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Understanding the Financial Aspects of Digital Pathology: A Dynamic Customizable Return on Investment Calculator for Informed Decision-Making

Orly Ardon*[1], PhD MBA; Sylvia L. Asa[2] MD, Mark C. Lloyd[3], Giovanni Lujan[4] MD, Anil Parwani[4] MD PhD MBA, Juan C. Santa-Rosario[5] MD, Jennifer Samboy[6] MHA, Danielle Pirain[7] BS, Scott Blakely[8] MBA, Matthew G. Hanna[1], MD

Affiliation:
[1]Department of Pathology and Laboratory Medicine, Memorial Sloan Kettering Cancer Center, New York, NY, USA
[2]University Hospitals Cleveland Medical Center, Case Western Reserve University, Cleveland OH 44106
[3]Fujifilm
[4]Department of Pathology, Wexner Medical Center, The Ohio State University, Columbus, OH 43210
[5] CorePlus
[6] Philips
[7]VisioPharm
[8]Hamamatsu

Email:
ardono@mskcc.org
pathlady01@gmail.com
mark.lloyd@fujifilm.com
giovanni.Lujan@osumc.edu
anil.parwani@osumc.edu
Juan.Santa@corepluspr.com
jennifer.samboy@philips.com
dpi@visiopharm.com
SBlakely@hamamatsu.com
hannam@mskcc.org

*Corresponding Author
Orly Ardon, PhD MBA
Department of Pathology
Memorial Sloan Kettering Cancer Center
1275 York Ave
New York, NY 10065
ardono@mskcc.org
212-639-5464

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Abstract

Background: The adoption of digital pathology has transformed the field of pathology, however the economic impact and cost analysis of implementing digital pathology solutions remain a critical consideration for institutions to justify. Digital pathology implementation requires a thorough evaluation of associated costs and should identify and optimize resource allocation to facilitate informed decision-making. A dynamic cost calculator to estimate the financial implications of deploying digital pathology systems was needed to estimate the financial effects on transitioning to a digital workflow.

Methods: A systematic approach was used to comprehensively assess the various components involved in implementing and maintaining a digital pathology system. This consisted of 1) Identification of key cost categories associated with digital pathology implementation; 2) Data collection and analysis of cost estimation; 3) Cost categorization and quantification of direct and indirect costs associated with different use cases, allowing customization of each factor based on specific intended uses and market rates, industry standards, and regional variations; 4) opportunities for savings realized by digitization of glass slides and 5) Integration of the cost calculator into a unified framework for a holistic view of the financial implications associated with digital pathology implementation. The online tool enables the user to test various scenarios specific to their institution and provides adjustable parameters to assure organization specific relatability.

Results: The Digital Pathology Association (DPA) has developed a web-based calculator as a companion tool to provide an exhaustive list of the necessary concepts needed when assessing the financial implications of transitioning to a digital pathology system. The dynamic Return on Investment (ROI) calculator successfully integrated relevant cost and cost saving components associated with digital pathology implementation and maintenance. Considerations include factors such as digital pathology infrastructure, clinical operations, staffing, hardware and software, information technology, archive and retrieval, medical-legal, and potential reimbursements. The ROI calculator developed for digital pathology workflows offers a comprehensive, customizable tool for institutions to assess their anticipated upfront and ongoing annual costs as they start or expand their digital pathology journey. It also offers cost savings analysis based on specific user case volume, institutional geographic considerations, and actual costs. In addition, the calculator also serves as a tool to estimate number of required whole slide scanners, scanner throughput, and data storage (TB). This tool is intended to estimate the potential costs and cost savings resulting from the transition to digital pathology for business plan justifications and return on investment calculations.

Conclusions: The Digital Pathology online cost calculator provides a comprehensive and reliable means of estimating the financial implications associated with implementing and maintaining a digital pathology system. By considering various cost factors and allowing customization based on institution-specific variables, the calculator empowers pathology laboratories, healthcare institutions, and administrators to make informed decisions and optimize resource allocation when adopting or expanding digital pathology technologies. The ROI calculator will enable healthcare institutions to assess the financial feasibility and potential return on investment on adopting digital pathology, facilitating informed decision-making and resource allocation.

Keywords

Digital Pathology, Cost, Revenue, Reimbursement, Return on Investment

Background

Digital pathology (DP) is offering pathology multiple benefits for improved diagnostic accuracy, faster turnaround times, and increased efficiency in pathology workflows[1–10]. Developing a digital pathology program requires additional infrastructure on top of the pre-existing analog pathology workflows[11–13]. The costs of implementing DP will vary greatly depending on the size and use cases of an organization, the specific technologies chosen and the needs and level of automation and integration with all other laboratory systems. Overall, the costs of DP operations can be significant, with the requirement of the set up cost for basic infrastructure - as well as the ongoing operations- viewed as a major barrier for its adoption [5,6,11–13,13–18] . In 2010, Walter H. Henricks, argued that "revenue from DP activities is not likely to cover the costs, at least in the near term but possibly not ever" [19] . Most later studies describe future, theoretical savings based on potential cost savings calculations [4,11,13,20]. Some examples include >19 working hours that were saved per day with digital slides in the Netherlands[20], annual savings of $CA 26 000 in courier costs, $CA 60 000 in travel, and $CA 45 000 in travel expenses in Canada[21]. Chong et al (2019), demonstrated savings of $24 per courier trip between UCLA's pathology sites and considerable cost savings in salary for a specialized pathologist who would otherwise be needed to support low-volume service[22].

As with other disruptive technologies, institutions will require the development of business plans that will include projected revenue or cost avoidance and savings that will offset the investment in DP. As with other hospital innovation projects, barriers may exist at various hospital levels that could stall successful prioritization of new technology[23].

Return on Investment (ROI) is one of several financial tools that forecast financial returns or profit from an investment. Its calculation is achieved by converting costs and financial benefits into a ratio and this ratio is then used as metric to help institutions make investment decisions.

In healthcare, ROI has been used to evaluate financial value of a program post implementation[24] and as an economic performance measure for meeting and improving product quality specifications[25]. ROI is also used as a performance management tool, to ensure that organizations achieve their desired strategic goals[26]. As ROI moved from commerce to healthcare frontlines, it became more a concept of returns or gains from an investment[24].

Financial ROI is typically calculated by taking the actual or estimated revenue from a project and subtracting the actual or estimated costs. That number is the total profit that a project has generated or is expected to generate. That number is then divided by the costs[26].

The formula for ROI is typically written as:

ROI = (Net Profit / Cost of Investment) x 100

$$ROI = \left(\frac{Net\ profit}{Cost\ of Investment}\right) x100$$

When a calculation yields a positive ROI, the initiative or project can be considered profitable, because it yields more in revenue than it costs to pursue. Alternatively, if the project yields a negative ROI, it means the project cost is more than it will generate in revenue. If the project breaks even, the total revenue generated by the project matches the expenses.

Developing a digital pathology program in most organizations relies on an **anticipated ROI**, similar to other disruptive technologies. Anticipated ROI (or expected ROI) will be calculated before embarking on a digital pathology program for the determination of the financial feasibility of the investment or during any DP expansion project. Anticipated ROI will use estimated costs, revenues, and other assumptions to determine how much profit the investment in DP is likely to generate. Numbers from multiple DP scenarios can then be used to understand institutional financial risk and, ultimately, decide whether an initiative should move forward.

Actual ROI is the true ROI generated from a project. This number is typically calculated retrospectively, after a project has concluded, and uses final costs and revenues to determine how much profit a project produced compared to what was estimated. In the case of novel technologies, such as digital pathology, actual ROI calculation is hard to obtain due to the long-term data generation required for such calculations.

Multiple publications have detailed the infrastructure required for establishing clinical digital pathology operations[1,3,6,7,12,12,17,27–34] . Yet the estimation of the DP infrastructure costs is complicated as costs will greatly vary between laboratories due to geographical locations, size of operations, use cases, timing of investment in DP infrastructure, number of operations sites, *etc*. Potential revenues will similarly vary greatly among institutions, adding to the difficulty of establishing ROI or other financial metrics for informed decision-making.

As a result of this variability in DP costs and potential revenues, there was a genuine need for a customizable calculating solution that could cater to most DP needs across different geographical locations.

Early publicly-available DP calculators were introduced by hardware vendors and did not offer a comprehensive list of all the associated costs of a digital pathology transformation as encountered by early adopters of the technologies. Moreover, a dynamic calculator still needs periodic updates with market developments (such as new Current Procedural Terminology (CPT) codes) as potential revenue and should be free of commercial bias.

The DPA recognized the need for such a tool and committed volunteers to establish a roadmap for development of a tool for the digital pathology community.

Materials and Methods

In March 2021 a working group was established with approximately 30 members from academic medical centers, industry, and regulatory leadership roles across various organizations. A cadence of virtual working group meetings was established. Stakeholders discussed several end products that may be useful to the community including but not limited to education sessions (e.g. webinars), development of an "ROI calculator", shareable spreadsheets, etc. Within the year, the working group finalized plans to develop a ROI calculator for the Digital Pathology Association members and geared towards brainstorming categories and concepts that would be included in such a tool. Industry partners who had already developed similar business-case calculators were shared and reviewed. In April 2022, a list of categories and related concepts was drafted and reviewed by the DPA working group. The list of concepts was finalized in January 2023 and was then submitted to be developed into an online form to be used as a calculator. A web-developer completed the ROI calculator build on the DPA website and the software was tested by internal and external working group members for validity. A webinar was hosted by the DPA featuring Drs Orly Ardon PhD and Matthew Hanna, MD in November 2023 to showcase the tool and gather beta testers from the community[35]. The website was made available to all DPA members on February 6, 2024 and is now available at https://digitalpathologyassociation.org/roi-calculator-2.

Results

Identification of all digital pathology capital and operational costs

The stand-alone slide acquisition cost of DP is higher than that of analog microscopy due to the need for the additional digitization step (e.g. scanner, personnel, software), interface construction with the laboratory information system (LIS), and data storage infrastructure (refs).

As a first step in developing an ROI calculator, all known digital pathology operations and infrastructure costs had to be accounted for and included in a working team document. These additional costs were

based on previous publications [11–13] and on unpublished real world experience based on current digital pathology practices.

Eleven unique input fields were identified and are listed in Table 1. Each one of these categories required user input in fields that were used for the various calculations. Each field/category can be skipped and /or filled independently to enable the customized calculation of the total cost of operations for the organizations' specific needs.

Table 1: User Input Cost Fields/Subcategories

Identified Digital Pathology Cost Category	User Entry Field
1. Laboratory Inhouse Cases	Number of operation sites
	Number of cases accessioned per/year
	Number of stained slides generated/year
	Number of days operating per week
	Number of operation weeks per year
	Estimated stained slides generated per day
	Cost to generate glass slide from laboratory
	Number of pathologists
	Avg FTE cost/annual salary for pathologist
	Number of pathologists using digital
	Anticipated productivity gain per pathologist using digital (%)
	Avg FTE cost/annual salary for technologist
	Average number of technologist hours worked per shift
	Avg FTE cost/annual salary for administrator
	Average number of administrator hours worked per shift
2. Frozen sections (FS)	Average number of FS/day
	Number of devices (scanners) to support FS
	Cost per device
	Courier costs supporting FS (per year)
	Anticipated Pathologist % productivity with digital workflow
	Anticipated Technologist % productivity with digital workflow
3. Rapid Onsite Evaluation (ROSE) procedures	Average number of ROSE procedures/day
	Number of devices (scanners) to support ROSE procedures
	Cost per device
	Courier costs supporting ROSE (per year)
	Anticipated Pathologist % productivity with digital workflow
	Anticipated Technologist % productivity with digital workflow
4. Outside institutions consultation cases	How many/year
	Time spent (mins) receiving each consult (accessioning,

	labeling, handling, distribution)
	Avg FTE cost/annual salary for Accessioner
	Anticipated % increase of digital consults
	Average revenue per consult case
5. Send out consults	How many/year
	Cost to send each consult (packaging, postage)
	Time spent sending out each consult (personnel time, mins)
	Avg FTE cost/annual salary for Case send out personnel
6. Labor Cost	Tech time spent assembling/collating each case (mins)
	Tech time spent delivering cases (hours/day)
	Avg FTE cost/annual salary for Lab Technician
	Courier time delivering cases (hours/week)
	Avg cost for Courier services per hour
7. Scanner costs	Scan time per slide
	Estimated glass slide throughput in whole slide scanners/hour
	Estimate scan operational hours/day
	Estimated number of whole slide scanners [output box]
	Estimated cost per whole slide scanner device
	Number of personnel operating scanner
	Avg FTE cost/annual salary for Scanner operator
	Estimated downtime (hours/day)
	License fee (one time fee)
	Installation/Integration fee
	Annual maintenance/service costs
8. Workstation costs	Cost per high-definition monitor
	Cost per input device
	Cost per workstation upgrade
9. QC needs	QC time per slide
	Avg FTE cost/annual salary for QC personnel
10. Integration with LIS	Cost per LIS interface
	Avg FTE cost of IT personnel (IT support)
	Estimated number of FTEs dedicated to digital pathology workflows
	Number of different scanner vendors
	Estimated cost of service contracts per year
11. Storage needs	Average file size per whole slide image (GB)
	Cost per TB/month digital storage (on-premise)
	Anticipated % of storage to be on-premise
	Cost per TB/month digital storage (cloud)
	Anticipated % of storage to be in the cloud
	Estimated annual storage needed (TB)

Identification of analog pathology costs that could be reduced or avoided with DP

Though there are added costs that are associated with DP, there are existing analog pathology costs that could be avoided or reduced when replaced with digital pathology[4,11,13,31]. These reduced and avoided costs will be institution dependent and should be accounted for whenever possible when calculating the anticipated ROI of DP.

The input in Table 2, is aimed to allow the calculation of cost avoidance or reduction that can be achieved when migrating to digital workflows.

Table 2: User input subcategories for cost savings and cost avoidance

Cost Savings and Avoidance Category	User Entry Field
1. Glass slide storage and retrieval	Glass slide storage costs per year
	Percent reduction in glass slide storage costs if relocated
	Average number of glass slide retrievals from outside storage
	Cost per retrieval from outside storage
	Cost per case archival to outside storage
	Anticipated % decrease in glass slide outside storage retrieval
	Tech time spent archiving (hours/week)
	Tech time spent retrieving (hours/week)
	Admin time spent archiving (hours/week)
	Admin time spent retrieving (hours/week)
	Number of archived shipments per week
	Number of retrieved shipments per week
	Other admin time*
2. Educational conferences	Number of cases presented at conference/year
	Total Admin prep time* (minutes/case)
	Total Pathologist prep time* (minutes/case)
	Number of educational recuts
3. Team review meetings	Avg number of team review meetings (e.g. consensus/QA) per week
	Avg number of cases reviewed per team review meeting per week
	Total Admin prep time* (minutes/case)
	Total Pathologist prep time* (minutes/case)
4. Potential legal costs	Medical malpractice cases related to missing slides
	Internal costs of legal action per medicolegal case
	Professional costs of legal action per medicolegal case
	Technical costs of legal action per medicolegal case
*Organizing cases, querying for cases, waiting for delivery, matching cases, searching for cases, transporting cases	

Identification of potential revenues

Many of the reported benefits of digital pathology are intangible and include multiple benefits to patients, pathologists, researchers and institutions [11,12,36]. As with other disruptive technologies, is often hard to measure and quantify the value of intangible benefits, these were not included in the development of the DP calculator. Other benefits offer cost savings or avoidance as detailed above. Currently, the identified revenue generating categories are the commercial research value of the digital images and the reimbursement that is available or becoming available for the extra digitization steps (Table 3)

Table 3: Potential digital pathology revenue categories for digital pathology for user entry fields.

Revenue Category	User Entry Field
1. Commercialization revenue	Anticipated number of slides used for commercialization
	Estimated revenue per slide used for commercialization
2. Reimbursement revenue: existing codes	Estimated number of manual quantified immunohistochemistry (e.g. ER, PR, HER2, Ki67, PD-L1, etc.)/year
	Anticipated percent of above to transition to computer-assisted quantified immunohistochemistry (e.g. ER, PR, HER2, Ki67, PD-L1, etc.)/year
	Anticipated revenue per 88361 CPT code (computer assisted) IHC quantification
3. Reimbursement revenue: new T codes	Estimated number of scanned slides for fee code 88302 and reimbursement for new add on CPT code 0751T
	Estimated number of scanned slides for fee code 88304 and reimbursement new add on CPT code 0752T
	Estimated number of scanned slides for fee code 88305 and reimbursement for new add on CPT code 0753T
	Estimated number of scanned slides for fee code 88307 and reimbursement for new add on CPT code 0754T
	Estimated number of scanned slides for fee code 88309 and reimbursement for new add on CPT code 0755T
	Estimated number of scanned slides for special stain for fee code 88312 and reimbursement new add on CPT code 0756T
	Estimated number of scanned slides for special stains for fee code 88313 and reimbursement for new add on CPT code 0757T
	Estimated number of scanned slides for frozen section/special stains for fee code 88314 and reimbursement for new add on CPT code 0758T
	Estimated number of scanned slides for special stains for fee code 88319 and reimbursement for new add on CPT code 0759T
	Estimated number of scanned slides for initial immunohistochemistry slide for fee code 88342 and reimbursement for new add on CPT code 0760T
	Estimated number of scanned additional immunohistochemistry slides with fee code 88341 and reimbursement for new add on CPT code 0761T
	Estimated number of scanned slides for each multiplex antibody stain procedure immunohistochemistry slide for fee code 88344 and reimbursement for scanned slide new add on CPT code 0762T
	Estimated number of scanned slides for each quantitative immunohistochemistry slide for fee code 88360 and reimbursement for new add on CPT code 0763T

A significant revenue can be derived from research collaborations, yet data as to the extent of commercialization revenue for pharma and other external collaborations is usually restricted with contractual agreements between institutions, and therefore, not publicly available. The commercialization revenue category in the calculator did not include any lump sum contractual payment user fields, but rather a user calculated revenue per slide digitized to allow informed decisions based on anticipated volumes scanned and not milestone payments. These per-slide

payments will vary among institutions, collaborators, size and scope of the scan project and the geographical location of the contracting parties.

The reimbursement climate is changing, and this topic is of interest to the American digital pathology community and the professional societies who are driving the efforts to increase reimbursements for the digitization steps. The College of American Pathologists (CAP) worked with the American Medical Association (AMA) CPT Editorial Panel to establish 13 new digital pathology add-on codes for 2023 and 30 new add-on fee codes in 2024[37]. The resulting Category III add-on codes (0751T-0763T), and new codes (0827T-0856T) that are intended to capture and report additional costs that are associated with digitizing glass microscope slides for primary diagnosis. As a result of CAP advocacy, these codes will help pathologists, pathology practices, and laboratories to appropriately report digitized services. The Digital Pathology CPT instructions were also revised clarifying that each Category III add-on code is reported as a one-to-one unit of service for each paired primary pathology service code (e.g. 88305 is coded with 0753T, Digitization of glass microscope slides for level IV, surgical pathology, gross and microscopic examination) [37]. To date, little is known as to the extent of current reimbursement, yet these codes were added to the calculator so that the calculator user can experiment with different scenarios and reimbursement rates to get an estimate of the anticipated revenue.

The reimbursement input fields will get updated once revisions are made by the AMA.

ROI Calculator Website

To allow easy accessibility to the digital pathology community, we created an interactive web-based calculator using the modeling developed by this working group. This calculator is available free of charge globally 24 hours per day to all members of the DPA.

All of the cost, cost avoidance/savings and potential revenue categories were grouped together in a summary table (Table 4). This table is displayed on the right side of the calculator, allowing the user an instant view of the updated results whenever the input fields get modified.

Table 4: Categories used for return-on-investment calculations.

Costs
Annual cost pathologists
Cost to generate stained glass slides per year
Cost for FS digital workflow
Cost for ROSE digital workflow
Cost Pathologist workstation
Cost for clinical digital workflow
Costs for information technology to support digital workflow
Costs for digital storage
Cost savings/avoidance
Cost avoidance by using digital workflow
Cost avoidance for FS digital workflow
Cost avoidance for ROSE digital workflow
Cost avoidance for Consult workflow
Cost avoidance for clinical digital workflow
Cost avoidance for glass slide storage
Cost avoidance glass slide retrieval
Cost avoidance educational recuts
Cost savings conferences (personnel time)
Cost savings Case Review & Collaboration
Cost avoidance Legal
Revenue
Additional consultation practice
Data commercialization
Computer assisted quantification reimbursement
Future CPT reimbursement

The customizable user input is used for predictions/calculations in real time that capture the projected estimated costs, cost avoidance and savings, and the projected revenue. This in turn allows the calculation of the expected ROI for the specific data entered. The display of this calculation is visible to the user, allowing visualization of the results as soon as user entries are made or edited.

The ROI calculation was based on the accepted formula for ROI calculations (Table 5), and can result in a positive or negative quotient between the sum of total costs, cost savings and

revenue and the sum of the costs. As ROI is most often expressed as a percentage, the quotient should be converted to a percentage by multiplying it by 100. When the calculator yields a positive ROI percentage, this means that the digital pathology initiative, as entered by the user in the input fields, is profitable. If this calculation has a negative ROI percentage, the initiative will yield revenue and cost savings lower than the total investment in this digital pathology initiative.

Table 5: ROI Calculation using input from costs, cost savings/avoidance and revenue (see table 1 and 2).

Projected costs	A
Projected cost savings and cost avoidance	B
Projected Revenue	C
Net	=(C+B)-A
Estimated ROI	=(C+B-A)/(A) X 100

Beta User Testing

Beta testing of the calculator took place for 8 weeks, following the alpha testing at MSK. The testing was done by 17 users, representing different institutions across different geographical locations in the US. These users represented academic institutions, hospital systems, private laboratories, pharmaceutical companies, and the technology sector.

Eight users responded to a survey with their feedback for the use of the calculator. Six of the users (75%) thought that the calculator was easy to use and chose “neutral” for their experience. The average rating for the calculator was 4.63 out of a maximum of 5. Six responses were available for the accuracy of the calculator in comparison to the users’ previous calculations, and these ranged between 50-90%. All 8 testers would recommend the use of the calculator to a friend or colleague who is in their initial exploration of digital pathology.

Discussion

The development of a web-based online calculator enhances the accessibility of this calculator to all DPA members, regardless of their geographical location. Users can easily input the relevant digital pathology operations categories and obtain relevant predictions for their costs, cost savings/avoidance and revenue with different scenarios of digital pathology operations. These in turn can be used for budget developments, technology selection, leadership buy-in and informed decision making.

ROI can be applied to any outcome and includes both qualitative and quantitative measures[38]. Each stakeholder will therefore have expectations of any investment made and they should all be considered as part of its evaluation[38].

Given all of DP's benefits to institutions and patient care, both tangible and intangible, financial ROI should be one factor in the institutional decisions to invest in DP technologies[11,12,36]. Our online calculator should help institutions in their DP planning and informed decision-making while keeping all those other benefits in mind.

There are inherent limitations to this first release of the ROI calculator. First, we included only costs and cost savings attributable to categories that were identified and known by the ROI subcommittee team pre-August 2023, when the website was developed. Other developing and future workflows were not factored into the analysis and will be added to the calculator once they become available. In addition, though adoption is well under way, we chose not to include the costs and benefits of AI tools; these will be added to the calculator in future releases.

There may be more opportunities for additional use cases that are yet in early stages of development, and as this calculator could not encompass all potential scenarios, there will be periodic updates that will be available on the DPA website. Improvements are expected and will be determined based on user input as well as new technologies or advancements in reimbursement as needs arise and as digital pathology adoption increases and matures.

Caution should be always taken when using the calculator findings and results should always be independently verified by the users before investments are made. The goal of the calculator was to provide an estimate for an anticipated ROI, and not an exact number, which is extremely difficult to achieve in complex investments in healthcare innovation.

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Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: