Digital Pathology for Consultation in the Military Health System: A Mixed Methods Evaluation of Pathologists' Impressions of Facilitators and Barriers Prior to Implementation

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Abstract

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Challenging pathology case consultations require shipment of irretrievable patient materials to the consultants' location for evaluation. In the military, consultants and generalists span geographically diverse locations. Shipped cases risk being lost, irreparably damaged in transit over extensive distances and diagnostic delays. Digital Pathology (DP) eliminates these risks.

DP implementation efforts in the Military Health System have been unsuccessful, yet an investigation of tri-service pathologists' attitudes towards this innovation has never been performed. Our explanatory mixed methods study used a web-based needs assessment and interviews to understand pathologists' perceived facilitators and barriers to using DP for consultation. We believe that understanding their perceptions is critical if further implementation efforts are to be successful.

Analyses showed that pathologists were receptive to enterprise-wide DP implementation, especially if it improved turnaround time and allowed immediate subspecialist feedback. Future DP implementation efforts may benefit from comprehensive technical support combined with a consolidated DP program office for implementation and sustainment guidance.

Disclaimer

The views expressed are those of the author(s) and do not reflect the official policy of the Department of the Army, the Department of Defense or the U.S. Government.

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1. Introduction

1.1 Digital Pathology in the United States Department of Defense

Transition to new processes in medicine require a catalyst, and support and cooperation from all involved stakeholders. The COVID-19 pandemic provided the catalyst that spearheaded a surge in all specialty telehealth applications, especially in pathology (Rojansky et al., 2023). Due to pandemic mitigation efforts, civilian laboratories explored digital pathology (DP) solutions. They noted increased efficiencies despite staff shortages, that helped them maintain patient care (Lujan et al., 2021). One of the most common applications of DP used was whole slide imaging for expert consultations also known as telepathology. Telepathology is a specialized category of telemedicine, that uses telecommunications to allow the electronic transmission of DP images to a different location. The patient tissue material (preserved on glass slides and blocks) is retained at the originating medical facility, while the digital image can be reviewed for primary diagnosis, second opinions or expert consultations, intraoperative consultations, quality assurance activities, multidisciplinary conferences, research, and education.

The MHS is the largest and most complex military health care delivery operation in the world. The system of over 700 facilities both within and outside of the continental United States (US), provides care to approximately 9.6 million people, comprising military retirees, active service members and their families. Not all facilities have on-site anatomic pathology services since histology laboratories and pathologists are selectively located at various clinics and hospitals in the US and abroad. Most military pathologists are not subspecialized and due to unique military staffing models, have less than 5 years of experience (Ho et al., 2012; Ho et al., 2013). Additionally, perceived civilian pathologist manpower shortages in the US have begun to be reflected in the MHS. Mitigating these challenges requires innovative solutions supported by key stakeholders – pathologists.

Military pathology did not respond to the pandemic in a similar fashion as its civilian counterparts and to date, the Military Health System (MHS) has not incorporated DP into workflows. This is likely due to the lack of DP infrastructure as well as the additional specialized military implementation administrative

requirements. With decreasing numbers of military pathologists, the expansive geographic distribution of treatment facilities and the need to prepare for more efficient future pandemic responses, development of novel digital processes is necessary to maintain delivery of quality healthcare.

Expert subspecialty consultation for challenging cases is a routine practice for Anatomic Pathology (AP) sections. Consultants are readily available in larger civilian practices, as there tends to be a greater number of subspecialty-trained pathologists in the same or nearby locations. Since most AP sections in the military are staffed with general pathologists (not subspecialty trained), this requires that consultations are sent to either external civilian facilities at substantial cost or to the military's pathology reference center, which may be as far as a continent away. Patient slides are packaged and shipped to the consultant's physical location, a risky proposition. DP can eliminate these risks but using whole slide images for diagnosis is a radical departure from the gold standard of viewing tissue on glass.

As early as 2002, researchers from Army hospitals in Washington D.C. and Germany, as well as the Armed Forces Institute of Pathology (AFIP) concluded that DP systems could allow expansive surgical pathology support between distant facilities. They also noted that practicing pathologists seemed reluctant to embrace the technology, offering several factors that may influence non-adoption (Ghosh et al., 2018). In 2013, researchers from the United States (US) Air Force Medical Service (AFMS) identified key processes and requirements for a DP transformation within the Air Force, but implementation efforts were also unsuccessful (Ho et al., 2013). It seems that although DP has a long and fitful history in Army and Air Force pathology departments, consistent and continuous engagement remains elusive, while to date, no published literature is available on United States (US) Navy experiences with DP. There are no existing digital slide workflows in any of the branch of services. A DP needs assessment of all-service and civilian MHS pathologists has never been performed, therefore a gap remains in understanding the factors behind the unsuccessful adoption of DP.

1.2 Aims

While interest in completely digital anatomic pathology workflows has grown worldwide, telepathology for consultation is one of the most widely utilized applications of DP in the civilian sector (Chen et al., 2014; Fragetta et al., 2021). The Joint Pathology Center, the primary AP reference laboratory for the Department of Defense (DoD), will begin offering digital consultations within the MHS. This is a critical first step in reintroducing DP to the MHS. The objective of our project is to understand pathologists' perception of the barriers to and facilitators of DP for consultation prior to implementation. We believe investigating the factors that affect pathologist adoption of telepathology could lead to implementation strategies that increase chances of successful adoption of the new consultative workflows and may be applicable to implementation of other DP workflows (Gohari et al., 2016; Hanna et al., 2020).

1.2.1 Specific Aims

AIM 1: Identify and understand military pathologists' perceived barriers and facilitators to the use of telepathology for consultation prior to implementation. We performed a voluntary web-based survey and optional web-based interview of all active duty and civilian pathologists in the MHS. We sought to identify individual and organizational supports and barriers to pathologist acceptance of telepathology consultation workflows as well as the factors related to the individual pathologist that affect interest and acceptance.

AIM 2: Identify targeted strategies to support future implementation efforts. We used the qualitative method, thematic analysis, from interviews and open-ended survey questions. We then combined it with quantitative analysis of Likert scale survey questions. We anticipated that this mixed method strategy would help us stratify pathologists' impressions of organizational barriers and facilitators to highlight previously unrecognized priorities and inform future digital consultation pilot study design.

1.3 Significance

The Army, Navy and Air Force missed overall recruiting goals for at least two consecutive years. In 2023, enlisted recruiting goals in those three branches fell short by between 11% to 45% (Novelly et al., 2023). The Army, the largest branch of service, will likely struggle to meet its 2024 recruitment goal of 55,000 active-duty and 60,000 reserve component soldiers. The Navy forecasted as much as a 50% recruiting gap in fiscal year 2024 (Garamone, 2023). Medical professionals are even harder to recruit due to factors such as pay disparities between the military and the civilian sector. A recent study on military medical student well being showed that about two thirds of students stratified to the low to moderate well-being category, indicating a higher risk of burnout and leaving the military (Ma et al., 2023). Decreased recruitment and retention have led to several medical specialties (including pathology) equilibrating at their lowest numbers. The MHS must find innovative ways to continue to provide high quality healthcare. Stakeholder engagement is key in implementation and sustainment of any proposed changes to legacy workflows. In pathology, consultation to the Joint Pathology Center (JPC) is agnostic to branch of service and represents a common workflow that is easily adaptable to an innovation such as DP (Haghighi et al., 2021).

As far as we know, our study was the first to explore MHS pathologists' perceptions of using DP as well as understanding sustainability concerns. We believe that future attempts at implementation have a greater chance of success if supports are identified and maximized, and solutions to perceived barriers are prioritized as part of the overall sustainment strategy (Griffin &Treanor, 2017). Opportunities for additional feedback via the optional web-based interview, may further empower pathologists by allowing them to include factors not addressed in the survey. Data generated from our assessment could be used to influence transitions to other DP applications and to encourage increased organizational support.

2. Background and Literature Review

The MHS has not developed a coordinated DP infrastructure, despite earlier forays into telepathology. While there may be other contributing factors to the lack of complete adoption, studies have suggested that understanding the key stakeholders' perceived barriers and facilitators are necessary for successful implementation (Bauer & Kirchner, 2020; Ho et al., 2013).

2.1 Historical perspectives on Telepathology

The military and Veterans Administration and were early adopters of telepathology in the United States (US). The Armed Forces Institute of Pathology (AFIP) provided a frozen section consultation service within the US Army Medical Department. They used static images initially, followed by dynamic images created by a robotic microscope for diagnosis. By 2000 the first whole slide imagers (WSI) became available. Telepathology and DP (the technology behind telepathology) began to be used interchangeably. In 2002, studies for the AFIP workflow validated the diagnostic accuracy of the process (Kaplan et al., 2002). In 2013, the US Air Force Medical Service (AFMS) used contextual inquiry to identify best practices for implementation of a complete DP workflow. This was the first and only documented attempt to formally evaluate stakeholder attitudes towards the emerging technology. They recommended initial assessments of current workflows, pathologist needs, organizational needs and infrastructure prior to implementation of digital systems (Ho et al., 2013). Limitations of this study included focus on only one branch of military pathologists and the relatively small sample size of less than 50% of total Air Force pathologists included in the study. Despite this, they were able to identify consultation workflows as one of the select areas of pathology that would most benefit from transition to DP.

2.2 Pathology Consultation – A Common Practice

Consultation is the practice of requesting second opinions/review on unusual or challenging cases by a referring pathologist to a consultant (subspecialist) pathologist. Intradepartmental and extradepartmental consultations are part of routine practice in AP. These consultations increase the diagnostic accuracy of reports, improving patient care (Shinohara et al., 2022; Peck et al., 2018). Intradepartmental consultations have a relatively simple workflow captured within the pathology department. Extradepartmental consultations involve review of the primary diagnosis or diagnostic differential diagnosis by a remote expert pathologist. This requires packaging, shipping, and tracking irretrievable patient material to the consultant pathologist. When slides are lost or broken, this can delay or impede diagnosis, leading to increased morbidity and increased cost on the health system. The frequency of consultations will likely increase as senior and subspecialty trained pathologists continue to leave the military with fewer replacements.

All pathology departments in the military have policies regarding mandatory secondary review of slides either as a part of their quality assurance program when patients seek clinical second opinions at a different institution or when internal consultations differ. Studies encourage consultation to ensure that patient clinical care decision are accurate. A retrospective second review of over 4000 cases in 2018 showed that 3.7% had major discordance (a substantial difference in histologic type) and 1% had a major discordance resulting in a change of clinical management such as modification in surgery or drug treatment (a serious diagnostic error). The authors recommended additional review of challenging cases (Farooq et al., 2021). Although this was a single tertiary institution study, the large sample size and diversity/complexity of cases support their findings. In another study, DP showed reliability and diagnostic accuracy when used for consultation as shown by a systematic review of 13,996 cases aggregated over 56 telepathology studies. Diagnostic concordance of 96.9% as compared to light microscopy review, supported non-inferiority of digital methods. Limitations of this study were based on the diversity of the studies, with many lacking specific inclusion and exclusion criteria and non-standard preanalytical variables (Dietz et al., 2020).

2.3 Needs Assessment Prior to Implementation is Recommended

Assessment prior to implementation of new technologies or workflows can show unexpected support and can identify significant issues to address during implementation. In 2019, Southern Denmark embarked on implementation of DP for several reasons: 1. Continuity of pathology services, 2. Digitization to increase data sharing and 3. To maintain a high level of reliability. Prior to implementation they measured expectations and readiness of all pathology professional groups (pathologists, laboratory technicians, secretaries and managers) throughout the four regional pathology departments (Mikkelson et al., 2022). They used semi-structured interviews based on the McKinsey's 7-s framework. They also used a questionnaire survey based on topics identified in the interviews which included parts of the normalization measure development questionnaire (NoMAD), and workflow observations at a single department. Authors found that staff were generally positive and motivated for implementation. They did express concern about resource allocation. Employees were pleased to be included in the planning process and acknowledged the benefits of implementing DP. As a result, regional leadership was optimistic about the success of implementation. Use of validated tools strengthened the results of this study, though English to Danish translation may have been challenging. Additional bias included small sample size of some groups (secretaries) and that all employees knew that implementation was imminent regardless of their responses.

Gohari et al. were able to identify the most common tissue type sent for digital consultation using a questionnaire distributed to 16 pathologists in the largest province in Iran. Their cross-sectional study identified the need for consultation in 7.5% of the cases. They recognized that certain types of tissue (in their study – bone and soft tissue) were most likely to need consultation and they recommended performing needs assessments to design digital consultative services. The small sample size was a significant limitation in this study as well as the homogeneity of the pathology practice. Their findings, however, reinforced similar recommendations for needs assessments.

Evaluation of the success of a telepathology system in Kuwait's government hospitals supported exploration of pathologists' perspectives. Buabbas et al. (2021) used a sequential explanatory mixed methods design comprising a questionnaire, followed by a semi-structured interview developed to discuss

the quantitative findings in the survey. They found that although most participants were satisfied with the system's quality, they were dissatisfied with the technical support and information quality. Demographics seemed to be significantly associated with some of these findings. Specifically, authors found that the more telepathology experience a pathologist had, the more satisfied they were with the information quality. Although the authors do not formally define information quality, we believe information quality included both image quality and manipulation. They also found end user engagement was key for success and advocated evaluation of attitudes before and after implementation. While this study focused on post-implementation attitudes, the association between demographics and pathologists' satisfaction helped guide the selection of some of our survey questions.

The literature review demonstrated the importance of consultation as part of standard pathology practice, the utility of using DP to perform consultations and the importance of a needs assessment of stakeholders to guide implementation. Prior to implementation of such a substantial change to the diagnostic process, we believe that it is critical to consider pathologists viewpoints and evaluate their willingness to support the transition to digital consultations (Gozali et al., 2017). Ho et al. (2013) used contextual inquiry to map Air Force AP workflows at four locations to identify areas that could be supported by DP. While we considered contextual inquiry methods, this method is labor intensive and not feasible for our needs. As our investigation encompasses all branches of services worldwide, we felt web-based surveys and interviews would best capture our participant pool.

3. Methods

3.1 Mixed Methods Study Design

This study used an explanatory, sequential, mixed-method approach to explore active duty and civilian Army, Navy and Air Force pathologists' perceived barriers and facilitators to using DP for extradepartmental consultation. This involved deploying a cross-sectional, voluntary, anonymous, needs assessment survey to all active duty and civilian MHS pathologists. The survey was completed on

computer or mobile devices. Pathologists were given the option to participate in an optional interview following the survey period. The combination of web-based needs assessment surveys and interviews was chosen due to the expansive geographical distribution of participants and the ability to gain a more comprehensive understanding of their perspectives. Descriptive statistics were used to describe participant demographics. Data were analyzed with the assistance of a biostatistician. Interview data were evaluated manually using reflexive thematic analysis.

To our knowledge, a needs assessment or interview of all active-duty and civilian pathologists has never been performed. This study addressed that gap and adds to the body of knowledge by evaluating how or if the unique military pathology practice influences perceptions and attitudes towards DP for consultation. The research team comprised a pathologist, a clinical scientist and a biostatistician. We chose a mixed methods approach as we felt that the quantitative data would help stratify perceived barriers and facilitators, while the qualitative approach would help frame these perceptions and create more substantive implementation recommendations. Data derived from this study will be used to inform the design of a subsequent multi-site DP pilot.

The survey was developed based on topics identified through a literature review and discussion with various military pathologists. The literature search was performed using PubMed with search terms “digital pathology” AND “implementation, “whole slide imaging” AND “implementation”, “telepathology” AND “implementation, “digital pathology” AND “needs assessment” and “telepathology AND success”. Based on the literature, questions identifying the participants’ characteristics were included in the survey, such as branch of service, experience level and subspecialty training. The survey comprised both open-ended and Likert scale questions.

Interview questions were designed to expand upon answers given in the survey.

3.2 Recruitment and Sampling

Using non-probability convenience sampling, pathologists were invited to participate in the needs assessment survey via an introductory email containing a QR code and link to the survey. All currently

practicing active-duty and government-employed civilian pathologists were included. **Table 1**. shows the number and status of all pathologists (practicing and non-practicing) in the MHS. Practice status was determined through discussion with pathology specialty leaders/consultants. Although government contract pathologists were excluded, their absence from the survey would not have had a significant effect on the study findings due to their small sample size.

Table 1.

Military Health System (MHS) Pathologists by Branch of Service and Status During Survey Period (Includes non-respondents)

Pathologist Status	**Army**	**Air Force**	**Navy**	**Total**
Active-duty Residents/Fellows	10	12	11	33
Active-duty staff	87	55	34	176
Civilian staff	9	0	1	10
Contractor staff	1	0	0	1
Total	107	67	46	220

3.3 Data Collection Method - Survey

Pathology specialty leaders from each branch of service provided updated email addresses of potential respondents. The survey was available on computers and mobile devices. Pathologists interested in participating in the optional interview were instructed to contact the primary investigator for scheduling. Although a recent best practice recommendation advocates multidisciplinary involvement in a laboratory digital transformation (administrative staff, technicians, pathologists and hospital information technology services), we felt that because of the focused use of DP in this study, we would focus our evaluation on the driver of consultations – the pathologists (Fraggetta et al., 2021).

We obtained survey approval from the Defense Health Agency (DHA) Survey Program Office/Information Management Control Office (IMCO) (Survey Exempt Number: DHA-1090-E). Madigan Army Medical Center's Human Research Protections Office determined our study to be "Not Human Research" (Protocol Number 223068). University of Washington's Human Subject Division reached the

same determination (STUDY00018492). The DHA Survey Exempt Number was displayed in the footer area on the survey instrument and related survey materials, in the following format: “DHA Survey Exempt Number: DHA-1090-E.”

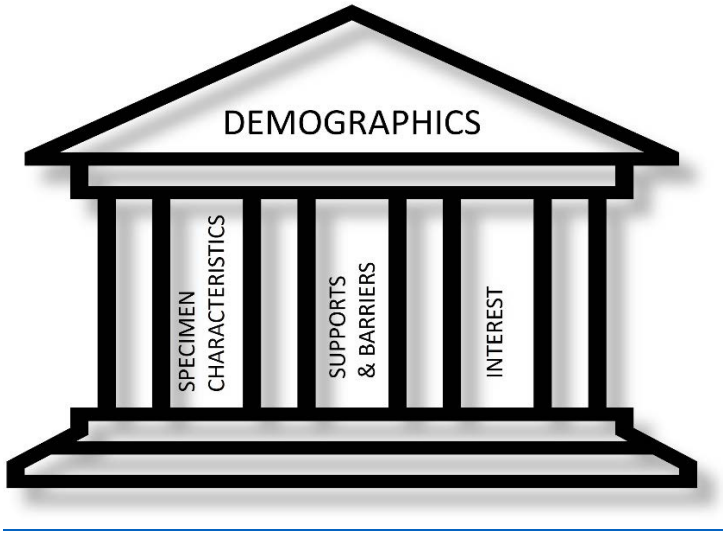
Pathologists received the survey via work e-mail addresses on 10 September 2023. The survey was available for four weeks. Reminder emails were sent at two weeks and again at two days before the deadline. The survey was voluntary and completion implied consent.

Researchers piloted the survey among five active-duty and one civilian pathologist to evaluate content and grammatical accuracy. Pathologists received verbal instructions and were emailed the link and QR code to complete the survey via Qualtrics© [November 2023], (Qualtrics, Provo, UT). Typographical errors were corrected and additional open-ended questions were added based on discussion feedback.

The final survey consisted of 18 questions separated into 4 sections. Section 1 (Q1- Q5) investigated most common specimen types currently sent and anticipated to be sent for consultation. Section 2 (Q6-Q8) investigated interest in using DP for consultation as well as other applications. Section 3 (Q9-Q12) explored barriers and supports to using DP for consultation. Section 4 (Q13-Q17) included demographics such as branch of service and level of experience (Hanna et al., 2020) **(Figure 1).** The last question (Q18) invited participation in the optional web-based interview. A copy of the survey is included in **Appendix A.**

Figure 1.

Needs Assessment Survey Design



3.4 Data Collection Method - Interviews

A pilot interview evaluated the feasibility of scheduling interviews on a shared investigator calendar and helped understand the limitations of the Microsoft Teams transcription feature. No changes were made to the interview questions. Semi-structured interviews administered via audio on Microsoft Teams, were available between 06 - 30 November 2023 and were conducted by at least two researchers (a practicing general pathologist and either an investigator with prior laboratory experience or a biostatistician with interest in technology innovation). The pathologist conducted all interviews. During the interviews, the other researchers served mainly as note takers and to ensure functionality of the Microsoft Teams transcribe feature. Interviews lasted approximately 20 minutes and were not recorded but were transcribed to encourage participation. All interviewers/researchers were able to ask participants to expand on responses. Follow-up questions were limited to maintain a uniform participant experience. Request to participate in the interview implied consent. Additionally, participants were given the opportunity to discontinue the interview at any time. Anonymity and confidentiality were protected. We aimed to conduct a minimum of six interviews to adequately analyze the data as recommended by Braun & Clarke (2019). A copy of the introductory email, follow-up email and telephone interview questions are included in **Appendices B - G.**

3.5 Data Analysis – Survey

The interview and survey data were stored on a secure, shared drive at Madigan Army Medical Center intended for research data and accessible only to this study's researchers. Interview participants' identifying information were redacted. Since the pathology community is small, we minimized use of direct quotes to maintain anonymity. Sample size was calculated using the Steven K. Thompson formula, with a 95% CI and an alpha of 0.05. The data from the survey were collected and exported using Qualtrics© [November 2023], (Qualtrics, Provo, UT).

Fisher's exact test was used to identify associations between demographic variables and all other categorical variables. Interest in telepathology was measured on an ordinal scale of 5 (Not interested – Very interested) and compared using the Kruskal-Wallis test. To evaluate differences between specific groups, the Dunn test was performed followed by the Bonferroni p-value adjustment. All analyses were performed and plots generated using R Statistical Software (v4.0.2 R Core Team 2020).

This study was powered to evaluate differences in provider interest based on demographics. To perform power analyses for the Kruskal-Wallis test and Fisher's exact test, we determined the minimum sample size required to detect a significant difference among groups with a given level of power (80%) and significance level (5%). Assuming equal sample sizes between the groups our sample sizes for each question varied if groups differed.

The output for an equal groups Fisher's exact test which was used for the minimum number of respondents showed that the power of the test was approximately 0.81 for a two-sided test at the 0.05 significance level. This means that if there was indeed a moderate effect size ($\eta^2 = 0.10$) in the population, we would have an 81% chance of detecting a significant difference among the three groups with the given sample sizes and significance level.

Open-ended survey questions were analyzed using reflexive thematic analysis methods as described below for interview data and assisted by NVivo 14 for additional data visualizations.

3.6 Data Analysis – Interviews

Constructivism is a philosophical theory based on the thought that individuals' realities are subjective interpretations based on internal and external influences. We were cognizant that knowledge gained during our research would be created at the intersection of both the participants' lived military experiences and the researchers' interpretations of their narrations. Therefore, we chose a constructivist paradigm for our reflexive thematic data analysis (RTA) as it best incorporated both the researchers' subjective interpretations, and the respondents' unique characteristics and experiences that influenced their perceptions of supports and hindrances. The coders' diverse backgrounds were viewed as advantageous due to promotion of varied contextual understanding of the data.

We performed RTA of qualitative data from the interviews based on the Braun and Clarke (2012) six phases as shown in **Table 2**. This was an iterative process with some phases being revisited as researchers were immersed in the data. All researchers acted as coders, and reviewed all interview transcripts and notes regardless of whether they participated in the interview or not. Neither a structured codebook, attempted consensus nor use of predetermined themes were used because unlike coding reliability and codebook approaches, their use is discouraged in RTA. Instead, latent (hidden) and semantic (explicit) coding were employed with the expectation that each coder would identify unique codes. We also chose not to use NVivo for interview data analysis as we felt that manual engagement would lead to increased reflexivity, better familiarization and thicker descriptions.

Researchers familiarized themselves with the transcripts and notes taken during the interviews, then generated initial codes independently. Since the principal researcher was a pathologist, independent familiarization and initial code generation was encouraged to reduce this researcher's potential influence on data interpretation by the other researchers. After independent codes were developed, researchers then collated codes by collaborative interpretation based on data familiarity (Byrne, 2022). All three researchers met regularly to review and refine codes, and to promote reflexivity. All transcripts were then

iteratively re-analyzed using the combined codes, oriented around common characteristics. All coding was performed in Microsoft Word. Final codes were combined in Microsoft Excel. In RTA, data saturation is not used to signal code completion. Rather, coding was considered complete when all coders were satisfied with the quality and relevance of their codes in relation to research aims. Themes and subthemes were developed and refined through regular communication between researchers. Identified themes were able to stand on their own in relation to the research aims and frequency of identified concepts were not considered as surrogate for importance (Braun & Clarke, 2019). Though we minimized quotes for privacy reasons, the quotes we included were coded into subcategories using Excel to allow comparisons across groups.

Data from the survey and interviews were analyzed and integrated as shown in **Figure 2.** They will be shared with participants on conclusion of the study.

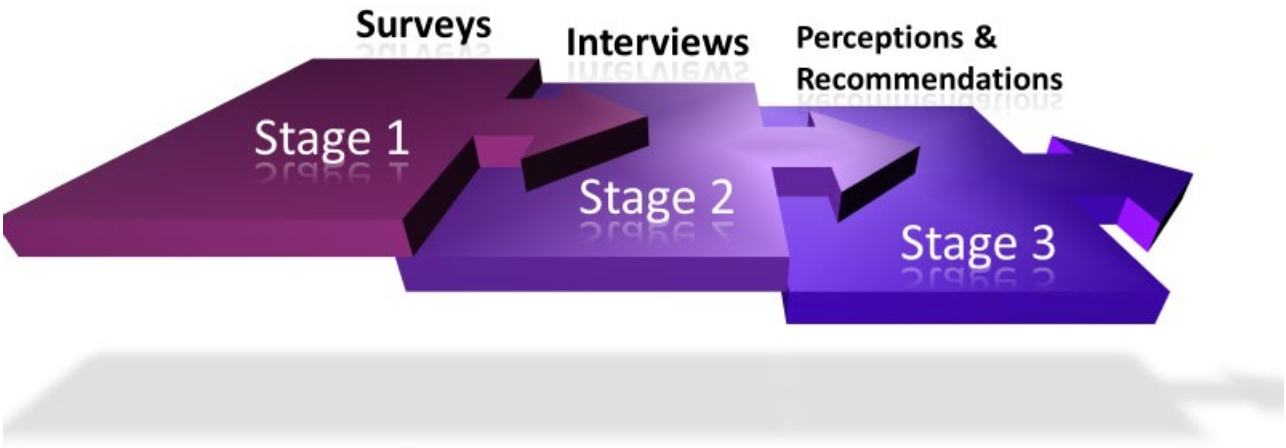
Table 2.

The Six Phases of Thematic Analysis

Phases of Analysis	**Coder Activities**
1. Data familiarization	Multiple readings of interview notes and interviewers' perceptions were performed.
2. Generating initial codes	Coding was conducted in Microsoft Word using the "comment" function. Coders tracked the evolution of codes with each iteration of data review. Evolving codes were discussed at predetermined intervals. Final codes were combined in Microsoft Excel.
3. Developing themes	All coders were involved in creating potential themes using assembled codes that derived meaning across the data.
4. Reviewing potential themes	Themes and subthemes were refined collaboratively.
5. Defining and naming theme	Themes and subthemes represented the data.
6. Reporting	The final report was generated and discussed.

Figure 2.

Survey and Interview Data Integration



4. Results

4.1 Results - Survey

Our survey aimed to identify the perceived barriers and facilitators to using DP for consultation, gauge levels of interest, garner implementation recommendations and understand if or how demographic characteristics proved influential. A sample size of 88 respondents was recommended by the Steven K. Thompson calculation. 189 of a total of 220 pathologists were identified as currently in practice. Of the 189 surveys distributed, 106 were sent to Army pathologists, 67 to Air Force pathologists, 46 to Navy pathologists and 10 to civilian pathologists. Overall, 93 surveys were completed and 13 were partially completed for a total response rate of 56%. By branch of service (respondents and non-respondents), Air

Force pathologists had the largest response rate (52%; N=35) followed by the Navy (43%; N=20), then the Army (34%; N=36). The civilian response rate was 20% (N=2).

The denominator in the calculations below varied because not all participants answered every question. Overall, we found that demographic characteristics' effect on pathologists' perceptions, interests or recommendations did not reach statistical significance.

93 respondents identified their branch of service. Most were from either the Army (39%; N=36) or the Air Force (38%; N=35), had five or fewer years of pathology experience (48%; N=45), were not subspeciality trained (60%; N=55), had five or fewer years of DP experience (84%; N=78) and did not hold leadership roles in pathology (55%; N=51). Only 6% (N=5) of respondents were trainees (residents or fellows). The demographic characteristics of the respondents are shown in **Table 3.**

Table 3.

Respondent Demographics by Branch of Service and Department Role

	Resident	**Fellow**	**Staff**	**Section Director**	**Chief**	**Total**
Air Force	0	0	19	9	7	35
Army	3	1	15	6	10	35
Navy	2	0	11	2	5	20
Civilian	0	0	0	1	1	2
Total	5	1	45	18	23	92

1 Army respondent did not indicate their role.

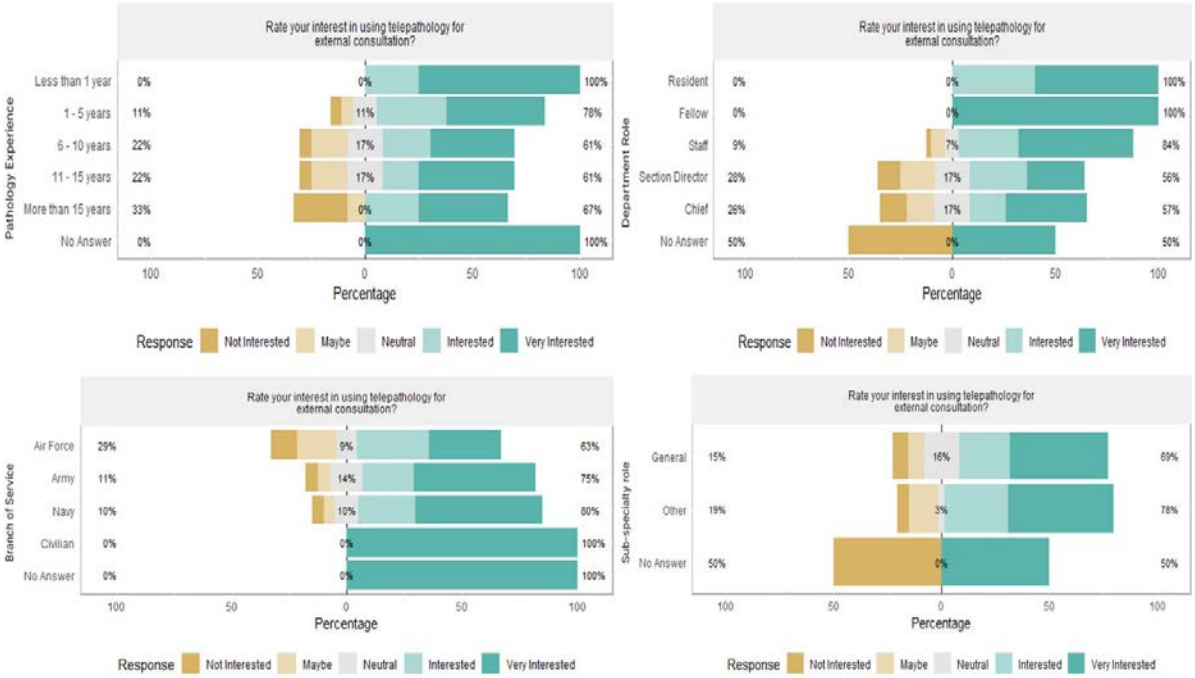
Pathologists were asked what percentage of their consult cases were sent to other institutions. The median reported distributions were: the JPC (71%); 20% were sent to other Military Treatment Facilities (MTFs) and the remining were split between regional hospitals (10%), Mayo Clinic (9%) and other facilities (9%). Most pathologists (56%; N=53) submit approximately 1-5 cases per month commonly comprising dermatopathology, hematopathology, gastrointestinal/liver/pancreas and breast cases. Less frequent case types include gynecologic pathology, genitourinary pathology, pulmonary pathology, neuropathology and cardiac pathology. Respondents indicated that the turnaround time for most consult cases was greater than 5 days (56%; N=53) followed by 4-5 days (37%; N=35).

Although DP for consultation is not a currently available service, 73% (N=68) of respondents indicated interest in using digital methods if made available with Navy pathologists showing the highest proportion of interest (80%; N=16) as compared to Army (75%; N=27) and Air Force (63%; N=22) **(Figure 3)**. 53% (N=49) of all respondents saw telepathology as a very useful tool and 33% (N=31) saw it as a somewhat useful tool. While our study was focused on consultative service, there was strong interest in using DP for education (88%; N=75), multidisciplinary tumor boards (63%; N=54) and intraoperative consultation support (17%). Additional uses included clinical collaboration outside of pathology, primary diagnosis and research. Most pathologists (58%; N=54) were very interested to interested in participating in future telepathology pilots as a submitting location while 18% (N=17) were not.

Most pathologists did not have significant prior telepathology experience. 56% (N=52) had less than one year of experience and 27% (N=27) had one to five years of digital pathology. Those that indicated prior digital experience were primarily exposed to digital slides for educational purposes only.

Figure 3.

Interest in Using Digital Pathology for Consultation



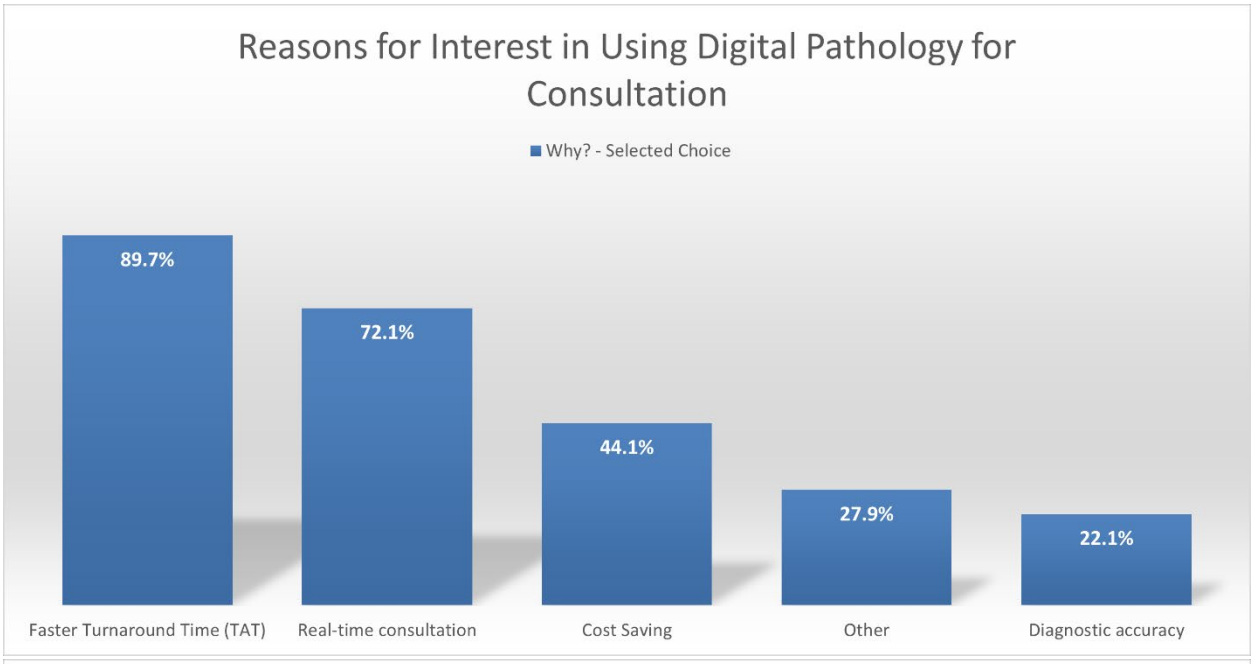
The most cited perceived barrier to use was technical/IT challenges (89%; N=23) followed by the impression that the process was time consuming (35%; N=9). The main perceived facilitators were the ability to have faster turnaround times (90%; N=61) and real-time consultations (72%; N=49). Concern for diagnostic accuracy was the least influential factor (22%; N=15) on pathologists' perception of facilitators as shown (**Figure 4) (Appendix H).**

Free text data from the survey was visualized using NVivo (Version 14) to understand which of the perceived barriers and facilitators were most important to pathologists. Network/IT challenges was identified as the most important barrier and the word tree **(Figure 5)** shows the context in which respondents described their concerns.

Although improved TAT was most frequently chosen as a facilitator, real-time consultations was equally considered as an important factor affecting interest. The word cloud highlights similar frequency of TAT (turnaround) and real time consultation **(Figure 6).**

Figure 4.

Factors Influencing Interest in Using Digital Pathology for Consultation



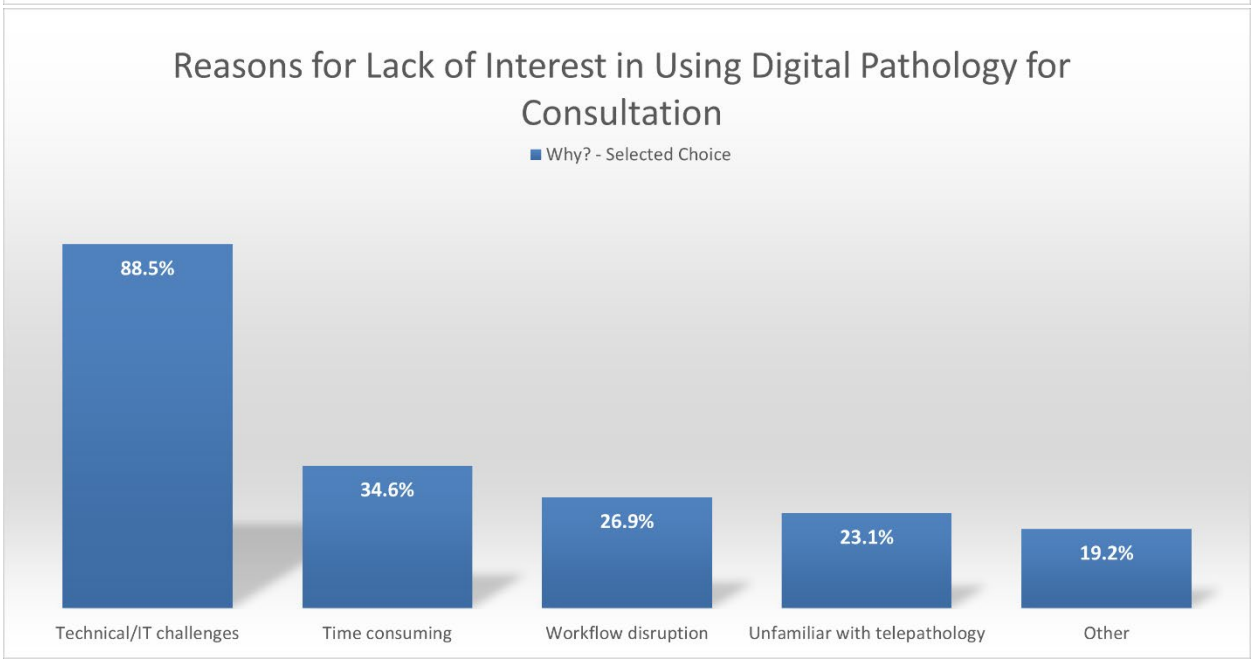


Figure 5.

Survey Word Tree Visualizing "Network/IT" in Context of Lack of Interest (Barriers) in Digital Consultation

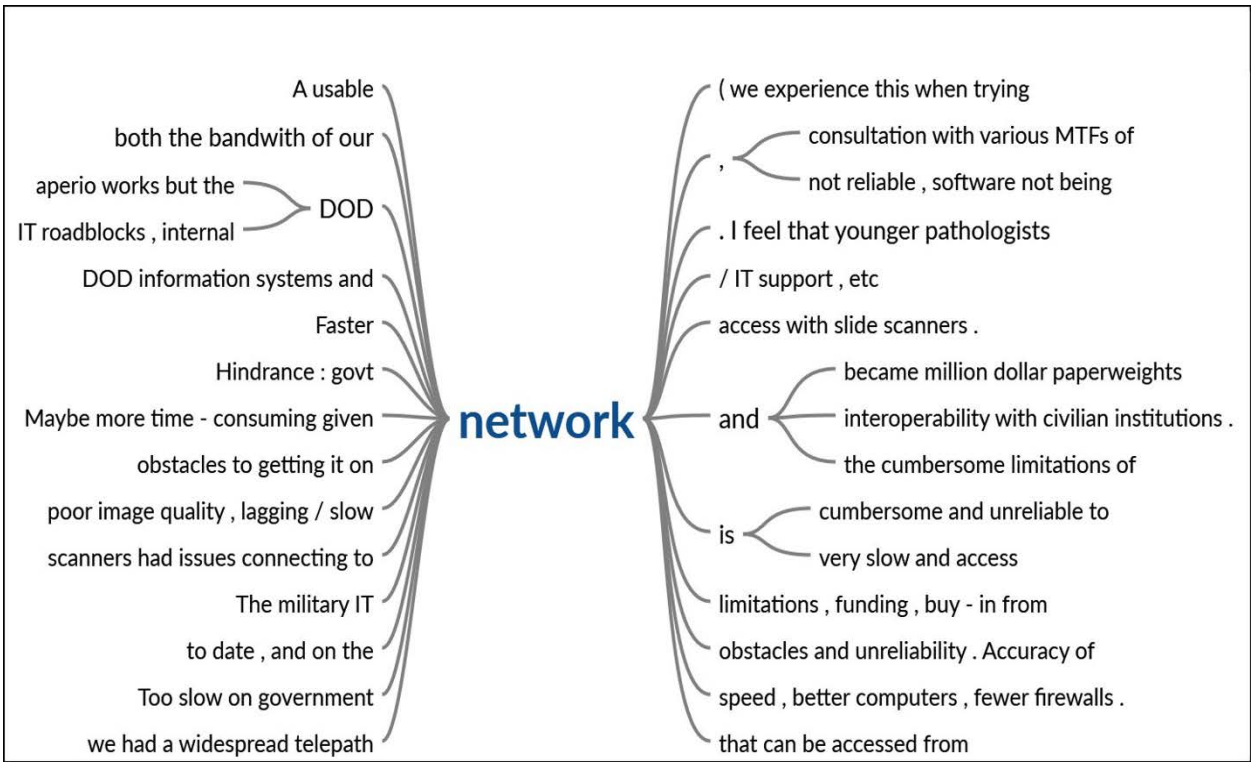


Figure 6.

Survey Word Cloud Visualizing Hierarchy of Perceptions Related to Interest (Facilitators) in Digital Consultation

4.2 Results - Interviews

32 respondents (30% of respondents) expressed interest in participating in an interview. 17 respondents completed the interviews, with one respondent requiring two interview time periods. Each interview lasted approximately 20 minutes (ranging from 15-60 minutes). Army pathologists comprised 41% (n=7) of the interviewees while the Air Force and Navy were each 30% (n=5). Most of the respondents were staff pathologists (82%; n=14) and the rest were residents/fellows (18%; n=3). Of the staff pathologists, 57% (n=8) were generalists and the others were subspecialists (43%; n=6). Thematic analysis revealed central components encompassing barriers, facilitators, implementation suggestions and overall impressions.

Table 4.

Summary of Themes and Subthemes Associated with Research Aims

Research Aims	Themes	Theme Description	Subthemes
Perceived Barriers to using digital pathology for consultation	Impressions of Lack of Support	A generalized absence of support at multiple levels, all critical to success of new initiatives and current operations	▪ Information Management Division (IMD) concerns and Support ▪ Lack of Institutional Support including cost/funding ▪ Resistance to change - Lack of Peer Support ▪ Specific Imager Attributes
Perceived Facilitators to using digital pathology for consultation	The Important Role of Communication	Coordinated education, training, guidance and access to subspecialists across all services and facilities	▪ Education/Training/Communication ▪ Telepathology Program and Implementation Support ▪ Understanding established Telepathology advantages
Concerns or suggestions related to implementation	Strong Desire for Standardization, Integration and System Design	Policies, procedures, equipment and defined expectations	▪ Standardization ▪ Anatomic Pathology Laboratory Information System (APLIS), EHR Integration and Deliberate System design
Overall Impressions	Feelings of Cautious Optimism	Largely positive sentiment but equal concern that barriers are too extensive to overcome.	▪ Positive Sentiments ▪ Addressing gaps with post pilot planning

4.2.1 Theme 1 – Impressions of Lack of Support (Barriers to use of Digital Pathology)

Theme 1 – Subtheme 1 - Information Management Division (IMD) Concerns and Support: DP relies strongly on information technologies to include the hardware, software, storage and imagers necessary to digitize slides, share and manipulate their images. A significant concern for many respondents related to ongoing issues with network latency and low bandwidth resulting in decreased system performance.

i. *"[…] biggest fear for digital pathology in general, it's like (a) latency while moving around the slide. I think (it is) a major factor that will hold people back even beyond whatever resolution or image quality you get."*

ii. *"[…] my experience on the military network so far compared to my network at home is miles different for looking at digital slides that are virtually hosted and to the point that I don't even try on the military network here."*

iii. *"And then also whatever… bandwidth or whatever for it to actually go across the networks are typically slow."*

Some respondents attributed latency to a "*hostile network and security policy."*

iv. *"[…] just the security of the cyber security networking aspect and getting them actively up and functional on the various networks I think are the some of the biggest challenges that I foresee."*

v. *"[…] network hostility at an institutional and policy level"*

vi. *"Just using the network (is difficult), let alone trying to do something as advanced as whole slide imaging."*

Other respondents prioritized *"dedicated troubleshooting support by IMD",* wanting to ensure that it was *"part of someone's job to troubleshoot the device"* for timely resolution of downtime.

vii. *"Who's gonna maintain that (IT) connection and who, like, how quickly can it get fixed and how often will it be online and up and running?"*

Theme 1 - Subtheme 2 - Lack of Institutional Support Including Cost/Funding: This subtheme covered several concerns to include perceived lackluster organizational leadership support, staffing decrements, insufficient funding support and instrument procurement assistance, as well as a general lack of DP infrastructure.

i. *"I think the three main resources are equipment, instrumentation, personnel."*

ii. *"Honestly I think the biggest barrier is the lack of infrastructure and funding."*

iii. *"So, I just feel like I am very skeptical that there's gonna be any kind of like buy in on anyone, like at higher levels to provide funding or infrastructure for this, because how do you relate this back*

to the battlefield? *I think digital pathology would be super useful for like the mercy and the comfort missions."*

iv. *"Some barriers that I think could happen would be 1. cost 2. Manning which are always up there for military and then 3. is just maybe like security firewall tech issues, I think … I don't know exactly all that goes into that, but I know that and the military network system, we can sometimes have issues."*

v. *"So, I imagine that due to budget constraints you might not get "the A type" scanner and might get the "B team" scanner or the "C team" scanner".*

Theme 1 – Subtheme 3 - Resistance to change - Lack of Peer Support: Respondents discussed resistance to change by senior pathologists and potentially needing to convince some pathologists of DP's usefulness. Difficulty adapting to new technologies was also identified as a barrier and that the possible workload increase for subspecialists may cause decreased buy-in.

i. *"I think convincing pathologists that it is useful and worthwhile is another hurdle, especially those that have never used it or aren't familiar with the capabilities."*

ii. *"I feel like, you know, there's a lot of us that just haven't realized how many advances have been made in the technology from 10 years ago".*

iii. *"But I'm also dealing with the reality where I'm still trying to get my fellow pathologists on board with material matching scans at the gross bench. Perhaps my staff, who are of the older generation where they might not want to change because they're just used to using glass slides and they don't want to change the process that they're familiar with, and perhaps that might be a barrier too."*

iv. *"[…] if you don't have buy-in across the board, it may be harder to get it off the ground, to get legs under it."*

Theme 1 – Subtheme 4 - Specific Imager Attributes: Pathologists expressed concern over the dearth of guidance in selecting the appropriate imager for their needs. They acknowledged the importance of usability and how poor image quality may cause diagnostic discrepancies between the image and glass.

Space and environment requirements, and workflow integration or "*the time required to actually perform the scanning."* were additional factors to consider.

i. *"So, I think a lot of like the (just) logistics of using the devices are things that I would anticipate possibly being a barrier."*
ii. *"If it's not friendly to use, then people will hate it."*
iii. *"Like that overall user-friendly nature of the platforms that for being considered umm I think helps because it does allow for better delegation of the task."*
iv. *"(our lab), It's not the biggest footprint, but definitely space I think is gonna be a consideration in certain locations."*
v. *"[…] but resolution can be an issue on some I think… makes it more difficult to interpret when you're relying on nuclear detail for making determination between something."*

4.2.2 Theme 2 - The Role of Communication (Facilitators to using digital pathology for consultation)

Theme 2 - Subtheme 1 - Education/Training/Communication: Widespread communication in the pathologist community was perceived as a strong enabler of adoption. Respondents expressed a desire for user education and training, resources for validation and operation requirements, guidance on setup and consult submission, consultant case tracking and correspondence, and support in navigating organizational hurdles.

i. *"[…] it seems like it would be helpful a how to guide on how to get started or something like that."*
ii. *"[…] just having like a like kind of like a clear, hey, this is the sort of cases that you know the."*
iii. *"If the block is needed like say, they need the block to do some IHC stains or something like that, like how that communication happens as fast as possible (is important)".*
iv. *"If we send a digital consult like, how do we notify the receiving institution that the console like exists?*

v. *"I can anticipate some pathologists at the various MTFs and instituting digital pathology of having like maybe learning modules that they'll have to learn on how to which website or software to use."*

vi. *"And then I know, I guess that was kind of again in that validation process and in getting things just properly talking to each other is yeah, sorting out the like expectations and paperwork; like how are we tracking this?"*

Theme 2 - Subtheme 2 - Telepathology Program and Implementation Support: Several interviewees suggested that a centralized DP program office would be helpful for establishing a digital consultative service. This office could support the pathology departments by advising on appropriate imager selection for workload, supporting the Authority to Operate (ATO) process, providing implementation and installation support, creating a contact directory for community connection and directed consults, designing a centralized consultant service and assisting with MHS wide workload distribution.

i. *"[…] just having like a centralized office that could support digital pathology, like across the enterprise, I feel (like) would be huge, it could act as a resource for MTFs that may be interested but not have the experience or knowledge to try and get something started. You know, service contracts and maintenance; some sort of program that could, you know, get the if there's an ATO in place, let people know or share that information or help facilitate getting that done whether it be in, in the form of you know funding or paperwork that needs to be done."*

ii. *"[…] you need to be able to support directed consults out to other parts of the enterprise, and it needs to be useful for those other parts of the enterprise…"*

iii. *"(I) think if there was like a system like already like you told us what to buy and somebody came and like installed it and taught you how to use it, that would make it easier."*

iv. *"We'll just keep going the way that they've been doing it the whole time, but I think if we actually have like a contract or someone comes out and like helps you through the whole process and then it'll be much more likely to be used across the MHS."*

v. *"So, if it was like across the MHS, everybody could use digital pathology. We would also be able to like move workloads. (To) The places that need or don't need workload. That way our pathologists are being better utilized."*

vi. *"And that knowledge of other people and being able to kind of direct things where you know they need to go; I think we'll definitely facilitate this process a bit. Uh, so yeah, having those different interactions but resources to you have a heme path here, here and here. You have a GI here, here and here."*

Theme 2 - Subtheme 3 - Understanding Established Telepathology Advantages: Clear communication to both pathologist communities and MTF leadership was identified as an important avenue to bring awareness of DP benefits. A few advantages described included cost savings, decreased accessioning workload, real-time consultation with remote experts allowing for faster feedback and educational opportunities (especially for trainees and junior pathologists), decreased turnaround times, patient material safety, improved patient care, archival capabilities and access to digital capabilities not available on light microscopy such as AI/ML.

i. *"[…] like greatly decrease the turnaround time… like you don't have to pay shipping fees."*

ii. *"It's less workload for the people accessioning, which is like it eases so many headaches."*

iii. *"[…] being able to get an answer in a day rather than a week, you know better for patient care."*

iv. *"[…] annotate images and do very precise measurements and do mitotic figure counts or other things where like you're counting off the individual cells."*

v. *"[…] having sort of some outlines of like what sort of things digital pathology could be good for you know like to support tumor boards or when it comes to resident or medical student education."*

vi. *"It would be amazing both for myself and for the patients and for the clinicians at that small MTF if they can get faster, turnaround time and the faster we can implement digital pathology, the faster that slides can be sent to the expert pathologist at the bigger MTF, who can therefore kind of give the result sooner."*

4.2.3 Theme 3 – Desires for Standardization, Integration and System Design (Implementation Recommendations)

Theme 3 - Subtheme 1 - Standardization: Recognizing that each laboratory may have to independently purchase their own digital imagers and viewers, respondents thought that standardizing procedures, hardware and software would promote participation and streamline implementation. This did not imply blanket uniformity but would outline recommended selections of equipment for smaller versus larger laboratories or for teaching facilities and ensure imager compatibility with image management programs. Standardized implementation and validation requirements, clear expectations of pathologists submitting cases for consultation as well as for the reviewing subspecialists was also discussed.

i. *"[…] you know if it was up to each MTF to buy, purchase, install their own scanner for this (I hope) that there would be some good recommendations for what the requirement would be."*
ii. *"Perhaps if the digital pathology transition was also planned to include workstation hardware upgrades we could potentially work faster."*
iii. *"My concern would be the uniformity of how these potential digital pathology consultation setups would be for the SOP in the various MTFs that institute digital pathology."*
iv. *"[…] have a standardized SOP that can be utilized in smaller MTF from maybe the larger MTFs."*
v. *"[…] the biggest one is the SOP standardization."*
vi. *"Having people having access to very well defined and easy to follow instructions on what the minimum necessary things are to validate the system."*

Theme 3 - Subtheme 2 - APLIS and EHR Integration, and Deliberate System Design:
Implementation suggestions included a prioritizing smaller and OCONUS locations, a phased rollout with over the shoulder support, ensuring APLIS integration and intuitive image management systems compatible with image analysis tools, software enhancements to allow for more functional input devices, consideration of network requirements and server locations to reduce latency for remote locations and future-proofing for machine learning algorithm capabilities.

i. "[…] *like rolling it out slowly and doing testing at certain sites just to get out the bugs before going system wide."*

ii. *"(The) APLIS that we're planning to take up as a part of MHS Genesis (I would like to know) whether or not the devices would be compatible with uploading images in a viewable way in the new AP PathNet. I think if this were an undertaking purely for consultation, that perhaps wouldn't be required, but I think it would make it more palatable and useful for medical directors to pursue the project."*

iii. *"[…] so whatever software is used for the viewer, hopefully will be compatible with other human interface devices such as like touch pads or other more creative specifically built products. Probably actually better than a mouse, but I think if the interface device for the human to control the image is bad, then that's a similar problem to latency issues because it's frustrating to wait on the image to move where you want it to."*

iv. *"Yeah, make sure it works OCONUS. You need to think through the test and evaluation plan."*

v. *"It would be good to … ask the vendors to provide an independent verification validation (of the) capabilities for machine learning algorithms that pathologists might want."*

vi. *"It would be helpful if, uh, they validated the architecture… or sponsor a live in a user experience way."*

4.2.4 Theme 4 – Feelings of Cautious Optimism (General Impressions)

Theme 4 – Subtheme 1 – Positive sentiments: Respondents were supportive of digital consultation efforts using terms such as "helpful", "excited" and "the future". They felt that it would be a key precursor to primary digital sign-out.

i. *"I do think this (digital pathology for consultation) is gonna be the next thing."*

ii. *"I'll be really happy to like see my MTF getting involved in any pilot project."*

iii. *"I'm appreciative of the fact that sort of like you guys are going about it like in sort of like a logical way rather than just be like hey everyone, here's your scanners like best of luck."*

iv. *"I think kind of normalizing the use of a digital images for diagnostic purposes I think is a good thing for pathology in general.*

v. *"And then also, once people are looking at digital and are used to it, there's more drive to set up a full-scale primary sign out digital.*

vi. *"This is an exciting opportunity for me, where I feel like I can actually choose to participate in something that can make an impact."*

vii. *"I think it's going to be the new standard and I think we're putting our military physician, pathologist at a disadvantage."*

Theme 4 - Subtheme 2 - Addressing Gaps with Post Pilot Planning: Pathologists at smaller facilities felt a sense of urgency for implementation and wanted reassurances that the digital consult service would be enduring post pilot.

i. *"[…] and that's very useful if you're at a small shop with not very many people with lack of expertise, so the rapid access to consultants is a huge driving factor for me."*

ii. *"So, for example, if this study has funding to provide scanners for locations once the study has concluded, what will happen to the scanners and will they be available for future permanent use or will cost be borne by the laboratory deciding to participate?"*

iii. *"A research-oriented approach to implementing digital telepathology is a much better approach."*

iv. *"[…] sooner rather than later, especially for smaller bases"*

5. Discussion

To our knowledge, this was the first study to explore all-service military pathologists' perceived facilitators of and barriers to using digital technologies for consultations.

5.1 Assessment of Pathologists' Digital Pathology Needs

Our survey, consistent with previous military studies, revealed that most pathologists were interested in using telepathology. Navy pathologists (80%) seemed most interested in digital consults and

in their desire to participate in future pilot studies offered. 40% already send greater than 10 cases for expert opinion per month. The appeal of DP to Navy pathologists may be a result of their smaller pathology practice groups and fewer subspecialty trained pathologists, necessitating more frequent consultations.

For all respondents, interest in DP appeared to increase with decreasing levels of pathology experience. Trainees and pathologists with less than 5 years' experience indicated greater interest compared to more senior pathologists. Our study showed that more experienced pathologists (>15 years) generally consult significantly fewer and likely more complex cases. The digital consults are either not seen as a necessity or would not be utilized anyway, since complicated cases require additional subspecialist workup. We found interest was unaffected by presence or absence of subspecialty training or prior telepathology experience. While casual relationships between demographics and interest were observed, these findings did not approach statistical significance. Pathologists documented that in general, DP was a useful tool and there was additional interest in using DP for other activities such as education, multidisciplinary tumor conferences and research.

Dermatologic, hematologic, gastrointestinal/liver and breast cases were most commonly sent for consultation. Consultative services focused on these subspecialities would maximize pilot study participation and encourage sustained adoption.

The main barriers and facilitators to implementation identified, were supported and expanded upon by the qualitative data. Interviews and survey free text data yielded similar findings that were associated with themes of: 1. Impressions of lack of support as a barrier, 2. The importance of communication as a facilitator, 3. Strong desires for standardization, integration and system design and 4. Feelings of cautious optimism.

5.2 Facilitators

Although pathologists have the option to send challenging cases to the JPC, other subspecialists at various MTFs or to civilian counterparts, 70% send their cases to the JPC in Silver Springs, Maryland.

This consultative workflow has been in existence since the JPC was created in 2011 and prior to that, the AFIP. In the Air Force, Ho et al., (2012) described coordination and communication breakdowns, delays in consultative findings and manual tracking methods involved in transporting cases outside of the originating facility for external consultation. Based on our study, these occurrences span all services. We found that typical turnaround time (inclusive of transportation times) was 4-5 days, with some pathologists reporting wait times of two weeks or more for a diagnosis. While there are several factors that influence turnaround time, such as case complexity and the need for additional staining, most of the delays were due to transit time. This was an important challenge for OCONUS pathologists, who experienced the longest wait times for results. One pathologist reported, “Sometimes we don't get an answer back for four weeks.”

Unsurprisingly, the most mentioned facilitator was the potential for faster turnaround times (89.7%), followed by real-time consultation capabilities (72.1%), then cost savings (44.1%). These factors are interrelated. Digital image transmission eliminates shipping delays and costs, which are inherently longer and more expensive with greater geographic distances. The ability to get immediate feedback during a live interaction obviates the need to wait for the final result or additional feedback and recommendations by the consultant. Faster turnaround times allow for earlier medical decision making, potentially avoiding over or under treatment and more definitive disposition. This survey finding was supported during the interviews where several pathologists expressed the desire for real-time consultations, and corroborated impressions of associated cost savings and improved turnaround times. To maximize these benefits though, pathologists identified that training, standard operating procedures and workflow guidance, part of the important role of communication, were necessary supporting activities for successful implementation. A previous post-implementation study in Kuwait similarly identified developing guidelines, arranging training and APLIS integration as important recommendations to realizing telepathology’s full potential (Buabbas et al., 2021).

5.3 Barriers

Survey participants perceived that technical/IT challenges were the most important barrier to implementation (88.5%). These are valid concerns. Telepathology requires data transmission. Insufficient IT personnel and immature IT infrastructure severely hamper performance. Low bandwidth and increased latency can render the system inoperable. Perceptions of the process being time consuming (34.6%) and of workflow disruption (26.9%) were additional barriers. The digital workflow does create additional steps of slide scanning, image quality control and image transmission, after the glass slides are created. Scanning or transmission challenges can disrupt workflows and increase time on task. Efficiencies can be recouped by the absence of slide packaging and shipping, and case accessioning, sorting and distribution at the receiving location. Workflow guidance to address pre-analytic/pre-scanning factors, assistance with appropriate imager selection and adequate network capabilities also address cited barriers. When pathologists discussed their impressions of lack of support though, varied network concerns were among the top factors. In a recent study on best practices for DP workflow implementation, Fraggetta et al., (2021) stressed the critical dependency of IT support to a successful digital practice. Additional technical considerations such as bidirectional integration of the slide imager with the APLIS and EHR and reliability of hospital networks were underscored as vital to success in a review of digital and computer-aided pathology by Nam et al., (2020). The authors also highlighted the relationship between the IT infrastructure and workflow efficiencies, a similar finding in our study as well.

5.4 Opportunities

We evaluated the quantitative data identifying the main barriers and facilitators alongside themes and subthemes from the qualitative evaluation, to create implementation recommendations as shown in **Table 5.** Our study supports similar findings by Ho et al., (2012). The authors used contextual inquiry to identify AP workflows suitable for DP transition. They included development of an Air Force DP network, global workload distribution, and access to efficient, regular and rapid consultations as targets for future digital workflows. We were able to expand on their study in several ways. First, although they used a

different methodology, we have shown that the Air Force findings reproduced in our study were broadly applicable to all branches of service. Second, since we sampled all services, we were able to develop wider recommendations for a DoD implementation **(Table 5).** Third, we have developed a framework of how a consolidated DP program office could function **(Figure 7).**

Table 5.

Recommendations for Future Implementation

Recommendations	**Descriptions**
R1. Create and maintain a consolidated digital pathology program	Liaison with other program offices critical to initiating and maintaining functionality to include innovation teams, device integration and cybersecurity and others. Responsible for coordinating R2. to R8.
R2. Dedicated IT support	Minimize downtime, reduce latency, assist with network, integration and storage troubleshooting
R3. Ensure appropriate imager selection	Includes input devices, appropriate imager throughput for pathology case volume and space requirements
R4. Develop a detailed implement plan	Using a phased rollout with training, over the shoulder support and post implementation assistance
R5. Communication planning	Disseminate information and guidance to leaders and end users
R6. Standardization of workflows and procedures	Validation and operation documents that act as a framework for locally developed SOPs
R7. Real time consultation capabilities	Primarily for simple questions, urgent requests or help in narrowing a differential. Useful for junior pathologists
R8. Expand subspecialist pool to include JPC and others.	Allows access to all subspecialties, assists with workload distribution, and allows directed consults

Figure 7.

Proposed Consolidated Digital Pathology Program Framework

Note. Adapted from *Create 5 steps circle infographic slide in powerpoint | free download | powerpoint university*. (2020)

6. Implications, Limitations and Future Directions

6.1 Implications

The findings from our study complement previous military and civilian studies on DP implementation, challenges, successes and recommendations. Our understanding of military pathologists' needs confirms the importance of implementation strategies focusing on infrastructure, user engagement,

simplifying workflows, mitigating perceived organizational barriers and sustainment planning. Our study, the largest sampling of military pathologists to date, suggests that many of the implementation barriers and facilitators are agnostic to the military experience. This means introduction and adaptation of many commonly used civilian digital consultative processes may be a feasible pathway to success. What is unique, is the size and complexity of our organization's structure, geographic distribution and aggressive network security. Our study brings awareness to potential implementation pitfalls, taps into the collective knowledge, encourages active participation of key stakeholders, and provides a framework for future DP pilot studies. Unlike our civilian counterparts, we have the added advantage of a unified EHR which would allow us to share images and metadata seamlessly, maximizing benefits of additional diagnostic and prognostic digital tools. Pilot study implementation artifacts can be shared with non-pilot sites contemplating transition. Successful pilot programs could lead to an enduring novel enterprise consultation process.

This research promotes incorporation of clinical stakeholders in evaluation of significant changes to workflows within the health system. The use of a needs assessment may be adopted by other military clinical communities to assess attitudes and predict adoption and acceptance, prior to introduction and adaptation of novel or commonly used civilian processes.

6.2 Limitations

Limitations to this study include: 1. Self-administered surveys may introduce a potential for selection bias in the responses; 2. Participants may have opportunity for collaboration on responses, distorting findings; 3. Since the participants are all affiliated with or in the military, this study's findings may not be generalizable to the broader civilian population of pathologists and their perceived barriers, facilitators or attitudes towards using DP for consultation; 4. While the overall the response rate was within acceptable ranges, subgroup participation was below the threshold of statistical significance, some with incomplete information. Therefore, any demographic influence or lack thereof on pathologists' perceptions may not be generalizable to the pathologist population tested and 5. The time period between

survey and interview was longer than anticipated as we needed to coordinate the interview schedule between researchers and interviews while adjusting for worldwide time zone differences. Some interview questions focused on expansion of previous survey comments potentially leading to recall bias. After the interview period, we were able to confirm that survey responses were consistent with interview data.

Despite these potential limitations, findings from this study will encourage future evaluation of stakeholders prior to implementation of significant workflow changes within the MHS. Barriers and facilitators proposed by our study are supported by published literature findings and identify additional factors unique to military medicine. Data from our study can be used as a foundation for future research and DP implementation efforts.

6.3 Future Directions

Needs assessments are conducted to determine appropriate, design, planning and execution of a subsequent pilot or project. Our study focused on military pathologists' attitudes and perceptions in preparation for a future pilot of DP for consultation. Although significant subgroup influence on findings could not be determined, we uncovered key opportunities to maximize implementation success. The next steps include designing a pilot that mitigates identified barriers, supports facilitators and builds on interest by enlisting self-identified pathologist champions.

Much of the previous research on pathologists' interest in and attitudes to digital pathology applications of all kinds (including consultations) has been focused on civilian practices. This study was focused on the unique population of active-duty and government-employed civilian pathologists. Wider generalizations of all our findings may be challenging in the civilian setting, especially in smaller hospital systems. Larger systems spanning greater geographical distances are most similar to the MHS and these affiliated pathology departments may build on our research to develop their own complementary needs assessments and to determine critical areas that require increased emphasis in implementation planning.

7. Conclusion

Most pathologists were interested in using digital pathology for consultation, with less experienced pathologists showing greater interest when compared to more experienced ones. Of all branches, Navy pathologists showed the highest proportion of interest in use and were more likely to volunteer for any future pilot studies offered. DP was also identified by all as a useful tool for additional activities such as education, multidisciplinary tumor conferences and research.

We stratified barriers and facilitators from survey data. We then expanded the data by developing themes through interview analyses. The theme of “lack of support” encompassed all barriers. Under this umbrella, the most important perceived barrier was technical/IT challenges. This was followed by the time-consuming aspects of a digital workflow that adds additional steps to legacy processes and the workflow disruptions that result. Facilitators were collated under the theme of “importance of communication”. The potential for faster turnaround times was most important to respondents, followed by real-time consultations and cost efficiencies.

Additional themes of “desires for standardization, integration and system design” and “feelings of cautious optimism” provide additional actionable strategies for pilot design. We developed eight recommendations for future implementation that spanned creation of a consolidated digital pathology operation, dedicated technology support and increased subspecialist availability for workload distribution and directed consults. From these recommendations we proposed a digital pathology program framework as an implementation strategy that addresses known and previously unrecognized priorities as perceived by pathologists.

Respondents identified that dermatologic, hematologic, gastrointestinal/liver and breast cases were the most common specimens sent for consultation. Consultative services focused on these subspecialities would maximize pilot study participation and encourage sustained adoption.

In general, military pathologists were receptive to an enterprise-wide implementation of DP for consultation, especially if it were efficient, improved turnaround time, allowed immediate subspecialist feedback and included support from all military subspecialists. They appreciated the opportunity to

provide feedback and were interested in supporting any emerging pilot studies. Future DP implementation efforts may benefit from ensuring comprehensive, dependable technical/IT support combined with a consolidated DP program office to provide consistent communication, process standardization, implementation and sustainment guidance.

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9. Appendices

9.1 Appendix A - Needs Assessment Survey

Table A1.

Digital Pathology (Telepathology) for Extradepartmental Consultation Needs Assessment

1.To what institution(s) do you send cases for external consultation? (% slider)	The Joint Pathology Center (JPC)	Other Military Treatment Facility	Regional University Hospital	Mayo Clinic	Other (List)
2.On average, how many cases do you send for external consultation each month?	Less than 1 case	1-5 cases	6-10 cases	>10 cases	
3.What types of cases do you send for external consultation? (Can pick multiple)	Dermatopathology	Hematopathology	Breast	Gastrointestinal/Liver/Pancreas	Other (List)
4.What type of case do you send MOST FREQUENTLY for external consultation? (Can pick multiple)	Dermatopathology	Hematopathology	Breast	Gastrointestinal/Liver/Pancreas	Other (List)
5.On average, what is the turnaround time (TAT) for cases sent for external consultation?	1 day	1-3 days	4-5 days	>5 days	
6.Are you currently using telepathology in your department?	Yes	No			
7.Rate your interest in using telepathology for external consultation?	Not interested (1)	Maybe (2)	Neutral (3)	Interested (4)	Very interested (5)
a. If yes (4-5), why? (Multiple answer) Other-List **b. What is the most important reason? Other - List**	Real-time consultation	Faster turnaround time (TAT)	Cost Saving	Diagnostic accuracy	Other-List
a. If no (1-2), why? (Multiple answer) (Other- List)	Time consuming	Workflow disruption	Technical/IT challenges	Unfamiliar with telepathology	Other-List

b. What is the most important reason? (Other-List)					
8.Other than consultation, what other uses of telepathology interest you? Multiple answer (Also, Other-List)	Multidisciplinary tumor board	Frozen section	Immunohistochemistry	Education	QA
9. What hesitations or hindrances do you foresee in using telepathology for external consultation? (Free text)					
10.What recommendations would you have for a successful implementation of telepathology for consultation? (Free text)					
11.Rate your interest in participating in a telepathology consultation pilot as a spoke (submitting) site?	Not interested (1)	Maybe (2)	Neutral (3)	Interested (4)	Very interested (5)
12.If offered, do you feel that telepathology would be a useful tool?	A great deal	Maybe	Neutral benefit	Maybe not	Not at all
13.How long have you been practicing pathology?	Less than 1 yr.	1-5 yrs.	6-10 yrs.	11-15 yrs.	>15 yrs.
14.What is your role in the pathology department?	Resident	Fellow	Staff	Section Director	Chief
15.What is your subspeciality? (Other – List)	General	Hematopathology	Dermatopathology	Cytopathology	Other-List
16.How many years of experience do you have using digital pathology (in any capacity)?	Less than 1 yr.	1-5 yrs.	6-10 yrs.	11-15 yrs.	>15 yrs.
17.What is your branch of service?	Army	Navy	Air Force	Civilian	
18.If you are interested in participating in a	Text box to enter				

brief interview, please enter your email address and the lead researcher will contact you to schedule.	participant email				

9.2 Appendix B – Survey Introductory Emails

INTRODUCTION EMAIL - SURVEY:

Digital Pathology for Consultation Needs Assessment Survey

DoD Pathologists,

We understand the ever-increasing demands on your time but hope that you will provide us with valuable information to improve the extradepartmental consultation process.

The Joint Pathology Center is interested in offering a digital consultative service. We would like to know your thoughts about using digital pathology - whole slide imaging for consultation as well as for other applications. Your responses will help us understand perceived facilitators and barriers to implementation of this service. We want to make digital consultation easier for you!

Please take time out of your busy schedule to complete this 5-7-minute survey. Your participation is voluntary and return of the survey is implied consent. The survey is anonymous unless you choose to participate in the telephone interview. If you do, any information obtained that can be associated with you, will remain confidential. Your survey answers will be aggregated, and we will share the results with you.

You only have 30 days to complete the survey. The survey is available until 2359 PST 10 Oct 2023 at: https://########

This link is available on all browsers and mobile devices. Questions about this survey or difficulties with the link? Email us at Joshua.h.sakai.ctr@health.mil

This is your opportunity to help design the consultation process, so fill out the survey today! We appreciate your participation.

Follow this link https://######## to start your survey now.

Victoria Mahar
LTC, MC
Clinical Informatics Fellow | Staff Pathologist
Madigan Army Medical Center

9.3 Appendix C – Survey Reminder Email

SURVEY REMINDER EMAIL:

DoD Pathologist,

You only have 14 days (or 2 days) left to complete the survey!

If you have already completed the survey, thank you and please disregard this email.

We wanted to make sure you did not miss the opportunity to participate in our Digital Pathology Needs Assessment Survey at https://######.

The survey will be available on computer and mobile devices until 10 Oct 2023. It takes about 5-7 minutes to complete.

Your distinct perspective will help us better understand DoD Pathologists' impressions of a digital consultative service and determine digital pathology priorities. We look forward to hearing from you soon.

Help us make digital consultation easier for you! Follow this link https://######## to start your survey now!

Thanks again,

Victoria Mahar
LTC, MC
Clinical Informatics Fellow | Staff Pathologist
Madigan Army Medical Center

9.4 Appendix D – Web-based Interview Introductory Email (Military)

INTRODUCTION EMAIL – INTERVIEW (DoD Email Address)
Digital Pathology for Consultation Needs Assessment Interview

DoD Pathologists,

We appreciate your interest in participating in the web-based interview. Due to high demand, we have transitioned the interview to Microsoft Teams. Please see below for interview instructions:

1. You will receive an email sharing the interview outlook calendar with you. Please click the accept button.
2. Interviews will be available between Nov 06 and Nov 30, 2023, between 0900 – 1200 and 1300-1600 PST.
3. You will see 20–30-minute interview blocks that are available for booking.
4. Please email #######@health.mil with your top 3 choices for interview dates and times (with applicable time zone). Include a good contact phone number, so that we may contact you in the event of technical difficulties during the interview.
5. You will receive a calendar invite confirming your booking. This contains the link to join the meeting and dial-in information. Please review your outlook calendar time zone so that time zone conversions are accurate.

Follow the link or use the dial in option to join the meeting at your scheduled date/time. During the interview, there is no need to turn your camera on. We will utilize both the Microsoft Teams transcription function and another investigator who will act solely as a note taker. Any information obtained that can be associated with you, will remain confidential. Please contact the lead investigator at #######@health.mil with any concerns or questions.

Thank you for your participation.

Very Respectfully,

V. Mahar
LTC, MC
Principal Investigator, Digital Consultation Pilot
#######@health.mil

9.5 Appendix E - Web-based Interview Introductory Email (Civilian)

INTRODUCTION EMAIL – INTERVIEW (non-DoD Email Address)
Digital Pathology for Consultation Needs Assessment Interview

DoD Pathologists,

We appreciate your interest in participating in a web-based interview. Due to the non-DoD email provided, the interview calendar cannot be shared with you. Instead, please see below for dates/times available in PST. Note that interviews start on the hour and half hour and are 20-30 mins long. For example, interviews between 0900-1000 start at 0900 and 0930.

The following dates/times are available for interviews:

06 Nov 1500-1530,
07 Nov 1500-1600,

14 Nov 0900-1600,
15 Nov 0900-1600,
16 Nov 1000-1130,
17 Nov 0930-1600,

20 Nov 0900-1430,
27 Nov 0900-1600,
28 Nov 0900-1600,
29 Nov 0900-1600,
30 Nov 0900-1600

Please email #######@health.mil with your top 3 choices for interview dates and times (with applicable time zone). Include a good contact phone number, so that we may contact you in the event of technical difficulties during the interview.

You will still receive a calendar invite confirming your booking. Please review your outlook calendar time zone so that time zone conversions are accurate.

Follow the link or use the dial in option to join the meeting at your scheduled date/time. During the interview, there is no need to turn your camera on. We will utilize both the Microsoft Teams transcription function and another investigator who will act solely as a note taker. Any information obtained that can be associated with you, will remain confidential. Please contact the lead investigator at #######@health.mil with any concerns or questions.

Thank you for your participation.

Very Respectfully,

V. Mahar
LTC, MC
Principal Investigator, Digital Consultation Pilot
#######@health.mil

9.6 Appendix F - Web-based Interview Reminder Email (Military and Civilian)

INTERVIEW REMINDER EMAIL

DoD Pathologists,

You only have 15 days left to participate in the interview!

If you have already completed or scheduled your interview, thank you and please disregard this email.

We wanted to make sure you did not miss the opportunity to participate in our Digital Pathology Needs Assessment Interview before the period ends on 30 Nov 2023.

The interview takes at most 20 minutes. The following dates are still available:

2023

Please email #######@health.mil with your top 3 choices for interview dates and times (with applicable time zone). Include a good contact phone number, so that we may contact you in the event of technical difficulties during the interview. You will receive a calendar invite confirming your booking.

Help us make digital consultation easier for you! We look forward to talking with you soon.

Thanks again,

Victoria Mahar
LTC, MC
Principal Investigator, Digital Consultation Pilot
#######@health.mil

9.7 Appendix G - Web-based Interview Script

OPTIONAL INTERVIEW - Script

Good Morning/Afternoon/Evening

Thank you for your participation. I am Victoria Mahar, the principal investigator and I will be conducting the interview. Also in the meeting are Dr. Colburn and Mr. Sakai, associate investigators on the project who will be acting solely as note takers. We will be using the transcribe feature on Microsoft Teams to assist with note taking. The meeting will not be recorded. Any information that can be associated with you will remain confidential and will be discarded at the end of the research period. Participating in the interview implies consent to documentation of your responses. Would you like to proceed with the interview?

1. Did you complete the online survey?

2. Demographics:
    a. Service (USA, USAF, USN, CIV etc.)
    b. Role (staff, resident etc.)
    c. Years in practice
    d. Subspecialty training? (List)
    e. Prior telepathology experience

3. Please share your perceived additional barriers to using digital pathology for consultation not already listed in the online survey that you would like to discuss. (Refresh memory on previously listed barriers)

4. Please share your perceived additional facilitators to using digital pathology for consultation not already listed in the online survey that you would like to discuss. (Refresh memory on previously listed barriers)

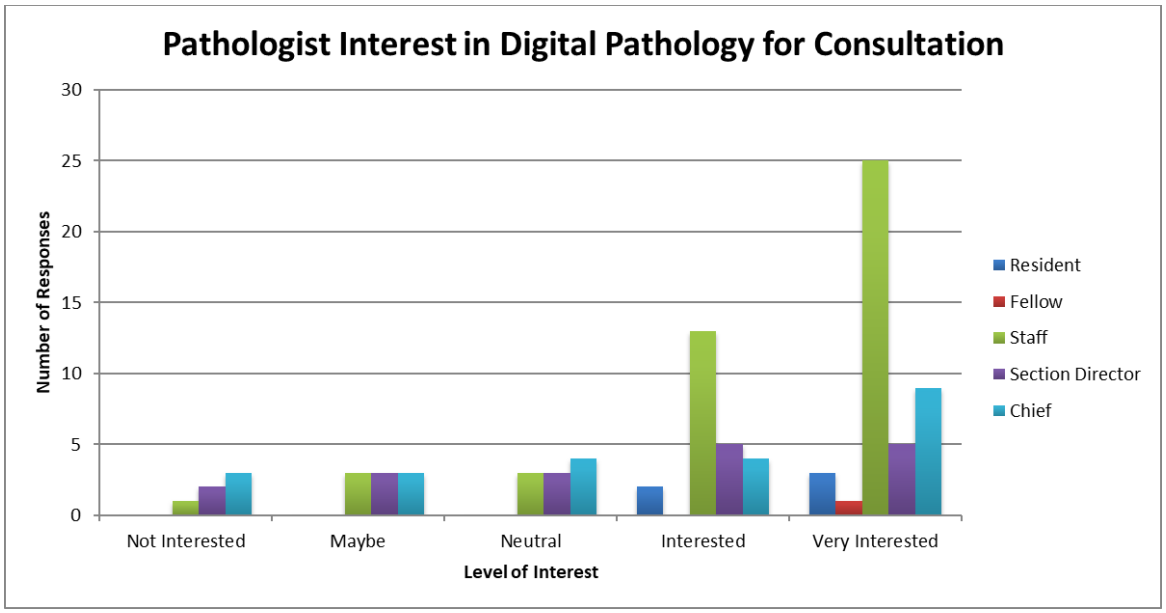
5. Please discuss concerns or suggestions related to the implementation process of digital pathology for consultation.

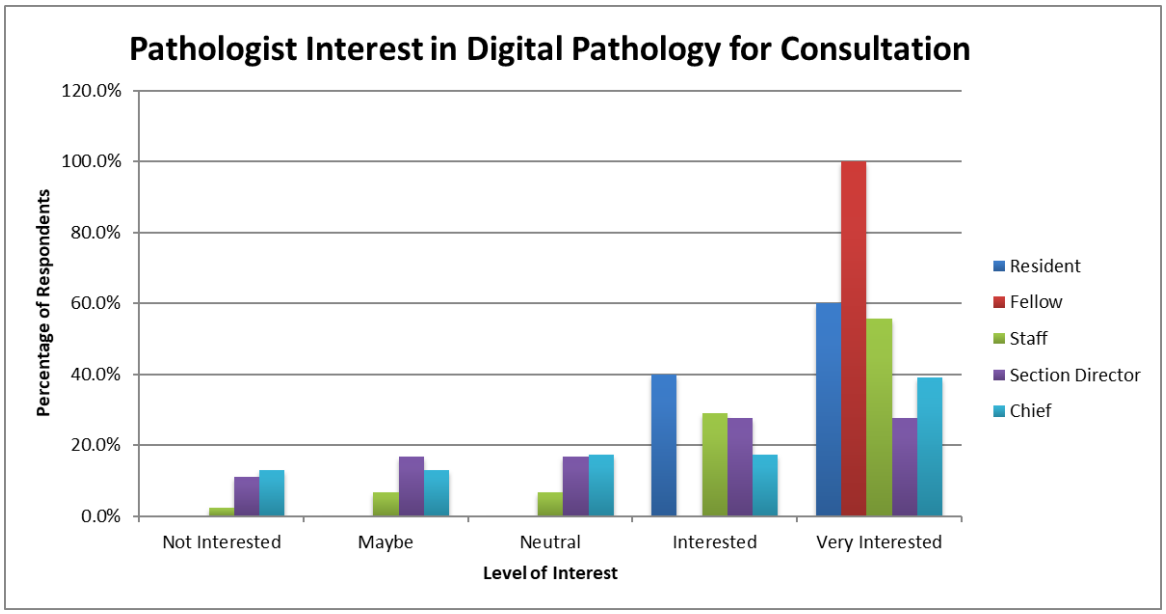
6. Is there anything else related to digital consultations that you would like to share?

9.8 Appendix H- Interest, Barriers and Facilitators in Digital Pathology for Consultation by Demographics

Figure H1.

Interest in Digital Pathology by Role in Pathology



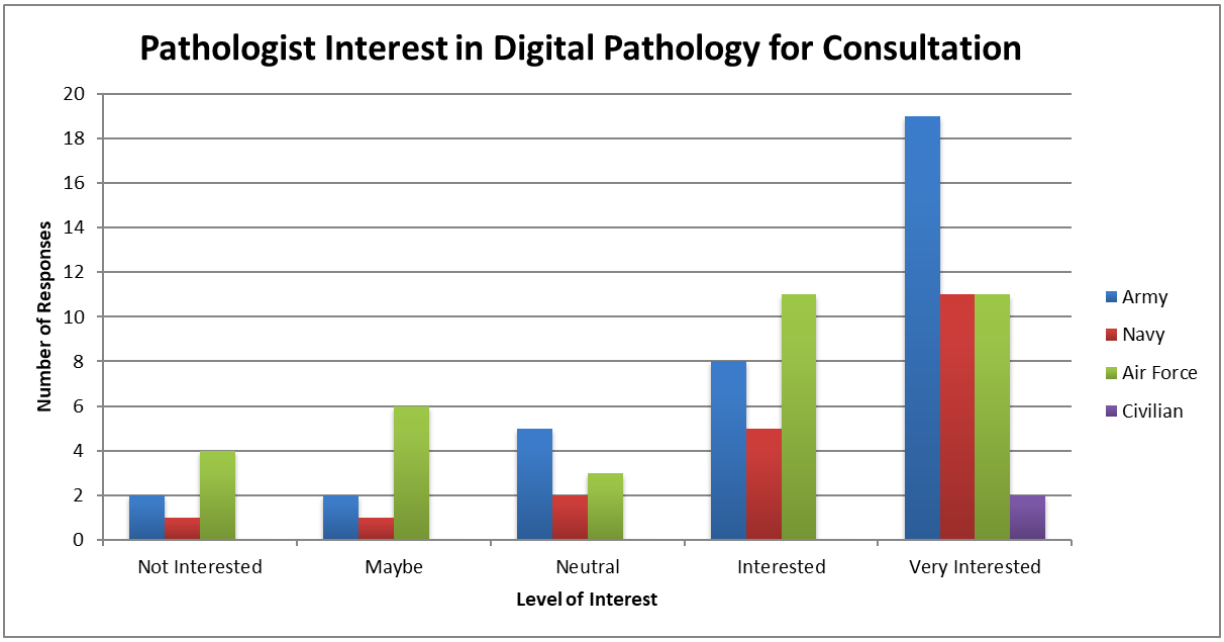


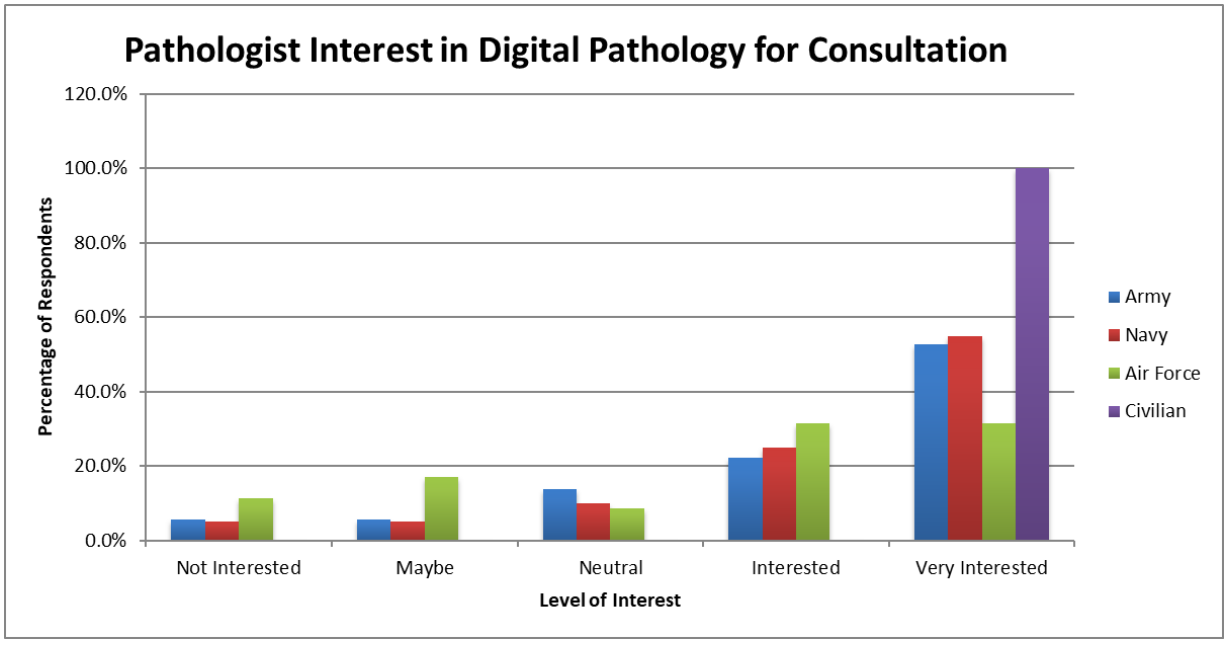
Chi-Squared Test

	Basic	Advanced
Statistical Significance (P-Value)	Not significant	0.642553
Effect Size (Cramér's V)	Medium	0.190896
Sample Size		92

Figure H2.

Interest in Digital Pathology by Branch of Service



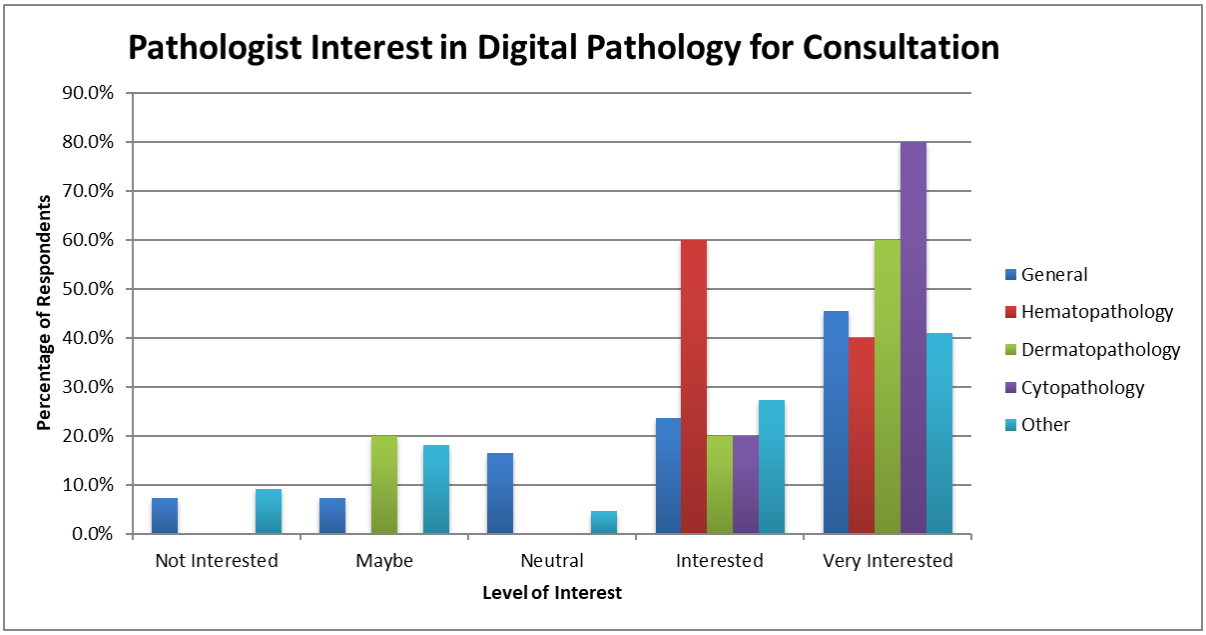


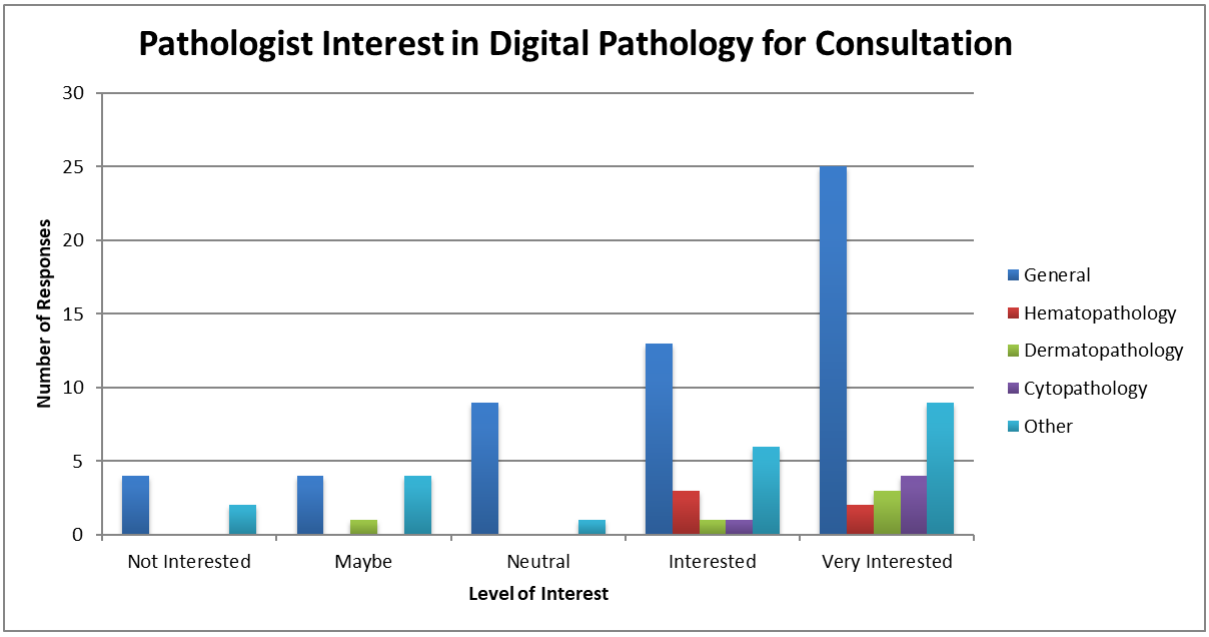
Chi-Squared Test

	Basic	Advanced
Statistical Significance (P-Value)	Not significant	0.622831
Effect Size (Cramér's V)	Medium	0.188578
Sample Size		93

Figure H3.

Interest in Digital Pathology by Subspeciality



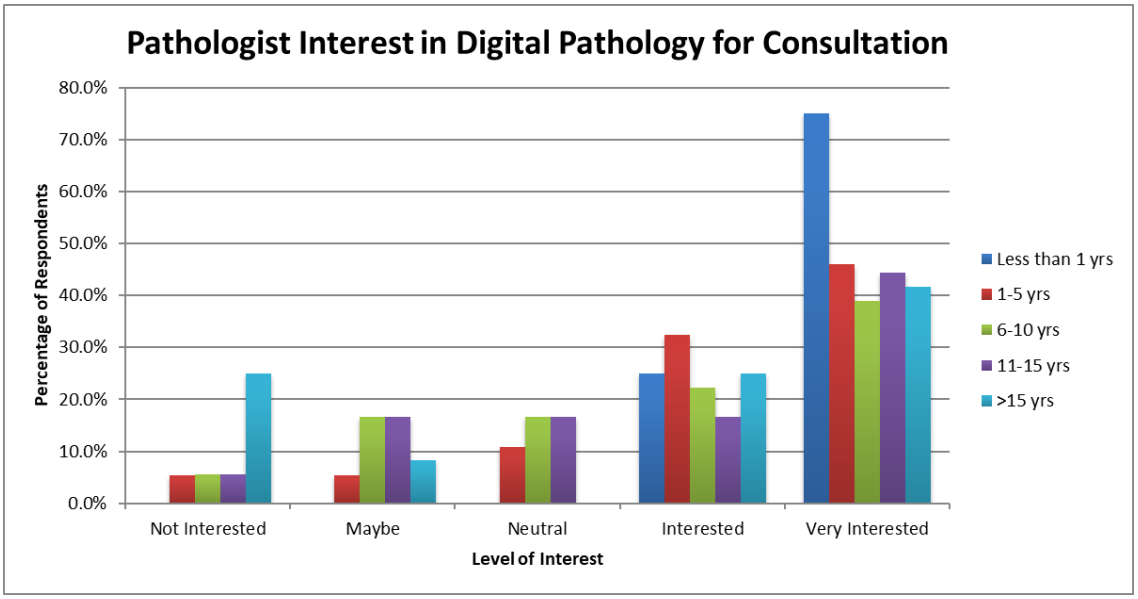


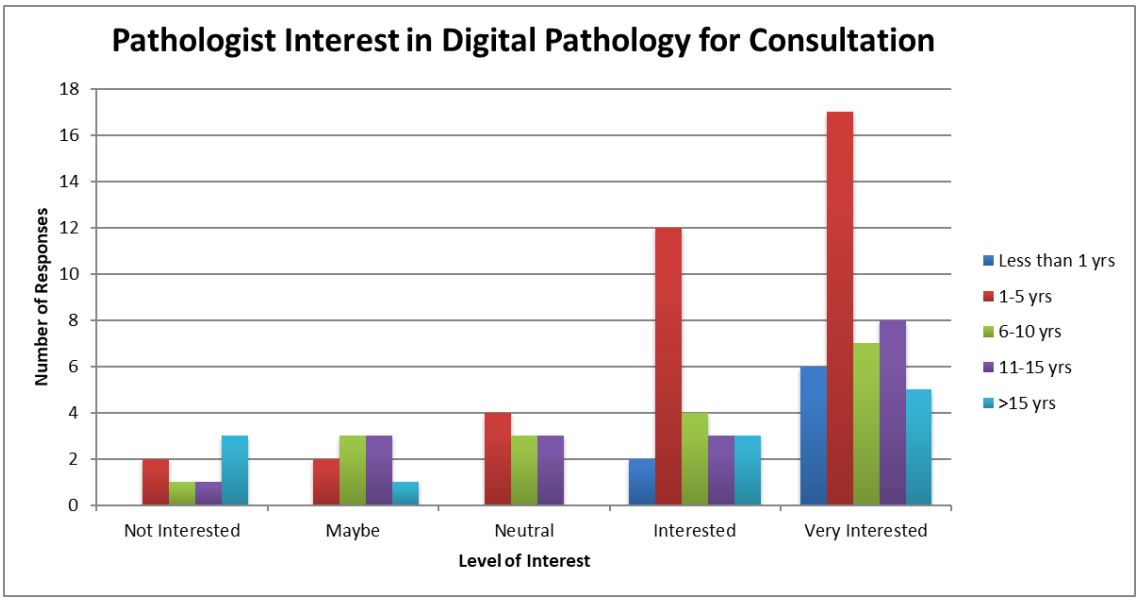
Chi-Squared Test

	Basic	Advanced
Statistical Significance (P-Value)	Not significant	0.690746
Effect Size (Cramér's V)	Medium	0.186156
Sample Size		92

Figure H4.

Interest in Digital Pathology by Pathology Experience





Chi-Squared Test

	Basic	Advanced
Statistical Significance (P-Value)	Not significant	0.486519
Effect Size (Cramér's V)	Medium	0.204294
Sample Size		93

Figure H5.

Reasons for Interest (Facilitators) by Role in Pathology

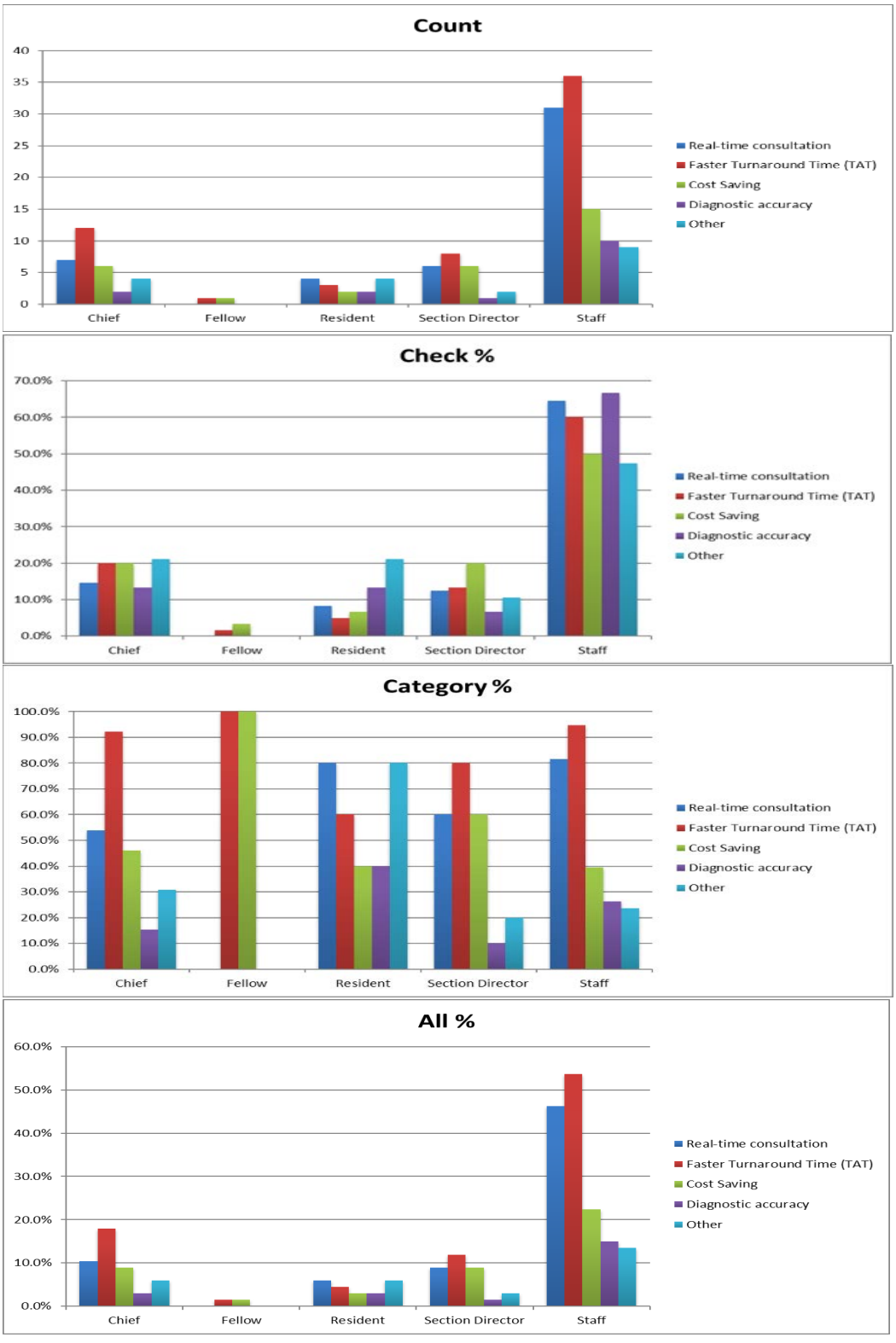
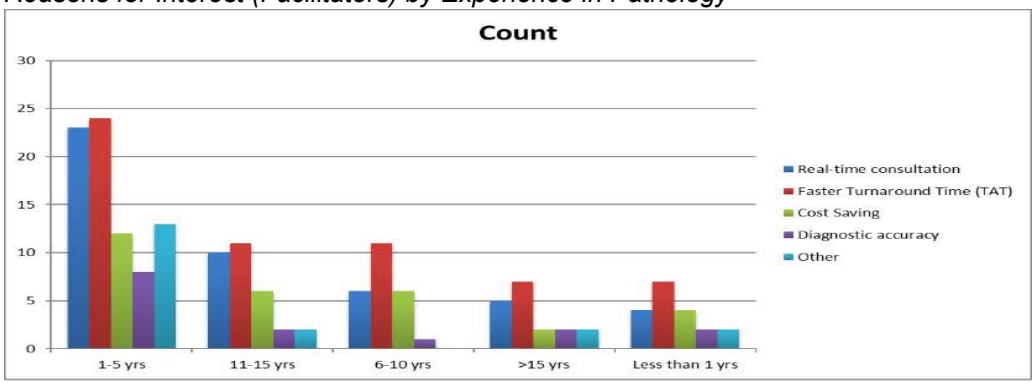
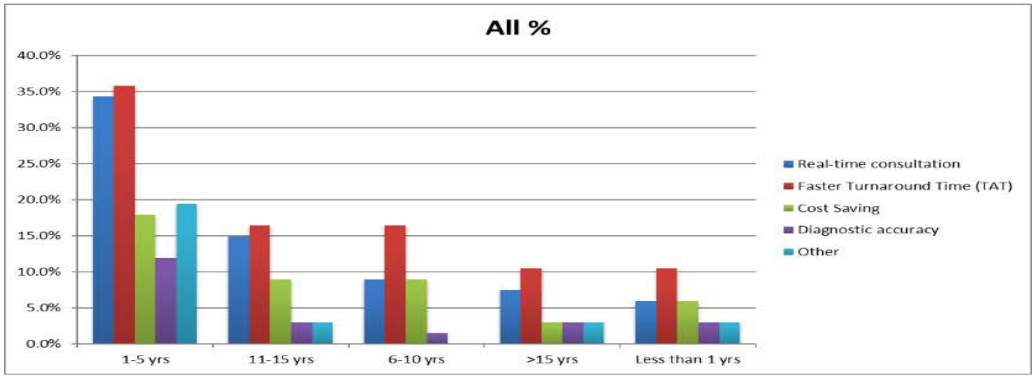
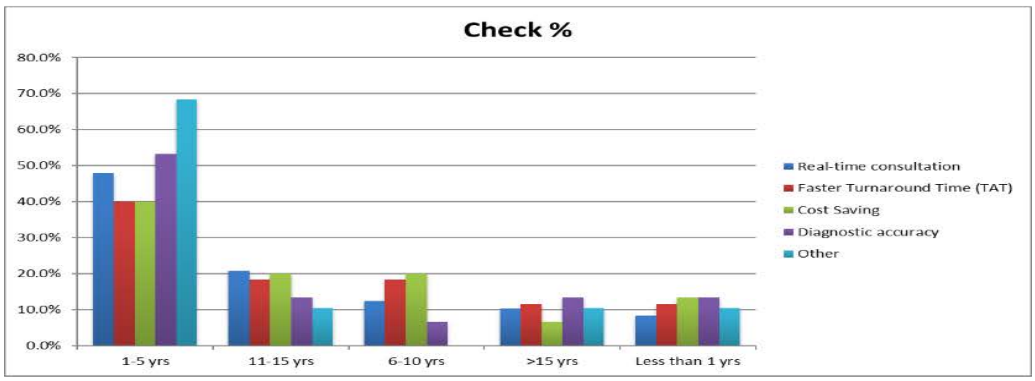


Figure H6.

Reasons for Interest (Facilitators) by Experience in Pathology







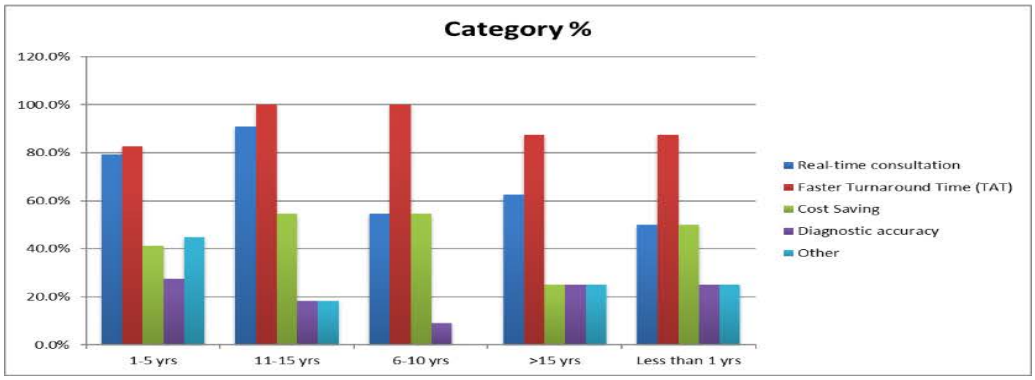
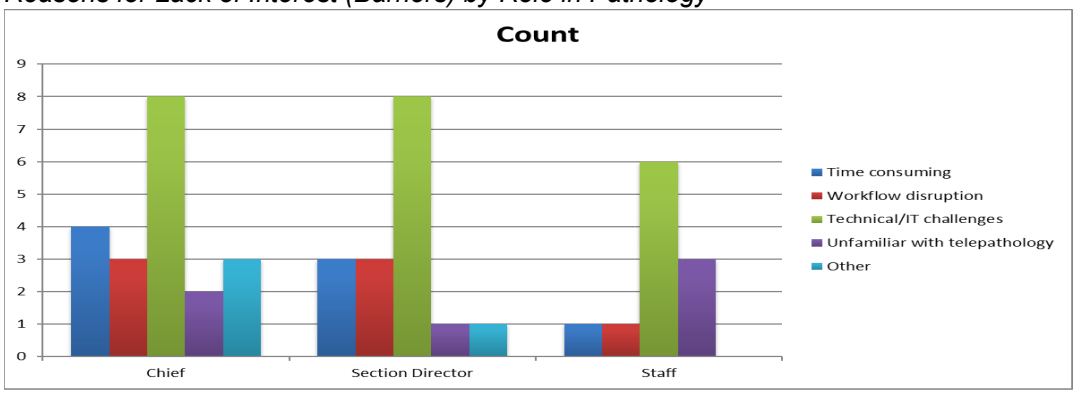
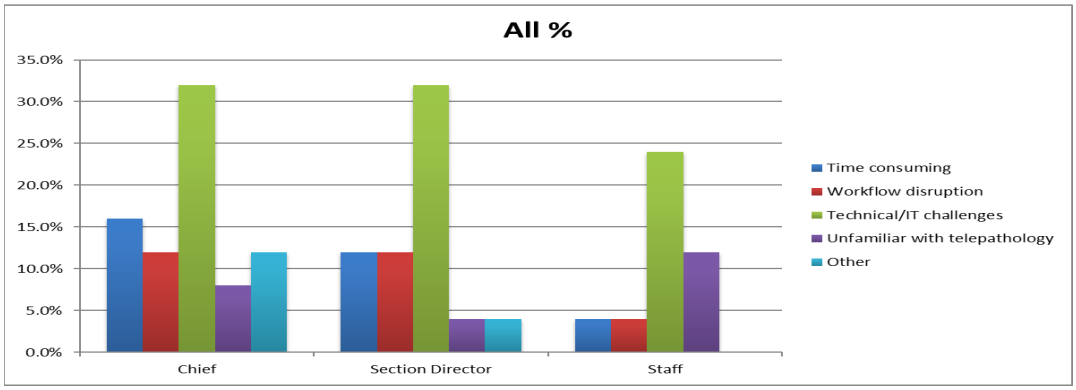
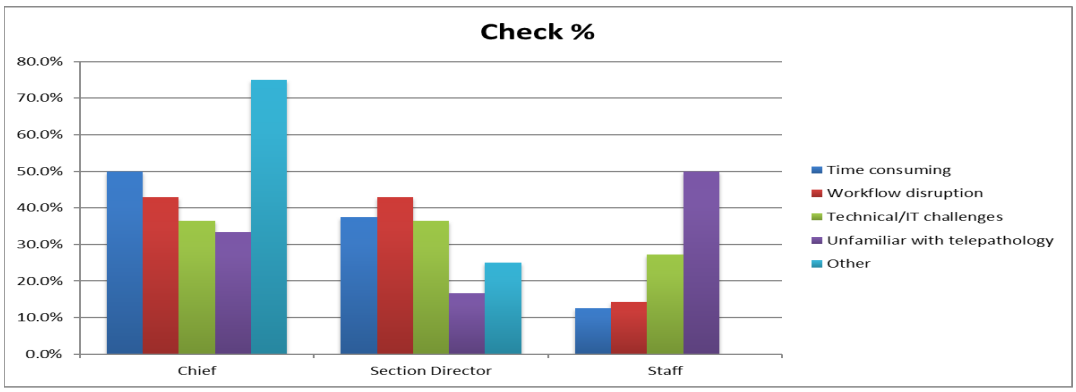


Figure H7.

Reasons for Lack of Interest (Barriers) by Role in Pathology







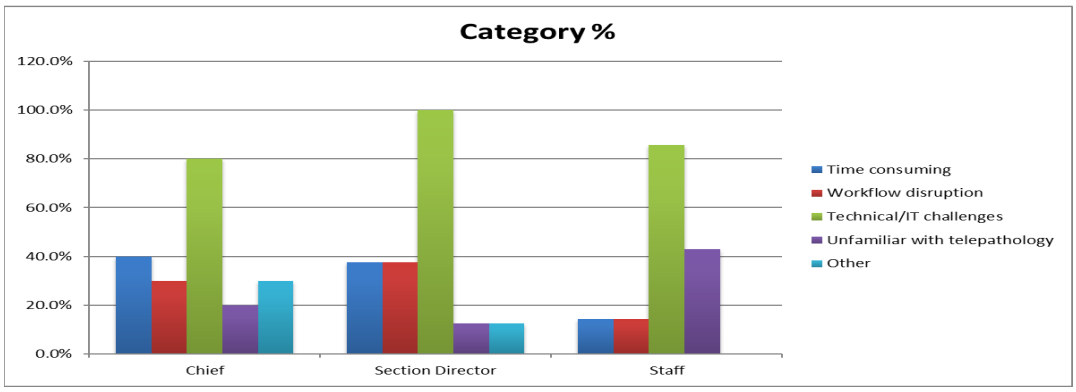


Figure H8.

Reasons for Lack of Interest (Barriers) by Pathology Experience