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ScienceDirect
Annals of Diagnostic Pathology 14 (2010) 107–124
Annals of DIAGNOSTIC PATHOLOGY

Productivity standards for histology laboratories

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Abstract The information from 221 US histology laboratories (histolabs) and 104 from 24 other countries with workloads from 600 to 116 000 cases per year was used to calculate productivity standards for 23 technical and 27 nontechnical tasks and for 4 types of work flow indicators. The sample includes 254 human, 40 forensic, and 31 veterinary pathology services. Statistical analyses demonstrate that most productivity standards are not different between services or worldwide. The total workload for the US human pathology histolabs averaged 26 061 cases per year, with 54% between 10 000 and less than 30 000. The total workload for 70% of the histolabs from other countries was less than 20 000, with an average of 15 226 cases per year. The fundamental manual technical tasks in the histolab and their productivity standards are as follows: grossing (14 cases per hour), cassetting (54 cassettes per hour), embedding (50 blocks per hour), and cutting (24 blocks per hour). All the other tasks, each with their own productivity standards, can be completed by auxiliary staff or using automatic instruments. Depending on the level of automation of the histolab, all the tasks derived from a workload of 25 cases will require 15.8 to 17.7 hours of work completed by 2.4 to 2.7 employees with 18% of their working time not directly dedicated to the production of diagnostic slides. This article explains how to extrapolate this productivity calculation for any workload and different levels of automation. The overall performance standard for all the tasks, including 8 hours for automated tissue processing, is 3.2 to 3.5 blocks per hour; and its best indicator is the value of the gross work flow productivity that is essentially dependent on how the work is organized. This article also includes productivity standards for forensic and veterinary histolabs, but the staffing benchmarks for histolabs will be the subject of a separate article.

Keywords: Histology standards; Work flow productivity; Overall performance standards

1. Introduction

How many blocks should a histotech cut daily, be it a histotechnician (HT) or a histotechnologist (HTL)? Up to how many cases per day can we process with our present staffing complement? Which is the overall productivity of our histolab? When should we start the work to have more slides ready earlier? These are only 4 of many questions that any director of pathology has asked the histology laboratory (histolab) staff at some point. The lack of general standards determines that the answers will only reflect the characteristics of each histolab because information from others is almost inexistent. This fact is behind the idea that each histolab is intrinsically different and that new productivity goals cannot be adopted from external sources, which is incorrect.

The instrumentation influences the histolab's turn-around-time (TAT), but only to a certain extent because most manual tasks are essentially instrument independent [1].The fact remains that there are no general benchmarked standards to measure the histotech's or the histolab's performance.

In an attempt to answer some of these questions, the Association of Directors of Anatomic and Surgical Pathology (ADASP) conducted 12 surveys from 1993 to 1997 dealing with technical and administrative tasks, workload, and staffing, gathering data from 136 histolabs. Notably, the fundamental survey requested in May 1995 about productivity indices remains listed as "in progress" at the present moment [2].

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doi:10.1016/j.anndiagpath.2009.12.005

The interest in determining productivity standards and benchmarks continued; and in 2002, the College of American Pathologists (CAP) tried to answer the question about the histotechs' individual cassette productivity and offered an estimate of 50 slides per day [3], which was not the question and which roughly represents a work output of less than 4 blocks per hour [4]. That productivity level is generally known to correspond to untrained or inexperienced histotechs [5], indicating that the CAP productivity figure was an underestimate that could not be used as an adequate standard.

Working toward the goal of determining productivity benchmarks for histotechs, the National Society for Histotechnology (NSH) created a Productivity Task Force that in 2004 published the results of a survey from 12 histolabs (10 from the United States and 2 from Canada) [6]. They presented the average time required to complete a unit of many tasks, but without offering the ranges [7] that would allow us to appreciate the differences between histolabs.

In 2005, the results of a CAP Q-Probe study on staffing benchmarks for clinical laboratories (labs) [8] only offered a workload of 8223 tissue blocks per year per histotech as benchmark from the 116 histolabs included. This figure is about 23% higher than the 2002 CAP figure, when their estimate of 12 000 slides per year that "each well-trained HT/HTL can be expected to produce" [3] is expressed in blocks per year [4].

Because the data on histolabs productivity were scant, a survey made from November 2005 to February 2006 added 40 histolabs from the United States and 13 other countries [9] to the existing information showing that the histotechs' productivity was not statistically different between countries.

In 2008, the College of Medical Laboratory Technologists of Ontario published "practice guidelines" for medical laboratory (medlab) technologists working in histology [10], offering only ranges without stating the sample size. Also in 2008, a study was published [11] with data from 15 Mexican histolabs in response to a questionnaire presented by this author at the annual meeting of the Asociación Mexicana de Técnicos en Patología (Mexican Association of Pathology Technicians) that took place in Huatulco, Mexico, on May 2008. The results of that survey again emphasized the international uniformity of histology practice.

Finally, between April and August of 2009, this author has conducted a much larger survey that, added to the previous ones [4,9,11], will be summarized in 2 articles: the present one about tasks and work flow productivity (WFP) standards, and a second one about personnel workloads and staffing benchmarks for the histolab.

2. Materials and methods

The 2009 survey was announced in HistoNet (www.Histonet.org), a Web site from the Department of Pathology at Southwestern Medical Center, University of Texas, with more than 1600 members worldwide. Those answering the questionnaire were promised and received an evaluation of their labs with the value of their gross WFP, as defined later on.

There were 45 questions: 39 about the histology work that included 9 on personnel, 19 on work volume, 18 with time information for productivity calculations, and 5 related to auxiliary tasks, and 6 additional questions dealing with the cytology work done in many histolabs. As invariably happens, not all the questionnaires were answered completely; and some tasks were not applicable to some histolabs, reducing the number of entries for some tasks. Some additional data came from the "other tasks" section of the questionnaire and from follow-up e-mails to some participants.

The results of the 2005 survey [9] and the questionnaire were translated to Russian, and both were posted in the Russian Society of Pathologists Web site (http://www.patolog.ru/laboratory_efficiency.htm). The answered questionnaires were translated to English at the Patho-Anatomical Bureau in Taganrog and sent to this author. The participating Russian histolabs were asked 10 additional questions about instrumentation.

A Spanish translation of the questionnaire was offered to the members of the Sociedad Colombiana de Patología (Colombian Pathology Society), to members of the Sociedad Argentina de Histotecnología (Argentinean Histotechnology Society) through their Web site (www.ht.org.ar), and also to other interested persons through several contacts in other Hispano-American (HA) countries. The Mexican survey questionnaire, used by 5 South American participants, included 18 questions about instrumentation.

The data from the People's Republic of China were obtained by one local colleague through interviews in 6 histolabs.

The information from this type of survey, where the questionnaires are answered only by those interested in doing so, cannot be corroborated independently; and some judgment has to be exerted to identify answers that cannot reflect the physical reality of the histolab, for which it is essential to calculate average values from as many sites as possible. Another indirect indicator about the validity of the reported data is obtained when similar responses are independently received from different cities and countries.

These facts prevent any design attempt aimed at obtaining data from histolabs with specific workloads or characteristics. The best alternative is to obtain as many answers from as many places as possible to increase the probability of reflecting the real characteristics of the histolabs. Furthermore, because histotechs work in all sorts of settings, the survey was expanded to include data from human, forensic, and veterinary histolabs.

This 2009 survey gathered 141 answered questionnaires that, added to those already published [9,11], make a total of 325 histolabs, 221 from the United States and 104 from 24 other countries.

The US sample included 159 human, 39 forensic, and 23 veterinary pathology histolabs from 42 states and the District of Columbia, representing 5% of human, 26% of forensic, and 6% of veterinary histolabs estimated to exist in the United States [12], which can be considered as a satisfactory sample.

The information from other countries included 95 human, 1 forensic, and 8 veterinary pathology histolabs distributed as follows: 16 from Mexico (5 states and the Federal District); 13 from the Russian Federation (7 cities); 10 from Canada (3 provinces); 7 each from Argentina (4 provinces, including 2 veterinary), Colombia (1 city), Spain (4 cities), and Venezuela (5 cities, including 1 veterinary); 6 from the People's Republic of China (3 cities); 5 from Australia (4 cities, including 2 veterinary); 4 each from South Africa (2 cities and 1 township, including 1 forensic) and the United Kingdom (4 cities, including 1 veterinary); 3 from Ecuador (2 cities); 2 each from Austria (1 city), the Philippines (1 city), and United Arab Emirates (1 city); and finally 1 each from Germany, India (veterinary), Malaysia, New Zealand, Pakistan, Poland, Saudi Arabia, Switzerland, and Uruguay (veterinary).

The numbers of working hours per day varied from 7.2 in British Columbia to 7.5 or more in other Canadian jurisdictions, and from 3 to 10 hours in other countries, with 8 hours per shift being the most frequent of all. In general, most labs operated 5 days per week; but others operated from 3 to 7 days, with the greatest variability in hours per day and days per week found in HA histolabs.

The Canadian productivity summary [10] used totals of 37.5 hours per week and annual values of 260 days with 1950 hours; but we used the most frequent values found in the survey that are weekly values of 5 days and 40 hours with annual totals of 260 days and 2080 hours.

With detailed data from 159 human pathology histolabs from the United States and 86 from other countries, it became highly desirable to determine the statistical significance of the indexes differences between and within both groups and to try to find the causes of those differences if they existed. Because the author has always favored parametric over nonparametric tests, it became necessary to determine if the data were normally distributed, which is not a realistic expectation for these types of data sets where so many economic and human factors are involved. As an example of the high probability that the data would not be randomly distributed, consider the case of the histotechs' cutting average productivity in blocks per hour in any histolab. It will be the result of their personal dexterity and training but will also reflect the fact that those with low productivity are usually assigned other tasks, increasing the probability that the data for this and similar tasks are skewed to reflect the most productive histotechs' values.

The first calculations showed that variances and means were not independent, with the slopes of their logarithmic relations always greater than 2 (2.4 for cutting blocks per hour, 2.5 for cases per year, and ≈3 for routine gross WFP), all requiring using their inverse values ($1/X_i$) to be normalized [13].

The parametric tests used were the 1-tail "Student *t*" to compare 2 sets of data and the analysis of variance or "F" test to compare several series simultaneously, followed by the Tukey test for significant differences. The Excel 2003 and Gnumeric programs and the online statistical resources of Vassar University (http://faculty.vassar.edu/lowry/anova1u.html) were used with a minimal accepted significant level of $P \leq 0.05$ with α-type error.

In industrial activities, the employees' performance standards are dictated by the completion of sequential steps in an assembly line set at a specific speed to reach a given overall productivity goal. In nonindustrial operations, especially in those where artisanship plays a fundamental role, the only way to determine performance standards leading to productivity norms is by studying a group of workplaces with similar final objectives. Histotechnology, with all its manual tasks, is a trade that requires sampling to calculate the averages or mean productivity values for each different task in the work flow to ascertain their productivity standards. As in all sampling situations, the results will better represent the whole operation under study the larger and especially the more diverse the sample is.

The information contained in this first article refers to tasks and workload productivity standards for histolabs from the United States and 24 other countries, combined or separately. The criterion used to combine the tasks' productivities from all sources was their range overlapping rather than their statistical analyses, which are essentially the result of local circumstances rather than caused by the histotechs' abilities to complete the tasks.

The data have been divided into 3 main categories of human, veterinary, and forensic pathology histolabs and also into technical and nontechnical tasks within each. Completing technical tasks requires special studies, training, and some level of certification or working licensure, whereas the nontechnical tasks can be completed either with automated instruments or by auxiliary or administrative staff. Within each group, each task is discussed along with some explanations of their calculations when such information clarifies the data.

The human pathology section concludes with the calculation of the standard time required to complete all the routine tasks stemming from a workload of 25 cases and how to extrapolate that time to any other workload with different levels of automation, including the number of full-time equivalents (FTEs) theoretically needed.

The data also include several types of WFP to make simplified analyses of each histolab, all of them representing the ratio between parts of the workload and the time used by the staff to complete them.

Routine gross WFP (in blocks per hour): To calculate it, the total numbers of blocks cut each year (those cut for the first time plus all other blocks cut for special procedures) is divided by 2080 hours per year times the sum of all histotechs, pathology assistants (PAs), and lab aides (LAs) in the histolab.

Routine net WFP (in blocks per hour) is calculated in the same way as the gross WFP but only the histotechs embedding and cutting are added to the number of PAs and LAs to be multiplied by 2080 hours per year.

Total WFP (in units per hour) includes all the blocks cut (new and for special procedures) plus the total number of frozen sections (FSs), histochemistry (HC), immunohistochemistry (IHC), and any other reported special procedures tests divided by 2080 hours per year times the same sum of personnel used in the routine gross WFP calculation.

Special procedures WFP (in units per hour) includes only the special procedures defined in the total WFP divided by 2080 hours per year times the number of histotechs reported as "doing special procedures."

The *staff available time* for each histolab is the product of the total number of FTEs times 8 hours per day; the *staff used time* is the sum of all the reported hours used to complete the daily tasks, and their relation is the *time usage per histolab*, in percentages.

All the findings are summarized in 12 tables and 1 figure, and their contents are commented when necessary.

3. Human pathology labs

The fundamental indices are in Table 1 including annual and daily workloads, their relations, and productivities when expressed as work units per hour. All the data are averages with their range values for histolabs from the United States, other countries, and total.

When the first 18 workload and productivity indices (excluding grossing productivity) in Table 1 are compared with the same indices from the 2005 survey [9], 11 new averages are lower and 7 are higher, with the paired differences being statistically significant ($P < 0.048$), the assumption being that the values from the much larger 2009 sample are more accurate.

Table 1
Human pathology labs: workloads and tasks productivities

Workloads and tasks	Total labs (245)	US labs (159)	Non-US labs (86)
	Range/Average	Range/Average	Range/Average
Cases/year (×1000)	0.6 to 116/22	0.6 to 116/26	0.6 to 62/15
Cases/day	2 to 446/86	2 to 446/100	2 to 238/59
Autopsies/year	1 to 2100/158	1 to 875/111	2 to 2100/220
Blocks/year (×1000)	0.6 to 338/61	0.6 to 338/71	0.8 to 165/49
Blocks/case	1 to 11.3/3.2	1 to 11.3/3.0	1 to 7.7/3.3
Blocks/day	5 to 1300/235	12 to 1300/280	5 to 646/198
Slides/block	1.0 to 6.7/1.5	1.0 to 3.1/1.6	1.0 to 6.7/1.3
Slides/day	5 to 4000/341	30 to 4000/442	5 to 1266/260
Grossing: cases/hour	3 to 33/14	5 to 30/13	3 to 33/16
Cassetting: cassettes/hour	11 to 185/54	11 to 139/49	11 to 185/60
Embedding: blocks/hour	11 to 185/50	13 to 176/56	11 to 185/44
Cutting: blocks/hour	5 to 70/24	5 to 67/23	8 to 70/24
Manual H&E: slides/hour	19 to 200/49	20 to 167/43	19 to 200/56
Manual H&E: % labs	49	25	68
Manual coverslip: slides/hour	25 to 500/80	25 to 500/102	40 to 475/74
Manual coverslip: % labs	57	35	78
Recuts: blocks/day	0.3 to 212/24	0.3 to 167/28	2 to 212/21
FSs/year	12 to 7800/1285	52 to 7800/1471	12 to 7020/1192
min/FS	2 to 40/15	3 to 40/15	2 to 40/16
HC: slides/year (×1000)	Ø to 67.6/5.6	0.2 to 67.6/6.8	Ø to 45.0/4.6
IHC: slides/year (×1000)	Ø to 105.0/15.1	0.2 to 105.0/17.2	Ø to 79.3/13.2
ISH/FISH/DIF/INDIF[a]	8 to 7020/834	8 to 7020/882	12 to 4080/786
TEM[a]	17 to 1404/473	17 to 1404/515	250 to 278/263
Recycling tasks: % labs	30	39	16
Staff available time (hour/day)	8 to 304/137	8 to 304/142	8 to 240/126
Staff used time (hour/day)	6 to 278/101	8 to 278/116	6 to 155/80
Time usage/lab (%)	30 to 130/74	34 to 130/82	30 to 116/64
Gross WFP (blocks/hour)	0.5 to 14.6/3.6	1.2 to 10.2/4.1	0.5 to 14.6/3.1
Net WFP (blocks/hour)	0.7 to 18.2/4.6	1.2 to 16.3/5.2	0.7 to 18.2/3.9
Total WFP (units/hour)	1 to 15.3/4.5	1.2 to 12.4/5.1	1 to 15.3/3.7
Special procedures WFP	0.01 to 49.5/6.3	0.3 to 25.3/6.9	0.01 to 49.5/5.7
Cytology[a] (×1000)	0.1 to 475.6/33.3	0.1 to 475.6/33.0	0.5 to 160.0/34.1

Ø indicates less than 100; DIF, direct immunofluorescence; FISH, fluorescent in situ hybridization; INDIF, indirect immunofluorescence; ISH, in situ hybridization.

[a] Cases per year for labs doing these procedures.

Perhaps the most important aspect to be considered in a histolab is its total number of cases per year. Whereas the 2005 average for 96 histolabs was 25 000 cases per year, for the present sample of 232 histolabs, it is 10% smaller (22 457 cases per year), this average reduction being caused by the inclusion of 39 smaller HA histolabs.

Another example of variation caused by the sample is the time required to prepare an FS: the NSH reported 12 minutes as the average time from 12 sites [6]; but the 1994 ADASP survey, also from 12 histolabs, reported 13 minutes per FS. The average from 40 histolabs in the 2005 survey [9] was 13 minutes; and in the present survey, the range is 2 to 40 minutes, with an average of 15 minutes, from 151 histolabs. The average rises to 20 minutes when the old CO_2 technique is used and goes up to 1 hour per case for renal biopsies. The ADASP survey assigns almost 3 of the total 13 minutes (22%) for the manual hematoxylin & eosin (H&E) staining.

The significance of the tasks' differences between US and non-US histolabs is presented in Table 2, with twice more instances of nonsignificance than those that are significant, caused by some real peculiarities, like the number of autopsies (which are much more frequent in foreign hospital-based histolabs than in the United States).

Some peculiarities found in histolabs from Russia and from Spain, Hispano-America, and the Philippines (SpHAP) affecting embedding and WFPs standards will be discussed later.

The large number of histolabs from other countries allowed grouping them into 22 from the Commonwealth of Nations, or just Commonwealth, formerly referred to as the *British Commonwealth*; 24 European; 11 Asian; and 38 HA histolabs. The number of cases per year for those 4 groups was statistically different ($P < 0.004$) because of the differences between the HA and the Commonwealth histolabs.

Table 2
Human pathology: comparisons between US and non-US histolabs

Task productivity and hour/day		Unit	US	Non-US	*df*	Significance
Autopsies/year		Autopsy	111	220	130	<0.01
Grossing		Case/hour	13	16	67	NS
		hour/day	9.4	5.6	67	<0.025
Assist in grossing		hour/day	4.3	3.8	54	NS
Cassetting		Cassette/hour	49	60	135	<0.05
		hour/day	5.7	4.3	103	NS
Embedding		Block/hour	56	44	167	<0.0005[a]
		hour/day	2.0	5.1	117	<0.0005[a]
Trim blocks before cutting		hour/day	1.0	1.4	77	NS
Cutting new blocks		Block/hour	23	24	175	NS
		hour/day	18.3	10.9	101	<0.01
Cutting special requests		hour/day	1.4	1.1	73	NS
Cutting controls		hour/day	0.4	0.2	27	NS
H&E staining	Manual	Slide/hour	43	56	64	NS
	Manual	hour/day	2.4	1.8	64	NS
	Automated	hour/day	1.3	1.3	55	NS
Coverslipping:	Manual	Slide/hour	102	74	72	NS
	Manual	hour/day	1.0	1.4	72	<0.05
	Automated	hour/day	0.7	0.6	47	NS
Diagnostic FS		min/case	15	16	144	NS
		hour/day	1.4	1.4	82	NS
Specimen transport to the histolab		hour/day	2.3	1.9	20	NS
Access specimens in LIS		hour/day	2.3	1.9	33	NS
Log in LIS specimen information/data		hour/day	3.2	1.3	14	<0.025
Collate slides with reports		hour/day	2.2	0.7	7	NS
File blocks/slides		hour/day	1.7	1.4	104	NS
Pull blocks for special requests		hour/day	0.8	0.6	19	NS
Clean the grossing area		hour/day	3.9	1.4	16	<0.025
Clean work area		hour/day	1.0	1.1	110	NS
Change reagents and waste disposal		hour/day	1.0	0.8	95	<0.025
Recycle solvents and alcohols		hour/day	1.0	2.2	49	NS
Specimens disposal		hour/day	0.5	0.3	23	NS
Histology lab staff only: time available		hour/day	142	126	112	NS
Histology lab staff only: time used		hour/day	116	81	103	NS
Routine gross WFP		Block/hour	4.1	3.1	177	<0.0001[b]
Total WFP		Block/hour	5.1	3.7	159	<0.00002[b]

LIS indicates laboratory information system; NS, difference not statistically significant.
[a] Because 60% of 52 Russian and HA histolabs do not have embedding centers.
[b] Because of 47 histolabs from SpHAP.

The histolabs were also grouped into 5 size categories (Table 3) based on their cases per year: less than 10 000 cases (26% of total), from 10 000 to less than 20 000 (28% of all), from 20 000 to less than 30 000 (20%), from 30 000 to less than 50 000 (18%), and at least 50 000 cases per year (8%).

In total, 54% of the histolabs had less than 20 000 cases per year, with differences between the United States (with 54% from 10 000 to <30 000 cases per year) and other countries (70% with <20 000 cases per year). The US general average was 26 061 cases per year; and for other countries, 15 226 cases per year. Histolabs with less than 20 000 cases per year were 48% in the 2005 survey and 54% in the present survey because of the inclusion of smaller HA histolabs.

Different productivity indices, automation levels, special procedures workloads, staff usage times, and WFP levels indicate that the most productive histolabs have at least 20 000 cases per year, probably because of greater automation and specialized personnel (Table 3).

Having fewer blocks per case in the at least 50 000 cases category is a characteristic of the reference histolabs included in it. In the 20 000 to less than 30 000 cases group, there are more blocks per case because it includes many university and teaching hospitals, where grossing is usually done by pathology residents known for submitting more blocks per case.

Less HC studies were done in the 50,000 and more cases per year category, probably because the reference labs receive many routine cases from private dermatology practices submitted to rule out any pathologic condition that ultimately turns out to be benign and thus not requiring any further special procedures.

It is also evident that IHC tests, with a frequency of 1 for every 1.5 cases, have become a preferred diagnostic tool over

Table 3
Human pathology: productivity by lab class

Task or aspect	Indicator	All labs	Lab classes (×1000 cases/y)				
			<10	10<20	20<30	30<50	≥50
Grossing (cases/hour)	n labs	69	15	18	18	11	7
	Average	14	14	11	13	17	21
Blocks/case	n labs	196	63	51	38	22	16
	Average	3.2	3.1	3.1	3.6	3.2	2.4
Cassetting (cassettes/hour)	n labs	136	46	39	23	16	12
	Average	54	50	64	67	57	31
Embedding (blocks/hour)	n labs	168	60	47	28	21	12
	Average	50	43	56	63	52	50
Cutting: (blocks/hour)	n labs	174	60	48	30	23	13
	Average	24	21	21	24	25	25
Automated H&E (% of labs)	n labs	138	48	40	20	19	11
	%	51	31	50	65	74	91
Automated coverslipping (% of labs)	n labs	174	45	37	21	17	9
	%	43	18	46	43	76	78
HC (1 test every n cases)	n labs	145	48	41	27	17	12
	n cases	4.0	2.6	3.0	3.0	2.9	5.4
IHC (1 test every n cases)	n labs	137	39	39	27	18	14
	n cases	1.5	2.5	1.3	1.2	1.6	1.6
Staff available time (hour/day)	n labs	118	43	31	21	12	11
	Average	68	27	51	94	125	143
Time usage (%)	Average	74	76	69	75	65	92
Gross WFP (blocks/hour)	n labs	196	67	56	35	20	18
	Average	3.6	2.9	3.6	4.3	3.8	4.8
	Median	3.2	2.7	3.0	4.0	4.1	4.5
Total WFP (units/hour)	n labs	168	59	48	28	17	16
	Average	4.5	3.5	4.3	5.4	4.8	6.0
	Median	4.0	3.1	3.6	5.1	5.0	5.7
Class average/total average							
Grossing: cases/hour			1.00	0.79	0.93	1.21	1.50
Cassetting: cassettes/hour			0.93	1.19	1.24	1.06	0.57
Embedding: blocks/hour			0.86	1.12	1.26	1.04	1.00
Cutting: blocks/hour			0.88	0.88	1.00	1.04	1.04
Daily time usage: %			1.03	0.93	1.01	0.88	1.24
Gross WFP: blocks/hour			0.81	1.00	1.19	1.06	1.33
Total WFP: units/hour			0.78	0.96	1.20	1.07	1.33
For each task or aspect, times the class is							
as productive or more than average			2/7	3/7	6/7	6/7	6/7
the most productive			0/7	0/7	2/7	1/7	5/7
Combined overall class productivity			0.90	0.98	1.12	1.06	1.14

the more conventional and less informative HC procedures, which are being done 2.7 times less frequently.

Using the combined overall class productivity values (Table 3), the most productive group is that of 50,000 and more cases per year, with the 20 000 to less than 30 000 cases per year group in a close second place. The 2 classes with less than 20 000 cases per year owe their fourth and fifth positions to the number of histotechs needed to finish the slides usually before noon. After finishing the slides, the histotechs do not have enough tasks to be really productive, except for histolabs with only 1 or 2 histotechs, as will be discussed in the article about staffing benchmarks.

3.1. Technical tasks

Technical tasks are those completed by staff specially trained and with the necessary theoretical knowledge and profound awareness of their role in patient care and of the quality control aspects of each task.

The histotechs constitute the part of the histolab personnel supposed to complete them; and at this moment with their numbers declining, some medlab technologists have been trained to perform complex procedures where there are no histotechs to cover new technical positions [12].

Table 4
Human pathology: technical tasks (time/unit)

Task (units)	Units/ hour	hour/100 units	dt/ units	n labs
Grossing (case)	14	7.1	4.3 min	69
Cassetting (cassette)	54	1.85	1.1 min	145
Embedding (block)	50	2.0	1.2 min	178
Label slides: manual[a] or automated	179	0.56	20 sec.	146
Prepare blocks to cut (block)[a]	158	0.63	23 sec.	97
Trim (block)	143	0.70	25 sec.	124
Cutting (microtomy) (block)	24	4.2	2.5 min	188
H&E staining (slide)[b]	49	2.04	1.2 min	73
Coverslipping (slide)[b]	80	1.25	45 sec.	79
Diagnostic FS (case)	4	25.0	15 min	151
HC organisms (in 10-slide batches)[c]	1.8	5.7	3.4 min	31
HC tissue components (in 10-slide batches)[c]	1.0	10.0	6.0 min	31
Manual IHC (in 3-slide batches)[c]	0.45	73.3	44.0 min	36
Manual IHC (in 30-slide batches)[c]	0.14	23.3	14.0 min	36
Manual Her2neu test (in 12-slide batches)[c]	0.42	20.8	12.5 min	7
Automated IHC (in 7-slide batches)[c]	0.31	45.7	27.4 min	23
Automated IHC (in 48-slide batches)[c]	0.21	10.0	6.0 min	23
Manual DIF (4 slides/test)[c,d]	1.5	16.7	10.0 min	11
Manual INDIF (1 titer/test)[d]	1.3	75.0	45.0 min	11
ISH (test)[d]	0.53	190.0	1.9 h	9
FISH (test)[d]	0.29	350.0	3.5 h	7
TEM (case)[d]	0.11	940.0	9.4 h	28
Decalcifying (acid and chelating) tissues (cassette)[d]	30	3.3	2 min	16

dt indicates time value; Her2/neu, test for human epidermal growth factor receptor 2.

[a] Can be completed by auxiliary personnel.

[b] If automated, the task can be completed by auxiliary personnel.

[c] The batch is the unit for "units per hour"; and the slide, for "dt per unit."

[d] Excluding processing, incubation, and/or polymerization times.

Table 4 presents the time required to complete 1 or 100 units, the number of units per hour, and the number of histolabs where such values come from.

3.1.1. Grossing

Grossing of complex surgical cases is one of the common tasks in the histolab, one that could affect the final diagnosis if some important characteristic or portion of the specimen is overlooked. It is a task done by pathologists, pathology residents, or PAs. Histotechs sometimes gross simple specimens submitted in toto, like skin or gastric biopsies; but no histotech should gross complex specimens, no matter how well trained he or she may be.

Even when the productivity values (cases per hour) and the hours assisting are not different between US and foreign histolabs, the number of hours dedicated to grossing are ($P < 0.025$) because the work is organized differently.

3.1.2. Cassetting

Cassetting sometimes is done simultaneously with grossing, either by the same person grossing or by an assistant, in this way being more productive because as a new case is started, the previous one is being cassetted by the LA. Alternatively, the grossing person may just separate the pieces into different containers to be cassetted later by a histotech.

Cassetting productivity is statistically different between US and non-US histolabs ($P < 0.05$) but not the time dedicated to the task because of greater productivity combined with less cases per day in other countries.

Grossing and cassetting are the only 2 technical tasks preceding tissue processing (TP), which is usually automated, although it is still a manual task in 29% of Russian and HA histolabs and also in some veterinary facilities. Manual TP is a technical task to be completed by histotechs.

3.1.3. Embedding

Embedding is the first of the post-TP technical tasks; and if you inquire of any histotech "how many tissues can be embedded in 1 hour," the most likely answer will be "it depends on the tissue type," a totally valid response.

The NSH report [6] presented values of 0.5 to 1 minute per block depending on the tissue. The range for the Canadian practice guidelines [10] is wider (0.3-1.2 minutes) and closer to the values of 0.3 to 1.4 with 1.2 minutes per block average in the present study.

The overall productivity (blocks per hour) and hours per day dedicated to embed are different between United States and other countries ($P < 0.0005$) because 60% of 52 histolabs from Russia and HA, with a productivity of 19 blocks per hour, do not have embedding centers, whereas those with embedding centers embed significantly more (40 blocks per hour, $P < 0.001$). If the histolabs without embedding centers are excluded, this task productivity is not statistically different worldwide, with the range of values from foreign histolabs inclusive of that from US histolabs.

In histolabs without embedding centers, 77% of which do not have paraffin dispensers either, embedding is done using Leuckhart metal rectangles, plastic molds for ice cubes, metal molds, and even paper molds, making their productivity less than 40% of the general productivity for this task.

The differences between United States and other countries extend also to the start, finish, and duration of the embedding period, with most US histolabs starting early in the morning and even before midnight. About 55% of all the tissues are embedded between 4:00 AM and 6:00 AM in US histolabs, but only 17% in other countries. Non-US histolabs usually start at 6:00 AM and have 50% of all their blocks cast between 6:00 AM and 7:00 AM, whereas those in the United States have about 70% of all their blocks ready by that time.

United States histolabs embed during an average total time of 5.24 hours per day (not considering the number of histotechs involved); but in other countries, embedding takes 3.89 hours per day, the difference mostly caused by the daily number of blocks (average of 280 for the United States and 198 in other countries).

Embedding and cutting are the 2 fundamental manual tasks in the histolab; and their productivity was calculated by dividing the number of new blocks each day by the hours reported embedding or cutting times the number of histotechs engaged in those tasks. In this way, each histolab ends with a single average per task to be used in the general calculations regardless of the number of participating histotechs, making it an "unweighed" average.

To find out the effect that the number of histotechs has, if any, in the final figure, a "weighed" average for 1067 histotechs from 92 US histolabs was calculated, resulting in 52 blocks per hour, a figure that is not significantly different to the unweighed average of 56 blocks per hour with 630 degrees of freedom (*df*). Similarly, a weighed average for 470 histotechs from 78 foreign histolabs (45 blocks per hour) is not statistically different either to the unweighed average of 44 blocks per hour with 546 *df*. These 2 comparisons further validate the averages calculated from the large number of histolabs in the sample.

Finally, it is worth mentioning that embedding is another manual task that has been automated using an embedding instrument capable of casting 120 blocks per hour (1 every 30 seconds), which is 2.4 times the average manual productivity of a histotech, thus eliminating a source of mechanical stress that frequently leads to carpal tunnel syndrome.

3.1.4. Labeling slides

Labeling slides can be done either before or after sectioning, manually or automated, in the same way as the cassettes can be written beforehand or while cassetting, also manually or automated. This is a task that can be completed by histotechs, by auxiliary personnel, or with an automated writer or etcher depending on the volume of work and the investment policies of the histolab. The time per unit in Table 4 refers to manual labeling.

It is worth noting that placing the correct section on the corresponding labeled slide is the step in the work flow more prone to mistakes and the reason for using bar-coded slides and blocks combined with scanners in the cutting stations to avoid mismatch mistakes.

3.1.5. Preparing blocks to cut

Preparing blocks to cut refer to organizing them after checking against the cassetting/embedding log, usually along with the slides if they have been numbered previously. This is also a task that can be completed by LAs. All these smaller tasks add up in cost savings when completed by LAs and also allow histotechs to do only the tasks requiring their expertise.

3.1.6. Trimming or facing off of blocks

Trimming or facing off of blocks to reach an even and complete area of the embedded tissue before taking the final sections is an intrinsic part of the cutting step but is described before because it precedes the actual sectioning. This is a technical task that can have different approaches, the most productive being trimming a group of blocks (from 10 to 20) and placing them face down over cold soaked paper towels to facilitate the final sectioning.

The reported values are between 5 and 80, with an average of 25 seconds per block, which is 8 seconds faster than in the previous survey [9]. There is a significant difference ($P < 0.0001$) between US histotechs (20 seconds per block) and those in other countries (32 seconds per block), although the hours per day for trimming are not different between both groups because of more blocks per day in US histolabs.

The trimming time difference is caused by 45% of Russian histolabs only using horizontal (sledge) microtomes and the paraffin blocks being clamped directly to the holder. In addition, most HA histolabs use plastic ring block holders secured to the microtome with manual screw clamps; and both situations determine that trimming is done one block at a time immediately before taking the final sections.

3.1.7. Cutting, sectioning, and microtomy

Cutting, sectioning, and microtomy are 3 designations for the most important manual task in the histolab, often relied on to define the histotech's dexterity.

If you ask any histotech "how many blocks can you cut each hour," the most likely answer will be subject to the type of tissue and the number of sections/slides needed from each. The experienced histotech will probably also add some caveats about adequate fixation and infiltration of the tissues, in the absence of which microtomy becomes very difficult and sometimes altogether impossible, making proper TP play an important role in the productivity of this task.

The NSH survey [6] concluded that "the average tech should be able to section 27 blocks with 1 corresponding slide per hour." This standard, although within the range of every survey [6,9,11], is above their averages and that of the present unweighed average of 24 blocks per hour from 188 histolabs. Weighed averages were calculated with a value of 22.5 blocks per hour for 1580 histotechs in 93 US histolabs and 23.4 blocks per hour for 473 histotechs in 79 histolabs from other countries. The differences between weighed and unweighed averages are not statistically significant.

The unweighed average differences between US histotechs (23 blocks per hour) and those from other countries (24 blocks per hour) are not statistically significant either, despite the fact that 23% of Russian and HA histolabs use sledge microtomes. In addition, 32% of them use permanent steel knives instead of disposable blades, this being a quite conclusive indication that histotechs' dexterity transcends countries and technical barriers. The need to manually sharpen the steel knives does not affect the cutting productivity but rather the overall WFP because the time required to sharpen them is not directly related to the production of slides but to the histotechs' total use of their working time.

The hours per day sectioning are different for United States and other countries, with some of the former starting to cut shortly after midnight, with 18% already cutting as early as 4:30 AM and 60% cutting before 7:00 AM. Histolabs in other countries start at 5:00 AM at the earliest; but because of smaller workloads, both groups have about 75% of their blocks cut by 8:00 AM despite the starting time differences. The daily workload differences also explain why the cutting period (without considering the number of histotechs involved) amounts to 6.37 hours in US histolabs and to 4.72 hours in other countries.

The attempts to automate sectioning have not been as successful as automating embedding, and the only instrument still being assessed can cut only 20 blocks every 2 hours or 2.4 times slower than the average histotech; so a highly productive automatic sectioning instrument is likely to be still many years away.

3.1.8. *Hematoxylin and eosin staining*

Although most of the special procedures, either HC, IHC, or in situ hybridizations, follow quasi-standard protocols, the routine hematoxylin and eosin (H&E), the most "humble" yet most valuable of all histology procedures, is also the most variable.

There are scores of protocols and hematoxylin solutions, both progressive and regressive, with variations to please the pathologists' preferences because, whereas some prefer strong nuclear staining, others prefer it weaker, or adding phloxine or orange G to the eosin to obtain different hues of red, with different acidity levels, or whatever visual patterns they are used to. All these variations, added to others for TP, are the fundamental factors in creating each histolab's "uniqueness myth" that so strongly defies the logical attempts at standardization.

Hematoxylin and eosin staining can be manual or automated. If *manual*, it is a technical task because the differentiation and bluing steps have to be visually controlled for each batch of slides. The slides can be run as single or multiple batches of usually 25 slides each determining the differences in the number of slides stained every hour.

The length of the protocol (usually from 20 to 60 minutes) determines that 4 hours will be needed to stain 100 slides with a 1-hour protocol and a single 25-slide batch, whereas the productivity will be readily doubled if 2 batches are stained simultaneously with the same protocol. The number of batches and the time of the protocol explain the differences of stained slides per hour among the surveyed histolabs, although those differences (43 slides per hour for US and 56 slides per hour for non-US histolabs) are not statistically significant.

After TP, H&E staining is the most automated task. Automatic stainers exist in 75% of US and in 32% of foreign histolabs, with only 5% of HA and none in our sample of Russian histolabs.

The time the *automated* H&E staining takes also depends on the length of the protocol; but being automated, the human intervention in the task is limited to placing the racks with the slides in and out of the instrument, which takes an average of 1 second per slide for 20-slide batches. This can be done by LAs, liberating the histotech to do technical tasks and limiting the paid time for this task to only few minutes per day. The impact of automated staining in the work flow is determined by the time of the staining protocol and by the number of stained slides per day and not by the time it takes to handle the slides in/out of the stainer.

3.1.9. *Coverslipping*

Coverslipping is a manual task in more than half of all histolabs, but less frequent in the United States (about one third of histolabs) than in other countries where more than three fourths coverslip manually. Manual coverslipping takes 35 seconds per slide in US histolabs and 49 seconds per slide in other countries, which is a statistically significant difference ($P < 0.05$).

Automated coverslipping is less frequent than automated staining, with about two thirds of US and less than one fourth of foreign histolabs using this technology. The time is from 3 to 5 seconds per slide for film coverslippers and 10 to 20 seconds per slide for glass coverslippers. Film has the advantage of enhanced productivity, but it does have some disadvantages. One is related to the personal preference of many pathologists who prefer glass over film for taking photomicrographs. Another more significant disadvantage is due to film coverslippers delivering less xylene than required due to calibration problems. This seemingly minor problem will determine that some archival slides may present film detachment that usually ruins the slide by pulling the tissue section attached to the film. All these factors need to be weighed when deciding which type of coverslipper to buy.

In the United States, 83% of histolabs with automated H&E staining also use automated coverslippers. However, in other countries, 31% of histolabs with automated staining coverslip manually; and in general, only 2% of histolabs staining manually use automated coverslippers.

3.1.10. Frozen sectioning

Frozen sectioning, which is the method of choice for making intraoperative diagnosis, is the only task with a CAP productivity standard set at 20 minutes after receiving the specimen in the lab, requiring documentation for those cases not meeting this standard.

The average times reported to complete an FS has been discussed earlier, and the total hours per day doing FS depend on the minutes for each and the number of cases per day; but neither of these 2 indicators are significantly different between US and foreign histolabs. Another component of this task is the time needed to clean/disinfect the cryostat that is usually 30 minutes per day, meaning that cleaning becomes a smaller fraction of the total time the more tests are done daily.

3.1.11. Special procedures

"Special procedures" fundamentally include HC and IHC tests, with the former having changed from being a major diagnostic tool to just an average of one test every 4 cases now or 2.7 times less frequent than IHC tests that are performed in 79% of US and 62% of foreign histolabs. Immunohistochemistry tests are limited mostly by cost or lack of trained personnel, and this could explain why in foreign histolabs those doing HC tests surpass by 14% those doing IHC procedures. Histolabs doing HC tests exclusively are 11% in the United States and 25% in other countries.

Even when both techniques can be automated, the IHC stainers are more abundant; and 48 histolabs reporting their use have an average of 110 slides per day that would require almost 26 hours to complete manually by at least 2 histotechs, compared with only 11 hours if automated. When automated, the total time will include about 2 hours dedicated to prepare each of at least 2 runs and less than 4 hours to prepare some solutions and cut the cases and controls, all by 1 histotech.

Table 5
Human pathology: technical tasks (hours per day)

Task	Range/Average	Median	n labs
Grossing	0.8 to 39/8.0	6.3	69
Assist grossing	0.2 to 24/3.8	2.0	60
Cassetting	0.25 to 39/4.2	2.0	113
Embedding	0.13 to 24/5.3	3.5	117
Label slides manually	0.1 to 7/1.2	0.6	100
Prepare blocks to cut	0.1 to 5/0.8	0.5	99
Trim blocks to microtomy	0.12 to 6.1/1.1	0.5	90
Cutting daily workload of blocks	0.3 to 72/14.3	7.8	116
Cutting special requests	0.02 to 11.2/1.3	0.8	83
Cutting controls	0.02 to 2.0/0.3	0.2	29
H&E manual staining	0.3 to 22/3.1	2.0	66
Manual coverslipping	0.2 to 22/2.0	1.0	77
Diagnostic FS	0.01 to 10.0/1.4	0.7	87
HC tests (manual)	1 to 8/3.6	3.0	31
IHC tests (manual)	2.2 to 14/6.6	7.0	36

Automating the IHC tests is also expected to produce more consistent results; so increased quality, faster results, and reduction in the overall salary budget are usually factors leading to the decision to automate IHC procedures.

3.1.12. Transmission electron microscopy

Transmission electron microscopy (TEM) is the most technically complex task because it involves a complete sequence from fixation to printing the photographs of the diagnostic areas selected by a pathologist. All the steps are hands-on except for histolabs with automated sample processors. The specialized histotech, usually attending only this task, has to be trained in the use of the ultramicrotome and its knives, the electron microscope, and all the photography steps. Transmission electron microscopy is presently less frequent in general histolabs and more limited to reference labs, especially because some of its diagnostic uses have been taken over by IHC tests.

The data from 28 histolabs show an average of 9.4 hours of hands-on work per case, with a range from 1 to 9 (average of 4.6) days per case depending on the quality of the original tissue sample and the cured block.

Table 5 presents the range, average, and median number of hours per day dedicated to technical tasks and the number of histolabs the information comes from; and as always, the number of hours per day depends on the productivity and the workload for each task.

3.2. Nontechnical tasks

Nontechnical tasks are those not requiring a specialized knowledge about tissues or how they are processed. Many

Table 6
Human pathology: nontechnical tasks (time/unit)

Task (unit)	unit/hour	hour/100 unit	dt/unit	n labs
Specimen transport (case)	43	2.3	1.4 min	22
Access specimens in LIS (case)	38	2.6	1.6 min	53
Gross transcription in LIS (case)	26	3.9	2.3 min	13
Label slides with etchers (slide)	417	0.24	8.6 sec	18
Prepare labels manually (label)	257	0.39	14 sec	83
Sort prelabeled slides (slide)	500	0.20	7.2 sec	5
Cassettes in/out of TP[a] (cassette)	9000	0.01	0.4 sec	15
H&E automated staining (slide)	75	1.33	48 sec	89
Automated coverslipping[b] (slide)	360	0.28	10 sec	57
Slides in/out of automated instruments[c] (slide)	500	0.03	1 sec	19
Collate/match slides with paper work (case)	24	4.17	2.5 min	14
File blocks/slides (block or slide)	138	0.73	26 sec	115
Pull blocks for special requests (block)	32	3.17	1.9 min	21
Prepare send out cases (case)	12	10.5	5 min	7
Manual billing (case)	30	2.0	2 min	4
Remove/dispose tissue (case)	188	0.52	0.32 min	28

[a] For 75 cassettes per basket.
[b] From 3 to 5 seconds per slide with film and from 10 to 20 seconds per slide with glass.
[c] For 20 slides per rack.

are completed by office staff or LAs trained in mechanically handling the cases through all the different steps. This is not to mean that they lack importance because all the tasks in the general work flow are interdependent and can be the source of mistakes and bottlenecks.

In small histolabs without LAs and with limited office personnel, many of them are completed by histotechs; and it can be considered that when pathologists sign their own cases, they are doing something usually done by secretarial personnel. Thus, it is likely that nontechnical tasks are completed by almost anybody within the histolab, whereas technical tasks are expected to be carried out by trained technical staff only.

Table 6 presents productivity data for these tasks; and Table 7, the number of hours per day dedicated to each. The combination of productivity and frequency causes the observed significant differences in the time dedicated for some tasks between United States and other countries (Table 2).

3.2.1. Transporting specimens

Transporting specimens to the histolab has a general average of 43 cases per hour, varying from 9 cases per hour in histolabs with less than 50 cases per day to 56 cases per hour in those with 76 cases per day, being another example of increased productivity with greater workloads.

3.2.2. Labeling slides

Labeling slides with a slides etcher is 2.3 faster than manual labeling, although the etched slides will have to be sorted for distribution to the histotechs before sectioning. This sorting step takes 84% as much time as etching them, making the automated productivity just 24% faster than manual productivity. The fundamental advantage is that the slides will be error free, more legible, and produced without human intervention. Slides etchers and cassettes writers are among the least frequent pieces of equipment and were present in only 11% of all histolabs (13% in the United States and 7% in other countries).

3.2.3. Automated H&E staining

Automated H&E staining includes the time needed to place the slides in/out of the stainer plus the time of the staining protocol that is always done in the same way. It eliminates the delays existing in manual staining and the need for the histotech's intervention in the differentiation step, explaining why the time per slide is 50% less than staining manually using similar protocols. Routine H&E staining is automated in 75% of US and in 32% of other countries' histolabs.

3.2.4. Automated coverslipping

Automated coverslipping exists in 65% of US and in 22% of non-US histolabs, with similar paid times for placing slides in/out of the instrument as for automated H&E staining. It is 3 times more productive than manual coverslipping when using glass coverslips and 11 times more when using film.

3.2.5. The NSH report

The NSH report [6] concluded that 1 FTE is enough to *file all the blocks and slides* corresponding to a workload of 25 000 cases per year. This is correct because, with an average of 26 s/units (Table 6), the 75 000 blocks and 120 000 slides corresponding to that workload require 1408 hours per year or 0.7 FTE to be completed.

Table 7
Human pathology: nontechnical tasks (hours per day)

Task	Range/Average	Median	n labs
Specimen transport	0.8 to 6.7/2.2	1.9	22
Access specimen in LIS	0.3 to 8.5/2.3	1.7	53
Gross transcription	0.4 to 5/3.9	3.1	13
Label slides manually	0.1 to 7/1.2	0.6	100
H&E automated staining	0.3 to 20/4.3	3.0	74
Automated coverslipping	0.2 to 24/2.6	1.0	56
Racks in/out of automated instruments	0.03 to 1/0.27	0.13	19
Collate/match slides with paper work	0.2 to 3.0/0.9	0.5	14
File blocks/slides	0.1 to 16/1.5	1.0	11
Pull blocks for special requests	0.1 to 5/0.8	0.5	21
Prepare send out cases	0.5 to 5/2.5	1.9	7
Manual billing	0.3 to 2/0.8	1.0	4
Remove/dispose of tissue	0.03 to 2/0.5	0.3	28
Inventory and stocking supplies	0.5 to 4/1.4	0.8	4
Supervisory tasks[a]	0.3 to 3/1.2	1.0	13
Change reagents/waste disposal	0.1 to 4.5/0.9	1	140
Cleaning workstation[b]	0.1 to 8/1	0.7	124
Cleaning grossing areas[c]	0.5 to 8.3/2.8	1.7	18
Recycling solvents and alcohol	0.1 to 5.0/0.9	0.8	69
Recycling formalin	0.3 to 0.4/0.3	0.3	3
Maintenance of automatic instruments	0.3 to 0.7/0.5	0.4	4
Miscellaneous tasks	0.03 to 51.8/6.3	5.2	151

[a] Scheduling/attendance, conferences, ordering supplies, workload stats, quality improvement tasks, troubleshooting customer service issues, and other personnel tasks.

[b] Workload-independent task.

[c] Includes cleaning cassettes to be reused for TP in some Russian and HA labs.

3.3. Work flow productivity

Work flow productivity can be calculated for different types (gross, net, total, and special procedures) as explained in "Materials and methods," each summarizing the overall productivity for different workloads and the personnel involved in their completion. Work flow productivities are easy to calculate and provide rough estimates of how the histolab is performing, and can become very useful tools for those entrusted with the histolab supervision from lead histotech to manager; and their values should be included in the daily report to the pathology director.

Their values depend on the relations between workloads and productivity of the personnel involved and can characterize work tendencies, especially in overstaffed histolabs or those with some bottlenecks in their flow.

3.3.1. The routine gross WFP

The routine gross WFP values present large variations (Table 1). It has values above average when the workload is completed by a small or more productive staff and will have lower values when the workloads combine with larger or less productive staff, both types of situations existing in any country.

The average of 4.09 blocks per hour for US histolabs is statistically different ($P < 0.0001$) to that of other countries (3.08 blocks per hour) because of lower values in histolabs from Russia and from SpHA. The latter group (with 2.54 blocks per hour) is also statistically different ($P < .008$) to the average for all foreign histolabs when it is excluded (3.56 blocks per hour).

The methodological problems in Russian and HA histolabs are not limited only to not having embedding centers, but also because 32% of them exclusively use steel permanent knives, 55% of which are sharpened manually. Furthermore, most Russian and some HA histolabs clean the cassettes to be reused in TP, thus increasing the overall time the staff dedicates to tasks other than the production of diagnostic slides.

One example of low gross WFP caused by overstaffing are 4 histolabs from the US Department of Defense with an average of only 2.2 blocks per hour because the personnel completes military tasks unrelated to the production of slides, which negatively impact their embedding and cutting productivity also.

3.3.2. The routine net WFP

The routine net WFP behaves similarly to the gross WFP with an average of 5.24 blocks per hour for US histolabs, statistically different ($P < 0.001$) to that of other countries (3.94 blocks per hour). This is caused by SpHA histolabs (2.98 blocks per hour for $P < 1 \times 10^{-7}$), but the difference between US and non-US histolabs when they are excluded (4.76 blocks per hour) is no longer statistically significant.

3.3.3. The total WFP

The total WFPs for US (5.06 U/h) and other countries' histolabs (3.74 U/h) are significantly different ($P < 0.0002$), as well as those from the United States and SpHA (2.82 U/h for $P < 1 \times 10^{-6}$) and between this latter group and the rest of foreign histolabs ($P < 1 \times 10^{-10}$).

3.3.4. The special procedures WFP

The special procedures WFP average for US histolabs (6.88 U/h) is not different to that of other countries (5.74 units/height) because it includes only special tasks with very similar productivities and that are frequently automated.

The WFP levels are determined by the relations between workload, the staff size, and its productivity and how the work is organized; but there are also intrinsic characteristics. In the sample from SpHAP histolabs, their WFPs have to do with other factors as well, like long-time–held customs about how the work shift is used and administered. Furthermore, in many HA histolabs, specially in those government funded, there also exists a combination of low salaries and labor unions trying to hire as much personnel as possible into irremovable positions, compounded with histotechs and even pathologists who, to provide for their needs, work in at least 2 separate histolabs [11]. All these factors affect the time usage (Table 1), determining that other countries' histolabs use the time 14% less effectively than in the United States, although histolabs with just the necessary staff for their workloads and high WFP values exist in all countries.

Trying to increase the WFP, several management methods have been applied to histolabs for many years [14]; but perhaps, the one causing the most expectation uses a Lean continuous throughput technology based essentially on a new design of tissue processor [15]. The samples are processed continuously in small batches with a very short protocol, but the time to complete the manual tasks before and after TP is independent of this step [1] and has more to do with the way the work is organized and how many FTEs participate.

The present survey includes 3 histolabs using this new Lean throughput technology, 2 in the United States (Florida and South Dakota) and 1 in Venezuela; but they are organized and staffed differently.

The one in Miami, FL, works continuously for 9 hours per day (8:00 AM to 5:00 PM) with 1 FTE every 2300 cases, for a total 13 FTEs and a gross WFP of 3.4 blocks per hour or 83% the average for US histolabs using conventional technology.

Embedding in the Sioux Falls, SD, histolab is done during 8 hours; but cutting is continuous during 24 hours with 1 FTE every 3850 cases, for a total of 14 FTEs and a gross WFP of 3.7 blocks per hour, which is equivalent to 90% the US average.

The histolab in Caracas works during 12 hours per day (6:00 AM to 6:00 PM) with 1 FTE every 8860 cases, for a total of 7 FTEs and a gross WFP of 7.2 blocks per hour, which is 175% the US and 232% the non-US histolabs' averages.

If these 3 histolabs use the same technology, what causes the WFP differences? The differences reside in just how the work is organized to optimize the FTE productivity, the one with the largest workload and the smallest staff having a gross WFP twice the average of the other two.

It is important to realize that this Lean throughput technology was conceived to have the reports soon after the cases arrive at the histolab. That has been accomplished [15] but at a premium paid for the instruments and requiring schedule changes for all the personnel involved, pathologists included [15]. If all the extra cost associated with the throughput technology does not increase the WFP or the capacity of the histolab to process more cases with the same staff and only translates into a shorter TAT, the only way to recuperate the investment is by charging a premium for that faster service. By doing so, the patient will end up paying more for a faster TAT that in most cases is unnecessary [16], the other option being decreasing the histolab profit margin.

Neither solution is good; so before adopting this throughput technology, it is fundamental to determine if there are other options available that could provide a faster TAT at a lower cost [1]. This is especially important for US histolabs where the reports are almost always completed within 24 hours of the specimen arrival and with almost all the slides ready usually by noon the next day (in compliance with the CAP guidelines of having 80% of all routine specimens completed within 48 hours from accessioning and 80% of resections within 72 hours also from accessioning) [14].

A different situation exists in other countries, especially in the 29% of histolabs processing manually, where the reports can take up to 5 days or even several weeks in some extreme cases. Furthermore, in only 17% of these histolabs are the slides ready before noon; and in the rest, slides are ready after 4:00 PM and up to 7:00 PM, for an additional 1-day delay in issuing the reports that are usually mechanically typed. How their work is evaluated is reflected in a report from a foreign histolab that considers a great achievement reducing from 3.2 to 2.0 days the TAT for surgical cases, which is a real progress for that histolab even when it is still 1 day too late when compared with the great majority of US histolabs.

3.4. *Performance standards for the histolab*

The WFPs discussed before constitute easy ways to evaluate the overall performance of each histolab but do not provide specific data allowing the pathology director to develop a plan of action to improve the situation when the WFPs values are below average.

The fundamental administrative objective of the histolab is to issue as many diagnostic reports with the shortest TAT, the least cost, and the highest quality possible; and to do that, each has to develop performance standards to remain competitive among all those providing a similar service; but an internal study of the operation will be almost meaningless. To evaluate the histolab, it is imperative to know how others operate, what are their productivity values, what criteria do they use to automate some tasks, and if they are asking too much or expecting too little from the staff. To answer those questions, the manager needs comparative information that is usually obtained from specialized consulting firms that jealously guard their findings obtained while studying other histolabs; and this is the reason why there is so little information available.

In 2000, a benchmarking and productivity workshop [17] offered a range from 3.2 to 3.5 blocks per total paid hour from accessioning to some unspecified type of slides ready for the pathologists as something the histolab management should be looking for to obtain. The 2005 survey presented an average of 4.2 blocks per hour [9] for the same sequence of routine tasks including automated TP, staining, and coverslipping, the differences between both standards most likely caused by different tasks productivity values used in their calculation.

It is also necessary to point out that the work flow performance standards or benchmarks should be adapted to the characteristics of each histolab, causing some managers to even reject the notion of general standards. Some prefer using only the standards they have developed as an excuse for not accepting change, thus perpetuating the tenuous validity about the uniqueness of their histolabs.

Pathologists and lab administrators always think in terms of cases, so the time needed by the histolab staff to complete all the routine technical (Table 4) and nontechnical tasks (Table 6) derived from 80 blocks and 120 slides generated from 25 cases appears in Table 8.

If there are no LAs, all the tasks marked as "d" in Table 8 have to be completed by histotechs, increasing the time to 13.67 hours from cassetting. If there are LAs and the H&E staining and coverslipping are automated, the purely technical tasks from cassetting to cutting are reduced to 6.96 hours; and those completed by the LAs and the instruments are 6.71 hours. The work of LAs, added to automating H&E staining and coverslipping, increases the histotechs' productivity 1.95 times, from 5.9 to 11.5 blocks per hour. In addition, the cost will be reduced by the salary difference between LAs and histotechs times the technical time saved.

Automating staining and coverslipping will cut 1.89 hours from technical tasks time every 25 cases, equivalent to 0.24 FTE or close to $12 500/y if the histotechs are paid $25/h [18]. The investment will be paid off in less than 4 years, or in just 1 year for a histolab with 100 cases per day.

Table 9 presents different productivity values depending on the level of automation for the routine tasks and the total hours per day for histolabs with workloads from 10 000 to 40 000 cases per year, including also the number of FTEs needed to complete those tasks.

The different automation levels of routine tasks determine productivity levels between 1.41 and 1.58 cases per hour or 4.53 and 5.07 blocks per hour (Table 9), but the special tasks should also be included to have a more realistic idea. The

Table 8
Human pathology: time (hours) for tasks from 25 cases

Nontechnical tasks[a]		Technical tasks	
Task	h	Task	h
Specimens transport	0.58	Grossing cases	1.79
Access specimen data	0.67	Cassetting[b]	1.47
Transcribe gross description	0.96	Embedding[c]	1.60
Cassettes in/out of processor[d]	0.01	Trim blocks	0.56
Label slides manually[d]	0.67	Cut blocks	3.33
Prepare blocks to cut[d]	0.51	Routine stain: manual	2.40
Collate slides with reports[d]	1.04	Coverslip: manual	1.50
File blocks/slides[d]	0.58		
MANUAL TASKS	5.02	MANUAL TASKS	12.65
Label slides automated	0.29		
Slides in/out of each instrument	0.12		
H&E stain automated	1.60		
Coverslip automated	0.33		
Automated tasks[e]	2.34		
All manual tasks			17.67
All manual tasks excluding staining and coverslipping			13.77

For time per unit calculations, 25 cases include 80 blocks and 120 slides.
[a] In small labs, these tasks sometimes are completed by technical personnel.
[b] Includes manual numbering of cassettes if there is no cassette writer.
[c] With an automated embedding instrument = 0.67 hours for 80 blocks.
[d] Completed by technical personnel if there are no LAs.
[e] Include 0.04 hours for each automated instrument = 0.12 hours.

Table 9
Human pathology: time for 25 cases[a] with different levels of staining and coverslipping automation (hours to be added to 13.77 hours of total manual base time)

Hour/day for the automation level		hour	Cases/hour	Blocks/hour	Slides/hour
Stain	Coverslip				
M = 2.40	M = 1.50	17.67	1.41	4.53	6.79
A = 1.64[b]	M = 1.50	16.91	1.48	4.73	7.10
M = 2.40	A = 0.37[b]	16.54	1.51	4.84	7.26
A = 1.64[b]	A = 0.37[b]	15.78	1.58	5.07	7.60

Calculation of total hours per day for different workloads and automation levels:
Example 1: histolab with 38.5 cases per day (10 000 cases per year) and all tasks manual:
(38.5 cases/25 cases) × 17.67 hours per day = 27.2 hours per day.
Example 2: histolab with 76.9 cases per day (20 000 cases per year) with automated staining and manual coverslipping:
(76.9 cases/25 cases) × 16.91 hours per day = 52.0 hours per day.
Example 3: histolab with 153.8 cases per day (40 000 cases per year) and fully automated:
(153.8 cases/25 cases) × 15.78 hours per day = 97.1 hours per day.
NOTE. With an overall time usage of 82% for US labs, the effective daily work time for 1 FTE is 6.56 hours per day; and the above calculated times will require at least 4.2, 7.9, and 14.8 FTEs, respectively.
A indicates automated; M, manual.
[a] Twenty-five cases generate 80 blocks and 120 routine slides.
[b] 0.04 hour added for slides in/out of the automated instrument.

histolab with 20 000 cases per year in Table 9 should have 8 FSs per day (=2 hours) and 26 HCs, about 75% of which are for organisms detection requiring 1.8 hours if completed manually. Furthermore, 60 IHCs done in 14 hours manually or in 6 hours with an autostainer should be included. These new tasks add 17.8 hours for a total of 69.8 hours if all are manual or 9.8 hours more for a total of 61.8 hours if IHC is automated.

A daily total of 246 blocks corresponds to this histolab, and the total WFP including the special procedures completed manually is 246 blocks ÷ 69.8 hours = 3.52 blocks per hour. If IHC is automated, the productivity is 246 blocks ÷ 61.8 hours = 3.98 blocks per hour, for a general range of 3.5 to 4.0 blocks per hour. These very same productivity values will correspond to any histolab with the same tasks and automation levels, regardless of its total workload.

The general gross WFP index (average of 3.61 blocks per hour) is the one better reflecting this general range of 3.5 to 4.0 blocks per hour, with 54% of 105 US, 42% of 50 foreign, and 13% of 47 SpHAP histolabs having values of more than 3.5 blocks per hour.

This performance standard range of 3.5 to 4.0 blocks per hour is reduced to 3.2 to 3.5 blocks per hour when an average of 8 hours for automated TP is added to the time needed for the above mentioned tasks.

The total WFP of 5.1 blocks per hour for all routine tasks automated (Table 9) can be divided into pre- and post-TP periods with 13 and 8.3 blocks per hour, respectively. When the average protocol of 8 hours for automated TP is added, the overall WFP is reduced to 3.4 blocks per hour for all the routine tasks.

If microwave technology is used for TP, as little as only 0.4 hours could be added, with a minor impact in the total WFP (4.9 blocks per hour); but if TP is manual, as in 29% of the histolabs from HA and Russian samples, up to 28 hours has to be added. Adding that many hours will have a large impact in the WFP and reduce it to just 1.8 blocks per hour, meaning that automating TP doubles the WFP, this being the fundamental reason for TP automation in most histolabs for more than 60 years [1].

4. Veterinary histolabs

Veterinary histolabs, with an estimated number of 465 labs [12], are the second most abundant type of histolab after those for human pathology and exist in each state agriculture department and in the 29 US Veterinary Medicine schools, and also include those operated by pharmaceutical companies. They employ about 1110 histotechs, half of which are licensed or accredited [12], the rest being students and researchers who carry out their own histology work,

Table 10
Veterinary pathology labs: workloads and tasks productivities

Workloads and tasks	Range/Average	Median	n labs
Cases/year (×1000)	Ø to 9.7/1.6	0.8	16
Cases/day	0.6 to 37/12	5	15
Autopsies (necropsies)/y	26 to 9300/1441	175	10
Blocks/year (×1000)	0.5 to 11.7/39.2	12.5	17
Blocks/case	1.3 to 120/14.5	6.6	17
Blocks/day	0.4 to 450/64	26	21
Slides/block	1 to 7.5/3.3	1.2	15
Slides/day	19 to 249/185	52	8
Cassetting: cassettes/hour	15 to 98/48	45	11
Embedding: blocks/hour	15 to 100/43	45	15
Cutting: blocks/hour	8 to 47/22	20	15
Manual H&E: slides/hour	24 to 106/35	36	11
Manual H&E: % of labs	37		19
Manual coverslip: slides/hour	45 to 172/61	54	10
Manual coverslip: % of labs	63		19
Recuts: blocks/day	1 to 75/18	8	13
FSs/year	230 to 259/245	245	2
min/FS	10 to 15/12	12	5
HC: slides/year (×1000)	Ø to 6.2/3.7	1.2	16
IHC: slides/year (×1000)	Ø to 26.0/9.3	1.4	10
Recycling tasks: % of labs	45		11
Staff available time (hour/day)	8 to 64/49	16	17
Staff used time (hour/day)	6 to 64/32	12	15
Time usage/lab (%)	34 to 149/65	75	15
Gross WFP (blocks/hour)	0.1 to 8.2/3.3	2.6	22
Net WFP (blocks/hour)	0.1 to 12.5/3.8	3.0	22
Total WFP (units/hour)	0.1 to 11.1/3.9	2.7	17
Special procedures WFP (units/hour)	0.1 to 15/2.3	1.3	16
Cytology cases/year (×1000)	0.4 to 9.4/6.5	9.2	4
File blocks/slides	0.25 to 1.0/0.55	0.5	10
Remove/dispose of tissues (hour/day)	0.25 to 1.0/0.7	0.5	2
Change reagents/waste disposal (hour/day)	0.25 to 1.5/0.7	0.5	12
Clean work areas (hour/day)	0.1 to 1.5/0.6	0.6	11

Table 11
Veterinary pathology: comparisons

Comparison between US and non-US veterinary histolabs

Task and hour/day	Units	US	non-US	*df*	Significance
Cases/year (×1000)	Case	2.2	0.8	14	NS
Blocks/case	Block	22	4	15	<0.025
Cassetting	Cassettes/hour	54	31	8	NS
Embedding	Blocks/hour	54	25	13	<0.01[a]
Cutting	Blocks/hour	22	22	13	NS
Recuts	Blocks/hour	26	4	11	<0.05
H&E staining[b]	Slides/hour	40	95	11	<0.025
Coverslipping[c]	Slides/hour	45	59	11	NS
FSs	min/FS	13	11	2	NS
Staff time available	hour/day	54	29	16	NS
Staff time accounted for	hour/day	39	15	14	NS
Routine gross WFP	Blocks/hour	4.5	0.9	19	<0.0005
Total WFP	Units/hour	5.3	1.3	16	<0.005

Comparisons between human and veterinary pathology histolabs

Task and hour/day	Units	Human	Veterinary	*df*	Significance
Autopsies/year[d]	Autopsy/necropsy	158	1441	140	<0.05
Cassetting	Cassettes/hour	54	48	153	NS
Embedding	Blocks/hour	50	45	185	NS
Cutting	Blocks/hour	24	22	201	NS
Routine WFP	Blocks/hour	3.6	3.3	220	NS
Total WFP	Units/hour	4.5	4.0	191	NS
Tissue disposal	Hour/day	0.5	0.7	28	NS
Change reagents	Hour/day	0.7	0.9	150	<0.025
Clean work area	Hour/day	0.6	1.0	133	<0.01

[a] Because 67% of foreign veterinary labs do not have embedding centers.
[b] Combined performance (37% manual and 63% automated).
[c] Combined performance (63% manual and 37% automated).
[d] *Necropsy* is the term used in veterinary pathology.

especially when working for either pharmaceutical companies or in pharmacy schools. Some small veterinary facilities send their samples to human labs, to larger veterinary labs, or even to commercial histolabs to prepare their slides.

Generally speaking, veterinary histology is much more complex and difficult for it requires working with an enormous variety of subject species from all environments and belonging to almost every animal phyla, many with very lean tissues requiring constant adaptations of the processing protocols, many done manually. Another peculiarity is that in many the work flow is irregular, depending on the reception of samples, some functioning as epidemic or forensic sites attending the wild and commercial animal populations in any given state or community.

This survey includes data from 23 veterinary labs from 11 states in the United States and 8 from other countries, 4 from the Commonwealth (2 from Australia and 1 each from India and the UK), and 4 from Hispano-America (2 from Argentina and 1 each from Uruguay and Venezuela). Some questionnaires were not answered completely; and some tasks are not performed in all labs, thus reducing the information about some tasks and indices to less than the total sampled.

A summary of workloads and tasks productivities, arranged in a similar manner as for human pathology histolabs, appears in Table 10; and the analysis of the differences between United States and other countries, and between human and veterinary histolabs is shown in Table 11.

In veterinary histolabs, the designation *case* can be applied to samples from an animal processed for diagnostic purposes or even samples from all the tissues from an autopsy (termed *necropsy*) from experimental animals used in pharmaceutical studies. Consequently, the number of blocks per case varies from 1.3 to 120 depending on the mission of the histolab and the type of study.

The embedding productivity differences between US and other countries' veterinary histolabs are significant because 67% of the latter do not have embedding centers. However, the differences for other manual tasks, like cassetting and cutting, are not significant for they depend on the histotechs' dexterity being independent of the histolab type.

The significant differences in WFPs between US and other veterinary histolabs are because, except for one, all others surveyed are run by students in veterinary schools and have different work organizations and characteristics with great intrinsic similar variability between them. These factors explain why the gross WFP of the 4 labs from the

Commonwealth (1.26 ± 1.12 blocks per hour) is not statistically different (*df* = 6) from that of the 4 HA labs (0.49 ± 0.38 blocks per hour).

The comparisons between human and veterinary histolabs (Table 11) show no differences between the productivities of the fundamental tasks of cassetting, embedding, and cutting, or between the WFPs, which is additional proof of the uniformity of the histology work in all types of histolabs.

The irregular work flow and lower workload in veterinary histolabs also determine that those in the United States have a time usage 10% lower than human histolabs, this difference increasing to 12% between foreign human and veterinary histolabs, with the always-existing exceptions of those whose workloads are larger, less variable, or better organized.

5. Forensic pathology labs

In a survey conducted about the work of 104 medical examiners (MEs) and coroner's offices, 35 of them (34%) employ a total of 48 histotechs to do their histology work; but the rest send their specimens to area hospitals [12] or even to commercial histolabs. The 35 ME offices employing histotechs are located in 25 states. Nine of them in 8 states with some workload information are included, along with one from South Africa.

Although all autopsies require a pathology report, the high cost of operating a histolab and the fact that histology reports have lesser priority than others like chemical or toxicology reports are the fundamental reasons why 66% of the ME offices send their tissue samples mostly to area hospitals to cover this aspect of their work, also ensuring a high quality of work that may include costly special procedures.

Table 12
Forensic pathology labs: comparisons

Workloads and tasks	Human (245)	Veterinary (22)	Forensic (9)
	Averages	Averages	Averages
Autopsies/year	158	1441	2185 [a]
Slides/block	1.5	3.3	1.0
Cassetting: cassettes/hour	54	48	50
Embedding: blocks/hour	50	43	33
Cutting: blocks/hour	24	22	14
Manual H&E: slides/hour	49	35	20
Manual coverslip: slides/hour	80	61	67
HC tests/y (×1000)	5.6	6.8	0.7
% of labs doing HC tests	72	76	100
% of labs doing IHC tests	58	57	50
File blocks/slides (Units/hour)	138	178	200
Change reagents/waste disposal (hour/day)	0.9	0.7	0.3
Clean work area (hour/day)	1.0	0.6	0.5
Gross WFP (blocks/hour)	3.6	3.3	4.2 [b]
Total WFP (Units/hour)	4.5	3.9	4.5 [c]

[a] Range = 426 to 7325 autopsies per year.
[b] Range = 1.4 to 6.9 blocks per hour.
[c] Range = 1.5 to 7.5 Units/hour.

The averages for some tasks done in forensic facilities are presented in Table 12, with values of slides per block; embedding, cutting, and staining productivities; as well as HC tests per year in the lower end of the ranges of the other 2 categories of histolabs. The rest of the tasks present quite similar values, including gross and total WFPs, underscoring again that the uniformity of the histology work transcends lab types.

As was expected, the number of autopsies per year is significantly different between human and forensic ($P < 0.005$ with $df = 135$) but not between veterinary and forensic histolabs. When comparing the number of autopsies between US human, other countries' human, veterinary, and forensic facilities, the differences are also significant ($P < 0.0001$) because of the lower averages of the 2 groups of human histolabs compared with the other 2 (veterinary and forensic). The same happens if all human histolabs are compared as a single group against veterinary and forensic ($P < 3.3 \times 10^{-8}$).

6. Conclusions

The histolab productivity depends on its type, specialty and workload, staff size and their training, and the existing instrumentation and automation level, but fundamentally on the way the work is organized. The result is that each histolab has an almost unique combination of all those factors, with some aspects within the standards values and others outside. Thus, the main task of the pathology director is deciding which standards to accept and pursue and which to ignore, as all are applicable to any type of histolab.

Furthermore, it is important to realize that pursuing high productivity cannot cause an increment in the error rate in the work flow; rather, error reductions should be a fundamental objective of the histolab, but not to the point in which the TAT is compromised.

One fact is certain: that the individual histotech's productivity is essentially the same in any setting. Provided that the training and the instruments are adequate, personal dexterity is quite similar all around the world, with the variations between histolabs being the cumulative effect of all the factors mentioned and especially how the work is organized. This explains why any histolab, after some years of operation, especially if processing more than 20 000 cases annually, will benefit from analyzing its work flow regardless of the management technique used for that purpose [14].

The fundamental manual tasks in the histolab, those requiring direct human intervention, are limited to grossing, cassetting, embedding, and cutting; and all the others have been automated. Embedding has been automated also, although the gained productivity with the automated instrument is partially reduced by the additional time required to set the tissue pieces in a specific position and to cut through the specimen plastic holding device, which reduces the cassetting and cutting productivity.

Besides the effect of the automation level on the productivity, Table 9 also presents the impact of the time utilization that for US human histolabs is 82%, meaning that 18% of the time is used on tasks not directly related to the production of finished slides, this being the first estimate of this variable. In human histolabs from other countries, 36% of the time (twice than that in the United States) is dedicated to tasks unrelated to the production of finished slides. Time utilization in veterinary histolabs is even lower, with an average of 72% in United States and 52% in other countries, again depending on a combination of workload, staff, and work organization.

The CAP calculated that 20.5% of the total paid hours in medlabs are spent in activities not included in the workload and considers that this is fairly standard but recognizes that other values can exist also [19]. This figure, close to the 18% for US histolabs, points to a common approach to the work organization for these 2 areas under the administration of the director of pathology in many large hospitals or reference labs.

The CAP has also defined the *CAP work unit* as "each paid minute used in the completion of the medlab tasks" including the time not directly used in completing those tasks in its calculation. Using their data [19], the work of an FTE in an average medlab amounts to 684 CAP U/d. The data in Table 9 represent a productivity of 394 CAP U/d per FTE in an average US histolab, meaning that a medlab FTE is 1.74 times more productive than a histolab FTE. This productivity difference is because about 80% of the medlabs' tasks are automated but less than 30% are automated in histolabs [20], meaning that the ratio should be even greater, about 2.6 instead of 1.7 for their relative productivities.

As discussed before, the best productivity indicator of the operation of any histolab is its gross WFP because it represents the relation between all the tasks derived from the blocks from new cases and for special procedures, and the time it takes the staff to complete them. Because histolabs usually have staff proportionate to their workload, the gross WFP value becomes essentially dependent of the way the work is organized, explaining why histolabs with very different workloads can have similar gross WFP.

The gross WFP values show differences between groups of histolabs (Fig. 1), with the 105 from the United States having a maximum frequency (26%) in the 3 to 3.9 blocks per hour class, with 69% of US and 82% of 50 foreign between 2.0 and 4.9 blocks per hour. The most abundant class in SpHAP histolabs is that of 1.0 to 1.9 blocks per hour (41%), and it is the only group with less than 1.0 block per hour (6% of all). The extremely skewed shape of their frequency polygon is mostly caused by their peculiar work organization because the histotechs' productivity differences are not significant, whereas cutting and the embedding differences are equipment dependent.

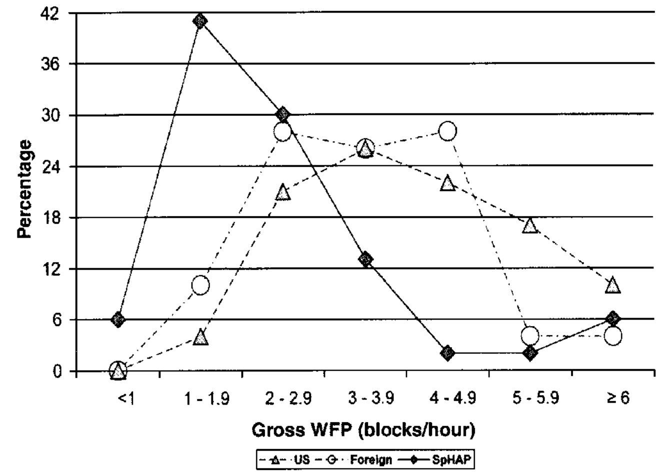

Fig. 1. Gross WFP (percentages of blocks per hour classes) for human histolabs: 105 from the United States, 50 foreign, and 47 from SpHAP.

In the same way that large groups of histolabs present significant differences in their productivities, histolabs in any country also exhibit them; and it is not the country or its cultural heritage per se that determines productivity, but the way the pathology director organizes the lab. Evidence of this fact is that, when using the newest Lean throughput technology available, the histolab with the largest workload and the highest gross WFP among those using it is in Venezuela, resulting from the combined effect of the technology with the essential number of well-trained histotechs organized in an optimal way. Furthermore, 10% of the SpHAP histolabs using conventional technology have gross WFPs greater than the average for US histolabs; therefore, the proper management of the human and technical resources is vital for a profitable histolab, ensuring a competitive TAT.

This first article offers the pathology director all the tasks productivities standards and their ranges to compare with those existing in any particular histolab, permitting to identify those that could be improved.

Any pathology director in the United States obtaining a value of less than 4 blocks per hour of gross WFP for the histolab should try to determine if the value is caused by below average productivity of some tasks, by overstaffing, or by a combination of both.

All the productivity standards are administrative tools to be used by the pathology director to improve the general operation of the histolab and its TAT, and to inform and manage the staff in order that they are aware of what is expected of them at current or projected workloads.

Acknowledgments

Alexander E Matsionis, MD, PhD, member of the Board of the Russian Society of Pathologists, posted the Russian translation of the productivity questionnaire in their Web site; and Maxim V Peshkov, BSc (Taganrog Patho-

Anatomical Bureau), translated the answers from the participating Russian Federation histolabs. Dr Gustavo Matute Turizo, President of the Colombian Pathology Society, provided information and was instrumental in obtaining the participation of Colombian pathologists; and Mr Augusto Marcuzzi provided information and contacts from Venezuelan histolabs. HanZhang Cheng, BS (Wuhan University, Hubei Province), personally gathered information from the participating histolabs from the People's Republic of China; and Sara Breeden, HT (ASCP), from the Veterinary Diagnostic Services of the New Mexico Department of Agriculture provided data and reviewed the "Veterinary histolabs" section. Finally, Richard E Edwards, BSc (University of Leicester, United Kingdom), reviewed and commented on the manuscript. The author wishes to thank them and all the 141 participants in his second productivity survey.

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