

Teaching funduscopy to undergraduate medical students: trends in the literature

O ensino do exame de fundo de olho na graduação médica: tendências na literatura

Norimar Pinto de Oliveira¹ norimar.oliveira@uepa.br
Robson Jose de Souza Domingues² domingues@uepa.br
Edmundo Frota Almeida Sobrinho² edmundofalmeida@gmail.com
Simone Argentino¹ simone.argentino@uepa.br
Walisson Ferreira Barbosa¹ walisson.barbosa.2024@gmail.com

ABSTRACT

Introduction: Funduscopy is a skill that should be utilized by medical professionals, especially in clinical contexts associated with systemic arterial hypertension (SAH), diabetes mellitus (DM) and neurological conditions. The teaching of this topic in medical undergraduate courses is a recurring subject in the literature, including approaches that consider not only the teaching of direct ophthalmoscopy (DO) but also techniques based on obtaining and analyzing images of the fundus.

Objective: To identify and analyze experiences and trends in the literature on the teaching of funduscopy in medical undergraduate courses.

Method: Bibliographic research comprising articles published in the period from 2013 to 2023.

Results: A total of 44 articles were selected through the review. The use of simulators and fundus images captured with devices coupled to cell phone cameras were teaching resources used in a large number of studies (52.3% of articles) with positive conclusions about the use of these elements for learning funduscopy. Direct ophthalmoscopy continues to be a recommended technique, although most studies identify difficulties in its learning and performance. Most research used controlled environments, had little follow-up time to ascertain the efficiency of the teaching processes and lacked uniform and clear educational objectives and learning methodologies that should be used in teaching funduscopy. Only two studies were carried out in authentic care environments.

Conclusion: There are several experiences reported on the teaching of funduscopy supported by various resources that proved to be pedagogically appropriate. Longitudinal and methodologically uniform studies must be conducted to obtain reproducible and comparable results that can warrant better efficiency in the teaching of funduscopy in medical education.

Keywords: Medical Education; Ophthalmoscopy; Teaching; Fundus oculi.

RESUMO

Introdução: O exame de fundo de olho (EFO) é um recurso semiológico importante e deve ser uma competência exercida pelo profissional médico, especialmente em contextos clínicos associados a hipertensão arterial sistêmica (HAS), diabetes mellitus (DM) e quadros neurológicos. O ensino do EFO na graduação médica é um tema recorrente e desafiador na literatura com experiências que consideram não somente o ensino da oftalmoscopia direta (OD), mas também técnicas de exame que se baseiam na obtenção e análise de imagens do fundo de olho.

Objetivo: Este estudo teve como objetivos identificar e analisar na literatura experiências e tendências sobre o ensino do EFO na graduação médica.

Método: Trata-se de uma pesquisa descritiva literária que coletou publicações compreendidas no período de 2013 a 2023.

Resultado: Foram selecionados 44 estudos publicados no período. O uso de simuladores e de imagens obtidas com dispositivos acoplados a câmeras de telefones celulares apresentou-se em 52,3% dos estudos com conclusões positivas sobre a utilização desses elementos para a aprendizagem do EFO. A OD continua sendo uma técnica recomendada e ensinada, muito embora a maioria dos estudos identifique dificuldades em seu aprendizado e exercício. A maioria das pesquisas utilizou ambientes controlados, teve pouco tempo de seguimento no sentido de averiguar a eficiência dos processos de ensino testados e não definiu com clareza os objetivos educacionais e as metodologias de aprendizagem que devem ser empregados no ensino do EFO. Somente dois estudos foram conduzidos em ambientes autênticos de atendimento.

Conclusão: Existem várias experiências relatadas sobre o ensino do EFO amparadas por diversos recursos que se mostraram pedagogicamente adequados. Estudos longitudinais e metodologicamente uniformes devem ser conduzidos para a obtenção de resultados reprodutíveis e comparáveis que possam garantir eficiência ao ensino do EFO na graduação médica.

Palavras-chave: Educação Médica; Oftalmoscopia; Ensino; Fundo de Olho.

¹ Universidade do Estado do Pará, Marabá, Pará, Brazil.

² Universidade do Estado do Pará, Belém, Pará, Brazil.

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INTRODUCTION

The literature on the teaching of fundoscopy in undergraduate medical courses is in agreement in the sense that medical students should recognize the importance of this semiological procedure and know how to proceed to access and analyze the fundus, especially in clinical contexts – many of them critical – related to systemic arterial hypertension (SAH), diabetes mellitus (DM) and neurological conditions^{1,2,3}. A study carried out in the state of Pará concluded that 58.7% of a sample of patients treated at a primary health care unit with SAH and/or DM and examined by direct ophthalmoscopy (DO) had fundus abnormalities⁴.

Teaching-learning and the practice of the traditional DO technique for fundoscopy have limitations. Studies conducted with students and physicians who have already graduated have shown that the vast majority do not satisfactorily perform direct ophthalmoscopy^{5,6,7,8}. There are controversies in the literature about this examination technique, with opinions that question its efficiency and question the validity of its teaching. However, most authors defend their learning, even recognizing their limitations^{9,10,11}.

Direct ophthalmoscopy requires skills that can only be improved with constant training and performance. It is recognized the fact that during undergraduate studies there is little availability for the teaching and practicing of this competency¹². A recent study conducted in the state of Mato Grosso (Brazil) showed that only about 10% of the medical students interviewed in the survey considered themselves to master the practice and theory related to direct ophthalmoscopy¹³. This reality, together with other factors, such as the need for mydriasis and adequate environments for the examination, the influence of media opacity, and the small observable field, contributes to making both the learning and the practice of direct ophthalmoscopy challenging^{14,15,16}.

In this context, studies have addressed several possibilities for teaching fundoscopy, many of them using simulators, in addition to testing other evaluation techniques, especially by obtaining and analyzing photographs of the posterior ocular pole, which is currently possible with the use of portable devices that, in general, work coupled to cell phone cameras^{17,18,19}. Biousse *et al.*²⁰ defend the acquisition of fundus images, stating that “effectively visualizing the fundus is more important than (discussing) the technique used for this purpose”.

In view of the need to teach fundoscopy in clinically relevant situations from an epidemiological point of view, it is important to address the problem of its performance and learning to ensure adequate training of general practitioners in accordance with the National Curriculum Guidelines for medical education. This review aims to explore pedagogical

experiences that indicate solutions for the optimization of the approach to this topic in medical courses.

OBJECTIVE

To describe and analyze the experiences and trends that are found in the scientific literature on the fundus examination, aiming to improve the teaching of fundoscopy in medical undergraduate courses.

METHOD

This is a literature review based on the following guiding question: “What are the examination techniques and teaching strategies that have been evaluated for the teaching of fundoscopy among medical students?”.

During data collection, a search was conducted for articles published in the last ten years (01/01/2013 – 07/06/2023), without language restrictions and using the following databases: Scielo; Virtual Health Library (VHL); PubMed; Cochrane; Web of Science; Capes Periodicals; Embase. Keywords were defined to set up the search strategies. The main keywords searched were: (“Exame de fundo de olho” or “Fundoscopia” or “Oftalmoscopia direta”) or (“Direct ophthalmoscopy” or “Fundoscopy”) and (“Ensino” or “Teaching” or “Enseñanza” or “Enseignement”) and (“Direct ophthalmoscopy” or “Fundoscopy” or “Fundus examination”) and (“Teaching” or “Technics, Training” or “Training Technics”).

The inclusion criteria included fully published articles that reported experiences in teaching the fundus exam, whereas abstracts in conference proceedings, articles with incomplete text, letters to editors, and publications of preliminary results were excluded. Review articles or articles on the teaching of fundoscopy in post-graduation were excluded.

The material obtained in the search was exported to a folder of the Rayyan® program, and duplicates were excluded. The articles were initially evaluated by reading titles and abstracts in relation to the inclusion and exclusion criteria and the search topic. Studies cited by the bibliographic references were also identified. The selected publications (44 articles) were read in full by the researchers, and analysis guides were filled out with the following items, which were cataloged in a Microsoft Excel 365® file: bibliometric data (main author, medical specialty, institution and country to which the main author is linked, journal of publication), general study design, main objective, sample characteristics and methodology and summary of conclusions.

RESULTS

Listed articles

As shown in the flowchart (Figure 1), 691 studies were initially identified, of which 265 duplicates were excluded.

The titles and abstracts of the 426 articles were read and analyzed, and 378 articles were excluded because they were not publications whose topic was in fact the teaching of the fundus examination aimed at medical students (these were articles of studies or various issues related to ophthalmoscopy or teaching at other levels of medical education, such as a residency). Thus, 48 studies were selected for reading in full. At the end of this process, eight more articles were excluded (4 abstracts, 2 letters to editors, and 2 that were not related to the undergraduate level) and 4 publications selected through search in the references were included. Thus, the final sample consisted of 44 publications, which comprise this review.

All 44 articles report experiences of teaching funduscopy in undergraduate medical studies conducted in controlled research settings or in real care settings. As teaching strategies, the publications refer to the use of simulators, the capture of fundus images with equipment coupled to cell phone cameras, direct peer ophthalmoscopy training and several other resources. Regarding the type of evaluation of educational interventions, the studies describe summative and formative evaluation processes that generated data used for analysis

and measurement of the intervention results, which included (but not in all experiences) the comparison between different study groups or between these and control groups, the latter generally consisting of training with a direct ophthalmoscope without the aid of other complementary resources.

Charts 1, 2 and 3 list the main author, the main educational institution linked to the study, the country in which the research was conducted and the year of publication of the article.

DISCUSSION

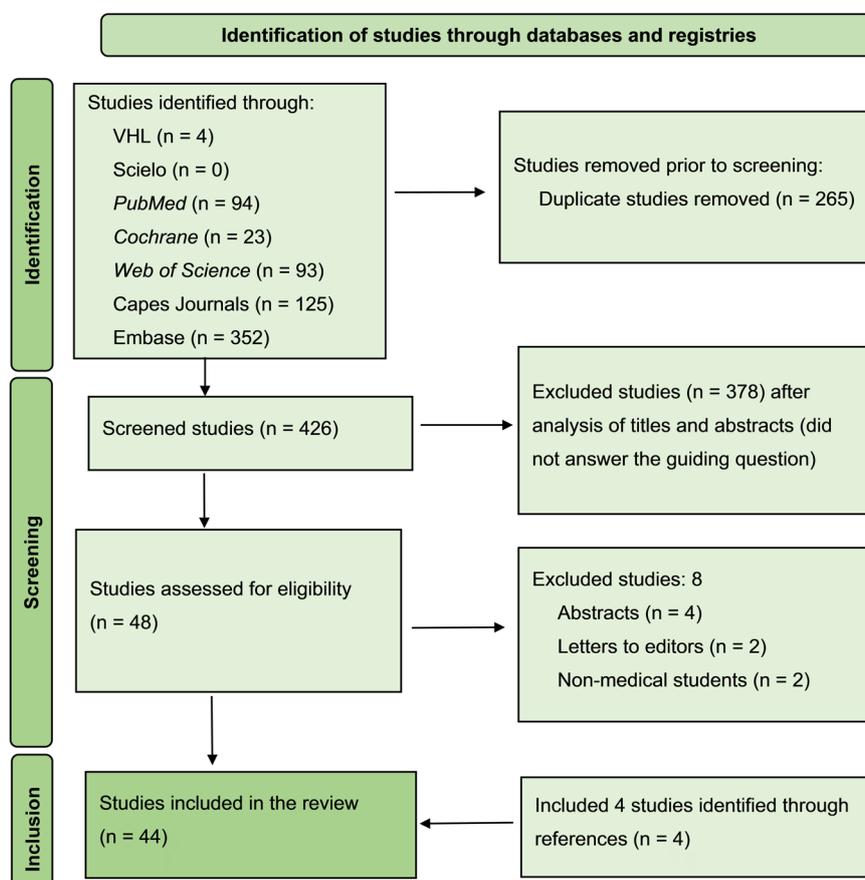
The main objective of this research was to study the scientific literature on funduscopy aiming to improve the teaching of the subject in undergraduate medical courses. In order to simplify the analysis and discussion of the results, the articles were categorized into three major groups (Graph 1):

Group 1 – Experiments with the use of fundus simulators;

Group 2 – Experiences with the use of fundus photographs obtained with devices attached to cell phone cameras (smartphones);

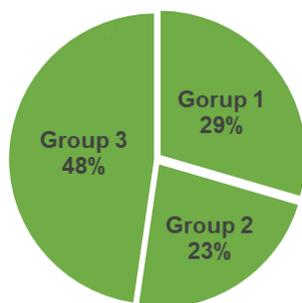
Group 3 – Experiences of teaching funduscopy with several resources.

Figure 1. Flowchart on article collection for bibliographic review.



Source: prepared by the authors, 2024.

Graph 1. Distribution of the reviewed articles by group according to the didactic resources used for teaching funduscopy:



- Group 1: Use of simulators (n=13)
- Group 2: Use of photographs with cellphones (n=10)
- Group 3: Several resources (n=21)

Source: prepared by the authors, 2024.

Next, the findings related to the set of each of the abovementioned groups will be presented and discussed.

Analysis and discussion of the articles of group 1: experiences with the use of fundus simulators

As summarized in chart 1, of the total number of retrieved articles, 13 studies focused on the use of simulators (29.5% of the studies).

For the purposes of discussion, two types of simulators stand out in the studies selected in this review: simulators sold commercially at high cost and low-cost simulators, usually manufactured and designed by the authors themselves.

Among the highest cost simulators, the following products were identified: EYE Simulator (Kyoto Kagaku), Eyesi Direct (VRmagic) and Eye Retinopathy Trainer (Adam, Rouilly).

Akaishi *et al.* (2014)²¹ and Larsen *et al.* (2014)²³ investigated the EYE Examination Simulator as a teaching tool for medical students, with samples, respectively, of 90 and 115 students. They concluded that the use of the simulator in the study group allowed a greater number of correct answers in assessment tests and greater confidence in the examination performance, as it allowed an increase in the frequency of funduscopy training. In the same sense of positive evaluation regarding the use of simulators, one can mention the studies conducted by Tso *et al.* (2021)²⁹ and Deuchler *et al.* (2021)²⁷, in which the Eyesi Direct (VRmagic) equipment was used as a teaching tool. Favorable conclusions to the use of simulators were also presented in three independent studies, conducted by Androwiki *et al.* (2015)²⁴, Mahmoud *et al.* (2021)²⁸ and Yusuf *et al.* (2017)²⁵, who analyzed the Eye Retinopathy Trainer (Adam, Rouilly). The intentional samples of these studies were, respectively, 90, 160 and 48 students and the results indicated that the simulator use allowed the improvement of the skills and knowledge necessary to perform the funduscopy.

Analysis and discussion of the articles of group 2: experiences with the use of fundus photographs obtained with devices attached to cell phone cameras (smartphones)

In the study by Wu *et al.* (2014)²², which involved a small sample of 12 students and evaluated the performance

Chart 1. Articles listed for bibliographic review on the teaching of funduscopy. GROUP 1 – Use of fundus simulators for the teaching of funduscopy.

ARTICLE	AUTHOR	RESEARCH INSTITUTION	COUNTRY	YEAR
1	Kelly <i>et al.</i> ²	Emory University	USA	2013
2	Akaishi <i>et al.</i> ²¹	Tokyo Medical University	Japan	2014
3	Wu <i>et al.</i> ²²	Northwestern University	USA	2014
4	Larsen <i>et al.</i> ²³	University of Nebraska	USA	2014
5	Androwiki <i>et al.</i> ²⁴	Universidade Federal de São Paulo	Brasil	2015
6	Yusuf <i>et al.</i> ²⁵	Oxford Medical School	United Kingdom	2016
7	Martins <i>et al.</i> ¹²	Universidade Federal de São Paulo	Brazil	2017
8	Souza <i>et al.</i> ²⁶	Universidade Federal do Piauí	Brazil	2017
9	Deuchler <i>et al.</i> ²⁷	Goethe-Universität Frankfurt am Main	Germany	2022
10	Mahmoud <i>et al.</i> ²⁸	Université de Monastir	Tunisia	2021
11	Tso <i>et al.</i> ²⁹	Indiana University School of Medicine	USA	2021
12	Wu <i>et al.</i> ³⁰	Pekin Union Medical College	China	2022
13	Howell <i>et al.</i> ³¹	Ucla Stein Eye Institute	USA	2021

Source: prepared by the authors, 2024.

of a simulator called FAK-I, the results indicated that the group of students who used the tool obtained a slightly higher percentage of correct answers in the evaluation process than the control group, but without a statistically significant result.

A study conducted by Souza *et al.* (2017)²⁶, with the participation of 24 students, analyzed the performance of two distinct groups. In the group that used a simulator, the objective mean score in the evaluation process was considerably higher, reaching 82%, compared to the group that underwent training with human volunteers, which obtained a mean score of 45% ($p = 0.01$). These results indicate a statistically significant difference favoring the group that used the simulator, suggesting that it was effective in teaching funduscopy. It is noteworthy that there was no statistically significant difference between the groups in relation to the degree of difficulty experienced in performing the exam.

Martins *et al.* (2017)¹² developed an educational model that involves the construction of an artisanal simulator. This instrument consists of a transparent acrylic sphere with a radius of 1.1 cm, inserted in a cardboard box, with openings that represent the pupils. Inside the model, 1 cm × 1 cm images containing words, numbers and images of the ocular fundus were inserted. The total cost of the material was about US\$ 1.00 or R\$ 5.00. This practice also helped to illustrate the concepts of physics pertinent to funduscopy, making the learning process more engaging.

In the study conducted by Howell *et al.* (2022)³¹, with the participation of 33 students, the main objective was to analyze the effects of frequent practice in simulators. Those who practiced more regularly showed improvements. Moreover, an increase in the ability to identify fundus lesions was observed, a core competence in funduscopy. These

results suggest that regular practice plays an important role in improving skills for the performance of funduscopy. Similar results were described by Wu *et al.*³⁰ in an experiment that involved a sample of 92 students.

Overall, the use of several simulator models showed a positive impact on medical students' learning, although none of the studies were longitudinal and, therefore, not able to measure the results in terms of knowledge retention or performance improvement in the long term. Many of the studies involved small sample sizes, which reduces confidence in the level of evidence generated by these studies.

It should be noted that performing direct ophthalmoscopy in real-life environments of care, peer training or with volunteer patients is not able to obtain samples of the various pathological signs of the fundus that are found in specific and infrequent situations, such as, for example, papilledema and subretinal hemorrhage, which may be present in intracranial hypertension and in patients with subarachnoid hemorrhage, among others. Thus, in addition to allowing constant repetition in the training of procedures, one of the advantages of using simulators is the fact that it also provides the observation of infrequent fundus changes in authentic environments. It is important to emphasize that the positive value of clinical and surgical simulations has long been recognized as effective complementary strategies that increase the level of safety in health professionals' training^{32,33,34,35,36}.

Of the total of 44 articles, ten articles were identified that studied the use of fundus photographs obtained with smartphones (22.7% of the retrieved articles). The years of publication were concentrated in the period from 2018 to 2023, showing that this teaching strategy and fundus assessment technique is depicted in relatively recent experiences, although

Chart 2. Articles listed for the review of the teaching of funduscopy. Group 2 – Use of fundus photographs obtained with devices attached to cell phone cameras.

ARTICLE	AUTHOR	INSTITUTION	COUNTRY	YEAR
14	Mantora <i>et al.</i> ³⁷	Sunderland Eye Infirmary	United Kingdom	2018
15	Wu <i>et al.</i> ³⁸	University of Nebraska Medical Center	USA	2018
16	Kim <i>et al.</i> ³⁹	University of California	USA	2019
17	Shikino <i>et al.</i> ⁴⁰	Chiba University School of Medicine	Japan	2019
18	Wang <i>et al.</i> ⁴¹	Shantou University	China	2023
19	Curtis <i>et al.</i> ⁴²	Kingston General Hospital	Canada	2021
20	Franzco <i>et al.</i> ⁴³	University of Sydney	Australia	2021
21	Kohler <i>et al.</i> ⁴⁴	University of Minnesota	USA	2021
22	Ahmed <i>et al.</i> ⁴⁵	University of Toronto	Canada	2022
23	Qader <i>et al.</i> ⁴⁶	University Joint-Committee	Malaysia	2022

Source: prepared by the authors, 2024.

the use of non-mydratic cameras for fundus photography in various scenarios has been the subject of study for years^{17,18}. A recent study carried out in São Paulo, Brazil, on the use of cell phone cameras used to detect diabetic retinopathy with the support of telediagnosis presented interesting results for the screening of this condition in primary health care⁴⁷.

In principle, it should be noted that one of the great advantages of the photographic record of the fundus concerns the possibility of filing, editing and sharing the photograph remotely, allowing remote evaluation (telediagnosis) and a more detailed analysis of the ocular structures. Fundus photographs obtained with portable devices in authentic care environments have already been the subject of competent studies that reinforce this technique usefulness, even suggesting its superiority in terms of accuracy over direct ophthalmoscopy⁴⁸.

The main devices integrated into smartphone cameras were the D-EYE device (Italy) and the iExaminer (Welch Allyn, Australia), the first of which was directly coupled to a smartphone, whereas the second also required a Panoptik direct ophthalmoscope (Welch Allyn, Australia).

Studies conducted by Wu *et al.* (2018)³⁸, Curtis *et al.* (2021)⁴² and Franzko *et al.* (2021)⁴³ demonstrated that capturing fundus photographs with the D EYE device can facilitate the learning of funduscopy by medical students. It should be noted, however, that these studies did not have sufficient follow-up time to assess the real long-term impacts on learning. Coincident results were reported by Shikino *et*

al. (2019)⁴⁰ who tested the use of the iExaminer in a sample of 115 students in a study in which they associated the use of the EYE Examination Simulator (Kyoko Kagaku Co) and concluded that the learning method with these elements improved the accuracy and overall performance of students when performing the funduscopy.

In the same sense, Kim *et al.* (2019)³⁹, in a study with a sample of 101 medical students, also identified a preference for fundus photographs and better student performance when using this technique. As weaknesses in this study, it should be mentioned that the structure evaluated was limited to the optic disc – similarly to other studies in this selection –, and the ophthalmoscopy was performed in non-dilated pupils, which does not correspond to the examination technique, which should preferably be performed in mydriasis. The statistical differences in the evaluation of the students' performance (control and intervention groups) were not high, suggesting that the use of photographs can be useful in learning, but does not disallow the teaching and evaluation of the fundus through traditional direct ophthalmoscopy.

Analysis and discussion of the articles of group 3: diverse experiences of teaching funduscopy

In this category, 21 articles were collected (47.8% of the total number of articles listed in this review).

The use of fundus photographs as a support in learning dynamics was identified in studies conducted by Milani *et al.*

Chart 3. Articles listed for review on the teaching of funduscopy. Group 3 – Diverse teaching experiences.

ARTICLE	AUTHOR	INSTITUTION	COUNTRY	YEAR
24	Milani <i>et al.</i> ⁴⁹	University of Illinois	USA	2013
25	Krohn <i>et al.</i> ⁵⁰	University of Minnesota	Norway	2014
26	Byrd <i>et al.</i> ⁵¹	University of New Mexico	USA	2014
27	Lowe <i>et al.</i> ⁵²	Eastbourne District General Hospital	United Kingdom	2015
28	Schulz <i>et al.</i> ⁵³	Brighton and Sussex School	United Kingdom	2016
29	Lippa <i>et al.</i> ⁵⁴	University of California	USA	2015
30	Yusuf <i>et al.</i> ⁵⁵	Oxford Eye Hospital	United Kingdom	2016
31	Kwok <i>et al.</i> ⁵⁶	Queen's University	Canada	2017
32	Wilson <i>et al.</i> ⁵⁷	Birmingham City University	United Kingdom	2017
33	Bénard S <i>et al.</i> ⁵⁸	University of Calgary	Canada	2017
34	Gilmour <i>et al.</i> ⁵⁹	Michigan State University	USA	2017
35	Dissanayake <i>et al.</i> ⁶⁰	University of Colombo	Sri Lanka	2017
36	Boden <i>et al.</i> ⁶¹	Saarland University Med Center	Germany	2019
37	Gilmour-W <i>et al.</i> ⁶²	Birmingham City University	United Kingdom	2019
38	Lee <i>et al.</i> ⁶³	University of Miami	USA	2020
39	Rose <i>et al.</i> ⁶⁴	Christian Medical College	India	2021

Continue...

Tabela 3. Continuation

ARTICLE	AUTHOR	INSTITUTION	COUNTRY	YEAR
40	Ayub <i>et al.</i> ⁷	Universidade de Campinas	Brazil	2021
41	Dunn <i>et al.</i> ⁶⁵	University of Sydney	Australia	2021
42	Shikino <i>et al.</i> ⁶⁶	Chiba University Hospital	Japan	2021
43	Vloka <i>et al.</i> ⁶⁷	University of Pittsburgh	USA	2022
44	Henick <i>et al.</i> ⁶⁸	Icahn School of Medicine	USA	2020

Source: prepared by the authors, 2024.

(2013)⁴⁹, Krohn *et al.* (2014)⁵⁰, Bénard-Séguin *et al.* (2017)⁵⁸, Kwok *et al.* (2017)⁵⁶ and Gilmour *et al.* (2017)⁵⁹, demonstrating that these resources are widely used in several teaching strategies.

Real-life scenarios were reported in only two articles. One of them by Yusuf *et al.* (2016) in a teaching experience in a primary health care service; the other by Byrd *et al.* (2014)⁵¹, who report a health action with vulnerable populations in New Mexico, and one quality of this last experience is the verification of skill retention after one year of integrated teaching and care activities.

Other studies have used diversified strategies, such as audiovisual resources such as videotapes to demonstrate the exam technique (Dissanayake *et al.*, 2017)⁶⁰, a virtual teaching environment developed in the southern region of India during the Covid-19 epidemic (Rose *et al.*, 2020)⁶⁴, peer-training (Henick *et al.*, 2017)⁶⁸, virtual and multisensory teaching model (Lippa *et al.*, 2015)⁵⁴, among others.

Ayub *et al.* (2021)⁷, in a recent study conducted with medical students at the University of Campinas (Unicamp, Brazil), represent one of the few longitudinal studies in this review, evaluating skill retention over a one-year period, comparing the Panoptik ophthalmoscope (Welch Allyn) and the traditional coaxial ophthalmoscope (Welch Allyn). The sample comprising 167 students is another positive aspect of this study, which indicates the same difficulties, according to other publications already documented, to maintain, in the long term, the skills and knowledge necessary for the competent performance of funduscopy.

A study conducted by Gilmour-White *et al.* (2019)⁵⁷ identified that, even with easy access to direct ophthalmoscopes, students did not maintain the habit of performing or maintaining confidence in the exam. Schulz *et al.* (2015)⁴⁸, identifying that one of the difficulties in learning the direct ophthalmoscopy technique was the impossibility of sharing the observation of the fundus with an instructor, developed an ophthalmoscope model that allows the instructor to observe the fundus together with the examiner/student. Although it is desirable and valuable, this innovation does not seem to have become widely used.

Finally, the study called Efocus 1, conducted by Dunn *et al.* (2021)⁶⁰ in a sample of 146 second-year medical students, identified the students' good perception regarding methods with image recording in criteria such as usability and easy to perform in relation to other fundus assessment techniques, corroborating the students' good response to obtaining and analyzing fundus photographs, a phenomenon also identified in other studies such as those conducted by Curtis *et al.* (2021)⁴² and Franzko *et al.* (2021)⁴³.

FINAL CONSIDERATIONS

Fundoscopy remains a challenging topic in medical education. The literature indicates that the direct ophthalmoscopy practice and the acquisition and interpretation of fundus images should and can be competencies of the medical professional. As reported, an important group of educational interventions describes the use of simulators, indicating simulation techniques as possible and effective in the teaching-learning process of ophthalmoscopy. Fundus photographs obtained with portable devices were cited in several analyzed studies and the conclusions were also favorable regarding the use of these resources. Thus, it is suggested that the use of these devices be incorporated into the teaching processes of funduscopy in medical education institutions.

Training in real-life care environments constituted the absolute minority of the studies, demonstrating that the practice of funduscopy does not seem to be stimulated and incorporated into medical students' daily lives. Almost all of the 44 studies included in this review were, symptomatically and paradoxically, conducted by ophthalmologists, with very little participation from other specialties. Other studies on funduscopy in general have occurred at levels of medical specialization, with publications mainly in the areas of neurology and pediatrics. A gap is identified due to the fact that the studies do not seek to clearly and rigorously identify what would be the objectives of learning funduscopy in medical undergraduate courses, and even less how the teaching and performance of this competence should be stimulated,

reviewed and evaluated throughout the undergraduate course in the context of integrated medical curricula.

This review, considering the analytical limitations of narrative studies, summarizes a series of teaching modalities, strategies, and resources with the potential to have a positive impact on the teaching of fundoscopy in medical undergraduate studies. The judicious use of these resources in a longitudinal teaching plan anchored in the concepts of an integrated curriculum and meaningful learning, with interventions that take advantage of opportunities and scenarios throughout the medical course and that are clear in the definition of educational objectives and evaluation processes, can be a way to improve and ensure efficiency in the teaching of fundoscopy.

AUTHORS' CONTRIBUTIONS

Norimar Pinto de Oliveira administrated and supervised the project. Robson Jose de Souza Domingues supported the administration of the project. Edmundo Frota Almeida Sobrinho supervised the project. Simone Argentino gave support to the writing of the manuscript. Walisson Ferreira Barbosa gave support to the methodology.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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