p = 0.5$.

exposure to water than those who did not report having dry skin ($p < 0.001$) (**Table I**). Water exposure in girls and boys with dry skin did not differ significantly ($p = 0.07$). Of those who reported dry skin, 60% fulfilled the criteria of AD ever.

Water exposure in relation to occurrence of hand eczema at age 16 years (1-year period prevalence) is shown in **Table I**. No statistically significant difference was found in water exposure between those with and without hand eczema ($p = 0.1$), or between girls and boys with hand eczema ($p = 0.9$) (data not shown). Analysing water exposure in relation to hand eczema ever (lifetime prevalence) did not reveal any significant differences ($p = 0.3$) (data not shown).

Water exposure in relation to AD is presented in **Table I**. Results for the variables AD ever, AD at age 16 years, occasional AD and persistent AD are presented. When

Table II. Results of a multivariate logistic regression analysis on reported daily water exposure at age 16 years

	Water exposure ≤ 10 times/day n	Water exposure > 10 times/day n	OR _{crude} (95% CI)	OR _{adj} (95% CI) n = 3,074	p-value
Sex					
Girls	1,144	429			
Boys	1,062	456	1.1 (1.0–1.3)	1.2 (1.0–1.4)	0.03
Dry skin					
No	1,391	481			
Yes	803	399	1.4 (1.2–1.7)	1.4 (1.2–1.7)	< 0.001
Hand eczema at 16 years of age (1-year period prevalence)					
No	2,105	832			
Yes	101	53	1.3 (0.9–1.9)	1.1 (0.8–1.6)	0.5
Atopic dermatitis (AD) ever					
No	1,265	505			
Yes	941	380	1.0 (0.9–1.2)	0.9 (0.7–1.1)	0.2
AD at age 16 years					
No	1,984	768			
Yes	222	117	1.4 (1.1–1.7)	1.2 (0.9–1.6)	0.2

Exposure ≤ 10 times/day was used as reference, > 10 times/day as dependent variable. Adjusted odds ratio (OR_{adj}) with 95% confidence intervals (95% CIs). Each variable was adjusted for all the other variables included. Bold type, 95% CI does not include 1.00.

comparing with the reports given by those with no AD, no statistically significant differences were found. There were also no significant exposure differences between girls and boys in relation to AD (data not shown).

Logistic regression analysis was used to analyse water exposure in relation to sex, dry skin, hand eczema at age 16 years, AD ever, and AD at age 16 years (**Table II**). Water exposure ≤ 10 times/day was used as reference, and exposure > 10 times/day as dependent variable. Dry skin gave a significantly increased OR_{adj} 1.4 (95% CI 1.2–1.7).

DISCUSSION

The adolescents in this large population-based birth cohort reported a fairly low level of water exposure on the hands in comparison with the results of earlier studies in adults. Boys reported a slightly higher exposure than girls, in contrast to the evident female preponderance reported in adults.

Water exposure at age 16 years is to be regarded as a baseline figure, reported in a period of life with low occupational exposure, as almost all the participating adolescents were still attending school. Most of the adolescents were still living in their parental homes, implying limited domestic wet work duties for many of them, although exceptions may occur.

In Sweden there is a long tradition of epidemiological surveillance, and both occupational and non-occupational skin exposure to water have been investigated in the general population (3, 4, 9, 10). In adults (age 18–64 years) high all-day water exposure on the hands, > 20 times/day, was reported by 21.7% (10), compared with 3.1% among the adolescents in the present study. The proportion of individuals with low exposure, ≤ 10 times/day, was 71.4% in the adolescents, in contrast to 41.8% previously reported in adults (10). It is thus apparent that water exposure during adolescence is much lower than that later in life, which is probably largely due to less occupational and domestic exposure.

In the present study, 2.3% of the girls and 3.9% of the boys stated all-day exposure > 20 times/day (Fig. 1). In the previous study in adults, the corresponding figures were 25.7% of the women and 14.6% of the men in the youngest age group, 18–29 years (10). The high extent of water exposure in adults seems to appear rather soon after individuals leave school and is probably due to both domestic and occupational exposure. The large difference between the sexes, with more prominent water exposure in women, is probably related to gender differences in choice of occupation and in exposure patterns outside of work (9, 10). Interestingly, this high level of all-day water exposure in young adult women appears to remain at a similar high level later in life, at least up to age 65 years. In contrast, a decreased exposure after age 40 years has been noted in men (10). A further follow-up of

the BAMSE cohort is planned and will provide us with the possibility of assessing whether the “adult exposure pattern” will appear in this cohort.

It has been shown that prolonged water exposure may induce skin irritation (18–20). External factors, such as exposure to skin irritants, e.g. wet exposure, and exposure to contact allergens, are well-known risk factors for hand eczema. The present study did not find any increased occurrence of hand eczema in relation to the reported water exposure; however, this is not expected, as the question used reflects current exposure to water, which might not have influenced the onset of the hand eczema in many of the cases. In addition, few individuals reported a high level of exposure.

In a previous report from the BAMSE project, the incidence of hand eczema was 573/100,000 person years; the same magnitude in adolescents as found previously in adults, but the 1-year period prevalence was lower; 5.2% (15). Female predominance was noted regarding both incidence and prevalence. In the present study, the almost even distribution of water exposure between the sexes indicates that there should be factors other than water exposure that explain the female dominance of hand eczema in adolescence. Of the adolescents with hand eczema 73% had symptoms of AD at some point during follow-up (16).

We did not find any correlation between AD and the reported water exposure, which might have been expected, since reducing exposure to water is common advice given to people with AD. It is likely that many of the participants with AD had not, at this young age, fully considered the importance of reducing skin water exposure on their hands. No written information regarding skin water exposure has been given in connection with previous BAMSE examinations. When considering choice of occupation it is important to be aware of the increased risk of hand eczema for individuals with history of AD (21–24). There is a defect in the skin barrier function related to AD (25), which entails an increased propensity to experience skin irritation.

Logistic regression analysis revealed that dry skin was the only variable significantly related to water exposure on the hands > 10 times/day. A history of dry skin is one of a number of criteria used for AD (26). An interesting observation in the present study is that as many as 40% of those who reported dry skin did not fulfill further criteria of AD ever. The question regarding dry skin is not restricted to the hands, in contrast to the question on water exposure. It is not evident how to interpret the self-reports of dry skin. A tendency to over-report water exposure when having dry skin is a possibility that cannot be ruled out. The concept of dry skin is usually based on subjective reports without generally accepted clinical definitions and the occurrence varies (6–73%) in different publications (27–30). The importance of skin water exposure is highly relevant considering current

research regarding the skin barrier, dry skin, filaggrin mutations and eczema (30–32).

This is the first study in which reports on skin water exposure in adolescents have been presented. When collecting self-reported data, validated questions should be used, if possible. A question on occupational exposure to water has been validated previously through observation in adults, resulting in a correlation of 0.680 and 0.521, respectively, regarding frequency of exposure (33, 34). The question used in the present study had a similar wording as the validated question; the only difference was that exposure during the entire day was asked for, not only exposure at work. It might be difficult to perform a validation by observation regarding all-day exposure. The question used for 1-year period prevalence of hand eczema has previously been validated in adults, where it was found that the question gives an underestimation of the true prevalence (sensitivity 53–59%, specificity 96–99%) (35). The cohort design of the BAMSE project, the large population-based sample size and high response rate are all strengths of the present study.

In conclusion, the extent of water exposure on skin of the hands at age 16 years is low and may be considered as baseline exposure during a period of life with limited occupational and domestic duties. At this age, the difference in exposure between the sexes is small, with a somewhat higher exposure in boys than girls.

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REFERENCES

- Jungbauer FHW, Lensen GJ, Groothoff JW, Coenraads PJ. Exposure of the hands to wet work in nurses. *Contact Dermatitis* 2004; 50: 225–229.
- Jungbauer FHW, Van Der Harst JJ, Schuttelaar ML, Groothoff JW, Coenraads PJ. Characteristics of wet work in the cleaning industry. *Contact Dermatitis* 2004; 51: 131–134.
- Anveden I, Wrangsjö K, Järvholm B, Meding B. Self-reported skin exposure – a population-based study. *Contact Dermatitis* 2006; 54: 272–277.
- Anveden Berglind I, Alderling M, Järvholm B, Lidén C, Meding B. Occupational skin exposure to water: a population-based study. *Br J Dermatol* 2009; 160: 616–621.
- Kralj N, Oertel Ch, Doench NM, Nuebling M, Pohrt U, Hofmann F. Duration of wet work in hairdressers. *Int Arch Occup Environ Health* 2011; 84: 29–34.
- Ibler KS, Jemec GBE, Agner T. Exposures related to hand eczema: a study of healthcare workers. *Contact Dermatitis* 2012; 66: 247–253.
- Hovmand Lysdal S, Johansen JD, Flyvholm M-A, Søsted H. A quantification of occupational skin exposures and the use of protective gloves among hairdressers in Denmark. *Contact Dermatitis* 2012; 66: 323–334.
- Visser MJ, Verberk MM, van Dijk FJH, Bakker JG, Bos JD, Kezic S. Wet work and hand eczema in apprentice nurses; part I of a prospective cohort study. *Contact Dermatitis* 2013; 70: 44–55.
- Meding B, Anveden Berglind I, Alderling M, Lindahl G, Wrangsjö K. Water exposure – challenging differences between occupations. *Contact Dermatitis* 2016; 74: 22–28.
- Meding B, Lindahl G, Alderling M, Wrangsjö K, Anveden Berglind I. Is skin exposure to water mainly occupational or nonoccupational? A population-based study. *Br J Dermatol* 2013; 168: 1281–1286.
- Uter W, Pfahlberg A, Gefeller O, Schwanitz HJ. Risk of hand dermatitis among hairdressers versus office workers. *Scand J Work Environ Health* 1999; 25: 450–456.
- Apfelbacher CJ, Funke U, Radulescu M, Diepgen TL. Determinants of current hand eczema: results from case-control studies nested in the PACO follow-up study (PACO II). *Contact Dermatitis* 2010; 62: 363–370.
- Committee on Hazardous Substances – AGS-management – BauA TRGS 401: technical rules for hazardous substances: risks resulting from skin contact – identification, assessment, measures. 2008. [last accessed 23 May 2016] Available at: <http://www.baua.de/en/Topics-from-A-to-Z/Hazardous-Substances/TRGS/TRGS-401.html>.
- Wickman M, Kull I, Pershagen G, Nordvall SL. The BAMSE project: presentation of a prospective longitudinal birth cohort study. *Pediatr Allergy Immunol* 2002; 13 (Suppl 15): 11–13.
- Grönhagen CM, Lidén C, Bergström A, Kull I, Wahlgren C-F, Meding B. Prevalence and incidence of hand eczema in adolescence: report from BAMSE – a population-based birth cohort. *Br J Dermatol* 2014; 171: 609–614.
- Grönhagen C, Lidén C, Wahlgren C-F, Ballardini N, Bergström A, Kull I, et al. Hand eczema and atopic dermatitis in adolescents: a prospective cohort study from the BAMSE project. *Br J Dermatol* 2015; 173: 1175–1182.
- Lagrelidius M, Wahlgren C-F, Matura M, Kull I, Lidén C. High prevalence of contact allergy in adolescence: results from the population-based BAMSE birth cohort. *Contact Dermatitis* 2016; 74: 44–51.
- Ramsing DW, Agner T. Effect of water on experimentally irritated human skin. *Br J Dermatol* 1997; 136: 364–367.
- Tsai T-F, Maibach HI. How irritant is water? An overview. *Contact Dermatitis* 1999; 41: 311–314.
- Fartasch M, Taeger D, Broding HC, Schöneweis S, Gellert B, Pohrt U, et al. Evidence of increased skin irritation after wet work: impact of water exposure and occlusion. *Contact Dermatitis* 2012; 67: 217–228.
- Meding B, Swanbeck G. Predictive factors for hand eczema. *Contact Dermatitis* 1990; 23: 154–161.
- Meding B, Järvholm B. Hand eczema in Swedish adults – changes in prevalence between 1983 and 1996. *J Invest Dermatol* 2002; 118: 719–723.
- Bingefors K, Svensson Å, Isacson D, Lindberg M. Self-reported lifetime prevalence of atopic dermatitis and comorbidity with asthma and eczema in adulthood: a population-based cross-sectional survey. *Acta Derm Venereol* 2013; 93: 438–441.
- Mortz CG, Bindslev-Jensen C, Andersen KE. Hand eczema in the Odense adolescence cohort study on atopic diseases and dermatitis (TOACS): prevalence, incidence and risk factors from adolescence to adulthood. *Br J Dermatol* 2014; 171: 313–323.
- Weidinger S, Novak N. Atopic dermatitis. *Lancet* 2016; 387: 1109–1122.
- Williams HC, Burney PGJ, Hay RJ, Archer CB, Shipley MJ, Hunter JJA, et al. The U.K. Working party's diagnostic criteria for atopic dermatitis. I. Derivation of a minimum set of discriminators for atopic dermatitis. *Br J Dermatol* 1994; 131: 383–396.
- Dalgard F, Holm JØ, Svensson Å, Kumar B, Sundby J. Self-

- reported skin morbidity and ethnicity: a population-based study in a Western community. *BMC Dermatol* 2007; 7: 4.
28. Misery L, Boussetta S, Nocera T, Perez-Cullell N, Taieb C. Sensitive skin in Europe. *J Eur Acad Derm Venereol* 2009; 23: 376–381.
 29. Halvorsen JA, Braae Olesen A, Thoresen M, Holm J-Ø, Bjertness E, Dalgard F. Comparison of self-reported skin complaints with objective skin signs among adolescents. *Acta Derm Venereol* 2008; 88: 573–577.
 30. Böhme M, Söderhäll C, Kull I, Bergström A, van Hage M, Wahlgren C-F. Filaggrin mutations increase the risk for persistent dry skin and eczema independent of sensitization. *J Allergy Clin Immunol* 2012; 129: 1153–1155.
 31. Landeck L, Visser M, Skudlik C, Brans R, Kezic S, John SM. Clinical course of occupational irritant contact dermatitis of the hands in relation to filaggrin genotype status and atopy. *Br J Dermatol* 2012; 167: 1302–1309.
 32. Molin S, Merl J, Dietrich KA, Regauer M, Flaig M, Letulé V, et al. The hand eczema proteome: imbalance of epidermal barrier proteins. *Br J Dermatol* 2015; 172: 994–1001.
 33. Anveden I, Lidén C, Alderling M, Meding B. Self-reported skin exposure – validation of questions by observation. *Contact Dermatitis* 2006; 55: 186–191.
 34. Anveden I, Meding B. Skin exposure in geriatric care – a comparison between observation and self-assessment of exposure. *Contact Dermatitis* 2007; 57: 253–258.
 35. Meding B, Barregård L. Validity of self-reports of hand eczema. *Contact Dermatitis* 2001; 45: 99–103.