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# Comparaison de quatre méthodes couramment utilisées pour la mesure de la charge de travail en pathologie

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## RÉSUMÉ

Les pathologistes ont besoin d'un moyen d'assurer une dotation adéquate de personnel afin que la charge de travail soit raisonnable, sécuritaire et pratique, sans toutefois être excessive. Plusieurs systèmes de mesure de la charge de travail ont fait l'objet de publications et sont disponibles. Nous avons choisi d'en évaluer quatre qui sont couramment utilisés : ceux de l'Association canadienne des pathologistes (ACP), du Royal College of Pathologists (RCP), de la Current Procedural Terminology (CPT) ainsi que Work2Quality (W2Q). Nous avons créé un logiciel capable de calculer simultanément la charge de travail selon tous ces systèmes de façon automatique, afin de déterminer le plus pertinent pour notre pratique. Les données résultantes ont fait l'objet d'un audit et d'une vérification manuelle pour en assurer l'exactitude. Les cas ont été répartis par catégorie selon le type de pratique, la spécialité, la surspécialité, l'intervention, les prélèvements et le pathologiste. Ils pouvaient tous faire l'objet d'un codage automatisé précis sur une période d'un an. Selon notre analyse, les nombres absolus et relatifs d'équivalents temps plein (ETP) fournis par les quatre systèmes variaient selon l'hôpital, la spécialité, la surspécialité et l'intervention. Le système de l'ACP a donné de meilleurs résultats pour la cytologie et la résection de tissu mammaire, et de moins bons pour les biopsies et la surspécialité de pathologie digestive. Le système du RCP, quant à lui, a donné de meilleurs résultats pour la cytologie, la gynécologie et la dermatologie, et de moins bons pour les biopsies et les surspécialités de pathologie digestive et génito-urinaire. Les systèmes W2Q et de la CPT ont donné des résultats très semblables pour toutes les catégories, excepté celles relatives aux lymphomes, aux biopsies rénales et aux coupes d'échantillons congelés. Certaines de ces variations ont pu être corrigées par l'application d'une limite au nombre de blocs par prélèvement (ACP), la non-prise en compte des éléments colorés multiples dans un même prélèvement (W2Q), la réduction de la valeur des éléments colorés par immunohistochimie (CPT), la réduction de la charge de travail quotidienne par ETP (RCP) et l'ajustement de la valeur associée à certains prélèvements. Dans l'ensemble, c'est le système W2Q qui s'est montré le plus équilibré et le plus efficace, pour la pratique tant en milieu communautaire qu'en milieu universitaire, et qui s'est le mieux comporté lors de l'automatisation; les valeurs assignées aux coupes d'immunohistochimie et aux coupes d'échantillons congelés nécessitent cependant quelques ajustements supplémentaires.

KEYWORDS:
anatomic pathology, workload, automation, benchmarking

# Comparison of Four Commonly Used Guidelines for Workload Measurement in Pathology

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## ABSTRACT

Pathologists require a mechanism to ensure proper staffing and a workload that is reasonable, safe and practical but not excessive. There are several published workload measurement systems that are available. We chose to evaluate four commonly used workload measurement systems: CAP, W2Q, RCP and CPT. We developed software that automatically calculates the workload for all these systems simultaneously to evaluate which one was most appropriate for our practice. The data was audited and verified manually to ensure accuracy. All cases were categorized by practice type, specialty, subspecialty, procedure, specimens and pathologist. All the cases were amenable to accurate automated coding over a one-year period. Analysis showed the four systems differed in the absolute and relative number of full-time equivalents (FTE) by hospital, specialty, subspecialty and procedure. CAP showed higher scores for cytology and breast resections and lower scores for biopsies and GI subspecialty. RCP showed higher scores for cytology, gynecology and dermatology and lower scores for biopsies, GI and GU subspecialties. W2Q and CPT showed very close correlation in all categories except lymphomas, renal biopsies and frozen sections. Some of these variations could be corrected by applying a limit to the number of blocks per specimen (CAP), discounting repeated stains per specimen (W2Q), reducing the value of IHC stains (CPT), reducing the daily workload per FTE (RCP) and adjusting the value for some specimens. Overall, W2Q showed a better balance and efficiency for both community and academic practices, and for automation, but it requires further adjustments in the scores assigned to immunohistochemistry and frozen sections.

## Workload Measurement in Pathology (cont.)

### INTRODUCTION

In Canada, a decreasing supply of pathologists has resulted in increased pathologist workload, with an estimated 17% increase in cancer cases per pathologist over the past decade.[1] Remuneration of hospital-based pathologists, as employees or contractors, is largely borne by the hospital "global" budget. This funding model has failed to accommodate workload increases over time and even new activity-based funding models do not account for pathology costs. Failure to adjust pathology manpower to accommodate workload increases can lead to excessive patient wait times, delays in initiating new cancer therapies, pathologist burnout, and high attrition rates as pathologists seek work at better-resourced hospitals with more optimal staffing levels. Workload measurement is an essential component of any staffing model, however, in Canada a unified pathology workload measurement system and workforce planning model has not yet been adopted. This has led to considerable variation in departmental and individual pathologist workloads across the country.

Pathologists are knowledge workers, not labour workers, which makes their productivity difficult to measure in a consistent manner. Specifically, the nature of their job is to solve a medical problem (make a diagnosis by interpreting pathological changes in tissue) using the knowledge that they have, rather than carry out predefined repetitive and invariable tasks. It is easy to quantitate a manual worker's workload, as the product of their labour is visually apparent. However, workloads are not immediately obvious with knowledge workers. The quality of a knowledge worker's output is at least as important as, if not more important than the quantity.[2] Furthermore, the output (diagnosis) is workflow independent; it cannot be determined solely by the number of slides to be interpreted, as the nature of the disease may vary considerably from patient to patient. There are also continual increases in the level of information and knowledge required, such as understanding of biomarkers and molecular tests, to inform good patient management in the era of personalized medicine. A study by Warth et al. showed that the evolution of diagnostic procedures over the last decade has resulted in a 60% increase in slide numbers per case, doubling of immunohistochemistry procedures, and more than tripling of molecular analyses.[3]

A further complication in workload measurements is related to other responsibilities of pathologists, particularly at teaching hospitals: teaching of medical students and postgraduate trainees (residents), conducting research, attending tumour boards and other multidisciplinary rounds, practice subspecialisation, heavy administrative burdens, attendance at hospital and external committee meetings, interruptions by clinical house staff seeking diagnoses, etc. In fact, numerous activities add up to 40-50% of time spent on non-diagnostic tasks.[4]

There is a definite need to adopt a standardized measure of workload for pathology in order to balance staffing with the anticipated increases in workload. In the absence of such a standardized system there remains a risk of episodic crises due to pathology manpower being overwhelmed by workload increases. There are several published proposals for pathologists' workload management systems (WMS), including the Kaiser Permanente system[5], Korner units,[6] KU units,[7] activity-based systems,[8-9] the Warwick system,[10] University of Washington-Seattle (UW) slide count method,[11] the Canadian Association of Pathologists (CAP-ACP) L4E system,[12] Work2Quality (W2Q),[13] the Royal College of Pathologists (RCP),[14] and the Current Procedural Terminology (CPT).[15] In order to find the most informative WMS for our institution, we decided to measure four WMS simultaneously, and to automate the process using an in-house open-source software that we have previously described.[16]

### MATERIALS AND METHODS

#### Cases

All cases in this study were retrieved sequentially from the Eastern Ontario Regional Laboratory Association (EORLA) anatomic pathology database, but we excluded forensic pathology as the latter already has provincial productivity guidelines based on case numbers per forensic pathologists per year. EORLA is an association of all the laboratory and pathology departments of Eastern Ontario that includes 18 facilities in 16 regional hospitals of different sizes. All pathology specimens and reports are managed in one centralized database operated by Sunquest PowerPath®.[17] The pathology department is divided into 3 community hospitals that have their own staff comprised of 2.5 to 4 general pathologists reporting in non-specialty practices, and one tertiary hospital that employs 32 academic pathologists operating in a subspecialty practice with additional academic and administrative responsibilities. The pathologists at these hospitals provide pathology services to 15 out of 16 hospitals, 11 of which have no pathologists on site. This study excludes work done at the Children's Hospital of Eastern Ontario which has not yet been integrated into the PowerPath system.

#### Software

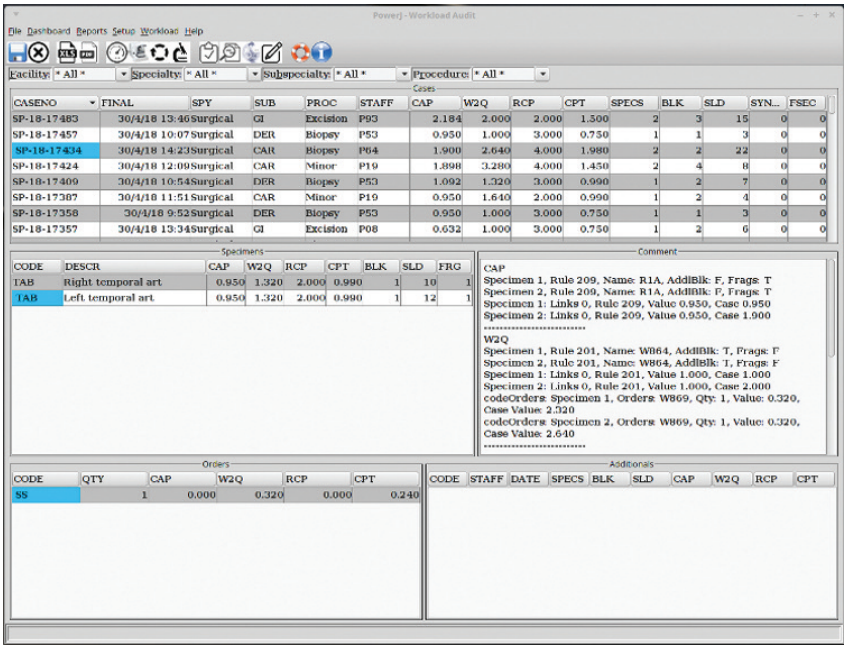
PowerJ was written in Java and its open-source code is available at Git-hub®[18] under the terms of the GNU general public license as published by the Free Software Foundation. It is a fully automated application that connects to our anatomic pathology database PowerPath® daily at 11 pm, calculates

## Workload Measurement in Pathology (cont.)

Workload measurement is an essential component of any staffing model, however, in Canada a unified pathology workload measurement system and workforce planning model has not yet been adopted.

the workload of the cases that have been reported since the previous day, and saves the results in a separate relational database running on Microsoft SQL Server® (Microsoft, Redmond, WA). All the calculations are stored at the single case level and by each specimen, and are tagged by hospital (H1 to H4), specialty (surgical, cytology, autopsy), subspecialty (breast, dermatopathology, renal, etc.), procedure (biopsy, excision, small organ, large organ, radical resection), pathologist, number of specimens, number of initial and additional blocks, hematoxylin and eosin (H&E) slides, levels, special stains (SS), immunohistochemistry (IHC), etc. Since data entry in PowerPath® is menu-driven and defined in system-wide dictionaries for accessioning specimens, printing blocks and ordering stains, PowerJ matches the specimens and orders by their unique numeric identifier (ID) to duplicated tables that define the corresponding workload rules and values for each specimen and order. The number of fragments or cores per specimen is extracted from the gross description when needed. Benign and malignant resection cases are identified by the absence or presence of the Cancer Care Ontario (CCO) synoptic report, which is mandatory for every malignant case which has undergone a resection in Ontario. Reports are generated using aggregate functions in SQL language and can be filtered by user-defined criteria for date range, hospital, specialty, and others. The reports can be exported to spreadsheet or PDF files for further analysis. The accuracy of the automated workload measurements was extensively audited by expert pathologists using a custom detailed screen that displays the steps used to code each case (Figure 1).

**Figure 1.**




PowerJ audit screen displaying cases (top table) filtered by user-defined criteria (top toolbar), the specimens of the selected case (middle left table), a description of how the case was coded (middle right text), orders from the selected specimen (bottom left table), and additional work performed by other pathologists (bottom right table) such as frozen section, internal review, tumour board.

### Academic and Administrative Workload

Academic and administrative workload is not within the scope of this study for several reasons. This workload is not amenable to automated tracking in our institutions and the university evaluates academic productivity based on separate rules and standards. In addition, we have a heterogenous practice of academic and non-academic staff. Therefore, we only measured the clinical activities of each pathologist based on the data available to us. This way, a non-academic pathologist is assigned a 1.0 full-time equivalent (FTE), whereas an academic pathologist is assigned 0.4 to 0.8 "clinical" FTE depending on the memorandum of agreement between each pathologist and the University of Ottawa.

### Pathology Assistants and Cytotechnologists

Both CAP-ACP and RCP reduce workload units by 5-10% when grossing is performed by a pathology assistant, or when cytology cases are pre-screened by a cytotechnologist. W2Q and CPT do not make this distinction. Since all 4 hospitals have pathology assistants and cytotechnologists, we used the workload

## Workload Measurement in Pathology (cont.)

units specific to microscopic activities for CAP-ACP and RCP.

### Comparisons

Since each WMS uses different units of measurements, we compared the estimates of number of FTE's and their percentages (relative weight) of the units assigned to each case by category. Since CPT does not officially define a daily or annual workload per FTE recommendation, we used the figure reported by Cloetingh et al (6,016 RVU's annual or 28.6 per workday for 210 workdays per 1.0 FTE).[7] A correlation analysis was performed using Pearson linear regression in Microsoft Excel (Microsoft, Redmond, WA).

## RESULTS

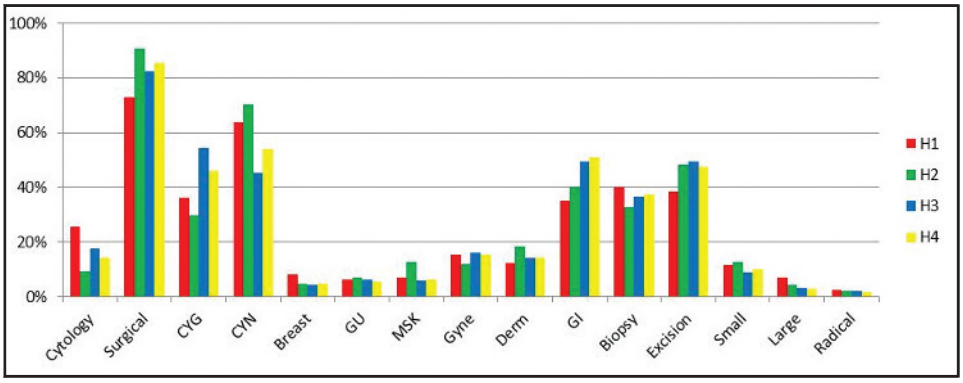
### Cases

There were 118,576 cases reported by EORLA pathologists from May 1, 2017 to April 30, 2018. These cases were comprised of 188,835 specimens, 431,014 blocks and 836,925 slides. The breakdown by hospital, specialty and

**Table 1.** Number of cases, specimens, blocks and slides and the units allocated by each WMS categorized by hospital, specialty, sub-specialty and procedure.

| | Cases | Specimens | Blocks | Slides | CAP-ACP | W2Q | RCP | CPT |
|---|---|---|---|---|---|---|---|---|
| **Total** | 118,576 | 188,835 | 431,014 | 836,925 | 250,983 | 254,927 | 361,563 | 199,728 |
| **H1** | 70,995 | 113,709 | 287,636 | 555,167 | 168,635 | 167,437 | 240,164 | 132,336 |
| **H2** | 5,289 | 7,214 | 17,166 | 29,813 | 8,180 | 8,672 | 12,676 | 6,593 |
| **H3** | 18,371 | 27,744 | 61,483 | 137,157 | 32,979 | 33,936 | 44,354 | 26,250 |
| **H4** | 23,921 | 40,168 | 64,729 | 114,788 | 41,189 | 44,882 | 64,369 | 34,549 |
| **Autopsy** | 177 | 181 | 3,433 | 4,550 | 4,289 | 3,596 | 5,028 | 2,646 |
| **Cytology** | 25,324 | 25,324 | 4,024 | 45,723 | 31,205 | 28,439 | 58,652 | 23,410 |
| **Surgical** | 93,075 | 163,330 | 423,557 | 786,652 | 215,489 | 222,892 | 297,883 | 173,672 |
| **CYG** | 10,024 | 10,024 | 0 | 8,491 | 9,524 | 5,618 | 20,048 | 4,213 |
| **CYN** | 15,300 | 15,300 | 4,024 | 37,232 | 21,681 | 22,821 | 38,604 | 19,197 |
| **HEME** | 67 | 67 | 71 | 257 | 138 | 100 | 206 | 91 |
| **EYES** | 886 | 1,040 | 1,338 | 5,657 | 851 | 1,122 | 3,060 | 1,055 |
| **GNRL** | 868 | 1,290 | 4,595 | 9,714 | 2,506 | 3,566 | 4,205 | 3,443 |
| **CARD** | 1,704 | 2,432 | 3,714 | 11,228 | 3,573 | 3,819 | 5,623 | 2,958 |
| **LYMPH** | 533 | 638 | 1,291 | 8,298 | 3,734 | 3,241 | 4,638 | 4,470 |
| **NEURO** | 1,088 | 2,038 | 3,472 | 7,778 | 3,707 | 3,961 | 6,239 | 4,043 |
| **RENAL** | 311 | 311 | 338 | 10,356 | 3,881 | 7,716 | 3,732 | 2,651 |
| **FS** | 1,183 | 2,146 | 2,624 | 3,116 | 5,657 | 3,098 | 6,510 | 4,146 |
| **THORX** | 1,146 | 2,843 | 8,748 | 15,157 | 4,410 | 5,907 | 9,676 | 4,434 |
| **ENT** | 2,501 | 3,673 | 16,615 | 24,210 | 6,742 | 5,834 | 8,026 | 4,421 |
| **MSK** | 6,384 | 7,459 | 16,117 | 19,701 | 6,771 | 5,835 | 10,881 | 4,647 |
| **DERM** | 12,421 | 16,220 | 37,480 | 66,831 | 14,263 | 18,088 | 38,205 | 15,152 |
| **GU** | 5,715 | 21,496 | 53,177 | 96,123 | 27,778 | 28,190 | 32,126 | 21,515 |
| **BRST** | 6,068 | 10,563 | 73,927 | 120,347 | 34,829 | 25,362 | 35,928 | 19,187 |
| **GYN** | 14,210 | 20,417 | 78,155 | 107,623 | 31,812 | 28,872 | 45,051 | 21,981 |
| **GI** | 37,990 | 70,697 | 121,895 | 280,256 | 65,629 | 77,318 | 83,777 | 60,516 |
| **Biopsy** | 35,354 | 66,899 | 82,975 | 282,198 | 75,667 | 97,393 | 100,916 | 75,710 |
| **Excision** | 39,401 | 62,425 | 116,976 | 228,435 | 50,359 | 59,149 | 90,452 | 45,489 |
| **Small** | 10,032 | 14,469 | 41,436 | 59,852 | 17,672 | 18,230 | 31,572 | 15,525 |
| **Large** | 4,969 | 12,305 | 118,540 | 146,104 | 44,998 | 32,350 | 48,039 | 23,373 |
| **Radical** | 2,136 | 5,086 | 61,006 | 66,947 | 21,136 | 12,672 | 20,394 | 9,430 |

**Figure 2.**




Distribution of cases among different hospitals by specialty, sub-specialty and procedure. Cytology and surgical pathology are expressed as percent of total cases per hospital, whereas CYG and CYN as percent of cytology cases per hospital, and the remainder as percent of surgical pathology cases per hospital.

other parameters is shown in Table 1. The difference in the distribution of cases between the 4 hospitals by specialties, subspecialties and procedures is shown in Figure 2.

### Software and Automation

All the cases were amenable to automated coding following the rules indicated by each WMS. The accuracy of automated coding was optimized at the single case level through multiple cycles of manual audits followed by corrections to the source code. CAP-ACP was the most difficult and challenging WMS to implement due to the complexity and multitude of rules and exceptions. Problems were encountered when the number of polyps or lesions was not specified by the clinicians. The grossing staff could not always agree on how to count fragmented cores or biopsies. In some cases, the number of pieces went as high as 70 cores, or just reported as innumerable. We, therefore, had to set an upper limit of 20 as was used in breast and prostate biopsies. The CAP-ACP rule for high grade dysplasia in polyps and dysplastic nevi was ignored for two reasons: a lack of a discrete identifier for automation, and a consensus that high-grade dysplasia can be as challenging to diagnose in the esophagus, endometrium and breast as in the colon or skin. The other three WMS did not pose any significant challenges or limitations to automated calculations.

### Comparison of Systems

Similarities and differences between the four WMS studied are summarized in Table 2. Pearson linear regression analysis showed a strong positive correlation between W2Q and CPT (0.915, $P < 0.01$), as well as between CAP-ACP and slide count (0.892, $P < 0.01$). There was a weaker positive correlation between CAP-ACP and RCP (0.775, $P < 0.01$), as well as between CAP-ACP and W2Q (0.773, $P < 0.01$).

### Total Workload

The total number of FTE's calculated (Table 2) was 34.0 for W2Q, 33.2 for CAP-ACP, 33.2 for CPT and 31.9 for RCP. The mean value was 33.07 and the median 33.20.

### Practice Type

The absolute number of FTE's calculated for the academic hospital (H1) was similar for CAP-ACP (22.3), W2Q (22.3) and CPT (22.0), but was lower for RCP (21.2). Within community hospitals, there was more variation in the allocation of resources, especially for W2Q that gave hospital H4 6.0 FTE compared to 5.5 given by CAP-ACP (Figure 3). Therefore, these differences appear to be due to the different mix of specimens and procedures between the hospitals, rather than differences between academic and community practices.

### Specialties

Autopsy scores showed no significant difference between the 4 WMS. However, RCP and CAP-ACP gave

... these differences appear to be due to the different mix of specimens and procedures between the hospitals, rather than differences between academic and community practices.

## Workload Measurement in Pathology (cont.)

**Table 2.** Number and percent of FTE's allocated by each WMS and categorized by hospital, specialty, sub-specialty and procedure.

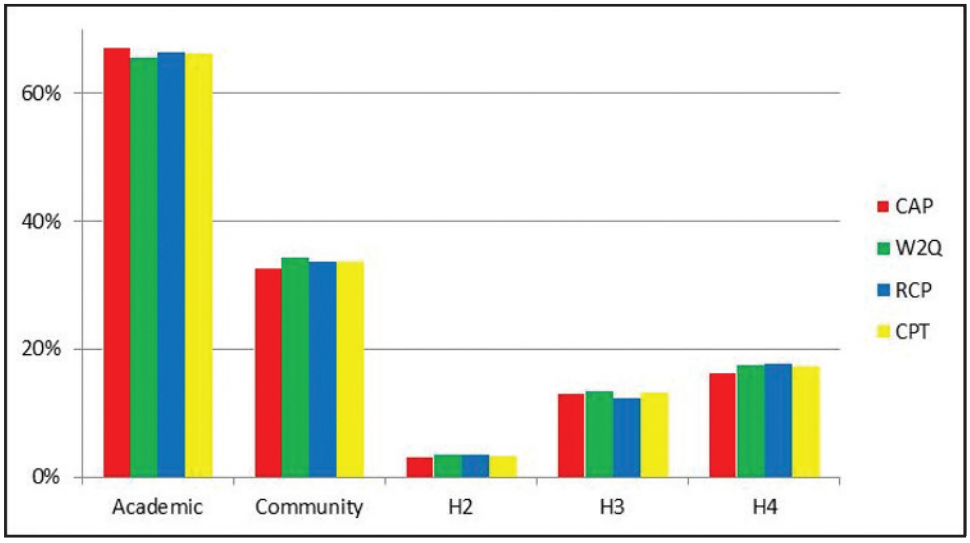
| | FTE | | | | Percentage | | | |
|---|---|---|---|---|---|---|---|---|
| | CAP-ACP | W2Q | RCP | CPT | CAP-ACP | W2Q | RCP | CPT |
| **Total** | 33.20 | 33.99 | 31.88 | 33.20 | | | | |
| **H1** | 22.31 | 22.32 | 21.18 | 22.00 | 67.19% | 65.68% | 66.42% | 66.26% |
| **H2** | 1.08 | 1.16 | 1.12 | 1.10 | 3.26% | 3.40% | 3.51% | 3.30% |
| **H3** | 4.36 | 4.52 | 3.91 | 4.36 | 13.14% | 13.31% | 12.27% | 13.14% |
| **H4** | 5.45 | 5.98 | 5.68 | 5.74 | 16.41% | 17.61% | 17.80% | 17.30% |
| **Autopsy** | 0.57 | 0.48 | 0.44 | 0.44 | 1.71% | 1.41% | 1.39% | 1.32% |
| **Cytology** | 4.13 | 3.79 | 5.17 | 3.89 | 12.43% | 11.16% | 16.22% | 11.72% |
| **Surgical** | 28.50 | 29.72 | 26.27 | 28.87 | 85.86% | 87.43% | 82.39% | 86.95% |
| **CYG** | 1.26 | 0.75 | 1.77 | 0.70 | 30.52% | 19.76% | 34.18% | 18.00% |
| **CYN** | 2.87 | 3.04 | 3.4 | 3.19 | 69.48% | 80.24% | 65.82% | 82.00% |
| **HEME** | 0.02 | 0.01 | 0.02 | 0.02 | 0.05% | 0.04% | 0.06% | 0.05% |
| **EYES** | 0.11 | 0.15 | 0.27 | 0.18 | 0.34% | 0.44% | 0.85% | 0.53% |
| **GNRL** | 0.33 | 0.48 | 0.37 | 0.57 | 1.00% | 1.40% | 1.16% | 1.72% |
| **CARD** | 0.47 | 0.51 | 0.50 | 0.49 | 1.42% | 1.50% | 1.56% | 1.48% |
| **LYMPH** | 0.49 | 0.43 | 0.41 | 0.74 | 1.49% | 1.27% | 1.28% | 2.24% |
| **NEURO** | 0.49 | 0.53 | 0.55 | 0.67 | 1.48% | 1.55% | 1.73% | 2.02% |
| **RENAL** | 0.51 | 1.03 | 0.33 | 0.44 | 1.55% | 3.03% | 1.03% | 1.33% |
| **FS** | 0.75 | 0.41 | 0.57 | 0.69 | 2.25% | 1.22% | 1.80% | 2.08% |
| **THORX** | 0.58 | 0.79 | 0.85 | 0.74 | 1.76% | 2.32% | 2.68% | 2.22% |
| **ENT** | 0.89 | 0.78 | 0.71 | 0.73 | 2.69% | 2.29% | 2.22% | 2.21% |
| **MSK** | 0.90 | 0.78 | 0.96 | 0.77 | 2.70% | 2.29% | 3.01% | 2.33% |
| **DERM** | 1.89 | 2.41 | 3.37 | 2.52 | 5.68% | 7.10% | 10.57% | 7.59% |
| **GU** | 3.67 | 3.76 | 2.83 | 3.58 | 11.07% | 11.06% | 8.89% | 10.77% |
| **BRST** | 4.61 | 3.38 | 3.17 | 3.19 | 13.88% | 9.95% | 9.94% | 9.61% |
| **GYN** | 4.21 | 3.85 | 3.97 | 3.65 | 12.68% | 11.33% | 12.46% | 11.01% |
| **GI** | 8.68 | 10.31 | 7.39 | 10.06 | 26.15% | 30.33% | 23.17% | 30.30% |
| **Biopsy** | 10.01 | 12.99 | 8.90 | 12.58 | 30.15% | 38.20% | 27.91% | 37.91% |
| **Excision** | 6.66 | 7.89 | 7.98 | 7.56 | 20.06% | 23.20% | 25.02% | 22.78% |
| **Small** | 2.34 | 2.43 | 2.78 | 2.58 | 7.04% | 7.15% | 8.73% | 7.77% |
| **Large** | 5.95 | 4.31 | 4.24 | 3.89 | 17.93% | 12.69% | 13.29% | 11.70% |
| **Radical** | 2.80 | 1.69 | 1.80 | 1.57 | 8.42% | 4.97% | 5.64% | 4.72% |

higher absolute and relative scores for cytology over surgical pathology (Figure 4). RCP scored both gynecologic and non-gynecologic cytology specimens higher, while CAP-ACP scored gynecologic cytology higher, but scored non-gynecologic cytology the lowest amongst the 4 WMS (Figure 5).

### Subspecialties

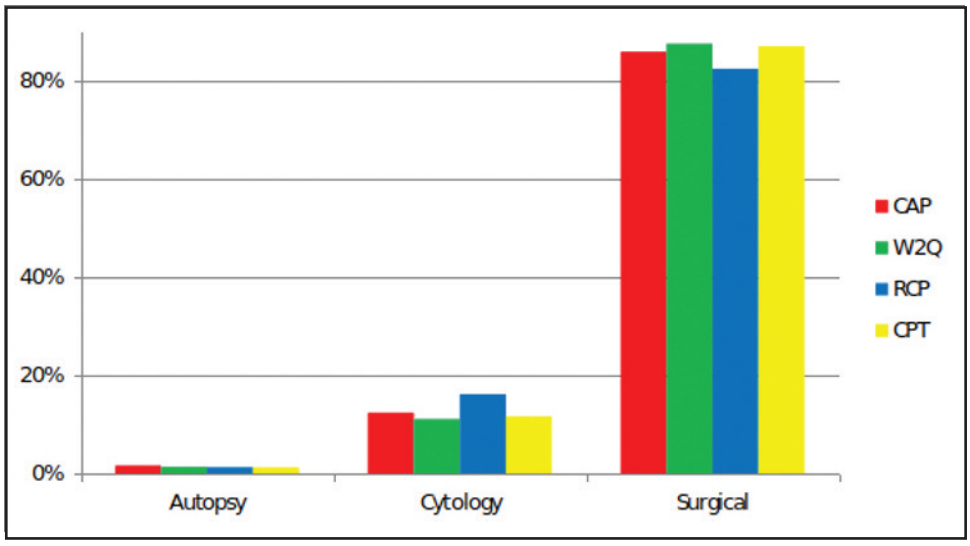
CAP-ACP assigned a higher score for breast, gynecology, ENT and frozen section (FS), while it assigned a lower score for gastrointestinal, dermatology and thoracic pathology. W2Q assigned a higher score for gastrointestinal and renal pathology, and a lower score for FS. RCP assigned a higher score for dermatology and gynecology, and a lower score for gastrointestinal, genitourinary and renal cases. CPT assigned a higher score for gastrointestinal and lymphoma cases, while it assigned a lower score for

**Figure 3.**




Workload distribution of all the cases by practice type and by hospital. The academic set is hospital H1. The community set is the sum of hospitals H2, H3 and H4.

**Figure 4.**




Workload distribution of all the cases by specialty.

breast and gynecological pathology (Figure 6).

### Surgical procedures

CAP-ACP assigned a higher score for large and radical resections, and a lower score for biopsies, excisions and small organs. RCP assigned a higher score for excisions and small organs, and a lower score for biopsies. W2Q and CPT showed a higher score for biopsies and a lower score for large specimens and radical excisions (Figure 7).

### Frozen Sections

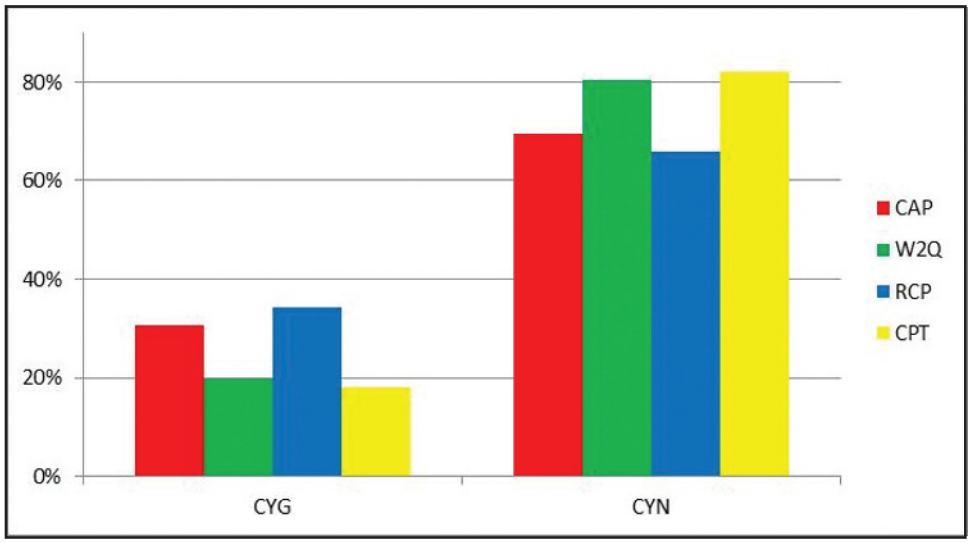
For 1,183 cases of frozen sections, W2Q assigned the lowest score compared to the other 3 WMS. In the largest case that was evaluated by FS and involved 18 specimens, 18 blocks and 18 slides, W2Q scored 15.02, CPT 32.4, CAP-ACP 35.15 and RCP 54.0.

### Number of Blocks

For some benign and most malignant resections, CAP-ACP assigns a score based on the number of blocks (rules 4 and 9). There were 89 cases with more than 100 blocks (61 BRS, 11 GU, 8 GYN, 5 GI, 3 ENT, 1 MSK) that together scored 3,930 CAP-ACP, 1889 RCP, 1353 W2Q and 916 CPT. In the largest case with 325 blocks, the scores were CAP-ACP 119.4, W2Q 47.5, CPT 16.1 and RCP 16.

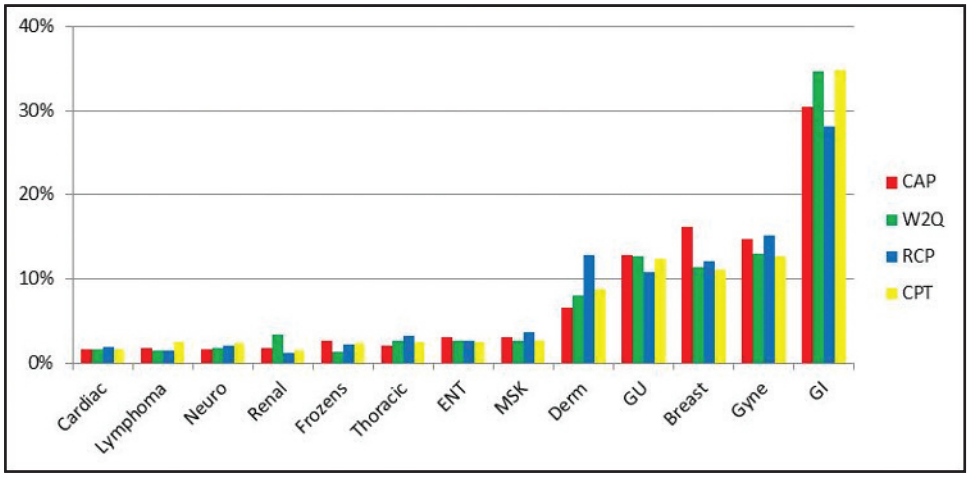
## Workload Measurement in Pathology (cont.)

**Figure 5.**




Workload distribution of cytology cases divided between gynecological (CYG) and non-gynecological (CYN).

**Figure 6.**




Workload distribution of surgical cases by subspecialty.

### Immunohistochemistry

For 68,475 IHC slides (8.2% of total slides) CPT assigned 39,454 units (19.8%), W2Q 32,968 units (12.9%), CAP-ACP 12,553 units (5.0%) and RCP 0. The effect was most notable in lymphomas that had the highest ratio of IHC stains to total slides (62%), hence the highest number in CPT. In the largest lymphoma case with 49 slides the scores were CPT 13.1, W2Q 9.0, RCP 8.0 and CAP-ACP 7.8.

For 6,302 immunofluorescence (IF) slides (0.75% of total slides), W2Q assigned 7,247 units (2.84%), CPT 2,354 (1.18%), CAP-ACP 1,991 units (0.79%). As renal biopsies had the second highest ratio of IHC stains to total slides (47%), but CPT imposes rule that each stain can only be coded once per specimen, it did not have the same effect on CPT as it did on W2Q for renal biopsies where 8 IF stains were repeated on each block, and if technically challenging on the same block. In the largest renal biopsy case with 2 blocks, 10 H&E, 32 IF and 20 SS, the scores were W2Q 46.21, CAP-ACP 16.76, RCP 12.0 and CPT 7.85.

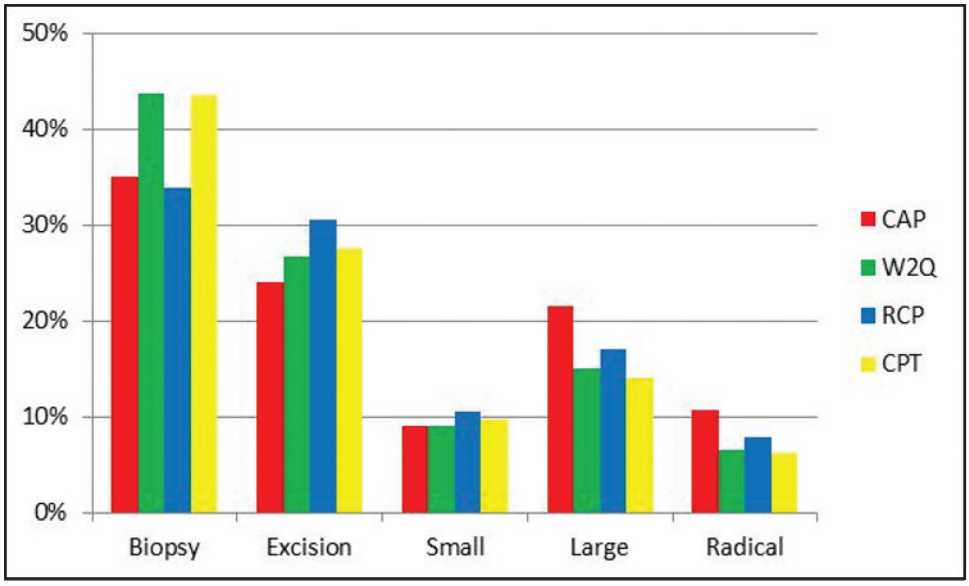
### Complexity

For the purpose of this study, complex cases were defined as those that score more than a complete autopsy in their respective units (CAP-ACP 32.4, W2Q 25.0, RCP 36.0, CPT 18.75). CAP-ACP scored 98 cases as complex, mostly breast (breast 68, GU 11, GYN 9, GI 6), W2Q scored 129 cases mostly renal (renal 78, breast 23, GYN 9, GU 6, GI 6), RCP 92 cases (GU 31, GI 22, dermatology 8, GYN 7), and CPT 70 cases (GI 17, breast 11, GYN 11, GU 8, neuro 7, thoracic 5, dermatopathology 4). Only 4 cases scored as complex in all 4 WMS (GU 2, breast 1, GI 1), and 18 cases scored as complex in at least 3 WMS: W2Q, RCP and CPT (GI 5, GU 5, GYN 3, dermatopathology 3, breast 2). Only CPT distributed complexity more evenly between subspecialties.

### Pathologists

For community hospital pathologists, high output was defined as above 1.0 FTE, and low output as below 1.0. For academic pathologists, the output is relative to their clinical assignment as per their individual memorandum of agreement (MOA) between each pathologist and the University of Ottawa. Each MOA specifies the proportion of time to be allocated for clinical service, teaching, research, and administration. All 4 WMS equally identified high output and low output pathologists (data not shown). The workload assigned to each pathologist was equally proportional within hospitals and within the same subspecialty. For community hospital pathologists, the range varied from 0.8-

**Figure 7.**




Workload distribution for surgical cases by procedure.

1.5 FTE, and for academic pathologists, it varied from 0.2 (i.e. department and division chiefs with heavy administrative responsibilities) to 1.2 FTE.

## DISCUSSION

We have evaluated and compared four commonly used workload measuring systems. Table 3 summarizes their similarities and differences. The CAP-ACP system is sponsored by the Canadian Association of Pathologists, and it assigns different units according to the specimen complexity. In some specimens the number of units changes according to the number of blocks submitted. In some biopsies the number of units changes according to the number of fragments, cores or lesions excised. Some specimens are coded combined as one (prostate biopsies whether single container or multiple containers; resections with or without lymph nodes dissection). H&E levels, additional blocks, special stains (SS) and immunohistochemistry (IHC) are assigned additional units if ordered after the initial screening, but not if routinely performed at accession time (kidney and liver stains are not assigned any additional values), except electron microscopy (EM). Cytology cell blocks are included in the specimen's code, whether done or not. Codes for Quality Assurance activities (QAA) exist for internal consults, external consults, multi-headed microscope rounds, case reviews and tumour board presentations. The recommended annual workload per Full-time Equivalent (FTE) is 7,560 (36 per day for 210 workdays/year).

W2Q is sponsored by the Ontario Medical Association and is based on the CPT but with values adjusted to align with the Schedule of Benefits of the Ontario Health Insurance Plan (OHIP). It also assigns different units according to the specimen complexity, but the number of units is not affected by the number of blocks, fragments, cores or lesions submitted. Each specimen is coded individually, even if similar (prostate biopsies). EM, SS and IHC are assigned additional units whether routine or not, but not additional blocks or additional levels. Cytology cell blocks are assigned additional units. Codes for QAA are similar to CAP-ACP. The recommended annual workload per FTE is 7,500 (35.7 per day for 210 workdays/year).

RCP is sponsored by the Royal College of Pathologists of the United Kingdom and is also used in a few institutions in Canada with some local adjustments. It also assigns different units according to the specimen complexity, and like W2Q, the number of units is not affected by the number of blocks, fragments, cores or lesions submitted. Like CAP-ACP, some specimens are coded combined as one (GI and prostate biopsies in multiple containers). The number of blocks, additional levels, SS, IHC, cytology cell blocks and QAA are all ignored except EM. There are no codes for gross-only specimens, Immunofluorescence (IF) only (dermatopathology), neuropathology or QAA. Autopsies have one code (36 points) whether complete or partial. The recommended workload per FTE is 36 units per half-day session and further recommends 7.5

Automation allowed us to measure the workload of a large group of pathologists over a long period of time seamlessly without interfering with daily clinical sign-out activities or imposition on pathologists' time.

## Workload Measurement in Pathology (cont.)

**Table 3.** Comparison of various WMS support to clinical tasks in anatomic pathology (– no support, + conditional/partial support, ++ unrestricted support)

| Variables | CAP-ACP | W2Q | RCP | CPT |
|---|---|---|---|---|
| Specimen Type | ++ | ++ | ++ | ++ |
| Blocks | ++ | – | – | – |
| Fragments | ++ | – | – | – |
| Lesions | ++ | – | – | – |
| Levels | ++ | – | – | – |
| SS | + | ++ | – | + |
| IHC | + | ++ | – | + |
| Molecular | ++ | ++ | – | ++ |
| Cell Block | – | ++ | – | ++ |
| Autopsy | ++ | ++ | + | + |
| Neuropath | ++ | ++ | – | ++ |
| Gross Only | ++ | ++ | – | ++ |
| IF Only | ++ | ++ | – | ++ |
| QAA | ++ | ++ | – | – |
| Admin/Academic | ++ | ++ | ++ | – |
| Annual Units per FTE | 7,560 | 7,500 | 11,340 | 6,016 |

half-day sessions of direct clinical care per week (the remaining 2.5 half day sessions allocated to professional activities not directly linked to clinical care). This averages to 54 units per workday or 11,340 units annually for 210 workdays/year.

CPT is sponsored by the American Medical Association and the Centers for Medicare & Medicaid Services (CMS) in the USA. It also assigns different units (RVUs) according to the specimen complexity, and like W2Q and RCP, the number of units is not affected by the number of blocks, fragments, cores or lesions submitted. Like W2Q, each specimen is coded separately, even if similar (prostate biopsies). Autopsies have codes similar to CAP-ACP and W2Q, but lack unit values assigned by CMS. However, the autopsy values are defined in a separate publication.18 Like W2Q, EM, SS and IHC are assigned additional units whether routine or not, but not additional blocks or levels. One rule that is unique to CPT is each stain (SS or IHC) can only be coded once per specimen. Cytology cell blocks are assigned additional units. CPT lacks codes for QAA. There is no official recommendation for daily or annual workload per FTE, and different institutions report between 4,000 and 8,000 units per year.[19] A mean of the 2011 rate (6,016 mean RVUs per year) was used to calculate the expected number of RVUs per hour for an academic pathologist in the study by Cloetingh et al.[20]

Given the variations in the rules of the different WMS (with CAP-ACP using complex, multi-point measurements that promise more precise and granular scores, RCP using simple, concise classification that combines many different specimens into 6 categories, enabling real-time, prospective adjustment of individual workload, while W2Q and CPT are midway in complexity and granularity), it is difficult to choose which system to follow without some benchmarking. Unlike RCP, and to some extent, CPT and W2Q, CAP-ACP is designed to assess workload after the work has been done, not prospectively, and all are subject to variation due to practice differences between pathologists and institutions.

Automation allowed us to measure the workload of a large group of pathologists over a long period of time seamlessly without interfering with daily clinical sign-out activities or imposition on pathologists' time. The process will continue on a daily basis for the foreseeable future. The selection of the most suitable WMS remains elusive since each system has advantages and disadvantages, particularly for an academic sub-specialty practice model.

CAP-ACP's high granularity did not show any advantage on the workload of the academic hospital compared to W2Q. On the other hand, it made it very difficult or cumbersome to implement

## Workload Measurement in Pathology (cont.)

Perhaps it is even counterproductive to reward the number of blocks or slides and accept that the specimen type-associated complexity score is the only reliable determining factor using average values.

accurately by automation or even manually. The number of biopsy fragments and cores is often exaggerated by tissue fragility and fragmentation. The number GI polyps or skin lesions is often not specified by the clinicians. The unlimited number of blocks per specimen gives a higher score mainly for breast resections at the expense of a lower score for biopsies and excisions. It also gives a higher score to PAP smears, and a lower score to gastrointestinal, dermatologic and thoracic specimens. CAP-ACP also gives the lowest score to the hospital that optimized its practice to have the highest output of cases per pathologist with the lowest number of blocks, slides and IHC stains per case. Thus, it imposes a penalty for efficient workflow design.

The RCP approach of incorporating all stains and slides into the specimen value is very innovative, and it can be used to measure the workload prospectively as well as retrospectively. Dividing the cases among pathologists on a daily basis can be better balanced if they can be assigned workload units by specimen types in advance. It also gives the pathologists the freedom to request the number of blocks and IHC stains they require to make the correct diagnosis, without the influence of its effect on the workload. However, RCP had the lowest number of total FTE's, the highest scores for cytology, dermatology and gynecology, and the lowest scores for gastrointestinal and genitourinary subspecialties and for biopsy procedures.

W2Q and CPT have a very good alignment with each other in all sub-categories, except for lymphomas, renal biopsies and frozen sections. This is due to the higher units assigned to IHC stains by CPT compared to W2Q that is most obvious for lymphomas, and due to W2Q allowing unlimited repeated stains (SS, IF and IHC) on the same specimen, a common practice for renal and dermatology biopsies at our institute. Also, W2Q assigns a lower score for frozen sections compared to the other 3 WMS. Finally, W2Q is more comprehensive for autopsies and QAA activities compared to CPT.

Until these discrepancies are addressed, it is difficult to decide which WMS is more accurate and truly reflects our practice. The pathologists are divided evenly in their choice among the 4 WMS, understandably each supporting the one that gives the highest score to their subspecialty practice. In the authors' opinion, W2Q offers the best balance for community and academic hospitals. Perhaps it can be improved by incorporating the IHC fraction to the workload of each specimen, as it is done now for autopsies. Measuring the workload of a knowledge worker is challenging, and in our opinion, does not reliably correlate with the number of blocks, slides or IHC stains. Perhaps it is even counterproductive to reward the number of blocks or slides and accept that the specimen type-associated complexity score is the only reliable determining factor using average values.

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