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Cost Accounting Method for Cytometry Facilities

THE setup and successful operation of a core facility requires specialized accounting practices that, to our knowledge, have not been described recently within the cytometry community. While yearly budgeted expenses such as employee's salaries, supplies, and instrument service contracts are easily estimated, it is more difficult to calculate overhead costs and equitably amortize total yearly expenses through core facility charges. At the most basic level, a facility must maintain accurate cost information so that fees for services can be set at levels to recuperate known portions of operating expenses. The charges recovered by the facility should be calculated in a way that complies with applicable grant funding standards such as Federal cost principles (OMB Circular A-21 and A-122) for US federal funding or higher education institutions' (HEI) transparent approaches to costing (TRAC) in the UK. However, more advanced methods also provide resource usage and resource availability data, which can provide a context in which cost data can be more fully understood (i.e., the manner in which a resource is used depends on an empirical understanding of its availability). Furthermore, the combination of cost and resource capacity data allow new opportunities for strategic planning so that a facility can grow and change over time.

Recently, we evaluated an activity-based accounting method called time-driven activity-based costing (TD-ABC) (1,2). This method is an alternative to conventional activity-based accounting, and it is more simplified so that a typical non-accountant laboratory manager can collect data and calculate a useful model within just a few days. Moreover, TD-ABC provides accurate resource usage data so that strategic decisions can be made to maximize resource use.

TD-ABC deviates from the conventional method in two significant ways. First, activities are measured by time intervals rather than proportions of work intervals. This greatly simplifies the data collection process since it is fundamentally easier to determine how much time is required to perform a particular activity than to survey employees on what fraction of their time is spent performing various activities. Second, the resources that support these activities are assigned practical capacity limits (hours). Therefore, as activities are performed, used and unused capacity hours of resources can be assessed. The primary goals of implementing a TD-ABC analysis in our facility were to:

- Devise a method that estimates the true cost of flow cytometry experiments regardless of the instrument or combination of facility resources used
- Determine where significant discrepancies in cost recovery occur
- Model new fee schedules with the goal of more accurately reflecting resource usage in fees while maintaining the ability to motivate users to make efficient use of facility resources (e.g., unassisted usage during off-peak hours)

INITIAL ESTIMATES AND CALCULATIONS

The first step in performing a TD-ABC analysis is to calculate cost-per-hour rates of the various resources or resource groups that are used in a facility—these rates are called capacity cost rates (CCRs). Multiple CCRs will usually need to be calculated, one for each resource type used when performing services in the facility. This process is often fairly straightforward because a facility's budget is already subdivided into general categories such as personnel, supplies, equipment, overhead, rent, etc. Each category can be considered as a resource and some resource categories like equipment should be further sub-divided into the costs of individual instruments. Although the NIH and HEIs require distinctions to be made regarding directly incurred, directly allocated, and indirect costs, these distinctions are not necessary at this point. Table 1A shows our example facility's resources categories and annual operating costs.

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Additional Supporting Information may be found in the online version of this article.

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To calculate the CCRs for each resource, simply divide the cost of the resource for a given time period (usually 1 year) by the resource's practical capacity for the same time period (Table 1C). For example, if a personnel cost of $150,000 supports three full-time scientists with a combined practical working capacity of 4,633 h per year (Table 1B), then the personnel CCR equals $32.38/h ($150,000/4,633 h). The personnel capacity is straightforward since labor laws regulate the length of a workweek; however, determining the capacity of non-human resources may require more consideration. For example, although the theoretical capacity of analyzer1 is 24 h per day and 7 days a week, this is not the actual capacity, or "practical" capacity, of the resource. If a facility staff member's assistance is required to use the analyzer, then there is a practical reduction in the instruments' capacity. The capacity values for building or laboratory space rental as well as utilities and facility maintenance may be determined as equal to the yearly hours of operation. When determining the practical capacities of resources, be sure the figures are reflective of the particular facility's operation strategy. Different facilities will inevitably have varying capacity limits for personnel and instrument resources depending on circumstances.

In our example, the calculation of a full set of CCRs required approximately 2 h of work (Supporting Information Table S3). We began the process with an accepted 2011 facility budget, with well-defined resource classification. The majority of time used for this process was spent verifying indirect costs that were accounted for by other institute cost centers such as maintenance contracts, depreciation, and overhead.

The second step in building the TD-ABC model involves listing the facility's core activities and identifying the average time durations required to perform each activity (Table 1D, columns 1 and 2). This list should contain enough detail to account for most of a facility's variety of work. At the same time, the activities should be general enough so they represent a consensus from the facility's team regarding the fundamental units of the work. Time durations should be assigned to each activity. In our example, a team of cytometrists identified 17 activities (Table 1D, items 1–17) that could be differentially combined to represent almost any experiment or assay performed in the facility. The team also determined there was still a small but significant portion of their work not described by these 17 activities and therefore generated four somewhat more general "per-hour" activities that could be used to represent the remaining categories of work (Table 1D, items 18–21). One should attempt to achieve a balance between building a set of activities that is overly extensive and cumbersome to work with and one that is overly simplistic and cannot sufficiently encompass a full enough range of the facility's work. The facility's staff will likely be the most qualified to generate such a list, and once consensus has been reached regarding the list of activities, two more columns are added to the table, cost drivers and cost of activity (Table 1D, columns 3 and 4). The term cost driver is defined as a specific resource or combination of resources that "drives" the cost of the activity and, in our case, was equal to the sum of all applicable CCRs. Therefore, in this column we identified the appropriate combination of CCRs (from Table 1C, column 4) associated with performing each activity by listing the resources that support the row's activity. Note that in the Table 1D cost driver column, personnel may or may not be included in the sum of CCRs depending on whether an experiment requires staff assistance. Lastly, the cost of activity column, which is defined as the cost of performing one instance or unit of the activity, was populated by multiplying the average time required for the activity by the sum of CCR values associated with each resource listed in the cost drivers column. An excel spreadsheet containing example calculations can be found in Supporting Information (http://db.tt/j30sxZV5).

This second step required approximately 2 h of facility staff group discussion. The TD-ABC concepts were introduced to the team during a lab meeting and the team was asked to generate the consensus list of fundamental unit of work (i.e., activity list). At the subsequent lab meeting, the team reexamined the list, made minor alterations and agreed upon the average time required to perform each activity (Supporting Information Table S3).

Data Collection and Analysis

One of the major disadvantages of conventional cost accounting methods is the amount of effort required to collect and maintain a dataset. In many cases, methods were abandoned for this reason alone (3). To avoid the same pitfall, we designed a database with a quick data entry format (Filemaker database files can be accessed at http://db.tt/j30sxZV5). Figure 1 shows an example of the database's primary layout for the collection of activity level and resource use data (activity data). Several features were crucial for quick and accurate data entry. Foremost, the layout was designed for a one-page view of the facility's fundamental units of activities, and radio buttons were used to enter numeric values; 0, 1, or "other." Also, most fields defaulted to the null selection, indicating that the activities were not performed during the service. If an activity was performed, the "1" radio button was selected; and when an activity was performed multiple times, the "other" selection opened a text field so that a number could be entered to represent the number of times the activity was performed. The resulting costs of activities for each service were automatically reported on a second page (Supporting Information Fig. S1).

Using this approach, data was entered following each experiment for several months (March to May 2011). Data entry took about 1 min per experiment, and the facility members' general consensus was that the system allowed activities to be mixed and matched to accurately represent all possible services provided by the facility. This example data set can be found within the referenced Filemaker database.

Initially, we used the database to calculate the example facility's actual cost and capacity usage and found that several summary representations of the dataset were useful as starting points for analyses. Examples of these analyses are included in Supporting Information (Figs. S2 and S3). However, this was not the limit of the database's usefulness. We designed the database so that multiple cost/capacity value sets could be tested against the activity data. This provided the opportunity

Table 1. Capacity cost rate (CCRs) calculations for a typical flow cytometry facility

A)

Cytometry Resources	Annual operating cost (payroll, materials, maintence agreements)	Annual Depreciation	Total Annual Cost
Lab Personnel	$ 150,000		$ 150,000
Supplies	$ 150,000		$ 150,000
Overhead(Maint./Util.)	$ 9,400		$ 9,400
IT Infrastructure	$ 5,000		$ 5,000
Computers	$ -	$ 6,667	$ 6,667
High-Speed Sorter1	$ 30,000	$ 40,000	$ 70,000
High-Speed Sorter2	$ 30,000	$ 40,000	$ 70,000
Analyzer1	$ 11,250	$ 15,000	$ 26,250
Analyzer2	$ 8,250	$ 11,000	$ 19,250
Analyzer3	$ 5,250	$ 7,000	$ 12,250
Analyzer4	$ 3,000	$ 4,000	$ 7,000
Macro Particle Sorter	$ 15,000	$ 20,000	$ 35,000

C)

Cytometry Resources	Total Annual Cost	Total Practial Capacity (hours)	CCR (cost/hour)	CCR (cost/minute)	Index
3 Lab Personnel	$ 150,000	4,633	$ 32.38	$ 0.54	P
Supplies	$ 150,000	6,240	$ 24.04	$ 0.40	S
Overhead(Maint./Util.)	$ 9,400	6,240	$ 1.51	$ 0.03	O
IT Infrastructure	$ 5,000	6,240	$ 0.80	$ 0.01	IT
Computers	$ 6,667	6,240	$ 1.07	$ 0.02	C
High-Speed Sorter1	$ 70,000	2,808	$ 24.93	$ 0.42	Sort 1
High-Speed Sorter2	$ 70,000	2,808	$ 24.93	$ 0.42	Sort 2
Analyzer1	$ 26,250	5,928	$ 4.43	$ 0.07	Analy 1
Analyzer2	$ 19,250	5,928	$ 3.25	$ 0.05	Analy 2
Analyzer3	$ 12,250	5,928	$ 2.07	$ 0.03	Analy 3
Analyzer4	$ 7,000	5,928	$ 1.18	$ 0.02	Analy 4
Marco Particle Sorter	$ 35,000	1,872	$ 18.70	$ 0.31	MPS

B)

Cytometry Resources	Days	Annual holidays	Annual vacation days	Theoretical capcity days per year	Theoretical capcity hours per day	Non production hours per day (breaks, training, maintenance etc.)	Practial capcity hour per day	Annual practical capacity per unit	Units	Total Practial Capacity
Lab Personnel	260	11	15	234	8	1.4	6.6	1,544	3	4,633
Supplies	260	0	0	260	24		24	6,240	1	6,240
Overhead(Maint./Util.)	260	0	0	260	24		24	6,240	1	6,240
IT Infrastructure	260	0	0	260	24		24	6,240	1	6,240
Computers	260	0	0	260	24		24	6,240	1	6,240
High-Speed Sorter1	260	0	0	260	24	13.2	10.8	2,808	1	2,808
High-Speed Sorter2	260	0	0	260	24	13.2	10.8	2,808	1	2,808
Analyzer1	260	0	0	260	24	1.2	22.8	5,928	1	5,928
Analyzer2	260	0	0	260	24	1.2	22.8	5,928	1	5,928
Analyzer3	260	0	0	260	24	1.2	22.8	5,928	1	5,928
Analyzer4	260	0	0	260	24	1.2	22.8	5,928	1	5,928
Marco Particle Sorter	260	0	0	260	24	16.8	7.2	1,872	1	1,872

D)

	Activity	Average Time Required for Activity (Hours)	X	Cost Drivers (Sum of Applicable CCRs)	=	Cost of Activity
1	Pre-Experiment Meeting	0.33	X	(P* + O)	=	$11.18
2	Post Experiment Discussion	0.25	X	(P* + O)	=	$8.47
3	Basic Written Report	0.5	X	(P* + O + IT + C)	=	$17.88
4	Advanced Written Report	1.5	X	(P* + O + IT + C)	=	$53.64
5	Manual Instrument Alignment	0.75	X	(S + O + IT)	=	$19.76
6	Fixed Instrument Alignment	0.25	X	(S + O + IT)	=	$6.59
7	Extra Lasers Alignment	0.08	X	(S + O + IT)	=	$2.11
8	Drop Delay Setup	0.25	X	(S + O + IT)	=	$6.59
9	Color Comp Controls (6 tubes)	0.3	X	(S + O + IT)	=	$7.90
10	FMO Controls (6 tubes)	0.5	X	(S + O + IT)	=	$13.17
11	Sample Run (0.25ml volume, 1 sample)	0.04	X	(S + O + IT)	=	$1.05
12	Sample Sort (1ml volume, 1 sample)	1	X	(S + O + IT)	=	$26.35
13	Post Sort Check using Beads	0.25	X	(S + O + IT)	=	$6.59
14	Post Sort Check using target cell population	0.33	X	(S + O + IT)	=	$8.69
15	Post Sort Check by microscopic exam	0.25	X	(S + O + IT + C)	=	$6.85
16	Remedy Clog	0.75	X	(S + O + IT)	=	$19.76
17	Instrument Shut Down	0.33	X	(S + O + IT)	=	$8.69
18	Sample processing (1hour intervals)	1	X	(S + O)	=	$25.54
19	Instrument idle Time (1hour intervals)	1	X	(O + IT)	=	$2.31
20	Sample Analysis (1hour intervals)	1	X	(P* + O + IT + C)	=	$35.75
21	Training (1hour intervals)	1	X	(P* + O + IT + C)	=	$35.75

Cytometry Resource	Abbreviation
Supplies	S
Overhead (Maintenance and Utilities)	O
IT infrastructure	IT
Computers	C
Personnel	P

(A) Total annual cost. Shown is a representative collection of costs associated with a flow cytometry facility including expenditures for personnel, supplies, equipment, and overhead. Total annual cost of each instrument is derived by adding the cost of an annual service contract (7.5% of initial instrument cost) plus yearly uncovered maintenance and the annual yearly depreciation of the instrument. (B) Calculation of practical capacity by resource. Shown are representative calculations of practical capacity for a given resource used within a flow cytometry facility per year. (C) Capacity cost rate per facility resource. Shown are representative CCRs associated with a flow cytometry facility. CCRs are derived by dividing the total annual cost of a resource by its total practical capacity. (D) TD-ABC costs of activities using the sum of multiple CCRs. Shown is a representative listing of core activities performed by a flow cytometry facility along with the average time required to complete each activity. To obtain a cost of activity for each specific task, the average time required to complete a given activity is multiplied by the sum of all applicable CCRs (cost drivers) derived from Figure 1. The resultant cost of activity is the cost of performing one instance of each activity.

*Personnel may or may not be included, depending on whether an activity requires staff assistance.

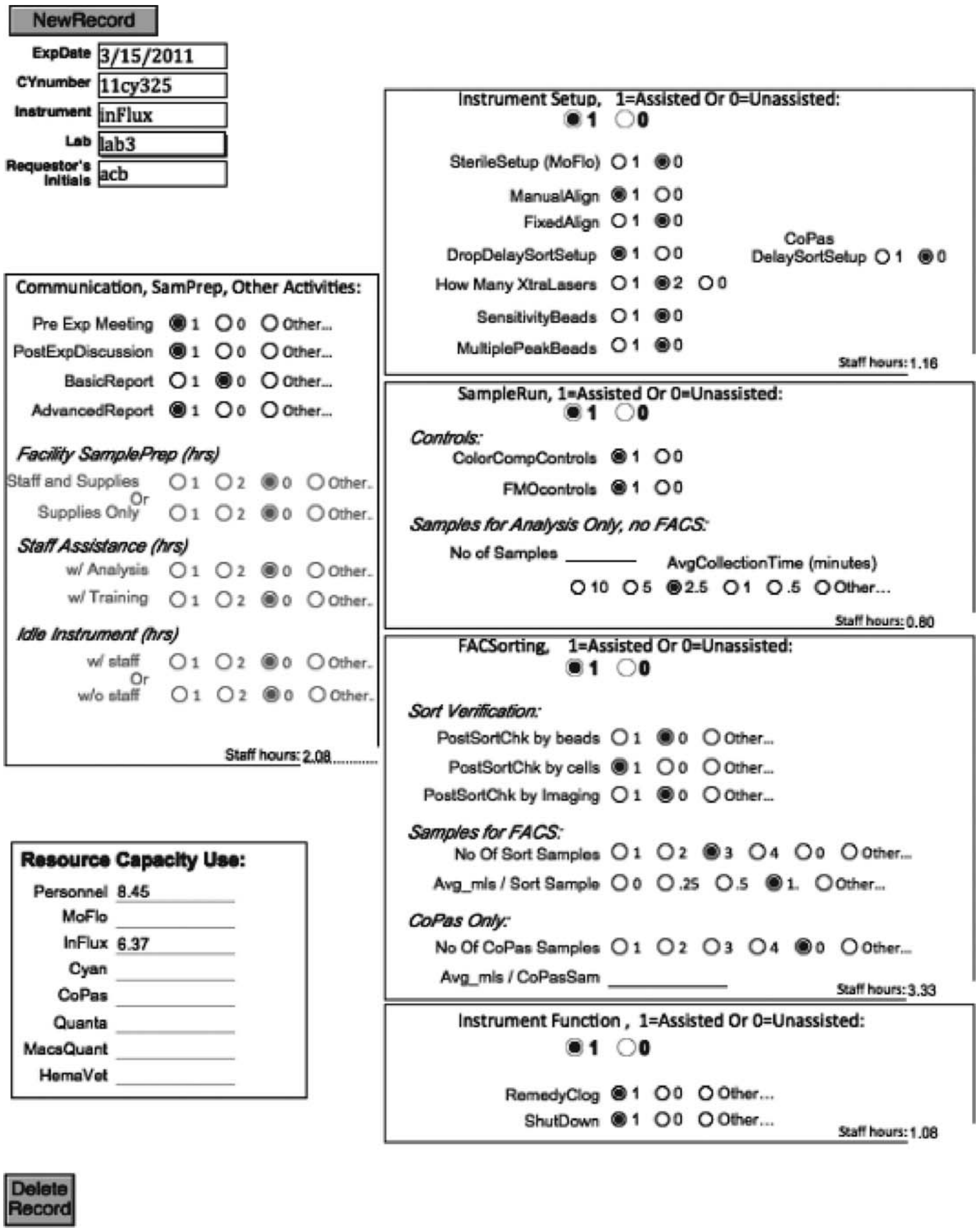

Figure 1. Screen shot of Filemaker TD-ABC data entry fields. Shown is a representative example of the primary layout of our flow cytometry facility's Filemaker database that allows for quick data entry of experimental variables required for TD-ABC calculations of experiment cost. The data-entry fields include five primary fields that described the service and 38 secondary fields that tallied the activity list items for each service. This example was performed on a high-speed sorter. Pre and post experiment meetings, as well as an advanced report, were tallied as ''1'' indicating that these were the communication activities of the service. The average time required for these activities was 2.08 h. The number ''1'' was selected at the top of the instrument setup, sample run, and instrument function boxes, indicating that instrument setup, operation, and shutdown were all performed by a facility staff member. The cumulative time of instrument use was 1.5 h; 0.75 h for a manual laser alignment, 0.42 h to run 10 samples at approximately 2.5 min per sample, and 0.33 h for instrument shutdown. The resource capacity use box showed a running total of the time use of the specific resource categories.

to strategically plan laboratory management decisions by forecasting the cost effects (i.e., how would the purchase of a new sorter, or a raise for an employee, or the lengthening of daily hours of operation affect the facility's long-term cost and capacity?). For this purpose, the database was structured as two distinct tables that could be related to each other through the use of a unique identifier, called "uniqueCCR-number" (Supporting Information Fig. S4). The first table was called TDABC_CCR_Values and it held the CCRs and activity list's average time duration values (from Table 1). Every time a new record was added to this table a uniqueCCR-number was auto-generated, as a field of that record. The second table was called TDABC_ActivityData and it held the activity data, described in the previous two paragraphs. Each record in this second table had a field for the selection of one of the uniqueCCRnumbers from the first table. Selecting a uniqueCCRnumber in this field of the second table would establish a database "relationship," or link, with the specified TDABC_CCR_Values record of the first table. When a link was established with a specific TDABC_CCR_Value record, the calculations for costs and resource capacity usage were performed using only that record's CCR values. This two-table approach made it possible for multiple versions of the facility's CCRs or activity time durations to be created; one for the current operations costs and capacities, and others for various hypothetical scenarios. These different versions were then available to be tested against the 3-month set of activity data. This database required about 2 working days for design, construction, and debugging.

Thus far, we have only considered the used portion of resource capacities and the cost to supply these capacities; however, it should be noted that unused portions of capacity are important to consider because they often lead to unreimbursed costs for the facility. In other words, an unused hour of a resource's capacity costs as much as a used hour; however, it is not typical to charge a facility user for unused resources, which has important financial consequences. In our example dataset, the unused capacities were determined by subtracting the used capacity hours for a resource (calculated by the database) from total practical capacities for that resource. Example results from such an analysis are described by Supporting Information Figure S2.

Although it is possible to use TD-ABC model to determine a set of charge rates for services performed in the facility (see below), it is also important to note that costs determined by the TD-ABC model as described so far should not be used directly to determine user charges (i.e., the precise cost for a service as determined by TD-ABC should not be equal to the charge for that service incident). The rationale for this is first, service charges should be predictable. If a requester is to book a service, a rate schedule should be easily recalled and/or predictable so that the financial expectations are clear. If the TD-ABC model were used to generate charges directly, it would be unrealistic to expect that a requestor would understand the interplay of resources and activities. Second, reasons sometimes exist to intentionally decouple actual costs from service charges to guide the use (and therefore capacity) of resources. For example, a reduced charge rate for after-hour use of an instrument can increase the instrument's overall used capacity by encouraging users to seek training for after-hours use. Lastly, the TD-ABC cost results are not subdivided as direct and indirect costs; however, governmental agencies such as the NIH or HEI's may require these distinctions to be made (4,5). Nevertheless, TD-ABC is a valuable tool for determining and categorizing exact operations costs, and this information is then available to indirectly guide the process for determining service charge rates. The specifics of how any particular facility translates costs into user fees or charge rates will depend on the financial circumstances and goals of the facility in question.

Although TD-ABC cost values should not be used directly as service charges, there is a simple way to use a modified version of the TD-ABC's CCRs to determine accurate service charge rates. First, evaluate the facility's financial structure and determine which types of costs are recoverable and which are not. This will depend on the region of the world, funding agencies involved, and guidelines of the facility's parent organization. Often, indirect operation costs such as utilities, facility maintenance, rent, equipment depreciation, and administration costs cannot be recovered through service charges. These costs are generally recovered through facility and administrative charges on grants or are covered by the institution. Whereas, direct costs like employees' salaries, supplies, and equipment operation costs are typically recoverable. After determining what costs are recoverable through user fees, subtract the nonrecoverable costs from the numerators of the respective resource's CCR (e.g., Table 1A, the depreciation amounts for a high-speed sorter, $40,000, would be subtracted from the yearly total). These subtractions should be performed as needed across the full set of applicable CCRs. If funds are available to subsidize core facility costs the subsidy should be applied to reduce expenses for items that are not directly scheduled by the user. These would be costs associated with resources that are shared across the facility versus resources identified and used in specific experiments. Applying institutional subsidies to the supplies resource, for example, would allow operations to be subsidized more equally than applying it to a specific instrument, since supplies are used across the majority of activities. Third, divide the remaining "charge acceptable" costs by the unchanged CCR denominators (practical capacity hours), to produce a set of service charge rates. For our example facility where institutional support pays most of the supplies costs, only the categories of personnel and equipment (subdivided based on instrument) retained significant values, which were then used as service charge rates. These rates were used in association with electronic resource calendars so users could schedule an experiment, make the selection of staff assistance or unassisted-use, and see the applicable service charge rates and estimated final charge values based on their selections.

There were several caveats regarding the use of this charge rate method. First, we chose the costs of unused resource capacities would not be recuperated through service fees. Instead, we challenged ourselves to design operational strategies that maximize the use of resource capacities. It was also important to note that unused capacities are common and valuable to maintain in facility environments. In our facility example, a macro-particle sorter was used six times in 3 months, 20.7 h (4.4%) out of 468 h of available capacity. The cost of operation of the macro-particle sorter for the three months was $10,000. We contend that it would not have been appropriate to charge $1,667/use ($10,000/6), nor decommission the sorter due to infrequent use. Rather, we recognized that the cost of an underutilized instrument is an unavoidable expense that should be absorbed by the institution when the instrument has sufficiently high research value. In this manner, a TD-ABC analysis empowers facility leaders to understand these types of costs and better communicate them to the research organization's leaders. Second, the charge rate method works best if the services performed by the facility were considered as unit times on a resource calendar (i.e., hours of use on a high-speed sorter), rather than as service units (e.g., one sorting session regardless of duration).

We believe the application of a TD-ABC model, or similar approach, in cytometry and other shared resource facilities allows for easier and more accurate facility accounting that is approachable even for individuals without a significant background in accounting, business or finance. In our own facility, application of these methods has facilitated the transition into a new fee schedule which, although more highly reflective of actual demands on resources, would have been significantly more difficult to justify and implement without the appropriate data provided by our TD-ABC model.

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