Educational Interventions to Support Primary Care Provider Performance of Diagnostic Skin Cancer Examinations: A Systematic Literature Review

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Abstract

To our knowledge, there is no available standardized educational curriculum designed to promote the incorporation of skin cancer examinations and procedures into general practice. To explore the contemporary training landscape, we conducted a systematic review of educational interventions designed to support skin cancer diagnostic examinations by primary care providers (PCPs). Our review uniquely encompasses all PCPs, including practicing physicians, residents, and advanced practice practitioners (APPs). The objective of this study is to review and synthesize worldwide data on educational interventions addressing PCP performance of skin cancer diagnostic examinations. A systematic review was performed in MEDLINE, Cochrane, EMBASE, and Scopus for English language articles worldwide published from 2000 onwards. Articles were screened for eligibility, and possibly overlapping datasets were resolved. Data extracted included curriculum content, delivery format, and educational outcomes. This review followed the PRISMA guidelines. A total of 63 studies were selected for data inclusion with one addressing training for resident physicians, 4 for APPs, and the remainder for practicing physicians. Educational interventions included in this review reflect the pre-SARS-CoV-2 pandemic educational environment: half provided live/synchronous instruction of about 5-h duration on average, and a quarter featured interactive components. Less than a quarter of interventions included practice change as a specific reported outcome. Without sustainable practice change, the anticipated long-term benefits of early cancer detection in patients remain limited. Previous and existing educational interventions designed to support skin cancer detection by PCPs demonstrate heterogeneous curriculum content, delivery methods, and educational outcomes. An ideal intervention would teach consensus-derived clinical competencies, provide meaningful learner feedback, and measure outcomes, such as knowledge/competency, confidence/attitudes, and practice change, using validated instruments.

Keywords Systematic literature review · Primary care provider · Melanoma · Skin cancer · Diagnosis · Education

Objectives/Hypothesis

Clinical skin examinations involving visual naked-eye inspection to detect skin cancer are cited as one of the most cost-effective and lowest risk-bearing cancer screening interventions in modern medicine [1]. In examining the skin, trained healthcare providers identify suspicious skin lesions or growths in a systematic manner, and they may perform exams unassisted or use diagnostic tools such as dermoscopy and total body photography. Early detection, or secondary prevention, of skin cancer enables diagnosis at stages where straightforward therapeutic options are potentially curative. In contrast, skin cancer diagnosed at more advanced stages carries significantly greater risks of therapeutic morbidity,

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financial toxicity, and potentially irreversible toxicity to immune checkpoint inhibitors [2, 3].

Early skin cancer detection is an integral part of dermatologists' practice, yet there are many regions of the USA with no dermatologists [4]. In these regions, primary care providers (PCPs) may provide essential skin cancer detection services. Here, when considering the PCP audience for the purposes of skin cancer detection, we include graduate (resident/trainee) and post-graduate (practicing) physicians in family medicine, internal medicine, combined internal medicine/pediatrics, or obstetrics/gynecology specialties. We also include trainee and practicing physician assistants (PAs) and nurse practitioners (NPs), referred collectively as advanced practice providers (APPs).

Working on the frontline of healthcare, PCPs often evaluate, diagnose, and treat patients with skin concerns. Up to 30% of primary care encounters address a patient's skin complaint with each encounter representing an opportunity to detect skin cancer [5, 6]. The Accreditation Council for Graduate Medical Education (ACGME) recognizes the diagnosis of skin cancer as a core competency in family medicine [7], and the Accreditation Review Commission on Education for the Physician Assistant (ARC-PA) includes instruction on "all organ systems" as an expectation for accredited PA training programs [8]. However, there are significant barriers to effective skin cancer detection training in PCPs. At present, there is no consensus statement reflecting specific skin cancer diagnosis and management competencies appropriate for PCPs. There is also no standardized skin cancer educational curriculum currently available for PCPs. In the absence of a consensus statement on clinical competencies or a standardized educational curriculum, many graduate medical training programs offer no formal skin cancer education, representing a key training gap for cancer control [9].

The current spectrum of educational curricula seeking to support the development of skin cancer diagnostic skills by PCPs is relatively broad. One of the most rigorous curricula, the Internet curriculum FOR Melanoma Early Detection (INFORMED), recently became unavailable as Adobe officially discontinued Adobe Flash Player support on December 31, 2020 [10]. Yet, feedback from PCPs on even this rigorously designed curriculum underscores the need for a more innovative educational approach: PCPs who completed INFORMED demonstrated improved knowledge and confidence, but in post-intervention focus groups, PCPs reported no intent to change practice [11, 12]. These PCPs cited two specific barriers: the need for more detailed instruction on skin cancer detection and the need for assistance with challenging cases encountered during patient care, or telemonitoring [12].

In the past few decades, numerous efforts have been devoted to promoting skin cancer detection by PCPs with varying degrees of success. To date, there is no available

standardized curriculum designed to support the incorporation of skin cancer examinations and procedures into general practice. To investigate the contemporary educational landscape of skin cancer training programs, we conducted a systematic review of literature addressing educational interventions for PCPs that are designed to support their performance of skin cancer diagnostic examinations. While previous reviews on this subject matter primarily evaluated training programs for subcategories of PCPs, we purposefully encompassed all PCPs, including MDs (allopathic doctors), DOs (osteopathic doctors), PCP trainees, and APPs, in our review.

Design/Methods

This systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [13]. A systematic search for relevant English language articles published between January 1, 2000 and April 1, 2021 was performed in MEDLINE, Cochrane, EMBASE, and Scopus. Search structures, subject headings, and keywords were tailored to each database by a medical research librarian specializing in systematic reviews (KJK). The search strings included combinations of terms identifying skin cancer, educational interventions, and PCPs (Online Resource 1). While searches were restricted to the English language, they were not restricted by study design or any other type of limit. Grey literature resources, such as conferences, dissertations, reports, and other unpublished studies, were included for additional relevant citations. Backward and forward citation searching was also conducted using Scopus.

In total, 1513 unique articles were retrieved for review and appraised according to the study inclusion criteria (Online Resource 2). Articles deemed appropriate for inclusion involved the evaluation of a skin cancer educational intervention developed for PCPs. Included articles could report the outcomes of interventions implemented by the author(s) or the post hoc analyses of collected or published data. Interventions that targeted non-PCPs were included. However, interventions that targeted dermatologists, dermatology trainees, or medical students were excluded because their educational needs significantly differ from those of PCPs.

Two investigators (ELP and KCL) independently screened titles/abstracts to identify potentially relevant studies using Rayyan, a web-based software tool developed to facilitate the independent screening process in systematic reviews [14]. Manuscripts for studies that passed the title/abstract review were retrieved for full-text review. Two investigators (ELP and KCL) then independently screened the remaining full-text manuscripts. Disagreements were resolved by

consensus or by seeking the opinion of a third investigator (KCN).

Of the 1513 articles retrieved for review, 63 studies met all criteria for inclusion in this systematic review [11, 12, 15–75]. The PRISMA flow diagram, shown in Fig. 1, outlines the review process from the original search to the final selection of studies. The investigators extracted and coded study variable data addressing curriculum content, delivery format of the educational intervention, and educational outcomes. Study variables, defined in Table 1, were modified from a previous systematic review on skin cancer education for PCPs [76]. In the circumstance that multiple publications addressed the same educational intervention, the publications were carefully reviewed to ensure the fidelity of methods across publications. Previous review articles were not included in the data analyses but were examined by the research team to identify potentially relevant manuscripts that were not identified during the literature search process.

Findings/Results

Through our systematic review of educational interventions designed to support PCP performance of skin cancer diagnostic examinations, we performed a thorough assessment of the evidence to date. In total, 63 studies were included for data analysis, yielding helpful insight into current and historical educational approaches. For each study, we evaluated and coded the study design, curriculum content, delivery

format, and educational outcome(s). A comprehensive table of the included studies and the coded study variable data is included in Online Resource 3.

Study Designs

A representative range of study designs was identified in our literature review. Of the 63 manuscripts selected for inclusion, 13 (21%) were randomized controlled trials (RCTs) that randomly allocated participants to an intervention or control group [22, 25, 27, 29, 33, 43, 48, 50, 57, 64–66, 73]. Thirty-seven (59%) were diagnostic accuracy (DA) studies that evaluated changes in diagnostic accuracy following nonrandomized educational or community interventions [11, 15–21, 23, 24, 26, 28, 31, 32, 34–36, 38, 39, 41, 42, 45–47, 49, 51, 54, 55, 59–61, 67, 69–72, 74, 75]. Most DA studies (73%) were prospective cross-sectional studies that evaluated educational outcomes immediately or soon after the intervention, often in comparison to a baseline measure [11, 19, 21, 23, 24, 26, 28, 32, 34–36, 39, 41, 42, 45, 46, 49, 51, 54, 55, 60, 61, 67, 69–71, 74]. In contrast, a subset of DA studies followed cohorts over time, typically greater than 6 months. These cohort studies included 7 DA single-cohort studies (5 prospective [11, 17, 18, 72, 75] and 2 retrospective [16, 38]), a DA two-cohort study (prospective [31]), and two DA three-cohort studies (1 prospective [59] and 1 retrospective [15]). Our review also comprised studies that primarily investigated changes in self-reported confidence/attitude, behaviors, and/or practice change as opposed to DA. Of these studies, our review identified 7 with a cross-sectional

Fig. 1 PRISMA flow diagram of the review process

Table 1 Definitions of each category within the criteria of curriculum, delivery format, and outcomes

Criteria	Specifics	Definition
Curriculum	Diagnosis	Clinical diagnosis unaided by dermoscopy. Basic principles of differentiating benign from malignant skin lesions for melanoma alone or for melanoma, squamous cell carcinoma, and basal cell carcinoma.
	Epidemiology	Provided background information on rates of skin cancer, high-risk skin types, family history, etc.
	Counseling	Instructed participants on photoprotection, skin self-examination, follow-up, and/or other prevention strategies. Can either be primary prevention (i.e., sun safe education) or secondary prevention (i.e., skin self-examinations).
	Management	Emphasis on determining a plan of action. Can either be (1) triage and refer or (2) diagnose and manage (the latter indicates a higher level of proficiency).
	Dermoscopy	Clinical diagnosis assisted by dermoscopy. Instructed participants on basic patterns of dermoscopy and/or how to incorporate it into a skin examination.
	Clinical algorithm	Use of a novel or pre-existing algorithm (i.e., ABCDE) as a learning tool to aid in clinical diagnosis and triage of skin lesions.
	Dermoscopic algorithm	Use of novel or pre-existing algorithm (i.e., TADA) as a learning tool to aid in dermoscopic diagnosis and triage of skin lesions.
Delivery format	Synchronous	Speaker gives live presentation (in a large lecture format or small group).
	Literature	Educational books, pamphlets, posters, cards, etc.
	Multimedia	CD-ROM, video, other audio-visual aids (excludes web-based applications).
	Feedback	Can be either simultaneous or delayed feedback. Examples include computer feedback vs. feedback from live education, structured feedback vs. case-based feedback, and feedback on knowledge vs. feedback on application.
	Interactive	Requires cognitive engagement for participation. Ranges from intermittent practice quizzes to participant-guided learning.
	Web-based	Online tutorials, often including audio and visual information that is meant to be in place of a live lecture. Such interventions are often also interactive.
Outcomes	Knowledge	Subjective or objective report of conceptual understanding.
	Competence	Subjective or objective report of clinical skills learned (ability to apply to clinical practice).
	Confidence/attitudes	Subjective report of confidence in, attitude towards, or beliefs about skin cancer intake and examination.
	Diagnostic performance	Objective assessment of diagnostic abilities in a clinical practice setting through audit or expert evaluation. Captures clinical diagnostic performance, competence in the actual clinical setting (i.e., review of a pathology report).
	Practice change	Subjective or objective assessment of behaviors in practice. Does provider start performing skin examinations, continue to use dermoscopy, etc.?

These variables were modified from a previous systematic review by Goulart JM, Quigley EA, Dusza S, et al. [76]

design (4 prospective [20, 37, 56, 62] and 3 retrospective [12, 58, 63]), 4 with a single-cohort design (3 prospective [30, 53, 68] and 1 retrospective [44]), and one with a two-cohort design (prospective [52]).

Curriculum

Each study was assessed for the incorporation of key curricular components, as defined in Table 1. A large majority of interventions in this review (79%) were found to include skin cancer diagnosis [11, 12, 15, 17–22, 26–29, 31–36, 38–40, 42–48, 50, 52–59, 61, 63, 65, 68, 70–75, 77]. Of these interventions, all taught the clinical appearance of melanoma, while the inclusion of keratinocytic carcinomas (i.e., basal cell carcinoma, squamous cell carcinoma) was variable. Only a third of programs (33%)

included skin cancer epidemiology [19–22, 26, 27, 32, 33, 39, 41–43, 46, 51, 52, 54, 55, 57, 61, 63, 75]. Counseling on sun safety and skin self-examinations was fairly uncommon (21%), and most interventions that included behavioral counseling for skin cancer prevention did not specify whether primary and/or secondary prevention topics were discussed [20–22, 26, 41–43, 51, 55, 59, 61, 63].

Over a third of the programs (38%) did specifically address skin cancer management [11, 19–23, 27, 38, 41, 44, 47, 48, 53, 55, 58, 59, 59–61, 65, 67, 69–71, 75]. However, most did not indicate specific approaches for management in their instructional design. Of those that provided further details on management, the majority directed PCPs to “triage and refer” to regionally available dermatologists [20–23, 27, 53, 60, 61, 65, 67, 69, 71]. Only a minority trained PCPs to “diagnose and manage,” a higher level of

proficiency that requires the performance of diagnostic biopsies, interpretation of pathology reports, and development of appropriate plans of care [38, 48, 55, 59, 60, 69, 71, 75].

One third of programs (33%) included dermoscopy [23–25, 29–31, 34, 40, 57, 59, 60, 62, 65, 66, 69–71]. Of all the programs, 17% and 21% taught clinical algorithms [11, 20–22, 29, 34, 48, 54, 55, 63, 75] and dermoscopic algorithms [23–25, 29, 30, 34, 40, 57, 65, 67, 69, 71], respectively, to support diagnostic accuracy.

Delivery Methods

Each study was also assessed for delivery methods and outcomes, as defined in Table 1. Over half of the included programs (52%) delivered their content via live/synchronous methods [20, 21, 23, 26, 29, 31–33, 35–38, 41, 42, 42–44, 44–46, 52, 54, 57–61, 63, 67–71, 73, 74]. In contrast, less than a third (30%) of the included programs adopted web-based delivery methods [11, 12, 15, 18, 19, 22, 30, 47, 50, 51, 53, 55, 56, 59, 65, 68, 70]. Roughly a quarter (24%) provided reference literature [20, 21, 26–28, 31, 35, 42, 48, 50, 52, 60, 70, 72, 73]. A minority (18%) incorporated multimedia [23–26, 42, 43, 48, 50, 52, 60, 63]. A quarter of the programs (25%) provided feedback [11, 12, 16, 23, 24, 26, 31, 33, 38, 47, 50, 55, 64, 65, 68, 75]. Over a quarter of programs (27%) also enabled interactive features [11, 12, 16, 26, 30–33, 36, 38, 42, 47, 53, 55, 61, 68, 71]. The web-based programs often featured interactive components [11, 12, 16, 30, 47, 53, 55, 68].

We estimated the total duration of the programs to be about 5 h on average, though this calculation was limited by variable and incomplete reporting across publications. If programs were reported as lasting a “day,” we extrapolated this to equal 8 h. In general, PCPs have indicated they often prefer live and interactive educational modalities (Fig. 2) [78]. However, schedule constraints have been cited as barriers to effectively implementing live formats [78]. Virtual or web-based formats diminish this constraint by eliminating travel time and lecture schedules. Further research is needed on the efficacy of web-based versus traditional delivery methods.

Outcomes

Of the programs included in our review, a majority (76%) assessed competence, or the ability to apply skills learned to clinical practice, using various methods [11, 15, 16, 19–24, 26, 28, 31–33, 35–37, 39, 41, 43, 45–50, 52, 54–57, 59–75]. A minority (41%) evaluated knowledge, or conceptual understanding [16, 21–24, 26, 28, 30–33, 37, 43, 49–53, 55, 56, 61, 63, 65, 67, 69, 71]. Confidence/attitudes towards skin cancer examinations, evaluations, and diagnoses were

Fig. 2 Radar plot showing the percentage of studies with each educational curricular feature. Color of text label on each axis corresponds to the three criteria: red text, curriculum criteria; blue text, delivery method criteria; green text, outcomes criteria

also investigated by a minority of programs (41%) [11, 12, 16, 18–22, 25–27, 30, 37, 42, 47, 49–51, 53, 55, 56, 58, 60, 65, 68, 74]. Measurements of these outcomes often relied on self-reported data. A third of the programs (33%) reported diagnostic performance [11, 16–18, 25, 29, 34, 38, 43, 44, 46, 48, 57, 59–61, 63, 64, 66, 72, 75]. Finally, only a few programs (22%) assessed practice change [11, 12, 20, 22, 27, 30, 37, 42, 44, 51, 56, 58, 62, 63, 68]. For all educational outcomes, the evaluative methods and instruments employed by study investigators varied in terms of their specific outcome measures, conditions for data collection, and timing relative to the educational exposure. The validation methods for evaluation instruments also varied across the studies.

Discussion

Evaluating and diagnosing suspicious skin lesions supports melanoma diagnosis at earlier stages with more curative therapeutic options. In areas without dermatologists, training PCPs to accurately and confidently detect skin cancer will aid in reducing melanoma mortality. This systematic review demonstrates that a variety of educational interventions has been evaluated in the primary care setting. We identified a relatively broad range of curricula content, delivery formats, and outcomes across the interventions. Due to large variability in study designs and outcomes, a meta-analysis was precluded in this study.

Curriculum

Dermoscopy education was included in only a minority of interventions. Within the context of primary care, improving skin cancer mortality is of utmost concern. However, given

the low prevalence of skin cancer in the general population, there is concern that regular skin screening may lead to overuse of invasive procedures and unnecessary harm [79]. Dermoscopy, a non-invasive tool which has been demonstrated to improve PCP skin cancer diagnosis, may provide a solution [73]. However, intensive training may be required to skillfully interpret dermoscopic images and apply the tool in patient care, and a lack of training opportunities is a key barrier to the use of dermoscopy in primary care [80]. PCP-targeted educational interventions involving dermoscopy to date have been variable, and no standard for PCP competency in dermoscopy has been established or proposed.

Instruction on clinical and dermoscopic algorithms provides another opportunity for educational uniformity. However, with algorithm-based approaches, PCPs may not detect skin cancers that fall outside of the algorithm guidelines. For dermoscopy, the alternative to diagnostic algorithms is pattern analysis, which involves the recognition of all the salient dermoscopic features in a lesion and the simultaneous assessment of each feature's diagnostic value [81]. While shown to be a reliable procedure for melanoma diagnosis, fluency in pattern analysis may require more intensive training, especially for nonexperts [81]. Given the number of patterns the provider would need to recognize and appraise, it is to be expected that the provider would require more time to develop proficiency, and this time requirement may supersede the availability of many active PCPs.

For the remaining interventions, the majority included education on clinical diagnosis but did not specifically reference other curriculum components evaluated in our review. In general, an effective educational intervention should include clinical diagnosis, potentially with graduated levels of proficiency to meet variable PCP educational needs, and skin cancer epidemiology.

Delivery Methods

Compared to previous explorations of skin cancer educational interventions in primary care, our review identified fewer interventions delivered in a live format, potentially due to the increasing prominence of online enduring materials in medical education [76]. Given the timeline of our literature search and expected publication lags, our review largely addressed pre-SARS-CoV-2 pandemic educational interventions. It remains to be explored whether the pandemic has accelerated this observed trend towards online educational programs. In our review, web-based learning appeared to have variable results [65]. In the broader literature, web-based learning has produced heterogeneous results when compared to non-web-based interventions, but studies suggest that they are comparable to traditional learning methods [82]. Only a minority of the included interventions featured interactive components such as workshops,

which have been shown to be more effective at promoting behavior change than passive learning alone [83]. Similarly, only a minority of interventions provided feedback, which has also been demonstrated to enhance learning [84]. An ideal intervention would encompass both interactive features and feedback in order to optimize the learning experience, while web-based dissemination would reduce geographic and scheduling barriers.

Outcomes

Most interventions demonstrated significant positive results across measured outcomes, but the specific reported outcomes varied widely. Across the interventions, competency was the most frequently reported outcome, while practice change was the least. Longitudinal follow-up of an educational cohort is best suited to evaluate the retention of knowledge and confidence and measure practice change and diagnostic performance in the “real world.” For the purposes of our study, we defined long-term follow-up as group or cohort evaluation occurring at least 6 months from the last educational intervention exposure. In our review, over a third of studies (38%) sought long-term follow-up, and the intervention effects at the follow-up time points varied [11, 15–18, 22, 25, 27, 29, 31, 33, 38, 43, 44, 48, 52, 53, 58, 59, 63, 66, 68, 72, 75]. For example, there were instances of immediate positive post-intervention effects on outcomes such as competency that were no longer present at follow-up [33]. In addition to varying in their reported educational outcomes, studies also differed in terms of their evaluation tools and instruments, conditions for data collection, and methods for data processing, all of which complicate comparison efforts. An ideal intervention would pursue longitudinal follow-up and measure gains in clinical knowledge/skills and self-efficacy through validated evaluative instruments.

Gaps in Research

Some important gaps in the research surrounding skin cancer training in PCPs are illuminated by this review. The diversity in curriculum content, delivery format, and outcomes makes it difficult to compare the efficacy of a given intervention against another. Most studies did not pursue long-term follow-up or assess real-world practice change, hindering efforts to determine which interventions were the most effective in producing long-lasting outcomes and potential benefits for patients. Furthermore, there is no established standard for competency in skin cancer care and diagnosis among PCPs. The development of a consensus-based competency standard for PCPs is important for assessing whether educational interventions meet such a standard.

There is also relatively less qualitative data compared to quantitative data represented in this review. Here quantitative

data is acquired through objective assessments or audits and may comprise the number of skin cancers or melanomas diagnosed, skin examinations performed, referrals made, or excisions performed [15, 29, 43, 57]. In contrast, qualitative data is acquired through surveys, interviews, or focus groups that may explore, for instance, the fit and feasibility of programs and/or participants' degree of satisfaction with the training content, delivery method, and evaluative instruments [12]. Qualitative studies may allow for a more thorough and comprehensive assessment of skin cancer educational needs from the perspective of PCPs.

The diversity of the PCP population, heterogeneity of their needs in regard to skin cancer detection training, and evolution of these needs over time pose additional challenges to comparative studies in this population. While one of this study's strengths is the inclusion of all PCPs, such as MDs/DOs, NPs, PAs, and trainees in primary care, certain types of providers may face different professional expectations and educational needs. Some providers, such as APPs, may be traditionally expected to triage and refer skin cancer as opposed to diagnosing and managing. Yet, as APPs in some areas of the country move progressively towards expanded or independent practice, there may be further opportunities to include APPs in skin cancer detection training [85].

Limitations

Evaluations of the interventions included in this review were limited by the degree of detail reported in the publications, such as the specifics of curricular components, delivery methods, and/or reported outcomes. While this review used a comprehensive and established method for searching and screening articles, some interventions may have been inadvertently overlooked. It is also possible that this review missed data not yet published or indexed into the queried databases. Lastly, our review was limited to articles available in the English language and may not fully reflect worldwide efforts to support skin cancer education training by PCPs.

Conclusion

Through this systematic review, we discovered a relatively large quantity of data on skin cancer educational interventions in primary care. However, these interventions were highly variable in their curricula, delivery methods, and measured outcomes. This heterogeneity complicates efforts to compare interventions and identify effective educational components. The standardization of curricular components and reported educational outcomes, as measured using validated instruments, would greatly strengthen initiatives to develop effective skin cancer detection education in an

efficient manner. Future endeavors should involve defining standards for clinical competency and developing convenient yet effective delivery formats while also taking into consideration the diverse needs and preferences in the PCP population. Further studies will be needed to investigate which educational interventions support sustainable practice change, leading to improved skin cancer outcomes for patients.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s13187-021-02118-8>.

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Author Contribution Eliza L. Posada and Kelly C. Nelson contributed to study conceptualization and design. Literature search and data collection were performed by Eliza L. Posada, Kyle C. Lauck, Tiffaney Tran, Kate J. Krause, and Kelly C. Nelson. Data and statistical analyses were performed by Eliza L. Posada, Kyle C. Lauck, Tiffaney Tran, and Kelly C. Nelson. All authors contributed and commented on drafts of the manuscript before submission. All authors reviewed and approved the final manuscript. Eliza L. Posada and Kyle C. Lauck contributed equal effort to the study.

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Availability of Data and Material All data compiled and analyzed in this review have been made available to the reader.

Declarations

Ethics Approval This is a secondary review of literature which has been published. Ethics approval was not required.

Consent to Participate This review of published literature did not directly involve any human subjects. In this review, informed consent was not required.

Conflict of Interest The authors declare no competing interests.

References

1. Losina E, Walensky RP, Geller A et al (2007) Visual screening for malignant melanoma: a cost-effectiveness analysis. *Arch Dermatol* 143(1):21–28. <https://doi.org/10.1001/archderm.143.1.21>
2. Thom B, Mamoor M, Lavery JA et al (2021) The experience of financial toxicity among advanced melanoma patients treated with immunotherapy. *J Psychosoc Oncol* 39(2):285–293. <https://doi.org/10.1080/07347332.2020.1836547>
3. Palmieri DJ, Carlino MS (2018) Immune checkpoint inhibitor toxicity. *Curr Oncol Rep* 20(9):72. <https://doi.org/10.1007/s11912-018-0718-6>
4. Glazer AM, Farberg AS, Winkelmann RR, Rigel DS (2017) Analysis of trends in geographic distribution and density of US

- dermatologists. *JAMA Dermatol* 153(4):322–325. <https://doi.org/10.1001/jamadermatol.2016.5411>
5. Verhoeven EW, Kraaijaat FW, van Weel C et al (2008) Skin diseases in family medicine: prevalence and health care use. *Ann Fam Med* 6(4):349–354. <https://doi.org/10.1370/afm.861>
6. Perera E, Xu C, Manoharan S. Real-life teledermatology cases. In: Soyer, H, Binder, M, Smith, A, Wurm, E, eds. *Telemedicine in Dermatol*. Springer Science & Business Media; 2011:123–129.
7. Recommended curriculum guidelines for family medicine residents: conditions of the skin. American Academy of Family Medicine (AAFP). Published 2017. Accessed June 15, 2021. https://www.aafp.org/dam/AAFP/documents/medical_education_residency/program_directors/Reprint271_Skin.pdf
8. Accreditation standards for physician assistant education, 5th edition. Accreditation Review Commission on Education for the Physician Assistant (ARC-PA). Published September 1, 2020. Accessed June 15, 2021. <http://www.arc-pa.org/wp-content/uploads/2020/12/AccredManual-5th-ed-9.20.pdf>
9. Moore MM, Geller AC, Zhang Z et al (2006) Skin cancer examination teaching in US medical education. *Arch Dermatol* 142(4):439–444. <https://doi.org/10.1001/archderm.142.4.439>
10. Adobe Flash Player End of Life (EOL) Enterprise. Published 2020. Accessed June 15 2021. <https://www.adobe.com/products/flashplayer/enterprise-end-of-life.html>
11. Eide MJ, Asgari MM, Fletcher SW et al (2013) Effects on skills and practice from a web-based skin cancer course for primary care providers. *J Am Board Fam Med* 26(6):648–657. <https://doi.org/10.3122/jabfm.2013.06.130108>
12. Jiang AJ, Eide MJ, Alexander GL et al (2017) Providers' experiences with a melanoma web-based course: a discussion on barriers and intentions. *J Cancer Educ* 32(2):272–279. <https://doi.org/10.1007/s13187-015-0910-4>
13. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Br Med J* 339:b2535. <https://doi.org/10.1136/bmj.b2535>
14. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A (2016) Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 5(210):10. <https://doi.org/10.1186/s13643-016-0384-4>
15. Weinstock MA, Ferris LK, Saul MI et al (2016) Downstream consequences of melanoma screening in a community practice setting: first results. *Cancer* 122(20):3152–3156. <https://doi.org/10.1002/cncr.30177>
16. Ferris LK, Saul MI, Lin Y et al (2017) A large skin cancer screening quality initiative: description and first-year outcomes. *JAMA Oncol* 3(8):1112–1115. <https://doi.org/10.1001/jamaoncol.2016.6779>
17. Shaub AR, Cheng J, Weinstock MA, Asch SM, Swetter SM (2017) Feasibility of primary care provider education and screening for skin cancer detection: pilot study within a Veteran Affairs (VA) health care system. John Wiley & Sons, Ltd., Published
18. Swetter SM, Chang J, Shaub AR, Weinstock MA, Lewis ET, Asch SM (2017) Primary care-based skin cancer screening in a Veterans Affairs health care system. *JAMA Dermatol* 153(8):797–801. <https://doi.org/10.1001/jamadermatol.2017.1324>
19. Orfaly VE, Berry EG, Stoos ER et al (2021) Melanoma toolkit for early detection for primary care providers: a pilot study. *Pigment Cell Melanoma Res* 34(5):984–986. <https://doi.org/10.1111/pcmr.12968>
20. Mikkilineni R, Weinstock MA, Goldstein MG, Dube CE, Rossi JS (2001) The impact of the basic skin cancer triage curriculum on providers' skin cancer control practice. *J Gen Intern Med* 16(5):302–307. <https://doi.org/10.1046/j.1525-1497.2001.00626.x>
21. Mikkilineni R, Weinstock MA, Goldstein MG, Dube CE, Rossi JS (2002) The impact of the basic skin cancer triage curriculum on providers' skills, confidence, and knowledge in skin cancer control. *Prev Med* 34(2):144–152. <https://doi.org/10.1006/pmed.2001.0961>
22. Markova A, Weinstock MA, Risica P et al (2013) Effect of a web-based curriculum on primary care practice: basic skin cancer triage trial. *Fam Med* 45(8):558–568
23. Wood A, Morris H, Emery J et al (2008) Evaluation of the Mole-Mate training program for assessment of suspicious pigmented lesions in primary care. *Inform Prim Care* 16(1):41–50. <https://doi.org/10.14236/jhi.v16i1.673>
24. Watson T, Walter FM, Wood A, et al. Learning a novel technique to identify possible melanomas: are Australian general practitioners better than their U.K. colleagues? *Asia Pacific Family Medicine*. 2009;8(1):3. doi:<https://doi.org/10.1186/1447-056X-8-3>
25. Walter FM, Morris HC, Humphrys E et al (2012) Effect of adding a diagnostic aid to best practice to manage suspicious pigmented lesions in primary care: randomised controlled trial. *Br Med J* 345:e4110. <https://doi.org/10.1136/bmj.e4110>
26. Anders MP, Fengler S, Volkmer B, Greinert R, Breitbart EW (2017) Nationwide skin cancer screening in Germany: evaluation of the training program. *Int J Dermatol* 56(10):1046–1051. <https://doi.org/10.1111/ijd.13688>
27. Lowe JB, Ball J, Lynch BM et al (2004) Acceptability and feasibility of a community-based screening programme for melanoma in Australia. *Health Promot Int* 19(4):437–444. <https://doi.org/10.1093/heapro/dah405>
28. Ahirah A, Fox C, Servoss T (2007) Brief intervention to improve diagnosis and treatment knowledge of skin disorders by family medicine residents. *Fam Med* 39(10):720–723
29. Argenziano G, Puig S, Zalaudek I et al (2006) Dermoscopy improves accuracy of primary care physicians to triage lesions suggestive of skin cancer. *J Clin Oncol* 24(12):1877–1882. <https://doi.org/10.1200/jco.2005.05.0864>
30. Atwan A, Vyas J, Gonzalez J, Piguat V, Gamanya R (2014) Online dermoscopy: an innovative method for teaching a transferable skill. *Br Association of Dermatologists* 171(S1):148
31. Augustsson A, Paoli J (2019) Effects of a 1-day training course in dermoscopy among general practitioners. *Dermatol Pract Concept* 9(3):195–199. <https://doi.org/10.5826/dpc.0903a04>
32. Badertscher N, Braun RP, Held U et al (2013) Diagnostic competence of Swiss general practitioners in skin cancer. *Swiss Med Wkly* 143:w13834. <https://doi.org/10.4414/smw.2013.13834>
33. Badertscher N, Tandjung R, Senn O et al (2015) A multifaceted intervention: no increase in general practitioners' competence to diagnose skin cancer (minSKIN) - randomized controlled trial. *J Eur Acad Dermatol Venereol* 29(8):1493–1499. <https://doi.org/10.1111/jdv.12886>
34. Bandic J, Kovacevic S, Karabeg R, Lazarov A, Opric D (2020) Teledermoscopy for skin cancer prevention: a comparative study of clinical and teledermoscopic diagnosis. *Acta Inform Med* 28(1):37–41. <https://doi.org/10.5455/aim.2020.28.37-41>
35. Bedlow AJ, Cliff S, Melia J, Moss SM, Seyan R, Harland CC (2000) Impact of skin cancer education on general practitioners' diagnostic skills. *Clin Exp Dermatol* 25(2):115–118. <https://doi.org/10.1046/j.1365-2230.2000.00590.x>
36. Beecher SM, Keogh C, Healy C (2018) Dedicated general practitioner education sessions can improve diagnostic capabilities and may have a positive effect on referral patterns for common skin lesions. *Ir J Med Sci* 187(4):959–963. <https://doi.org/10.1007/s11845-018-1788-z>
37. Bradley HB (2012) Implementation of a skin cancer screening tool in a primary care setting: a pilot study. *J Am Acad Nurse Pract* 24(2):82–88. <https://doi.org/10.1111/j.1745-7599.2011.00669.x>
38. Bridges C, Morris C, McElroy JA, Quinn K, Dyer J, Becevic M (2021) Utility of dermatology Extension for Community Healthcare Outcomes (ECHO) sessions in the adult and paediatric

- population. *J Telemed Telecare* 27(6):376–381. <https://doi.org/10.1177/1357633x19874200>
39. Brochez L, Verhaeghe E, Bleyen L, Naeyaert JM (2001) Diagnostic ability of general practitioners and dermatologists in discriminating pigmented skin lesions. *J Am Acad Dermatol* 44(6):979–986. <https://doi.org/10.1067/mjd.2001.113442>
 40. Carew B, Muir J, Kitchener S, Palmer C. The QRME Tele-derm project: vertically integrated dermatology training. *Australasian J Dermatol*. Published 2012. <https://dermcollabstracts.com/abstract/the-qrme-tele-derm-project-vertically-integrated-dermatology-training/>
 41. Carli P, De Giorgi V, Crocetti E, Calдини L, Ressel C, Giannotti B (2005) Diagnostic and referral accuracy of family doctors in melanoma screening: effect of a short formal training. *Eur J Cancer Prev* 14(1):51–55. <https://doi.org/10.1097/00008469-200502000-00007>
 42. Chen C, Woyansky S, Zundell C (2015) The effects of education on compliance with skin cancer risk reduction guidelines. *J Dermatol Nurses' Association* 7(2):97–100. <https://doi.org/10.1097/JDN.0000000000000119>
 43. de Gannes GC, Ip JL, Martinka M, Crawford RI, Rivers JK (2004) Early detection of skin cancer by family physicians: a pilot project. *J Cutan Med Surg* 8(2):103–109. <https://doi.org/10.1007/s10227-002-0142-1>
 44. Dewan P, Panagou E, Kagen S, Bewley A (2010) Are NICE skin cancer guidelines being followed in primary care? A re-audit to review changes in practice in an inner city setting. *Br J Dermatol* 163(S1):65
 45. Dixon A, Rosengren H, Connelly T, Dixon J (2009) Education in skin cancer management—assessing knowledge and safety. *Aust Fam Physician* 38(7):557–560
 46. Duarte AF, da Costa-Pereira A, Del-Marmol V, Correia O (2018) Are general physicians prepared for struggling skin cancer?—cross-sectional study. *J Cancer Educ* 33(2):321–324. <https://doi.org/10.1007/s13187-016-1078-2>
 47. Eide M, Asgari M, Shaikh W et al (2012) Web-based curriculum improves primary care providers' skin cancer detection skills. *J Invest Dermatol* 132:S47
 48. English DR, Burton RC, del Mar CB, Donovan RJ, Ireland PD, Emery G (2003) Evaluation of aid to diagnosis of pigmented skin lesions in general practice: controlled trial randomised by practice. *Br Med J* 327(7411):375. <https://doi.org/10.1136/bmj.327.7411.375>
 49. Fengler S, Breitbart EW (2018) Skin cancer screening in Germany: evaluation of the training program in 2016. *Oncol Res Treat* 41(S1):39
 50. Gerbert B, Bronstone A, Maurer T, Berger T, McPhee SJ, Caspers N (2002) The effectiveness of an Internet-based tutorial in improving primary care physicians' skin cancer triage skills. *J Cancer Educ* 17(1):7–11. <https://doi.org/10.1080/08858190209528784>
 51. Goodman H, Pacheco CL, Loescher L (2018) An online intervention to enhance nurse practitioners skin cancer knowledge, attitudes, and counseling behaviors: a pilot study. *J Dermatol Nurses Assoc* 10(1):20–28. <https://doi.org/10.1097/JDN.0000000000000367>
 52. Grange F, Woronoff AS, Bera R et al (2014) Efficacy of a general practitioner training campaign for early detection of melanoma in France. *Br J Dermatol* 170(1):123–129. <https://doi.org/10.1111/bjd.12585>
 53. Gulati A, Harwood CA, Rolph J et al (2015) Is an online skin cancer toolkit an effective way to educate primary care physicians about skin cancer diagnosis and referral? *J Eur Acad Dermatol Venereol* 29(11):2152–2159. <https://doi.org/10.1111/jdv.13167>
 54. Harkemanne E, Goublomme N, Sawadogo K, Tromme I (2020) Early melanoma detection in primary care: clinical recognition of melanoma is not enough, one must also learn the basics. *J Cancer Educ*. <https://doi.org/10.1007/s13187-020-01897-w>
 55. Harris JM, Salasche SJ, Harris RB (2001) Can Internet-based continuing medical education improve physicians' skin cancer knowledge and skills? *J Gen Intern Med* 16(1):50–56
 56. Hartnett PD, O'Keefe C (2016) Improving skin cancer knowledge among nurse practitioners. *J Dermatol Nurses' Association* 8(2):123–128. <https://doi.org/10.1097/jdn.0000000000000206>
 57. Koelink CJ, Vermeulen KM, Kollen BJ et al (2014) Diagnostic accuracy and cost-effectiveness of dermoscopy in primary care: a cluster randomized clinical trial. *J Eur Acad Dermatol Venereol* 28(11):1442–1449. <https://doi.org/10.1111/jdv.12306>
 58. Lam TP, Yeung CK, Lam KF (2011) What are the learning outcomes of a short postgraduate training course in dermatology for primary care doctors? *BMC Med Educ* 11:20. <https://doi.org/10.1186/1472-6920-11-20>
 59. Marra E, van Rijsingen MCJ, Alkemade JAC et al (2021) The effect of a dermato-oncological training programme on the diagnostic skills and quality of referrals for suspicious skin lesions by general practitioners. *Br J Dermatol* 184(3):538–544. <https://doi.org/10.1111/bjd.19214>
 60. Menzies SW, Emery J, Staples M et al (2009) Impact of dermoscopy and short-term sequential digital dermoscopy imaging for the management of pigmented lesions in primary care: a sequential intervention trial. *Br J Dermatol* 161(6):1270–1277. <https://doi.org/10.1111/j.1365-2133.2009.09374.x>
 61. Oliveria SA, Nehal KS, Christos PJ, Sharma N, Tromberg JS, Halpern AC (2001) Using nurse practitioners for skin cancer screening: a pilot study. *Am J Prev Med* 21(3):214–217. [https://doi.org/10.1016/s0749-3797\(01\)00354-3](https://doi.org/10.1016/s0749-3797(01)00354-3)
 62. Patel B, Coldrey D, Kaye A et al (2020) Community intermediate lesion clinic reduces 2-week rule skin cancer referrals. *Br J Dermatol* 183(S1):55
 63. Peuvrel L, Quereux G, Jumbou O, Sassolas B, Lequeux Y, Dreno B (2009) Impact of a campaign to train general practitioners in screening for melanoma. *Eur J Cancer Prev* 18(3):225–229. <https://doi.org/10.1097/CEJ.0b013e32831bc3b2>
 64. Raasch BA, Hays R, Buettner PG (2000) An educational intervention to improve diagnosis and management of suspicious skin lesions. *J Contin Educ Health Prof* 20(1):39–51. <https://doi.org/10.1002/chp.1340200108>
 65. Robinson JK, Jain N, Marghoob AA et al (2018) A randomized trial on the efficacy of mastery learning for primary care provider melanoma opportunistic screening skills and practice. *J Gen Intern Med* 33(6):855–862. <https://doi.org/10.1007/s11606-018-4311-3>
 66. Robinson JK, MacLean M, Reavy R, Turrissi R, Mallett K, Martin GJ (2018) Dermoscopy of concerning pigmented lesions and primary care providers' referrals at intervals after randomized trial of mastery learning. *J Gen Intern Med* 33(6):799–800. <https://doi.org/10.1007/s11606-018-4419-5>
 67. Rogers T, Marino ML, Duszka SW et al (2016) A clinical aid for detecting skin cancer: the triage amalgamated dermoscopic algorithm (TADA). *J Am Board Fam Med* 29(6):694–701. <https://doi.org/10.3122/jabfm.2016.06.160079>
 68. Rutkowski D, Asfour L, Welch C et al (2020) The DECIDE™ education programme: precision medicine for nondermatologists. *Br J Dermatol* 183(S1):187
 69. Sawyers EA, Wigle DT, Marghoob AA, Blum A (2020) Dermoscopy training effect on diagnostic accuracy of skin lesions in Canadian family medicine physicians using the triage amalgamated dermoscopic algorithm. *Dermatol Pract Concept* 10(2):e2020035. <https://doi.org/10.5826/dpc.1002a35>

70. Secker LJ, Buis PA, Bergman W, Kukutsch NA (2017) Effect of a dermoscopy training course on the accuracy of primary care physicians in diagnosing pigmented lesions. *Acta Derm Venereol* 97(2):263–265. <https://doi.org/10.2340/00015555-2526>
71. Seiverling EV, Ahrns HT, Greene A et al (2019) Teaching benign skin lesions as a strategy to improve the triage amalgamated dermoscopic algorithm (TADA). *J Am Board Fam Med* 32(1):96–102. <https://doi.org/10.3122/jabfm.2019.01.180049>
72. Shariff Z, Roshan A, Williams AM, Platt AJ (2010) 2-week wait referrals in suspected skin cancer: does an instructional module for general practitioners improve diagnostic accuracy? *Surgeon* 8(5):247–251. <https://doi.org/10.1016/j.surge.2010.03.004>
73. Westerhoff K, McCarthy WH, Menzies SW (2000) Increase in the sensitivity for melanoma diagnosis by primary care physicians using skin surface microscopy. *Br J Dermatol* 143(5):1016–1020. <https://doi.org/10.1046/j.1365-2133.2000.03836.x>
74. Williams NM, Muñoz AM, Londoño AM, et al. 14234 Skin cancer and dermoscopy training for primary care physicians in Colombia: effect on skin cancer diagnosis. *J Am Acad Dermatol*. 2020;83(6):AB21. doi:<https://doi.org/10.1016/j.jaad.2020.06.171>
75. Youl PH, Raasch BA, Janda M, Aitken JF (2007) The effect of an educational programme to improve the skills of general practitioners in diagnosing melanocytic/pigmented lesions. *Clin Exp Dermatol* 32(4):365–370. <https://doi.org/10.1111/j.1365-2230.2007.02414.x>
76. Goulart JM, Quigley EA, Dusza S et al (2011) Skin cancer education for primary care physicians: a systematic review of published evaluated interventions. *J Gen Intern Med* 26(9):1027–1035. <https://doi.org/10.1007/s11606-011-1692-y>
77. Fried LJ, Tan A, Berry EG et al (2021) Dermoscopy proficiency expectations for US dermatology resident physicians: results of a modified Delphi survey of pigmented lesion experts. *JAMA Dermatol* 157(2):189–197. <https://doi.org/10.1001/jamadermatol.2020.5213>
78. Seiverling E, Ahrns H, Stevens K et al (2021) Dermoscopic lotus of learning: implementation and dissemination of a multimodal dermoscopy curriculum for primary care. *J Med Educ Curric Dev* 8:2382120521989983. <https://doi.org/10.1177/2382120521989983>
79. Welch HG, Mazer BL, Adamson AS (2021) The rapid rise in cutaneous melanoma diagnoses. *N Engl J Med* 384(1):72–79. <https://doi.org/10.1056/NEJMs2019760>
80. Morris JB, Alfonso SV, Hernandez N, Fernández MI (2017) Examining the factors associated with past and present dermoscopy use among family physicians. *Dermatol Pract Concept* 7(4):63–70. <https://doi.org/10.5826/dpc.0704a13>
81. Pagnanelli G, Soyer HP, Argenziano G et al (2003) Diagnosis of pigmented skin lesions by dermoscopy: web-based training improves diagnostic performance of non-experts. *Br J Dermatol* 148(4):698–702. <https://doi.org/10.1046/j.1365-2133.2003.05168.x>
82. Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM (2008) Internet-based learning in the health professions: a meta-analysis. *JAMA* 300(10):1181–1196. <https://doi.org/10.1001/jama.300.10.1181>
83. Davis D, O'Brien MA, Freemantle N, Wolf FM, Mazmanian P, Taylor-Vaisey A (1999) Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? *JAMA* 282(9):867–874. <https://doi.org/10.1001/jama.282.9.867>
84. Dutta P, Blitz GR, Johns on PE, et al. SimCare: a model for studying physician decisionmaking activity. In: Henriksen K, Battels JB, Marks ES, Lewin DI, eds. *Advances in Patient Safety: From Research to Implementation*. Agency for Healthcare Research and Quality (US); 2005.
85. Xue Y, Ye Z, Brewer C, Spetz J (2016) Impact of state nurse practitioner scope-of-practice regulation on health care delivery: systematic review. *Nurs Outlook* 64(1):71–85. <https://doi.org/10.1016/j.outlook.2015.08.005>

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