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Whitepaper | Quantifying the added value of Abbott Architect instrumentation, in conjuntion with Accelerator Laboratory Automation system and process optimization

A case study in the Clinical Biomechemistry and Pharmacology lab of the the Odense University Hospital

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INTRODUCTION

The continuous push for qualitative, responsive and cost-efficient services drive hospital laboratories as well as other labs towards integrated automated systems in an attempt to do more with fewer resources while at the same time improving overall quality. The present study attempts to quantify the added value of switching to the Abbott Accelerator Laboratory Automation system with associated process automation and optimisation by quantifying in monetary value potential cost and efficiency gains in a series of representative case studies.

METHODS

Site

The Clinical Biochemistry and Pharmacology (CBF) lab of the Odense University Hospital (OUH) was selected as a reference centre suitable for a case study representing a large scale Northern European hospital lab. OUH comprises one of the three main centres in the Danish Hospital Service and is the largest of four hospital areas in the Region of Southern Denmark. The CBF serves a wide range of stakeholders in local, regional and national health care: the OUH wards and outpatient clinic, other hospitals in the region of Southern Denmark, where CBF acts as a highly specialized laboratory on certain areas, general and specialist practices in the region of Southern Denmark and other hospitals in Denmark as a country service.

Scope

The scope of the present analysis was limited to the quantification of costs and efficiency gains due to implementation of the Abbott Accelerator Laboratory Automation system and process automation and optimisation. Specifically, we investigated the analytical phase of lab processes related to tests which were transferred to the Abbott Accelerator Laboratory Automation system between 2007 (pre-installation phase) and 2011 (post-installation phase). This included tests which were run on Perkin Elmer (Autodelfia), Siemens (Immulite), Roche (Modular, PSD-1 and Integra) and Abbott (IDX) devices as well as tests which were performed externally in 2007.

Data collection and analysis

Financial (cost data), staff number, turnaround time (TAT) and test tube usage data for the pre-installation (2007) and post-installation (2011) phases were provided by the lab over the course of two site visits between December 2011 and June 2012. Data collection, processing and analysis were performed by **hict** as an independent project partner. All data inputs, processing and results were validated by lab management (Mads Nybo, et al.)

Costs data

Costs data related to the execution of tests in scope were collected for the 2007 pre-installation and 2011 post installation phase. Costs data included costs for consumables (washer fluids, tubes, etc.), reagents, device and maintenance costs and staff costs. Overhead costs (heating, electricity, cleaning, floor space or waste) were not included in the analysis as the lab is not directly charged for these costs and lab-specific data were not available within the University Hospital administration. Likewise, explicit costs for quality were not included in the analysis. Quality in the CBF lab is maintained through quality assurance programs and trainings which did not change between the pre- and post-installation phase and as such are not influenced by installation of the Abbott Architect system and process automation and optimisation. Separate costs or numbers of errors (false positives/negatives) are not available in the lab and difficult to quantify objectively. Extra costs for manual verification, other than those indirectly included in lab staff costs, are not available in the lab. Likewise, costs for retests are indirectly included in the consumables, reagents and staff costs; separate data are not available in the lab.

Consumables and reagents costs

Consumables and reagents costs in the 2007 pre-installation phase were charged per unit used. The unit costs and resource use booked in 2007 for the tests in scope were used as inputs for the consumables and reagents costs calculations. Additionally, the number of tests performed in 2007 for each of the tests in scope was provided.

Consumables and reagents costs in the 2011 post-installation phase are charged per delivered result. The unit costs per result and the total number of results for each test in scope were used as inputs for the consumables and reagents costs calculations.

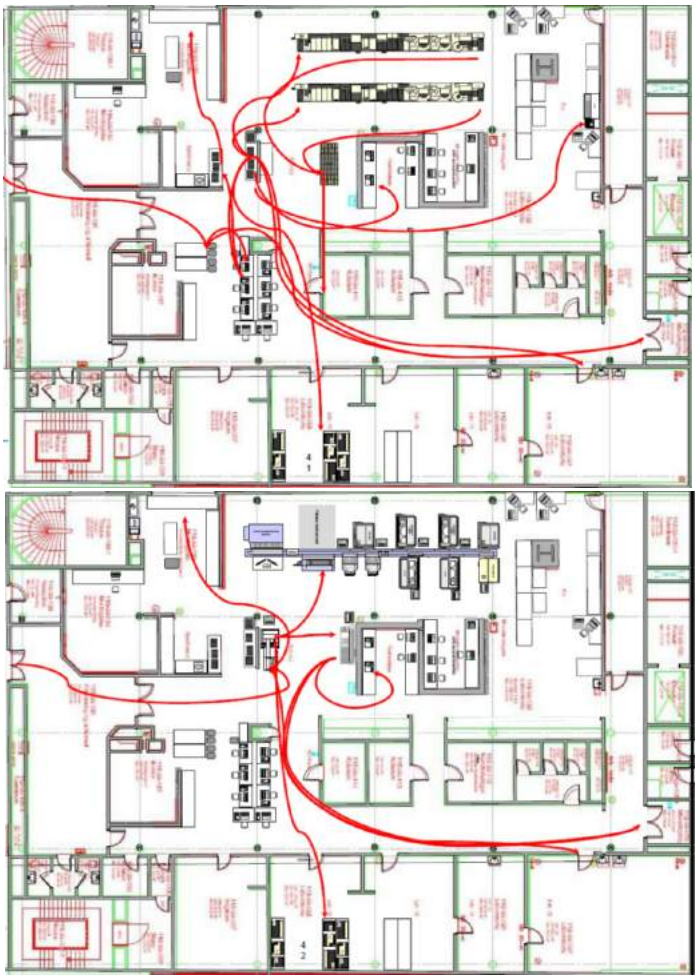

Figure 1: Lab setup and workflow for the 2007 pre-installation (top panel) and 2011 post installation (bottom panel) phases

Device and maintenance costs

The total investment cost for all devices in scope was collected, both for the 2007 pre-installation and the 2011 post-installation phase. Device costs were depreciated over 8 years to calculate the annual device investment cost. Additionally, costs for maintenance contracts for the devices in scope in the 2007 pre-installation and 2011 post-installation phase were collected and added to the yearly device investment cost to calculate a total device cost per year.

Taking into account inflation

For an accurate comparison of 2007 to 2011 costs, the consumables, reagents, device and maintenance costs for 2007 were adjusted to account for the average yearly inflation rates between 2007 and 2011 (Table 1).

Table 1: Average inflation (CPI) for Denmark by year

Year	Average Inflation (CPI)
2007	1.71%
2008	3.40%
2009	1.33%
2010	2.30%

Staff numbers and costs

The number of full time equivalents (FTEs) for the day, evening and night shifts during weekdays and weekends, respectively, both for the 2007 pre-installation and 2011 post-installation phase were collected. The total average wage cost for a lab staff FTE (including taxes, benefits, etc.) was obtained from the OUH administration. Additionally, the percentage time spent by lab management on tasks related to the tests in scope of the present analysis was queried from relevant lab management members, both for the 2007 pre-installation and 2011 post-installation phases. Wages for management staff were provided by the lab administration. To calculate and compare staff wage costs, all wage costs were calculated based on 2011 wages.

TAT and test tube usage data

TATs were calculated from a database provided by the lab containing, for all tests performed in 2007 and 2011, the time the sample was scanned at entry in the lab and the time the final result was presented to the lab information system (LIS). For each test in scope, an average TAT was calculated per test from the individual tests performed in 2007 and 2011.

RESULTS

Figure 1 illustrates the setup and workflow in the OUH CBF lab in the 2007 pre-installation (top panel) and 2011 post-installation (bottom panel) phases.

Costs

The total cost breakdown for consumables and reagents costs, device and maintenance costs and staff costs is summarized in Table 2 and Figure 2. Though the number of tests increased by 26% from 2007 to 2011, the total costs decreased by 36% (from DKK 21,685,211 to DKK 13,825,692). The percentage cost decrease was similar for all cost categories. When taking into account the 26% increase in numbers of tests by calculated an average cost per test, total costs per test were reduced by 49% (Figure 3).

Though test numbers increased by 26%, total lab costs for consumables, reagents, device investments, maintenance and staff costs were reduced by 36% after switching to the Abbott Accelerator Laboratory Automation System.

Consumables and reagents costs

Consumables and reagents costs decreased by 37%, from DKK 11,731,036 in 2007 (after inflation) to DKK 7,381,421 in 2011.

Device and maintenance costs

Total yearly device investment and maintenance costs decreased by 32%, from DKK 2,367,867 in 2007 (after inflation) to DKK 1,607,500 in 2011.

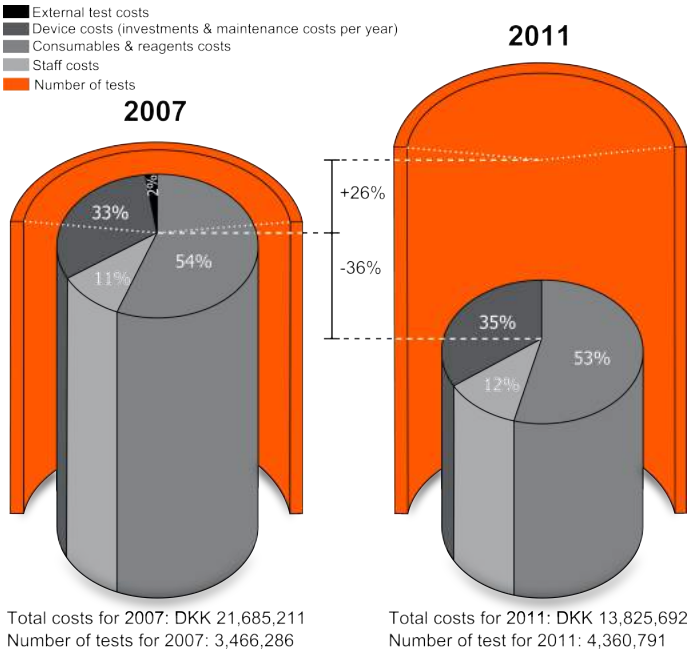

Figure 2: Total costs and number of tests for the 2007 pre-installation (left) and 2011 post-installation (right) phases

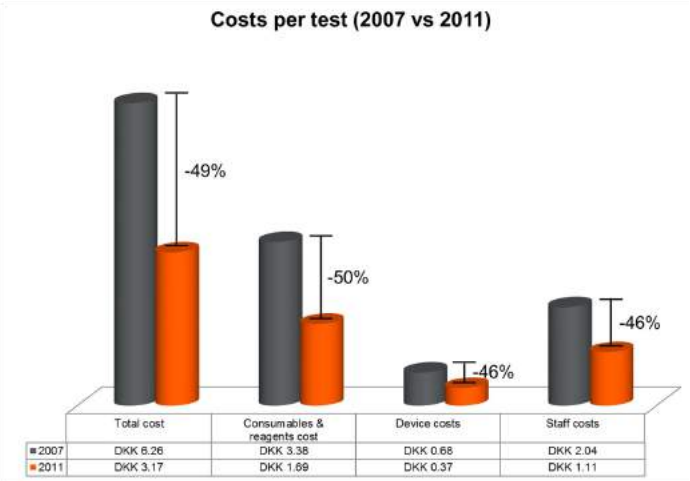

Figure 3: Relative costs (cost per test) for the 2007 pre-installation (grey) and 2011 post-installation (orange) phases

Staff numbers and costs

The decrease in staff costs is primarily the result of the decrease in staff members required for the analytical phase of the lab processes. Table 3 shows the FTEs required during day, evening and night shifts in weekdays and weekend for the 2007 pre-installation and 2011 post-installation phases. Additionally, there was small gain due to reduced time spent by lab management on lab activities (Table 4).

Table 2: Total cost breakdown for the 2007 pre-installation (after inflation) and 2011 post-installation phases

Category	2007 (after inflation)	2011	% difference
Consumables and reagents costs	DKK 11,731,036	DKK 7,381,241	- 37%
Device and maintenance costs	DKK 2,367,867	DKK 1,607,500	- 32%
Staff costs	DKK 7,058,307	DKK 4,836,771	- 31%
External analyses costs	DKK 528,000	-	- 100%
Total	**DKK 21,685,211**	**DKK 13,825,692**	**- 36%**

Table 3: Lab staff (FTE) required for the analytical phase in the 2007 pre-installation and 2011 post-installation phases

Period	2007 FTE	2011 FTE
Weekday – day shift	11.25	6.00
Weekday – evening shift	1.25	1.25
Weekday – night shift	1.25	1.25
Weekend – day shift	1.00	0.50
Weekend – evening shift	0.50	0.50
Weekend – night shift	0.50	0.50
Total (FTE)	**15.75**	**10.00**
Total cost	**DKK 6,444,154**	**DKK 4,091,526**

Table 4: Time spent by management on lab related activities in the 2007 pre-installation and 2011 post-installation phases

Management position	% of total time spent in 2007	% of total time spent in 2011
Doctor 1	25%	40%
Doctor 2	20%	-
Middle management 1	40%	60%
Middle management 2	30%	15%
Total cost	**DKK 770,759**	**DKK 745,245**

The net result of these staff reductions is that total staff costs decreased by 36%, from DKK 6,444,154 in 2007 (after inflation) to DKK 4,091,526 in 2011.

Automating the workflow has reduced the number of staff required for lab analytics from 15.75 to 10 FTE.

TAT and test tube usage

Figure 4 illustrates for each test run continuously in 2011: the TAT in 2007 (grey bars), the difference between the TAT in 2011 and 2007 (TAT in 2011 minus TAT in 2007, orange bars) and the resulting TAT in 2011 (black bars). The black line shows the volume of tests in 2011 for each test. Due to low volumes, 10 tests are run in batches instead of continuously; these tests were excluded from the analysis. Tests for which the orange bar is negative indicate tests for which the TAT was reduced from 2007 to 2011. TAT was reduced in 63% of all tests; the average reduction in TAT for those tests was 18.75h. TATs were only slightly increased in the remaining tests, on average by 0.67h.

To illustrate the net effect of TAT reductions, the total analysis time was calculated for 2007 and 2011 by multiplying for each test the average TAT by the number of tests performed in 2007 and 2011, respectively. Figure 5 illustrates the impact of TAT reductions on this total time spent. The top panel shows that if TATs would not have been reduced from 2007 to 2011, the total time spent would have increased by 46% due to the 26% volume increase in number of tests. Actual time spent in 2011, however, was reduced by 42%. The bottom panel of Figure 5 shows how the time gained due to TAT reductions overcompensates for the time lost due to the increased volume of tests to actually reduce total time spent in 2011 in comparison to 2007.

For 63% of tests run daily, TATs were significantly reduced by installation of the Abbott Accelerator Laboratory Automation System and associated process automation and optimization.

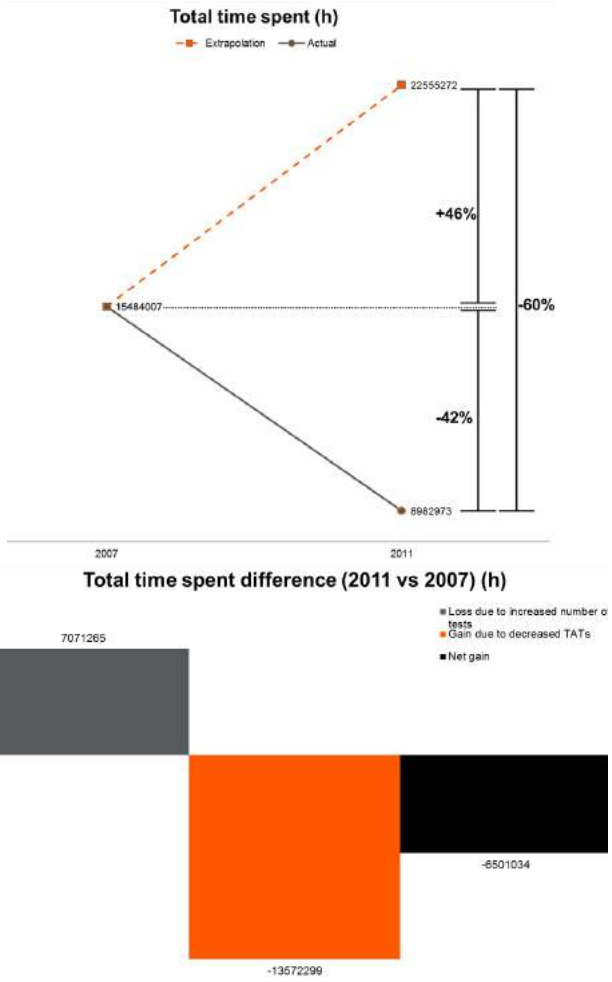

Figure 5: (top) Total time spent in the 2007 pre-installation and 2011 post-installation phases, calculated by multiplying, for each test, the TAT by the volume of tests performed in 2007 and 2011, respectively. The dotted line shows the projected increase in total time spent from 2007 in 2011 if TATs would not have been reduced in 2011 (bottom). The net decrease in total time spent (black bar) is the result of the compensation due to reduced TATs in 2011 (orange bar) of the increase in total time spent due to the volume increase from 2007 to 2011 (grey bar).

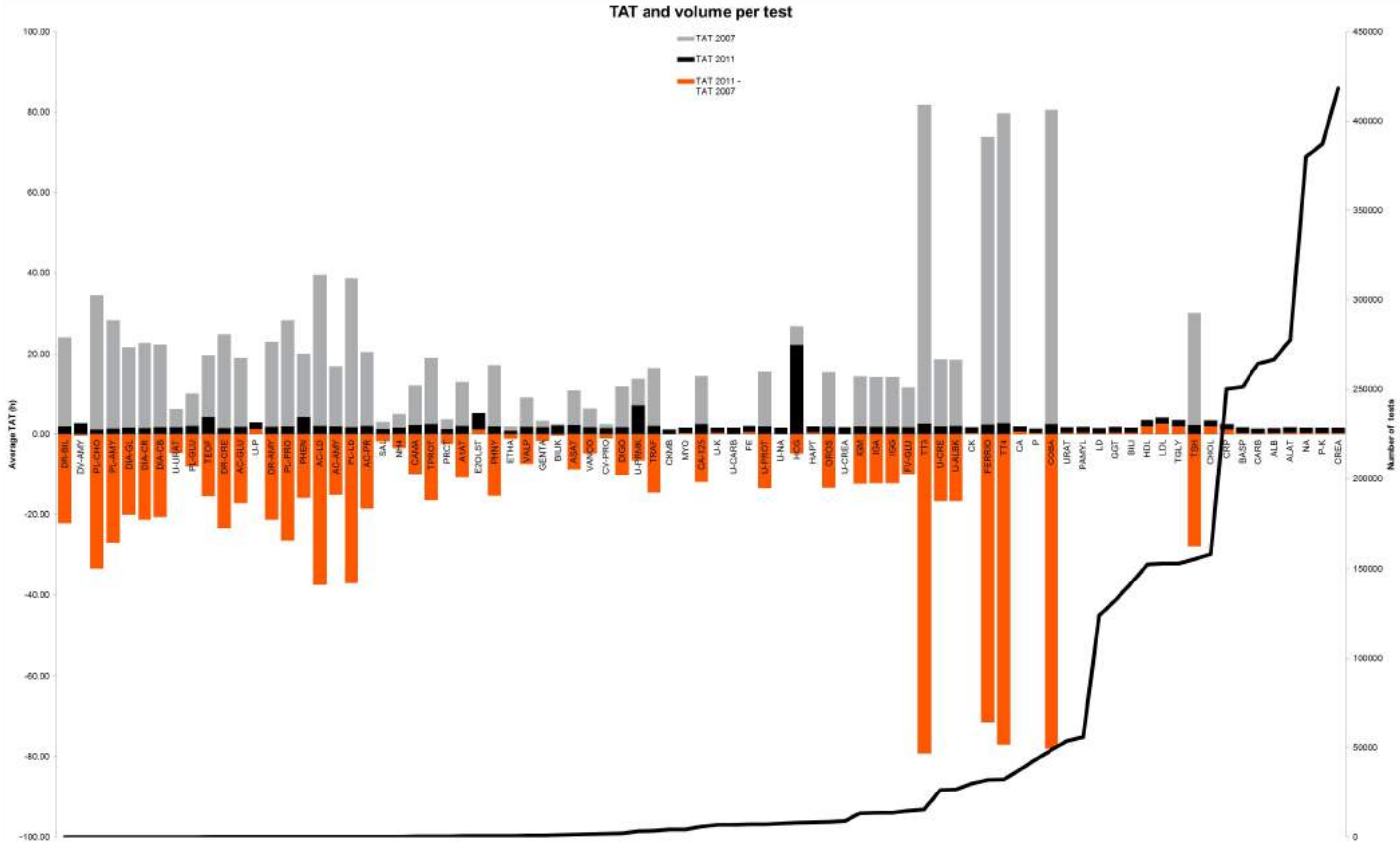

Figure 4: TAT per test for the 2007 pre-installation phase (grey bars), the 2011 post-installation phase (black bars) and the difference between 2011 and 2007 (orange bars). The black line indicates the volume of tests performed in 2011 for each test.

Table 5, finally, shows that test tube usage efficiency increased by 20% from 2007 to 2011: though the amount of tests increases by 26%, the number of tubes used to perform these tests only increased by 5%.

Table 5: Number of tubes and average number of tests per tube for the 2007 pre-installation and 2011 post-installation phases

Year	Number of tubes	Test per tube
2007	525000	6.6
2011	550000	8.0

DISCUSSION

"Abbott delivered on what was promised for productivity gains".

The main motivators for the OUH CBF lab for switching to the Abbott Accelerator Laboratory Automation system with its automated processes were, according to the lab, a drive for increased cost-efficiency and the technical abilities to accommodate the expected growth in test numbers for the coming years.

According to lab management, Abbott delivered on what was promised for productivity gains. The FTEs which were made available due to the reduced levels of staff required to operate the analytical phase after implementation of the Abbott Accelerator Laboratory Automation system and associated process automation and optimisation allowed the lab to accommodate a 26% growth over 4 years' time without increasing lab staff levels and with similar workloads for management. In the lab's opinion, this sustained growth without increasing resources would not have been possible without switching to the Abbott Accelerator Laboratory Automation system.

The reduction in FTEs for the analytical phase due to automation and optimisation has permitted the lab to accommodate the 26% growth between 2007 and 2011 without increasing total staff levels.

Cost-efficiency has increased as well. As the results of the present analyses show, even without adjusting cost figures for growth significant cost reductions were achieved across the board with considerable savings for consumables, reagents and device investment and maintenance costs as compared to the 2007 pre-installation phase.

An important additional benefit from the switch to Abbott Architect is that consumables and reagents are now charged per result, whereas in the pre-installation phase, consumables and reagents were charged per unit used. The use of an integrated cost per result makes consumables and reagents costs easier to manage and plan and is perceived as a major advantage in daily lab management.

Overall, the switch to the Abbott Accelerator Laboratory Automation system and its automated processes has yielded important gains in TAT reductions. It should be noted that for the present analyses, TATs are calculated from the time samples are scanned at entry in the lab up to the time results are presented to the LIS. This means that part of the pre-analytical phase is included in these TATs. Restricting TAT measurements to the analytical phase only could show increased benefits of the Abbott solution compared to the pre-installation phase. Nevertheless, according to lab staff, the overall reduction in TAT has shifted the main bottleneck for further TAT improvements from the analytical to pre-analytical phase for most tests. The impact of the reduced TATs on hospital operations is as of yet still limited. The increased speed at which results can now be delivered is not yet widely known in the hospital and should actively be advertised. As awareness and trust in reduced TATs increases, hospital workflows could be adapted to take advantage of the quicker return of results, potentially yielding cost or efficiency gains outside of the limits of the lab setting.

With the reductions in TAT as a result of the introduction of the Abbott Accelerator Laboratory Automation System with automation and optimisation, the main bottleneck for growth has shifted from the analytical to the pre-analytical phase for most lab tests.

Costs of waste were not specifically included in the present analysis. The 20% test tube usage increase, however, clearly indicates the potential benefit of the Abbott solution, allowing for more tests to be done on a single blood tube. Another important benefit for waste handling is that the Abbott solution does not require aliquots, significantly reducing plastic waste in the test processing. Moreover, the automated storage and waste disposal of blood tubes, frees valuable human resources from the menial task of following up and disposing of expired blood tubes and searching for tubes which require additional tests after the initial test run.

CONCLUSIONS

The results of the OUH CBF case study demonstrate the cost-efficiency of switching to the Abbott Accelerator Laboratory Automation system with associated process automation and optimisation, for costs as well as efficient staff use and overall TAT decrease. Future research should focus on quantifying the process improvements leading to staff reductions, capturing the added value of cost-efficiency improvement for overhead costs, most notably waste and attempt to measure the potential impact of TAT reductions on lab customer workflow and associated gains.

Disclaimer
Data collection, processing and manuscript preparation were independently performed by **hict**. Project funding was provided by Abbott. All inputs, analyses and results were validated by the OUH KBF lab.

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