

1 The development of a protocol for diagnosing hand dermatitis from photographic images

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39 **ABSTRACT**

40 **Background**

41 A hand photography protocol was needed to ascertain the presence and severity of
42 dermatitis in a trial testing the effectiveness of a behaviour change intervention to prevent
43 hand dermatitis in nurses.

44 **Methods**

45 We developed the protocol in three stages: (i) established a procedure for collecting hand
46 photographs; (ii) conducted a stepwise validation process to agree rules for diagnosing and
47 determining severity of hand dermatitis and; (iii) trained a research nurse to screen out
48 'clear' cases.

49 **Results**

50 We developed and trained fieldworkers (n=97) in a procedure for collecting hand
51 photographs. Study dermatologists established interpretation rules to diagnose and
52 determine the severity of dermatitis from photographs. Prior to the establishment of the
53 rules, inter-observer agreement between the two dermatologists on the presence or absence
54 of hand dermatitis was moderate (kappa 0.5). At the final stage of the validation process, the
55 dermatologists agreed on 88% cases from independent assessments, with consensus
56 reached for the remaining 12% following joint deliberation. Following training, a subgroup
57 analysis of 250 cases screened by the nurse and characterised as 'clear' found two (0.8%)
58 'positive' cases were missed.

59 **Conclusion**

60 We have developed a hand photography protocol, which may be used in other studies or in
61 hand dermatitis health surveillance programmes.

62 **Key words:** photographs, photography protocol, hand dermatitis, nurses, research trial.

63 **1. Introduction**

64 Hand dermatitis is recognised as a major occupational skin disease for primary healthcare
65 workers (1, 2), with the point prevalence among healthcare workers estimated to be 24%
66 compared to less than 10% in the general population (3). While various methods and tools
67 have been developed to diagnose and assess severity of hand dermatitis (4-9), limitations in
68 their acceptability have been observed. In particular, these approaches typically rely on
69 visual inspections and clinical assessments by clinicians in clinical settings or by patient self-
70 assessment. This renders many of them of limited use in large population-based intervention
71 studies where clinical follow-up may be impractical due to the dispersed nature of study
72 participants.

73 Teledermatology is a mature approach which yields results similar to those of face-to-face
74 consultations (5, 10). There is also supportive evidence that interpretation of digital
75 photographs is sufficiently sensitive to detect early signs of dermatitis (10). Teledermatology
76 has been shown to have high intra- and inter-rater reliability when compared with face-to-
77 face assessment in NHS intensive care nurses and nursery nurses (5), with a slight
78 tendency to over-estimate the prevalence of hand dermatitis (5, 6, 10) The self-assessment
79 of hand dermatitis (or no 'clear' hand dermatitis) by healthcare workers and non-healthcare
80 workers using the photographic method proposed by Coenraads et al (11) has also been
81 shown to be an effective approach in several studies (12-14). However, this method could
82 not be used in the present trial as study participants needed to be blinded to the assessment
83 of whether hand dermatitis was present or not, as this was the primary outcome of the trial.
84 In addition, we required a method, which would reliably distinguish dermatitis towards the
85 milder end of the spectrum.

86 The purpose of this paper is to describe the three distinct stages we took in developing a
87 new hand photography protocol for the skin care intervention in nurses (SCIN) trial in the
88 United Kingdom. This new protocol offers a method for diagnosing hand dermatitis and its
89 severity which relies on dermatologist and research nurse inspection of hand photographs
90 from research participants (in lieu of physical examinations), with comparisons then made
91 from standardised images contained in Coeraands et al photographic guide (11). The stages
92 include: (i) developing a standardised procedure for hand photography (ii) a stepwise
93 validation process of rules for the study dermatologists to diagnose and determine the
94 severity of the hand dermatitis and (iii) training by a dermatologists of a research nurse to
95 screen out hand photographs of study participants without dermatitis ('clear cases'). In
96 developing the new method, we had several requirements:

- 97 1. The method had to measure presence or absence of hand dermatitis as well as
98 severity.
99 2. The method could not involve physical examination of the participants, as that would
100 be logistically very difficult, expensive and likely to result in poor response rates.
101 3. The method had to be objective and not based on self-report as self-report tends to
102 over-report hand dermatitis.
103 4. The severity scale needed to be able to distinguish dermatitis towards the milder end
104 of the disease spectrum.

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106 **2. Methods**

107 **2.1 Study background**

108 The skin care intervention in nurses ('SCIN') trial is a national multi-centre cluster
109 randomised controlled trial examining the effectiveness of a complex intervention to reduce
110 the prevalence and incidence of hand dermatitis in at-risk nurses working in the National
111 Health Service (NHS) in the United Kingdom (1). We recruited two groups of nurses who are
112 at risk of hand dermatitis: student nurses who had a history of atopic disposition and
113 intensive care unit (ICU) nurses due to higher frequency of hand washing. The main study
114 intervention is based on an online behaviour change programme (BCP), grounded in the
115 theory of planned behaviour (15) combined with provision of hand moisturisers and optimal
116 equipment for hand care. We recruited 2042 participants from 35 participating sites in the
117 NHS. Each participant had four photographs taken of their hands at baseline (left palmar, left
118 dorsal, right palmar, right dorsal) and four photographs of their hands at 12 months follow-
119 up. Several fieldworkers (occupational health practitioners and research nurses) at each site
120 were trained by the central trial team and were responsible for recruiting study participants
121 and collecting study data, this included taking hand photographs.

122 The primary outcome measure was the difference in the point prevalence of hand dermatitis
123 between participants in the intervention and control arm of the trial from baseline (T1) to 12
124 months (T2) on photographs assessed by the two study dermatologists.

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126 **2.2: Development of the hand photography procedure and fieldworker training** 127 **(Stage 1)**

128 In collaboration with a medical photographer, we developed a detailed hand photography
129 procedure to standardise the collection, screening and assessment of hand photographs.
130 This provided fieldworkers with step-by-step instructions on setting up and using high-

131 resolution digital SLR cameras for taking the hand photographs from each participant (see
132 appendix 1). A flexible grey/white photographic exposure card was used as a background
133 screen when taking the photographs. The hand photography procedure required
134 fieldworkers to check the correct settings of camera set up functions, that the camera flash
135 was switched on, and that a minimum distance (75cm) of the camera from the participants'
136 hands was maintained (11). Before the trial started we trained fieldworkers in the use of the
137 photography protocol, including practical photography demonstrations. During the follow up
138 period, we also provided participants with an opportunity to take hand photographs on their
139 smart phones and send them to the research team via email. Specific instructions on how to
140 take and send in hand selfie photographs were sent to participants and these were based on
141 key aspects of the main photography protocol'

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144 **2.3 Establishing agreed assessment rules for diagnosing hand dermatitis and** 145 **for ascertaining the severity of dermatitis (Stage 2)**

146 We assessed hand dermatitis via photographic images taken of each two side of the hand
147 (palm and dorsum) of both left and right hands i.e. four images per participant. The presence
148 of dermatitis was based on comparisons made with the standardised images of severity at
149 various stages of diseases that were contained in Coenraads et al photographic severity
150 guide (11). For each of the four images, the study dermatologists were required to indicate
151 whether dermatitis was "clear" (absent), "almost clear", "moderate", "severe", or "very
152 severe" for each image. These four variables (dermatitis in the right hand at the back, right
153 hand in the palm, left hand at the back, and left hand in the palm) were then dichotomised as
154 clear vs almost clear/moderate/severe/very severe in any of the four images per participant.
155 A single binary variable was generated for the presence of dermatitis (No / Yes).

156 Agreement/disagreement on the severity of hand dermatitis was not assessed during the
157 validation process since we realised early on that the likelihood of our two dermatologists
158 agreeing on the severity grading (five grades) at four different sites was likely to be poor and
159 that perfect agreement according to each site was not necessary for our study that sought to
160 establish a global estimate of hand dermatitis severity. We took the pragmatic view that each
161 participant's overall severity of hand dermatitis would be defined as the most severe
162 combined score from both dermatologists on the Coenraads et al scale from their four hand
163 photographs. Agreement between the two dermatologists on the binary rating (Yes / No) was
164 assessed using the Cohen's kappa statistic.

165

166 In a prior feasibility study before setting agreement rules of diagnosing dermatitis between
167 the same dermatologists, we found a moderate (κ 0.5) interobserver agreement in the
168 assessment of photographs. This was mainly due to disagreement on the threshold of very
169 mild versus no dermatitis. The study dermatologists therefore established rules for
170 undertaking the assessments in the main study. To complete this task, we undertook the
171 following stepwise validation process. The study dermatologists were provided with hand
172 photographs from an initial sample of 70 cases (study one) from the main study population to
173 independently assess for dermatitis followed by a further enriched sample of 71 cases (study
174 two) with a high percentage of dermatitis cases (as identified by the chief investigator). To
175 minimise bias, we ensured the study dermatologists remained blinded to any other
176 participant information such as self-reported information in the questionnaires or each
177 other's independent assessment outcomes. The study dermatologists independently scored
178 the hand photographs using the photographic assessment guide developed by Coenraads et
179 al (11). Discordant cases were then identified by the central trial team and sent back to the
180 study dermatologists who remained blinded to other information about the participants for
181 their follow up joint assessment. Both dermatologists looked at the discordant cases together
182 and explained why one or other had decided that the participant had some degree of hand
183 dermatitis. Very often these discordant cases were very difficult to judge and so a set of
184 rules were developed which are referenced in appendix 2. The study dermatologists met and
185 jointly refined these 'mini rules' for deciding whether a case met the criteria for dermatitis.
186 This validation process was repeated again (study three). A final arbitrator (an independent
187 dermatologist) was available for consultation in circumstances where the study
188 dermatologists were unable to agree. The intra-observer error was calculated to determine
189 the degree of error in the dermatologist assessments. Diagram 1 outlines flowchart for
190 assessing hand photographs.

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192 **2.4 Dermatology research nurse training (Stage 3)**

193 Due to the large number of hand photographs collected during the trial, we appointed a
194 dermatitis research nurse to screen out all the photographs where no dermatitis was evident.
195 This cut down on dermatologist time as they only assessed those images the dermatology
196 research nurse was unsure or sure that dermatitis was present. One of the study
197 dermatologists provided the nurse with two hour training sessions, including the
198 following assessment principles: (i) a quick look for abnormal erythema (or surface
199 changes) using pattern recognition skills; (ii) if suspicious areas were identified,
200 images were enlarged to lifesize (but not beyond) to determine if the abnormality

201 was dermatitis (poorly defined erythema with surface change such as scaling,
202 lichenification or vesicles) and (iii) if the research nurse ruled out evidence of
203 dermatitis on first inspection, a final inspection was carried out by the research nurse
204 on high risk areas such as fingers, interdigital webspaces or around rings if worn,
205 and easily missed areas such as the wrist. We ensured the dermatology research
206 nurse was also aware of the agreed rules that the study dermatologists would
207 adhere to during their own assessment process.

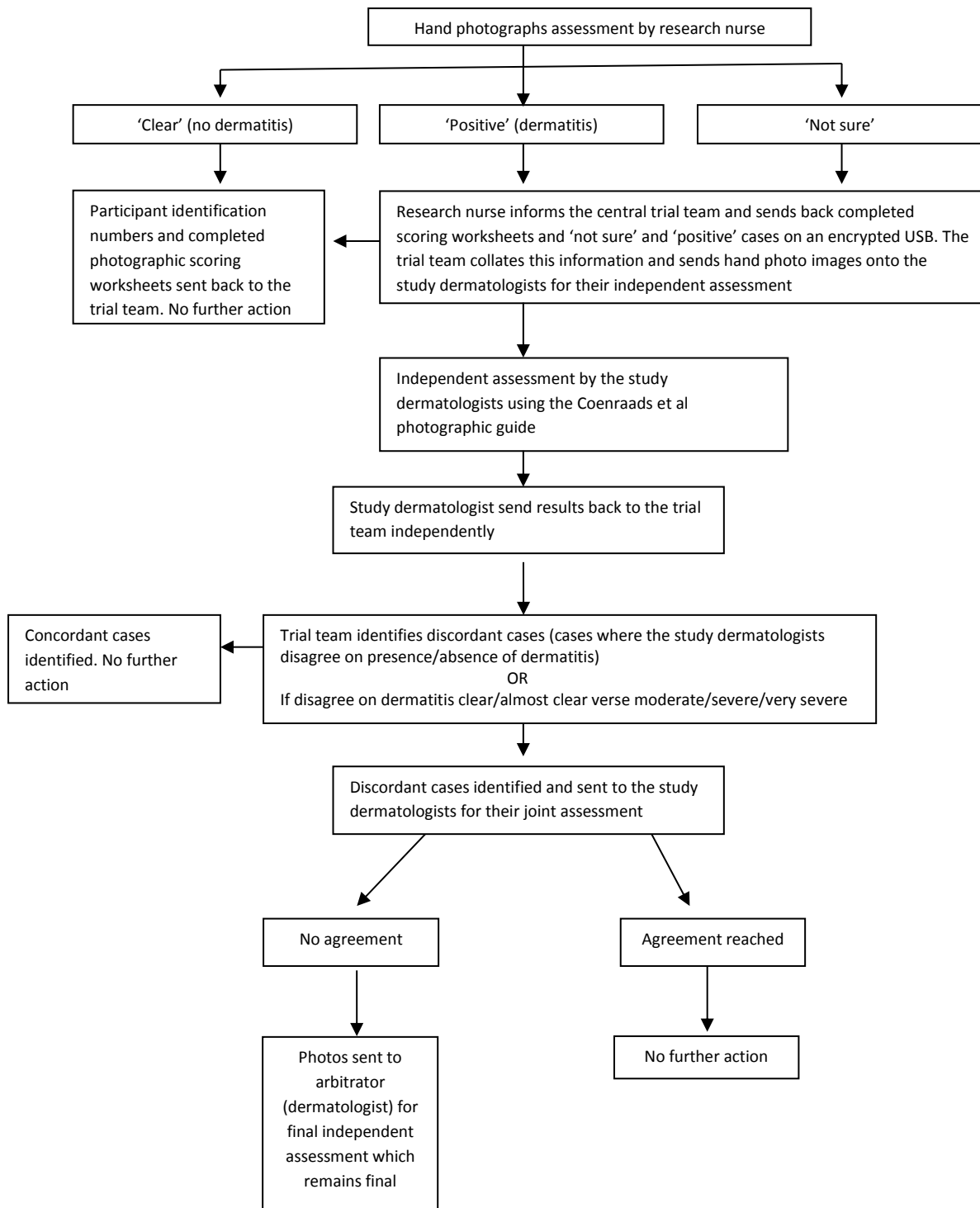
208 To ensure the screening by the dermatology research nurse had a high specificity, we
209 conducted a subgroup reliability analysis. A subsample of 250 cases (images of the dorsum
210 of the right hand only) from the main study population that were initially assessed by the
211 dermatology research nurse as 'clear' (no dermatitis) were sent to one of the study
212 dermatologists for assessment (study four) as this is the area where occupational hand
213 dermatitis is most likely to be seen.

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Figure 1: Flowchart for assessing hand photographs



219 **3. Results**

220 **3.1 Procedure for taking hand photographs (Stage 1)**

221 We trained ninety-seven local fieldworkers from 35 participating sites in the use of the hand
222 photography protocol. To differentiate the specific time points in which the hand photographs
223 were taken ('recruitment' T=0 month or 'follow up' T=12 months) we used specific
224 photographic label cards containing unique sequence codes to which the dermatologists and
225 research nurse were blinded. We sent regular reminders to fieldworkers to ensure the
226 correct label cards were being used during the follow up period. Moreover, it became evident
227 following the recruitment period that fieldworkers occasionally forgot to use the camera flash
228 when taking hand photographs. This meant that there were a number of sets of hand
229 photographs (n=10) that could not be included in the final data set due to the difficulties in
230 conducting a reliable assessment due to their poor image quality.

231

232 **3.2 Establishing agreed assessment rules for diagnosing hand dermatitis and**
233 **for ascertaining dermatitis severity (Stage 2)**

234 From the initial sample of 70 sets of hand photographs from the main study sent to the study
235 dermatologists for independent assessment as part of our validation process (study one), we
236 found they agreed on 66/70 (94%) cases and disagreed on 4/70 (6%) (kappa 0.30). From
237 the follow-up enriched sample of 71 sets of hand photographs sent to the study
238 dermatologists for independent assessment (study two), the proportion of agreements
239 versus disagreements is shown (Table 1) (kappa = -0.14). After joint discussion, the study
240 dermatologists agreed on all 29 cases that they had previously disagreed on.

241

242 Of the additional 100 photographs from the main trial that were sent to the study
243 dermatologists for their independent assessment as part of our final validation process
244 (study three), a further 12 (12%) discordant cases required joint deliberation. Following
245 discussion, the study dermatologists agreed on all of the 12 cases. The final arbitrator was
246 not used during the development of the photography protocol or during the main trial. This
247 stepwise validation procedure allowed the study dermatologists to further refine their rules
248 for diagnosing hand dermatitis until the inter-observer agreement exceeded a kappa score of
249 0.60. A full list of the mini rules is in appendix 2.

250

251 The joint review of discordant cases showed that one of the dermatologists had a lower
252 threshold for diagnosing dermatitis than the other study dermatologist. In particular, one of

253 them was more likely to grade dryness as meeting the criteria for dermatitis. Therefore, the
254 study dermatologists agreed to exclude very borderline cases of non-inflamed dermatitis as
255 not meeting the criteria for dermatitis. Agreement/disagreement on severity of hand
256 dermatitis was not assessed during the validation process. Table 2 shows the results from
257 the intra-observer assessment of the 71 cases that were randomly selected from the
258 baseline database and were reassessed by the dermatology research nurse and of the 53
259 cases that were randomly selected from the baseline database and were reassessed by the
260 study dermatologists.

261

262 Figure 1 is an example which shows early signs of hand dermatitis which both study
263 dermatologists agreed during their independent assessment, Figure 2: a moderate case of
264 dermatitis and Figure 3, dry and crinkly skin but assessed as 'clear'.

265

266 **3.3 Dermatology research nurse training (Stage 3)**

267 From the subgroup analysis of the 250 cases (images of the dorsum of the right hand only)
268 that were screened by the nurse and categorised as 'clear', the study dermatologists found
269 two 'positive' (0.8%) cases of hand dermatitis had potentially been missed (study four). The
270 study dermatologists suggested that both cases could be considered possible cases of
271 dermatitis because one image had dermatitis on the right lateral surface of the right thumb
272 (i.e. not the back of the right hand which was the primary site for the subgroup analysis) and
273 the other showed dermatitis on the right index finger, although the photograph was
274 underexposed and was difficult to interpret.

275

276 **4. Discussion**

277 We developed a novel and practical photography protocol suitable for use in a large-scale
278 multi-centre research trial examining hand dermatitis prevention in nurses. The hand
279 photography procedure was a useful instructional guide to promote standardisation of hand
280 photography for later diagnostic assessment. During the stepwise validation procedure, we
281 gained a number of important insights into the complexities of the independent assessment
282 process, which required careful deliberation and refinement. This played an important role in
283 formulating an agreed list of assessment rules to use as a reference guide during the study.

284 We found that hand photographs taken by trained field workers using high-resolution digital
285 SLR cameras provided a practical method for collecting the data on presence or absence of
286 dermatitis in participants who were geographically dispersed across the UK. We successfully
287 trained a dermatology research nurse to competently pre-screen hand photographs as ‘clear’
288 (no dermatitis), ‘positive’ (present dermatitis) or ‘not sure’, thereby reducing the assessment
289 burden on the study dermatologists. The use of a broad range of hand photographs,
290 showing varying degrees to asymptomatic and symptomatic dermatitis, played an important
291 role during the dermatology research nurse training sessions.

292

293 An important observation from our study is that high quality photographic images of hands
294 will always reveal small areas of scaling, erythema and surface changes that could be
295 deemed to be very early signs of hand dermatitis. This observation reinforces the view that
296 hand dermatitis is a continuum from surface damage to frank dermatitis with cardinal signs
297 such as lichenification and vesicles. Furthermore, we found that agreement between the
298 dermatologists on moderate or severe cases was very good whereas agreement on the
299 gradation between very mild and simply dry “overwashed” hands is more difficult and
300 therefore to be expected. To address this issue, we incorporated a joint assessment
301 procedure and mini rules that the study dermatologists followed when assessing borderline
302 cases to minimise the risk of misdiagnosis. Such an approach will always be needed in
303 population (as opposed to clinic) based studies where the threshold for diagnosing disease
304 is blurred and difficult to assess.

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309

310 Figure legends

311 Figure 1: Flowchart for assessing hand photographs

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313 Figure 2: Illustrates presence of early stages of hand dermatitis appearing under ring

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316 Figure 3: Moderate case of hand dermatitis

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320 Figure 4: Dry and crinkly skin but assessed as 'clear'

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326 **Online supplement appendix 1: Procedure for taking hand photographs**

327 See separate upload file

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334 **Table 1:** Results from the study dermatologists' independent assessment

Classification (n=71)	Agree	Disagree
Clear (no evidence of dermatitis)	2 (3%)	-
Positive (presence of dermatitis) on either hand	39 (55%)	29 (41%)
Positive (presence of dermatitis) but disagreement on which hand	1 (1%)	

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337 **Table 2:** Intra-observer assessment

	Agreement	Kappa
Dermatology research nurse	81.7%	0.56
Dermatologist 1	69.8%	0.40
Dermatologist 2	81.1%	0.63

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References

1. Madan I, Parsons V, Cookson B, et al. A behavioural change package to prevent hand dermatitis in nurses working in the National Health Service.(the SCIN trial): study protocol for a cluster randomised controlled trial. *Trials*. 2016;17(145).
2. Hamnerius N, Svedman C, Bergendorff O, et al. Wet work exposure and hand eczema among healthcare workers - a cross-sectional study. *British Journal of Dermatology*. 2018;178:452-61.
3. Thyssen JP, Johansen JD, Linneberg A, et al. The epidemiology of hand eczema in the general population - Prevalence and main findings. *Contact Dermatitis*. 2010;62:75-87.
4. Carlsson A, Svensson Å, Anderson CD, et al. Scoring of Hand Eczema: Good Reliability of Hand Eczema Extent Score. *Acta dermato-venereologica*. 2017;97:193-7.
5. Steiner M. Workplace health surveillance for occupational skin diseases: diagnostic accuracy and reliability of a teledermatology tool. [PhD dissertation]: University of Aberdeen; 2011.
6. Baumeister T, Weistenhöfer W, Drexler H, et al. Spoilt for choice - Evaluation of two different scoring systems for early hand eczema in teledermatological examinations. *Contact Dermatitis*. 2010;62:241-7.
7. Held E, Skoet R, Johansen JD, et al. The hand eczema severity index (HECSI): a scoring system for clinical assessment of hand eczema. A study of inter- and intraobserver reliability. *British Journal of Dermatology*. 2005;152:302-7.
8. Skudlik C, Dulon M, Pohrt U, et al. Osnabrueck hand eczema severity index - A study of the interobserver reliability of a scoring system assessing skin diseases of the hands. *Contact Dermatitis*. 2006;55:42-7.
9. Weistenhöfer W, Baumeister T, Drexler H, et al. How to quantify skin impairment in primary and secondary prevention? HEROS: A proposal of a hand eczema score for occupational screenings. *British Journal of Dermatology*. 2011;164:807-13.
10. Baumeister T, Weistenhöfer W, Drexler H, et al. Prevention of work-related skin diseases: teledermatology as an alternative approach in occupational screenings. *Contact Dermatitis*. 2009;61:224-30.
11. Coenraads PJ, van der Walle H, Thestrup-Pedersen K, et al. Construction and validation of a photographic guide for assessing severity of chronic hand dermatitis. *British Journal of Dermatology*. 2005;152:296-301.
12. Ibler K, Agner T, Hansen J, et al. The Hand Eczema Trial (HET): Design of a randomised clinical trial of the effect of classification and individual counselling versus no intervention among health-care workers with hand eczema. *BMC Dermatology*. 2010;10(8).
13. Hald M, Veien NK, Laurberg G, et al. Severity of hand eczema assessed by patients and dermatologist using a photographic guide. *British Journal of Dermatology*. 2007;156:77-80.
14. Hald M, Agner T, Blands J, et al. Clinical severity and prognosis of hand eczema. *British Journal of Dermatology*. 2009;160:1229-36.
15. Ajzen I. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. 1991;50:179-211.