

## ORIGINAL ARTICLE

# The impact of dermoscopy on melanoma detection in the practice of dermatologists in Europe: results of a pan-European survey

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## Abstract

**Background** Dermoscopy is a widely used technique that can increase the sensitivity and specificity of melanoma detection. Information is lacking on the impact of dermoscopy use on the detection of melanoma in the real-life practice of European dermatologists.

**Objective** To identify factors that influence the benefit of using dermoscopy for increasing melanoma detection and lowering the number of unnecessary biopsies in the practice of European dermatologists.

**Methods** We conducted a survey of dermatologists registered in 32 European countries regarding the following: the demographic and practice characteristics, dermoscopy training and use, opinions on dermoscopy and the self-estimated impact of dermoscopy use on the number of melanomas detected and the number of unnecessary biopsies performed in practice.

**Results** Valid answers were collected for 7480 respondents, of which 6602 reported using dermoscopy. Eighty-six per cent of dermoscopy users reported that dermoscopy increased the numbers of melanomas they detected, and 70% reported that dermoscopy decreased the number of unnecessary biopsies of benign lesions they performed. The dermatologists reporting these benefits were more likely to have received dermoscopy training during residency, to use dermoscopy frequently and intensively, and to use digital dermoscopy systems and pattern analysis compared to dermatologists who did not perceive any benefit of dermoscopy for the melanoma recognition in their practice.

**Conclusions** Improving dermoscopy training, especially during residency and increasing access to digital dermoscopy equipment are important paths to enhance the benefit of dermoscopy for melanoma detection in the practice of European dermatologists.

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## Conflicts of interest

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## Introduction

Dermoscopy is an established tool for the clinical diagnosis of a wide range of skin diseases,<sup>1–8</sup> but its main role remains the facilitation of melanoma diagnosis. Dermoscopy used by trained

physicians has been shown to increase the sensitivity of melanoma detection up to ninefold compared to the clinical examination alone.<sup>9–11</sup> Moreover, it allows for the earlier detection of thinner melanomas<sup>12,13</sup> by revealing subtle changes of melanocytic lesions, invisible to the naked eye. As such, it is a valuable aid for melanoma screening and for the monitoring of high-risk

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patients, which is recommended by the current practice guidelines for melanoma diagnosis.<sup>14–17</sup> At the same time, multiple studies have shown that dermoscopy use at an expert level can increase the specificity of melanoma diagnosis, which translates into the reduction in unnecessary biopsies of benign lesions.<sup>18–20</sup> These results are supported by indirect evidence from the analysis of dermatological practices,<sup>20–22</sup> where the number needed to excise (NNE), calculated as the number of all melanocytic lesions excised for each confirmed melanoma, reportedly decreases from 20 to 40 in general dermatology practices to 4–8 in specialized skin cancer clinics using dermoscopy.

The proven capacity of dermoscopy to increase the diagnostic accuracy for melanoma suggests that this technique, if used systematically, could have a population-wide impact, by improving early detection and hence the prognosis of melanoma, while reducing the need for invasive diagnostic procedures and their related human and material costs. So far, most evidence on the impact of dermoscopy on melanoma early detection comes from controlled studies in several expert centres, involving a limited number of dermatologists. However, very little is known on how dermoscopy actually impacts everyday dermatology practice in Europe<sup>18,23</sup> and on the factors that enhance or limit the benefits that dermatologists derive from its use regarding melanoma diagnosis.

In this context, we conducted the first pan-European survey of the patterns, motivations and obstacles of dermoscopy use. Herein, we explored the perceptions of European dermatologists about the benefits of dermoscopy in increasing their capacity to detect melanomas and reducing the number of unnecessary biopsies. We analysed further the demographic, practice- and training-related factors that influence these perceptions.

## Methods

The Eurodermoscopy pan-European survey of dermatologists was conducted under the auspices of the International Dermoscopy Society (IDS), and its methodology and detailed data handling were described in detail elsewhere.<sup>24</sup> In brief, the *study instrument* consisted of a 20-item questionnaire,<sup>24</sup> covering demographic, practice-related and dermoscopy training characteristics, and including questions about the patterns of use and dermatologists' attitudes and opinions about dermoscopy. The questionnaire did not include any personal identification information and was translated in all the participating countries' languages. It was intended for all licensed dermatologists registered in European countries and was administered as an online survey in 32 participating countries. The dissemination of the survey in each country occurred through the national contact databases of dermatologists, under the responsibility of National Coordinating Teams, who collaborated with national dermatology and dermoscopy professional associations and were led by a National Coordinator elected from the members of the IDS Board of Directors or the Country Coordinators of Euromelanoma campaign. Online responses were collected through the IDS web-

based tool for online surveys, into an access-restricted central database, grouped by country access code. Data cleaning of the study database was performed by three independent investigators (GG, AMF and PT).

The current work focuses on the answers to questions regarding the opinion of dermatologists on the impact of dermoscopy in increasing melanoma detection and reducing the number of unnecessary biopsies in their daily practice.

For *statistical analysis*, R software<sup>25</sup> was used. Comparing proportions of two groups' chi-squared test and comparing proportions of ordered groups' chi-squared test for trends in proportions were used. Continuous data are given as means and standard deviations unless stated otherwise, and parametric tests for comparing groups were only used if corresponding assumptions were met. For multivariate analysis, all variables significant in univariate analysis were entered to a model with backwards elimination, controlled for sex, age, years in practice and numbers of (skin cancer and overall) patients per month. Remaining significant predictors are given as odds ratios (OR) with 95% confidence intervals (CI). A *P*-value < 0.05 was regarded statistically significant. In univariate analyses *P*-values were adjusted by the method of Holm.<sup>26</sup>

## Results

We collected 8519 responses from 32 countries in which a total number of 38 300 dermatologists were registered as for the year 2014. After the data cleaning, 7480 valid responses were retained for analysis, of which 6602 reported to use dermoscopy. These were further analysed to assess the perceived impact of dermoscopy on the number of detected melanomas and on the number of unnecessary biopsies of benign lesions.

### Factors associated with a perceived benefit of dermoscopy use in improving recognition of melanoma

Eighty-six per cent of all 6602 dermoscopy users reported that dermoscopy improved their ability to recognize melanoma compared with the naked-eye clinical examination (Table 1a). This positive perception showed a statistically significant association with younger age, working in public healthcare facilities, shorter duration of practising dermatology, higher number of patients seen/month, with receiving dermoscopy training during residency, and having trained in dermoscopy by any interactive form of education (courses, online courses, conferences, training with mentor/tutor) (Table 1a). It was also associated with the use of polarized light dermoscopy and digital dermoscopy, and with more frequent use of dermoscopy in their practice (Table 1b). Dermatologists who felt that dermoscopy improved their melanoma recognition were more likely to use the ABCD rule and pattern analysis than dermatologists who did not perceive a benefit of dermoscopy in increasing melanoma detection (31% vs. 26% and 31% vs. 25%, respectively, *P* = 0.01). Using no particular algorithm regularly was reported by 41% of

**Table 1** Factors associated with the perception that dermoscopy use improved melanoma recognition in the daily practice. (a) Demographic and practice setting factors associated with the perceived benefit of dermoscopy in the recognition of melanoma in the daily practice. (b) Practice factors associated with a perceived benefit of dermoscopy for the recognition of melanoma in the daily practice

(a)	Do you feel that using dermoscopy has increased the number of melanomas that you detected, in comparison with the naked-eye examination?		
	Yes	No	P-value
<b>N = 6228</b>	5373 (86.27%)	855 (13.73%)	
<b>Female participants</b>	67.23%, n = 3594	67.37%, n = 574	1.000
<b>Age (mean)</b>	46.6 (SD: 10.93)	49.37 (SD: 10.98)	<b>&lt;0.001</b>
<b>Place of work</b>			
Individual private practice	36.57%, n = 1965	49.12%, n = 420	<b>&lt;0.001</b>
Private ambulatory hospital	19.75%, n = 1061	21.99%, n = 188	0.702
Public ambulatory hospital	31.92%, n = 1715	23.27%, n = 199	<b>&lt;0.001</b>
University hospital	21.11%, n = 1134	22.81%, n = 195	0.836
Involved in teaching for dermatology residents	12.99%, n = 698	12.28%, n = 105	1.000
<b>Years as dermatology specialist (mean)</b>	15.79 (SD: 10.63)	18.53 (SD: 10.68)	<b>&lt;0.001</b>
<b>No. of patients seen/month (mean)</b>	442.84 (SD: 413.95)	395.71 (SD: 323.73)	<b>0.002</b>
<b>No. of skin cancer patients seen/month (mean)</b>	61.02 (SD: 102.64)	51.69 (SD: 140.91)	0.413
<b>Dermoscopy training during residency</b>	44.72%, n = 2374	24.11%, n = 203	<b>&lt;0.001</b>
<b>Types of dermoscopy training received outside residency</b>			
Dermoscopy course	66.65%, n = 3581	45.61%, n = 390	<b>&lt;0.001</b>
Online dermoscopy course	19.17%, n = 1030	13.45%, n = 115	<b>0.001</b>
Attended conferences/congresses	73.14%, n = 3930	66.78%, n = 571	<b>0.002</b>
Books/atlasses	81.00%, n = 4352	77.43%, n = 662	0.163
Mentor/tutor	24.49%, n = 1316	16.73%, n = 143	<b>&lt;0.001</b>
No training	3.03%, n = 163	4.33%, n = 37	0.413
(b)	Do you feel that using dermoscopy has increased the number of melanomas that you detected, in comparison with the naked-eye examination?		
	Yes	No	P-value
<b>Duration of dermoscopy practice</b>			
<2 years	10.74%, n = 575	11.87%, n = 101	0.256
2–5 years	19.56%, n = 1047	22.91%, n = 195	
>5 years	69.70%, n = 3731	65.22%, n = 555	
<b>Types of dermoscopes used</b>			
Non-polarized immersion contact	53.17%, n = 2857	57.08%, n = 488	0.294
Polarized light dermoscope	53.97%, n = 2900	47.72%, n = 408	<b>0.008</b>
Dermoscope with digital camera	24.01%, n = 1290	14.62%, n = 125	<b>&lt;0.001</b>
Digital videodermoscopy system	27.55%, n = 1480	15.56%, n = 133	<b>&lt;0.001</b>
<b>Average frequency of using dermoscopy</b>			
<1 ×/month	0.84%, n = 45	1.29%, n = 11	<b>&lt;0.001</b>
1–4/month	3.86%, n = 207	6.44%, n = 55	
>1 ×/week	10.39%, n = 557	13.47%, n = 115	
Daily	84.91%, n = 4553	78.81%, n = 673	
<b>Regularly used dermoscopic algorithm</b>			
ABCD rule	31.23%, n = 1678	25.50%, n = 218	<b>0.011</b>
CASH	0.69%, n = 37	0.35%, n = 3	1.000
Menzies algorithm	2.62%, n = 141	2.57%, n = 22	1.000
Seven-point checklist	8.32%, n = 447	5.73%, n = 49	0.137
Pattern analysis	31.01%, n = 1666	24.91%, n = 213	<b>0.005</b>
No particular algorithm	27.40%, n = 1472	41.05%, n = 351	<b>&lt;0.001</b>

P values <0.05 are highlighted in bold.

dermatologists who did not feel that dermoscopy improved their melanoma detection ability, compared to 27% of those who considered dermoscopy to be useful for increased melanoma detection ( $P < 0.001$ ) (Table 1b). Dermatologists who reported a benefit of dermoscopy in increasing their melanoma detection reported higher self-confidence in their dermoscopic diagnostic skills for all categories of inflammatory and neoplastic skin diseases and were more likely to have positive opinions about dermoscopy's utility and benefits for the practice (Table S1, Supporting Information), in comparison with the dermatologists who did not consider that dermoscopy use increased the melanoma detection in their practice.

In multivariate analysis, the following factors remained significantly associated with perceived improvement of melanoma recognition (Table 2): working in a public healthcare facility, dermoscopy training during residency, receiving any kind of dermoscopy training except atlases/books, positive opinion about the utility of dermoscopy in monitoring non-melanocytic lesions and self-confidence in the assessment of pigmented lesions. Dermatologists who did not use any particular algorithm were less likely to perceive a benefit of dermoscopy in increasing melanoma detection (OR 0.814, 95% CI: 0.675–0.985).

#### Factors associated with the perceived benefit of dermoscopy in reducing the number of unnecessary biopsies

The majority (70.7%) of dermoscopy users observed that dermoscopy allowed them to reduce the number of unnecessary

biopsies of benign lesions (Table 3a). This positive perception was associated with the following: working in private practice or in university hospitals, shorter duration of practising dermatology, higher number of patients and skin cancer patients seen per month, having received dermoscopy training during residency and having received dermoscopy training in the form of courses, conferences or atlases/books (Table 3a). It was associated also with longer dermoscopy practice, with the use of polarized light dermoscopy and of digital dermoscopy, with more frequent use of this technique and with using pattern analysis for the dermoscopic diagnosis (Table 3b). Use of the ABCD rule or using no particular algorithm at all was reported more frequently by dermatologists who have not perceived any benefit of dermoscopy in reducing biopsies (Table 3b). Further, self-confidence in the dermoscopic skills for all categories of inflammatory and tumoral skin diseases, and positive opinions about dermoscopy's advantages for the practice were associated with a perceived benefit of dermoscopy in decreasing the number of unnecessary excisions (Table S2, Supporting Information).

In multivariate analysis, the following factors remained significantly associated with perceived reduction in the number of unnecessary biopsies (Table 4): working in private practice, shorter duration of practising dermatology, training in dermoscopy in the form of attending conferences, longer duration of practising dermoscopy and more frequent use of this technique, use of digital dermoscopy devices and self-confidence in the dermoscopic diagnostic skills for pigmented lesions. Using the ABCD rule or no particular algorithm decreased the

**Table 2** Factors associated with a perceived benefit of dermoscopy for the improvement of melanoma recognition in the daily practice (multivariate analysis)

Dermoscopy use increased detected melanoma	OR	2.5% CI	97.5% CI	P-value
<b>Place of work</b>				
Individual private practice	0.791	0.640	0.977	0.029
Private ambulatory/hospital	0.736	0.585	0.929	0.009
Public ambulatory/hospital	1.573	1.269	1.959	<0.001
<b>Dermoscopy training during residency</b>	1.485	1.198	1.847	<0.001
<b>Dermoscopy training</b>				
Dermoscopy course	1.611	1.336	1.942	<0.001
Online dermoscopy course	1.362	1.057	1.773	0.019
Attended Congresses	1.293	1.056	1.580	0.012
Mentor/Tutor	1.353	1.073	1.717	0.012
<b>Regularly used dermoscopic algorithm</b>				
No used algorithm	0.814	0.675	0.985	0.033
<b>Opinion on the utility of dermoscopy in the following situations</b>				
Follow-up of non-melanocytic skin lesions*	1.659	1.347	2.046	<0.001
<b>Self-confidence in the dermoscopic diagnosis of</b>				
Pigmented skin tumours*	1.626	1.175	2.232	0.003
<b>Perceived advantages of dermoscopy use</b>				
Increases confidence of clinical diagnosis*	2.361	1.141	5.015	0.022
Reduces the number of unnecessary biopsies/excisions *	1.769	1.311	2.369	<0.001

OR, odds Ratio; CI, confidence interval.

\*Variables with a calculated linear correlation.

**Table 3** Factors associated with perceived benefit of dermoscopy in reducing unnecessary benign biopsies. (a) Demographic factors associated with the perceived benefit of dermoscopy in reducing the number of unnecessary biopsies of benign lesions. (b) Practice factors associated with perceived benefit of dermoscopy in reducing unnecessary biopsies of benign lesions

(a)	In your practice, how did the use of dermoscopy influence the number of excisions of benign lesions that you performed?		
	Reduced excisions of benign lesions	Did not reduce excisions of benign lesions	P-value
<i>N</i>	4406 (70.76%)	1820 (29.24%)	NA
<b>Female participants</b>	66.36%, <i>n</i> = 2906	69.33%, <i>n</i> = 1259	0.178
<b>Age (mean)</b>	47.09 (SD: 10.81)	46.74 (SD: 11.4)	0.884
<b>Place of work</b>			
Individual private practice	40.06%, <i>n</i> = 1765	34.45%, <i>n</i> = 627	<b>&lt;0.001</b>
Private ambulatory/hospital	18.02%, <i>n</i> = 794	25.11%, <i>n</i> = 457	<b>&lt;0.001</b>
Public ambulatory/hospital	29.05%, <i>n</i> = 1280	34.56%, <i>n</i> = 629	<b>&lt;0.001</b>
University hospital	22.47%, <i>n</i> = 990	18.35%, <i>n</i> = 334	<b>0.004</b>
Involved in teaching activity for dermatology residents	13.12%, <i>n</i> = 578	12.31%, <i>n</i> = 224	0.884
<b>Years as dermatology specialist (mean)</b>	15.94 (SD: 10.54)	16.79 (SD: 11.01)	<b>0.044</b>
<b>Patients seen/month (mean)</b>	459.02 (SD: 418.65)	384.17 (SD: 357.31)	<b>&lt;0.001</b>
<b>Skin cancer patients seen/month (mean)</b>	66.47 (SD: 114.12)	43.21 (SD: 92.11)	<b>&lt;0.001</b>
<b>Dermoscopy training during residency</b>	44.94%, <i>n</i> = 1954	34.33%, <i>n</i> = 618	<b>&lt;0.001</b>
<b>Types of dermoscopy training received outside residency</b>			
Dermoscopy course	67.48%, <i>n</i> = 2973	54.73%, <i>n</i> = 996	<b>&lt;0.001</b>
Online dermoscopy course	18.86%, <i>n</i> = 831	17.36%, <i>n</i> = 316	0.884
Attended congresses	75.44%, <i>n</i> = 3324	64.89%, <i>n</i> = 1181	<b>&lt;0.001</b>
Books atlases	81.59%, <i>n</i> = 3595	77.86%, <i>n</i> = 1417	<b>0.008</b>
Mentor tutor	23.88%, <i>n</i> = 1052	22.25%, <i>n</i> = 405	0.884
No training	2.59%, <i>n</i> = 114	4.73%, <i>n</i> = 86	<b>&lt;0.001</b>
(b)	In your practice, how did the use of dermoscopy influence the number of excisions of benign lesions that you performed?		
	Reduced excisions of benign lesions	Did not reduce excisions of benign lesions	P-value
<b>Duration of dermoscopy practice</b>			
<2 years	7.25%, <i>n</i> = 318	19.67%, <i>n</i> = 357	<b>&lt;0.001</b>
2–5 years	17.98%, <i>n</i> = 789	24.85%, <i>n</i> = 451	
>5 years	74.77%, <i>n</i> = 3280	55.48%, <i>n</i> = 1007	
<b>Types of dermoscopes used</b>			
Non-polarized immersion contact	52.81%, <i>n</i> = 2327	55.88%, <i>n</i> = 1017	0.178
Polarized light dermoscope	56.20%, <i>n</i> = 2476	45.66%, <i>n</i> = 831	<b>&lt;0.001</b>
Dermoscope with digital camera	24.26%, <i>n</i> = 1069	18.90%, <i>n</i> = 344	<b>&lt;0.001</b>
Digital videodermoscopy system	29.23%, <i>n</i> = 1288	17.75%, <i>n</i> = 323	<b>&lt;0.001</b>
<b>Average frequency of using dermoscopy</b>			
<1×/month	0.48%, <i>n</i> = 21	1.82%, <i>n</i> = 33	<b>&lt;0.001</b>
1–4/month	2.39%, <i>n</i> = 105	8.64%, <i>n</i> = 157	
>1×/week	8.51%, <i>n</i> = 374	16.45%, <i>n</i> = 299	
Daily	88.63%, <i>n</i> = 3896	73.10%, <i>n</i> = 1329	
<b>Regularly used dermoscopic algorithm</b>			
ABCD rule	27.71%, <i>n</i> = 1221	36.98%, <i>n</i> = 673	<b>&lt;0.001</b>
CASH	0.61%, <i>n</i> = 27	0.71%, <i>n</i> = 13	0.884
Menzies algorithm	2.88%, <i>n</i> = 127	1.92%, <i>n</i> = 35	0.266
Seven-point checklist	8.37%, <i>n</i> = 369	6.87%, <i>n</i> = 125	0.308
Pattern analysis	33.66%, <i>n</i> = 1483	21.92%, <i>n</i> = 399	<b>&lt;0.001</b>
No particular algorithm	27.78%, <i>n</i> = 1224	32.86%, <i>n</i> = 598	<b>0.001</b>

P values <0.05 are highlighted in bold.

**Table 4** Factors associated with a perceived benefit in reducing excisions of benign lesions (multivariate analysis)

Dermoscopy-reduced excisions of benign lesions	OR	2.5% CI	97.5% CI	P-value
<b>Age</b>	1.029	1.013	1.045	<0.001
<b>Number of years of dermatology practice</b>	0.963	0.948	0.978	<0.001
<b>Place of work</b>				
Individual private practice	1.211	1.031	1.423	0.020
Private ambulatory hospital	0.836	0.704	0.994	0.042
<b>Type of dermoscopy training received outside residency</b>				
Attended congresses	1.170	1.001	1.365	0.047
Duration of dermoscopy practice*	1.552	1.300	1.852	<0.001
<b>Types of dermoscopes used</b>				
Dermoscope with digital camera	1.188	1.006	1.406	0.044
Digital videodermatoscopy system	1.274	1.073	1.515	0.006
<b>High frequency of using dermoscopy*</b>	1.691	1.068	2.709	0.026
<b>Particular dermoscopic algorithm regularly used</b>				
ABCD rule	0.666	0.564	0.786	<0.001
No used algorithm	0.707	0.598	0.835	<0.001
<b>Self-confidence in the dermoscopic assessment of the following</b>				
Pigmented skin tumours*	1.430	1.078	1.899	0.013
Inflammatory skin lesions*	0.707	0.611	0.820	<0.001
<b>Perceived advantages of dermoscopy use</b>				
Reduces the number of unnecessary biopsies/excisions*	5.396	4.023	7.384	<0.001

OR, odds ratio; CI, confidence interval.

\*Variables with a calculated linear correlation.

likelihood to report a benefit of dermoscopy in reducing unnecessary excisions (OR 0.66, 95% CI: 0.56–0.78 and OR 0.70, 95% CI: 0.59–0.83, respectively).

## Discussion

The ultimate goal of dermoscopy for melanocytic lesions is to increase the early recognition of melanoma while reducing the number of invasive procedures needed for diagnosis. The capacity of dermoscopy to achieve this goal, increasing the sensitivity and specificity of melanoma diagnosis, has been solidly documented in multiple studies.<sup>9,10,27</sup> Hence, it is natural to hypothesize that making more widespread and better use of this accessible and affordable technique could have an impact at population-based scale, on improving melanoma prognosis through earlier detection, while reducing diagnostic costs. Testing this hypothesis is challenging and first requires understanding the current place and impact of dermoscopy in the real-life dermatology practice, as well as the drivers and barriers for future improvement. Our study performed the largest survey of dermatologists so far, as a step towards this understanding.

Our results confirm at pan-European scale that dermoscopy is a useful tool for the practice of dermatologists, allowing them to detect more melanomas and to reduce the number of unnecessary benign excisions performed. Our findings reinforce the crucial importance of proper training in translating the potential advantages of dermoscopy into real benefits for melanoma diagnosis. Notably, dermoscopy training during residency almost doubled the proportion of dermatologists reporting that

dermoscopy allowed them to detect more melanomas than naked-eye examination alone (Table 1a), and this effect was maintained in the multivariate analysis (OR 1.51, 95% CI: 1.22–1.88) (Table 2). Residency dermoscopy training also related, although less markedly, to the reported benefit of dermoscopy in reducing the number of unnecessary biopsies.

To our knowledge, this is the first study that explores the impact of dermoscopy training during dermatology residency on the subsequent dermatology practice across Europe. Dermoscopy training during residency has been shown to improve the opinions about dermoscopy, increase the self-confidence in the skin cancer diagnosis and improve the diagnostic accuracy of dermatology residents in USA.<sup>28–31</sup> Such studies were lacking in Europe. Dermatology residency curricula are diverse across the European continent, not all include dermoscopy training or have included it only recently, and the actual form of training is also highly heterogeneous. Given that dermoscopy training is relatively new, it is notable that 38% of all European dermatologists participating in our study reported dermoscopy training during residency.

In our study, dermatologists who trained in dermoscopy through interactive methods (courses, conferences, mentoring/tutoring) were more likely (OR 1.36–1.64, Table 2) to report increased melanoma recognition through dermoscopy, while this effect was not seen for training through atlases/books. This trend was less clear in regard to the reduction in unnecessary biopsies, and further research on the most efficient forms of dermoscopy training for melanoma diagnosis is warranted.

The greater experience with dermoscopy for skin cancer detection, as reflected through more years of dermoscopy practice and higher number of patients with skin cancer seen per month, appeared relevant for the reduction in unnecessary biopsies, but less so for increased melanoma recognition. This concurs with previous reports showing that even brief dermoscopy training in inexperienced users can improve the sensitivity of melanoma recognition,<sup>9,32–34</sup> but that the increase in specificity occurred mostly at an expert level and in specialized centres.<sup>18,19,21</sup>

A positive impact of dermoscopy on melanoma detection was expectedly associated with more frequent use of dermoscopy, across all disease categories, as well as with self-confidence in dermoscopic skills for pigmented lesions. Expertise, experience and confidence seem to engage in a positive feedback loop that enhances the use and the benefits of dermoscopy. This supports the argument that investment in training and in providing dermatologists with the opportunity to use dermoscopy could also improve the efficient use of this technique, for better detection at lower costs. Consistent with our findings, a recent study<sup>35</sup> used a melanoma disease model to demonstrate that adequate dermoscopy training of dermatologists is cost-effective, in terms of increasing patients' quality-adjusted life-years (QALY) and lowering the medical costs. In this context, it is noteworthy that only 56% of dermoscopy users reported confidence in their skills for the diagnosis of pigmented lesions, although this is the main indication and topic of training in dermoscopy. Optimizing educational efforts are needed, and the question remains open how to achieve this. A more detailed analysis of our study data regarding the patterns of dermoscopy training across Europe, and their consequence for the dermatologists' practice, is ongoing and will be reported in the future.

In our study, the use of polarized light dermoscopy and digital dermoscopy was associated with a perceived benefit of dermoscopy both for improving melanoma recognition and for reducing unnecessary excisions. Monitoring melanocytic lesions by means of sequential digital dermoscopy has been demonstrated to increase the early detection of thinner melanoma and to lower the NNE rates, increasing dermoscopy's cost benefits.<sup>12,36–41</sup> This approach is increasingly recommended by the current European guidelines of melanoma management.<sup>14,16,17</sup> Our results confirm the importance of access to and use of digital dermoscopy for increasing the performance of melanoma diagnosis in dermatologist practice Europe-wide. As 35.7% of our responding dermatologists reported the use of a form of digital dermoscopy, this leaves room for significant improvement in the future, while more research is needed to establish the true cost-effectiveness of widespread use of digital dermoscopy for melanoma early detection.

The classic ABCD rule and pattern analysis were the most frequently reported by dermatologists, likely because they are the oldest and the most widely taught algorithms. They also represent two diverging concepts of diagnostic approach, heuristic and analytical, both subjects of a long-term debate over which is

superior.<sup>40,41</sup> It was noteworthy that the use of the ABCD rule was associated with increased melanoma recognition (Table 1b) but decreased the likelihood for reducing the number of unnecessary biopsies (Table 4); pattern analysis increased both melanoma recognition (sensitivity) and the specificity of diagnosis (Tables 1b and 3b). These findings suggest that pattern analysis is the best algorithm for increasing accuracy of melanoma diagnosis and should be emphasized in the training of dermoscopy. Nonetheless, using any algorithm vs. no algorithm at all was better for increasing melanoma recognition and reducing the number of unnecessary biopsies.

The impact of dermoscopy on the diagnostic performance for melanoma varied according to the practice setting for European dermatologists, with two particular contrasting scenarios standing out. On the one hand, dermatologists working in individual private practices were less likely to report a benefit of dermoscopy to increase detection of melanomas, but noted greater benefit in reducing the number of unnecessary biopsies. Conversely, dermatologists working in public healthcare facilities experience the most benefit of dermoscopy in increasing melanoma detection, but were less likely to report a reduction in the number of biopsies. For individual practices, it might be argued that they face a greater pressure to reduce costs and to limit invasive procedures for their patients, so the main benefit is perceived in this area. Dermoscopy appears to fulfil the role of screening for melanoma, which is an important task of public healthcare facilities, attending for the vast majority of patients in the European health systems. However, screening appears to occur without significant reduction in unnecessary biopsies, and hence of the costs for public healthcare – not a good omen in the current landscape of austerity in healthcare budgets. It is thus of vital importance to examine how to further reduce biopsies by dermoscopy also in public hospitals. Our prior finding<sup>24</sup> had revealed that dermatologists working in public facilities were the least likely to use dermoscopy at all, or if they used it, it was less intensively; they were also the most likely to report the lack of dermoscopy equipment as a barrier to use dermoscopy. Therefore, proper training and improved access to dermoscopy equipment, especially digital, may be the main ways to address this issue in public hospitals.

Our analysis has several limitations. The main one is the subjective nature of the responses. The difference in melanoma diagnosis numbers or in NNEs through dermoscopy use could not be verified from the practice records of such a large pan-European sample of respondents. Similarly, our study allowed for a qualitative, but not quantitative evaluation of the benefit of dermoscopy for melanoma detection and reducing the unnecessary biopsies. Nonetheless, our results are consistent with previous national surveys<sup>23,42</sup> and with the evidence of the effect of dermoscopy on diagnostic accuracy while providing an unprecedented insight into dermatologists' perceptions on the role of dermoscopy. We acknowledge that responses are likely influenced by the background factors related to the national systems

of dermatology training and healthcare practice, which are highly heterogeneous in Europe. However, the free movement of people, including widespread mobility of the patients, physicians and medical trainees, is a fundamental concept in Europe, and medical licenses are virtually automatically recognized in EU countries. Therefore, a common European vision is needed and all efforts must be made to ensure that disparities between countries<sup>43</sup> are narrowed and the quality of medical training and care becomes *de facto* similar throughout the continent. In this perspective, our pan-European results are particularly informative.

## Conclusion

Our pan-European survey confirms that dermoscopy is a valuable tool to improve melanoma recognition and reduce the number of invasive diagnostic procedures in the daily dermatology practice across the continent. However, in many cases, this technique is not used to its full potential. The study brings compelling evidence that enhancing dermoscopy training, especially during dermatology residency, and increasing dermatologists' access to dermoscopy equipment, especially digital dermoscopy, would contribute significantly to improving the accuracy of melanoma diagnosis in Europe, with potential to alleviate the current disparities in early detection and prognosis of this deadly tumour.

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## Appendix 1

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### Supporting information

Additional Supporting Information may be found in the online version of this article:

**Table S1.** Attitudes associated with a perceived benefit of dermatoscopy for the recognition of melanoma in the daily practice.

**Table S2.** Attitudes associated with a perceived benefit of dermatoscopy in reducing unnecessary biopsies of benign lesions.