Regular Article

Academic Pathology: Volume 7
DOI: 10.1177/2374289520951922
journals.sagepub.com/home/apc

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Pathology Trainees' Experience and Attitudes on Use of Digital Whole Slide Images

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Abstract

Digital whole slide images are Food and Drug Administration approved for clinical diagnostic use in pathology; however, integration is nascent. Trainees from 9 pathology training programs completed an online survey to ascertain attitudes toward and experiences with whole slide images for pathological interpretations. Respondents (n = 76) reported attending 63 unique medical schools (45 United States, 18 international). While 63% reported medical school exposure to whole slide images, most reported ≤ 5 hours. Those who began training more recently were more likely to report at least some exposure to digital whole slide image training in medical school compared to those who began training earlier: 75% of respondents beginning training in 2017 or 2018 reported exposure to whole slide images compared to 54% for trainees beginning earlier. Trainees exposed to whole slide images in medical school were more likely to agree they were comfortable using whole slide images for interpretation compared to those not exposed (29% vs 12%; $P = .06$). Most trainees agreed that accurate diagnoses can be made using whole slide images for primary diagnosis (92%; 95% CI: 86-98) and that whole slide images are useful for obtaining second opinions (93%; 95% CI: 88-99). Trainees reporting whole slide image experience during training, compared to those with no experience, were more likely to agree they would use whole slide images in 5 years for primary diagnosis (64% vs 50%; $P = .3$) and second opinions (86% vs 76%; $P = .4$). In conclusion, although exposure to whole slide images in medical school has increased, overall exposure is limited. Positive attitudes toward future whole slide image diagnostic use were associated with exposure to this technology during medical training. Curricular integration may promote adoption.

Keywords

digital whole slide imaging, virtual microscopy, pathology training, medical education, optical microscopy, digital pathology

Received February 14, 2020. Received revised June 22, 2020. Accepted for publication June 30, 2020.

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Introduction

There is a nascent shift in the field of pathology and laboratory medicine toward integrating digital whole slide images (WSI) for surgical pathology and medical diagnosis following Food and Drug Administration (FDA) approval of the first whole slide imaging system for primary diagnosis in 2017.[1,2] Further developments in scanning systems and viewing software are expected to arrive quickly.[3,4] However, studies indicate there are lengthy delays in adopting new technologies into clinical practice.[5-7] Education of future pathologists, as they transition from medical students to practicing pathologists during residency training, is a potential driver of future uptake and utilization of digital pathology.

Navigating a digital WSI is quite different from traditional microscopy.[8] The pathologist is not confined to a physical microscope requiring manual manipulation of a glass slide viewed through a set of ocular lenses to provide varied magnification of the tissue biopsy. Rather, the digitized images of the histology tissue sections are viewed on a computer screen using a pointing device such as a mouse, trackpad, or dedicated console to manipulate location and magnification of the image (pan and zoom). The technology may be easily adapted to virtual reality glasses.[9-11] Given these important differences between digital WSI and traditional microscopy, adoption and effective use of WSI in clinical practice requires exposure to and training using this new format.

The future integration and deployment of digital WSI may be influenced by whether trainees are exposed to WSI during medical school and subsequent pathology residency training. While both the Liaison Committee on Medical Education, the accrediting body for US medical schools granting an MD degree, and the AOA Commission on Osteopathic College Accreditation, the accrediting body for the DO degree have general requirements for pathology education, neither includes specific requirements for training that include digital WSI. A few institutions have examined the efficacy of digital slides as a teaching tool,[12-14] whether students favor one method over the other,[15,16] and whether students' performance and competence were improved with adoption of whole slide imaging in the curriculum.[16-18] The existing literature does not include the extent to which formal exposure to WSI is provided during medical school and subsequent pathology training. In addition, information on pathology trainees' perspective on adoption of this new technology into clinical practice is missing.

To address this knowledge gap, we surveyed US pathology trainees with medical degrees from a wide variety of United States and international medical schools about the training they received using digital WSIs as well as their attitudes regarding the future use of WSI.

Methods

Study Context

This research is part of a large longitudinal NIH/NCI-funded study evaluating how pathology trainees in academic medical centers across the US approach the diagnostic process when interpreting digital WSI and how that approach may change over the course of their residency training. Nine pathology training programs from eight different states (CA, KY, MA, NH, UT, VA, VT, and WA) participated in the first year of the study. Each site was provided information about the study, introduced the study to their trainees, and provided names and contact information for candidate participants but were not otherwise involved in data collection or analyses. All procedures were HIPAA compliant, and approval was obtained from the appropriate institutional review boards (IRB), with UCLA acting as the IRB of record.

Baseline Survey and Data Collection

Data presented here were collected between January and October of 2019. Eligible participants were enrolled in an anatomic pathology (AP) or combined anatomic and clinical (AP/CP) pathology training program (including post sophomore fellowships or other specialized AP fellowships) and were available during a site visit to their institution. Invitations to participate were sent via email (maximum of 4 attempts).

Study procedures for the larger study included completing an online consent form, online baseline survey, interpreting 14 digital WSIs of breast biopsies, and completing a diagnostic histology form for each case (data not shown). Participants received a US $50 gift card following completion of study activities. Only data from the baseline survey are described in this paper. Briefly, the content of the baseline survey included demographic information, medical school training, attitudes and experiences interpreting pathology, and attitudes on digital whole slide imaging. The survey was programmed and administered using Qualtrics Software. See Table 1 for the key survey questions described in this paper. The full survey is available in Supplemental Appendix 1.

Data Analyses

Descriptive statistics, including means, SD, and frequencies of trainees' responses, were calculated and hypothesis testing was performed using the Fisher exact test. All tests were 2-tailed. A P value $< .05$ was considered statistically significant. SAS version 9.4 (SAS Institute) was used to perform all statistical analyses.

Results

We invited 159 trainees to participate in the study. Of those invited, 3 were ineligible and 29 were unavailable to participate on the day of the site visit (eg, due to competing clinical responsibilities, working off site at another hospital on the day of the site visit, vacation, etc). Of the 127 pathology trainees who were eligible and potentially available to participate, 76 (60%) were able to join the study and completed the baseline survey. Data collection for the trainees' review of the WSI cases required an individual 1-hour appointment during the site

Table 1. Key Survey Questions.

- In addition to viewing PowerPoint slides during medical school histology/pathology training, how many hours did you spend using glass slides and/or digital images? (For example, a semester long course with 2-3 hour lab per week is approximately 25-30 hours). Please estimate the number of hours you spent using:
  - A traditional microscope with glass slides*
  - Digital WSIs (virtual microscope with pan and zoom viewing on a computer monitor)*
- What are your thoughts on H&E digital WSI being used for primary diagnostic purposes? (We refer to digital WSI as digital slides)
  - Accurate diagnoses can be rendered using digital slides†
  - Digital slides are useful for obtaining a second opinion†
  - I am comfortable interpreting cases using digital slides†
- In 5 years, I predict that in my professional practice as a pathologist I will use digital WSI for:
  - __% of cases for primary diagnosis
  - __% of cases when I provide a consultative second opinion

Abbreviation: H&E, hematoxylin and eosin; WSI, whole slide image.
* Categorical responses: 1 to 5 hours, 6 to 10 hours, 11 to 25 hours, 26 to 50 hours, 51 to 100 hours, >100 hours, I have never used a traditional microscope with glass slides.
† Likert scale (1 = strongly disagree, 6 = strongly agree).

visit day(s), and as only 1 trainee could participate at a time, only a small number of appointments were available during each site visit limiting our ability to accommodate all trainees at all sites.

Demographics

The mean age of trainees was 33 years (range: 27-46, SD: 4). Just over half of the trainees were female (53%). The following describes the distribution of pathology training year: post-sophomore medical student fellows in pathology or Program Year 1: n = 20; Program Year 2: n = 27; Program Year 3: n = 20; and Program Year 4 or higher including post-residency Pathology Fellows: n = 9.

Medical School and Trainees' Digital Training

Trainees graduated from 63 different medical schools: 45 (71%) medical schools were in the United States (across 27 states), and 18 were located internationally (Figure 1). Most trainees (56 of 76 participants, 74%) graduated from US medical schools and the remaining 20 (26%) graduated from international medical schools.

The total number of hours reported by trainees spent using digital WSI during medical school training was: none by 25 (33%), 1 to 5 hours by 17 (22%), 6 to 10 hours by 10 (13%), and at least 11 hours by 21 (28%). Figure 2 illustrates the full distribution showing reported hours using digital WSI in the United States compared to international medical schools. While 33% reported no exposure at all, 67% reported having at least some experience in digital WSI during medical school. Those who began pathology training more recently were more likely to report at least some exposure to digital WSI training in medical school compared to those who began earlier (P value for trend = .10). Specifically, 75% of trainees who began in 2017 or 2018 reported WSI training compared to 54% for trainees who began pathology training in prior calendar years.

Trainees' Attitudes Regarding Digital WSI

Most trainees agreed with the survey question that accurate diagnoses can be achieved using digital WSI for primary diagnostic purposes (92%; 95% CIs: 86-98) and that the digital format is useful for obtaining second opinions (93%; 95% CIs: 88-99; Figure 3). Only a quarter of trainees (24%, 95% CIs: 14-33) agreed that they are comfortable interpreting cases using digital slides. Trainees exposed to digital WSI in medical school, compared to those who were not exposed, tended to indicate that they are comfortable interpreting cases using digital slides (29% vs 12%; $P = .06$; Figure 4). There was no statistically significant association between trainees' attitudes regarding digital WSI and their year of pathology training. The percentages of trainees who agreed that they are comfortable interpreting cases using digital WSI are 20% for post-sophomore/first year, 33% for second year, 15% for third year, and 22% for fourth year or higher (ie, fellow).

Trainees' Perspectives About Future Use of Digital WSI

Most trainees predicted that in 5 years they would use digital WSI for either primary diagnosis or for providing a consultative second opinion for at least some of the cases in their professional practice as a pathologist (Figure 5). Trainees who had at least some experience interpreting cases using digital WSI during post-medical school pathology training were more likely to predict that in 5 years, they would use digital WSI for primary diagnosis (64% vs 50%; $P = .3$) and for providing a second opinion (86% vs 76%; $P = .4$). Trainees who thought digital slides are useful for obtaining a second opinion were more likely to predict that they would use digital WSI for either primary diagnosis (54% vs 40%, $P = .6$) or providing second opinions in their future practice (80% vs 40%; $P = .03$).

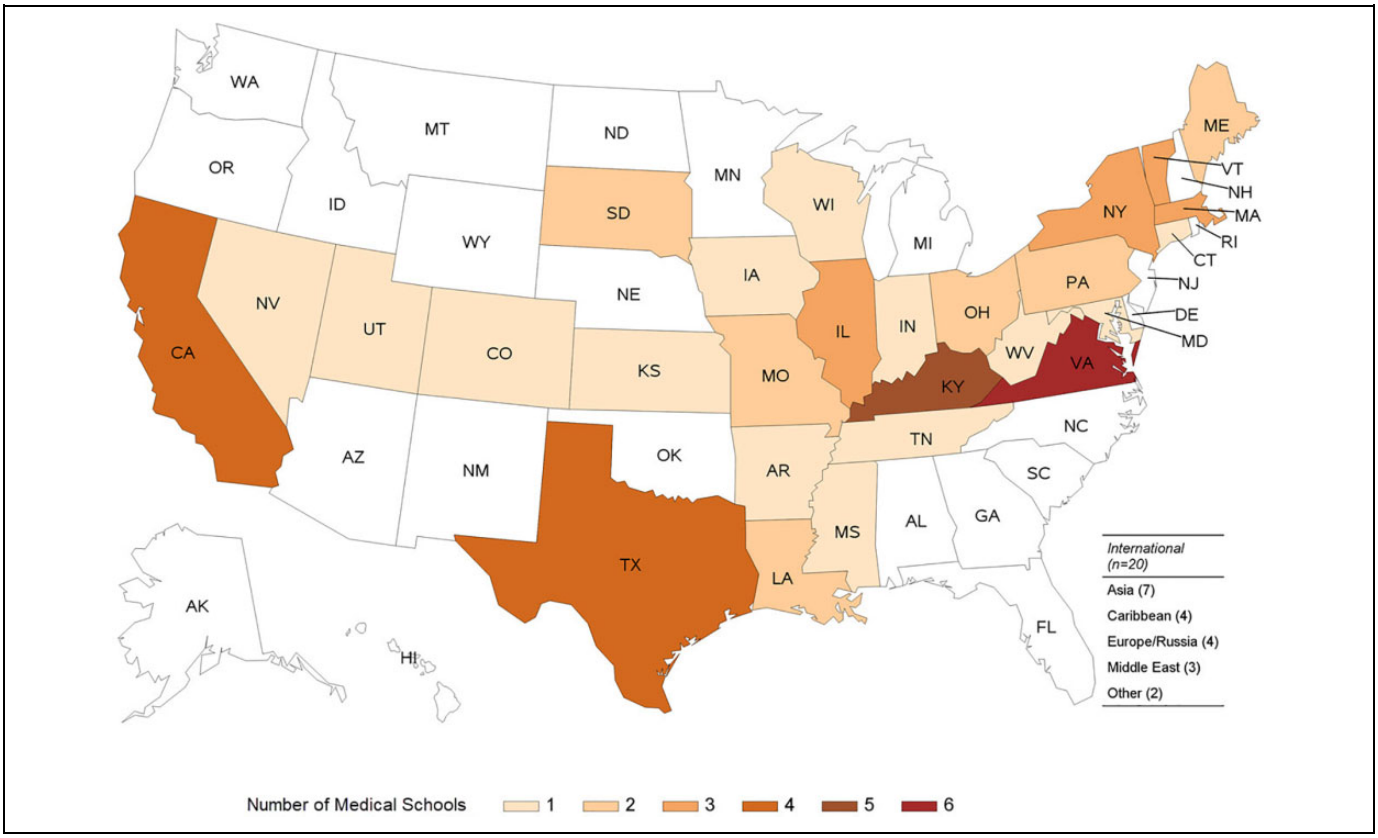

Figure 1. Geographic distribution of medical schools attended by pathology trainees participating in our study (3 participants indicated that they attended medical school in another country but did not specify which medical school. In the numbers reported, we assume that all 3 of these participants attended a different medical school from each other and other study participants. If this assumption is incorrect, then the number of different medical schools represented could be 60 rather than 63.).

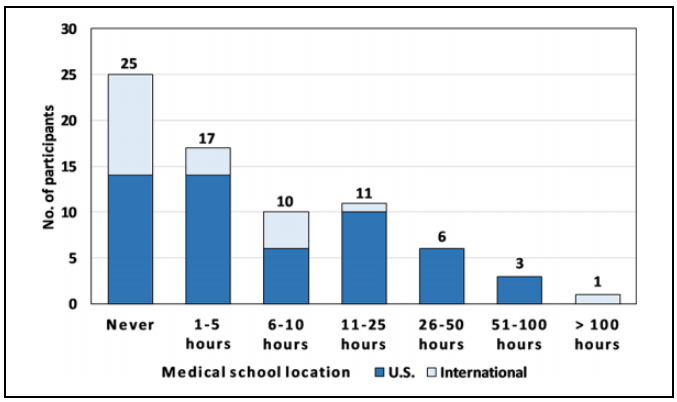

Figure 2. Number of hours spent using digital WSI during training by medical school location (3 trainees with missing data). WSI indicates whole slide image.

Discussion

This study is unique in that it provides an overview of training across numerous medical schools, both in the United States and internationally and it queried pathology trainees shortly after FDA approval for WSI was granted. The data provides insight on exposure to training using digital WSI, including possible increased use in recent years, and it provides perspectives regarding future use among trainees who will begin independent clinical practice in a few years.

The findings indicate that though most respondents reported no or minimal WSI exposure during undergraduate medical education, trainees who entered pathology training in more recent years (2017/2018) reported slightly more exposure, suggesting that exposure to WSI may be increasing in graduate medical education. Further, trainees' predictions regarding whether they will use WSI in their own future practice are especially positive.

Implementing curricular changes in medical education is time-intensive, and accreditation requirements are often primary drivers of curricular change.[19,20] Internationally, the field of pathology and pathology education is shifting toward adoption of virtual microscopy using WSI.[21-23] In addition, histology and microscopic anatomy courses are also transitioning towards incorporating virtual microscopy in their curricula.[24] To understand how the clinical application of this technology will shape the future of clinical medicine, it will be increasingly important to assess incorporation of and proficiency with digital WSIs in undergraduate and graduate medical training programs.

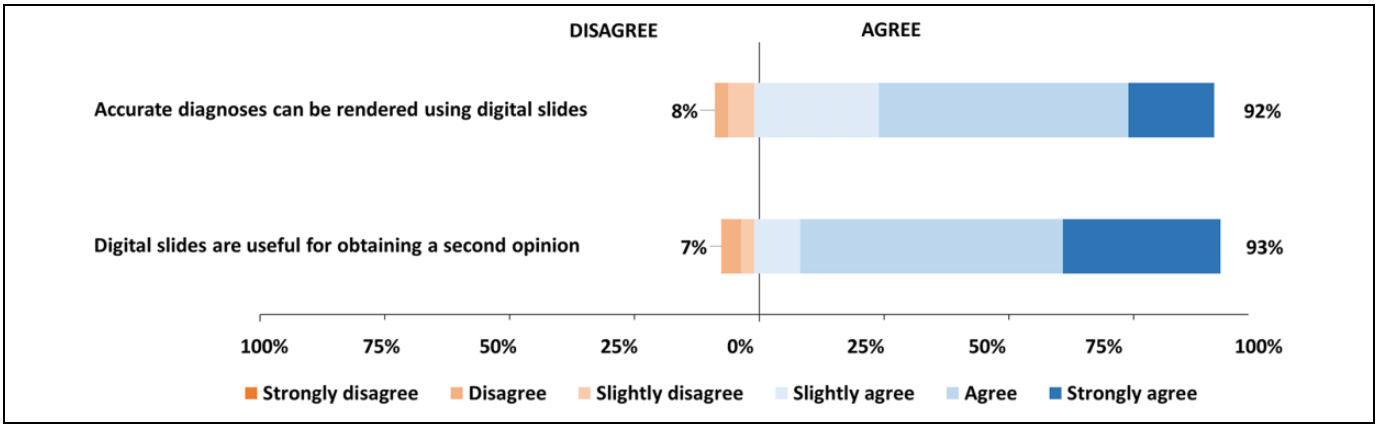

Figure 3. Pathology trainees' response to a Likert scale survey question on the use of digital WSI for primary diagnoses and second opinions. WSI indicates whole slide image.

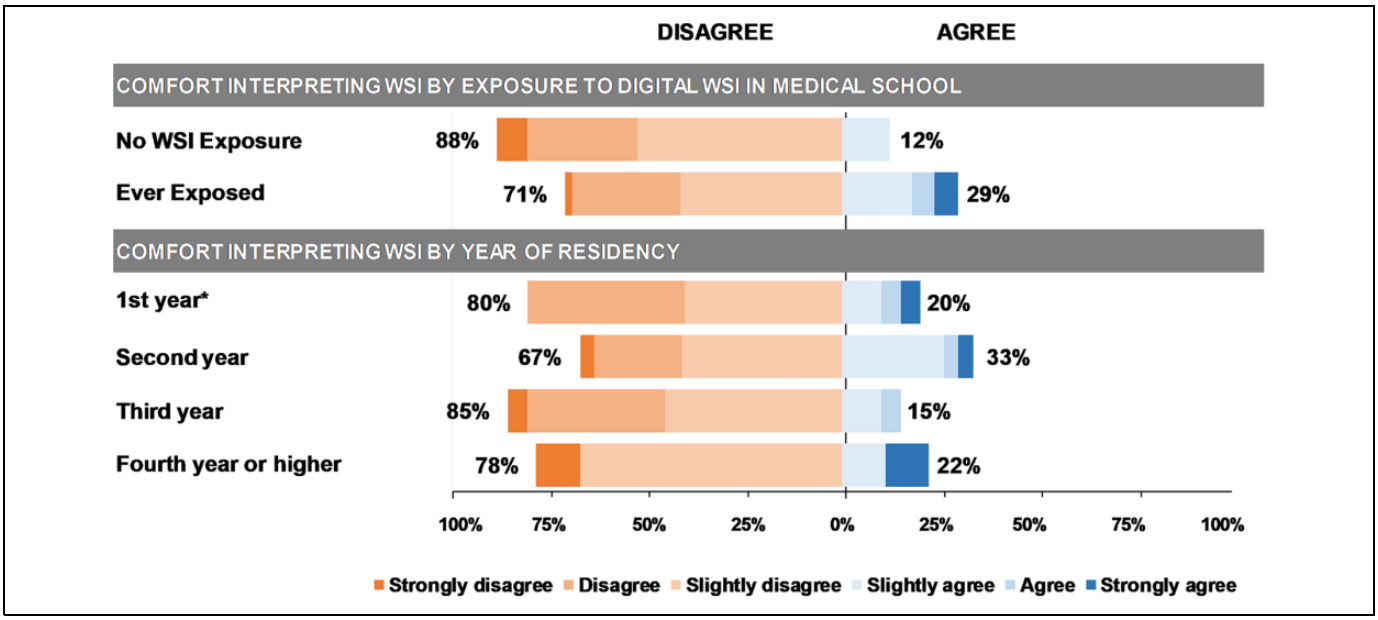

Figure 4. Pathology trainees' response to survey question "I am comfortable interpreting cases using digital slides" by their exposure to digital WSI in medical school and year of training (*includes 1 post-sophomore fellow). WSI indicates whole slide image.

Limitations of the study include that the sample included only 9 pathology residency sites, although more than 50 medical schools were represented. While the response rate of 60% was modest, this was a logistic consequence of the study, which required potential participants to be available during a specific site visit date and as only a limited number of appointments were available on each day, we stopped enrollment once full. A possible selection bias exists as trainees were incentivized by a gift certificate for participating. It is currently unknown whether exposure to WSI during medical education may be higher in those who pursue pathology training versus other career choices. Medical schools also vary in terms of when pathology courses are taught and the level of detail covered (eg, some programs have advanced courses in histology or pathology). We do not know which medical schools offered advanced courses in pathology or which trainees may have taken additional courses or elective rotations in pathology during undergraduate training.

Conclusions

Our findings indicate that although exposure to digital WSIs during training was higher among pathology trainees who began training in recent years (2017-2018), overall exposure to digital WSIs and virtual microscopy is limited to just a few hours for most trainees. The positive attitudes of current pathology trainees toward future use of digital whole slide imaging in their own practices for both primary diagnoses and second opinions highlight the importance of exposure to this technology in training programs if successful integration of WSI into clinical practice is expected.

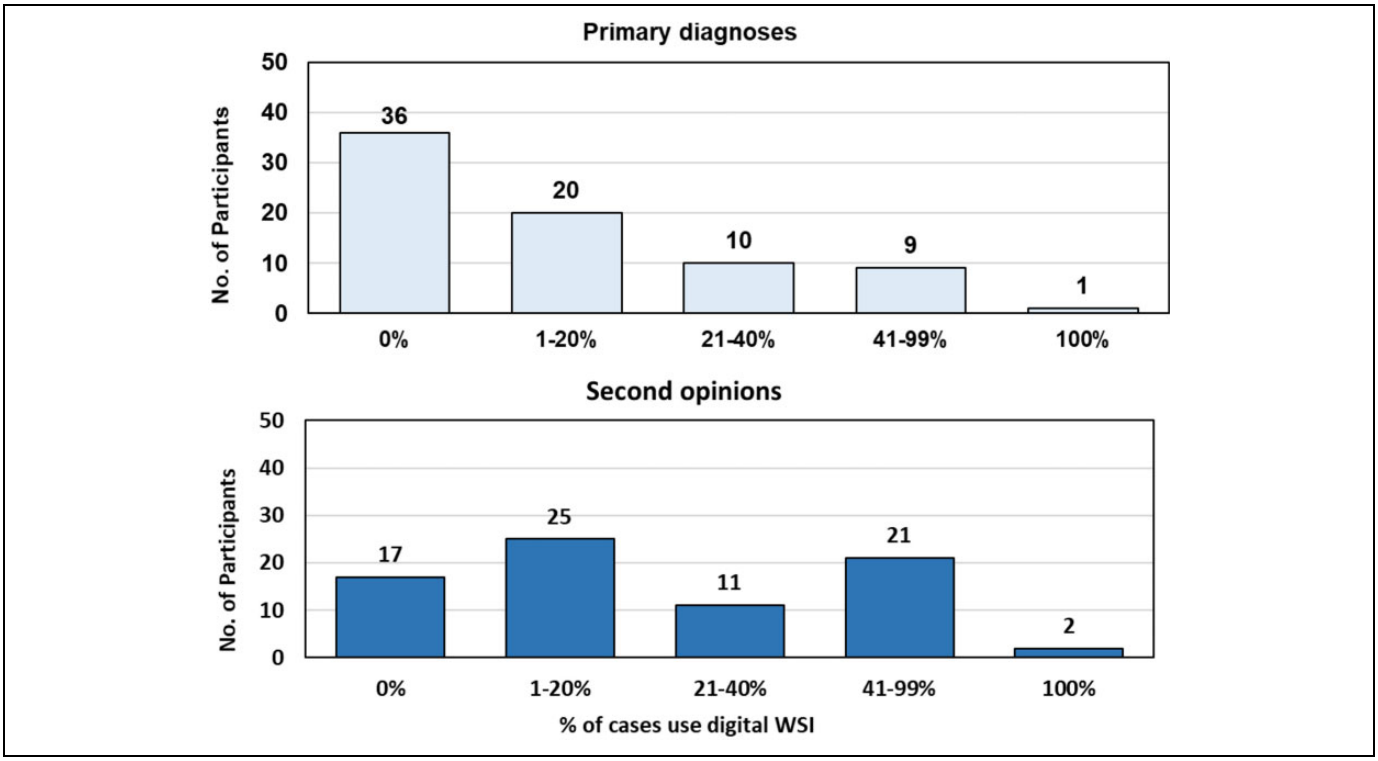

Figure 5. Trainees' predictions on the percentage of cases that will be interpreted using digital whole slide images in their future professional practice for primary diagnoses and second opinions.

Author's Note

Tad T. Brunyé is also affiliated with Center for Applied Brain and Cognitive Sciences, Medford, MA, USA.

Acknowledgments

The authors appreciate the support and involvement of staff and trainees at the various pathology training programs across the United States for their participation and help in this study.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Dr. Elmore serves as Editor in Chief of Adult Primary Care topics at UpToDate.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Research reported in the article was supported by R01 CA225585, U01 CA231782, and R01 CA200690 from the National Cancer Institute of the National Institutes of Health. The funder had no role in the design and conduct of the study.

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Supplemental Material

Supplemental material for this article is available online.

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