A Universal Approach for Full Microbiology Lab Automation: metrics, evidence, and future vision

M. Lucchini, Senior Scientific Affairs Specialist

Copan WASP, via Achille Grandi, 32, 25125 Brescia (BS). *matteo.lucchini@copangroup.com*

SUMMARY

Over the past several years, clinical microbiology laboratories have faced increasing operational pressure, a trend that emerged during the COVID-19 pandemic and has persisted thereafter. This pressure is largely driven by a combination of **rising testing demand linked to the ageing population in Western countries, growing awareness of infectious diseases, global increase in antimicrobial resistance (AMR), and significant workforce shortages**. The latter has become a major structural challenge, as fewer professionals are entering laboratory and other manual-intensive healthcare roles, while the labour market increasingly shifts toward specialized and technology-driven positions. These constraints have been further highlighted by recent healthcare workforce crises, including large-scale nurse and healthcare worker strikes in the United Kingdom, which exposed the fragility of current staffing models.

Several long-term solutions have been proposed, such as increased funding or structural reorganization; however, Western healthcare systems often face economic constraints and political barriers that limit rapid implementation. In this context, **laboratory automation remains one of the most effective and immediately applicable strategies to mitigate manual workload, manage increasing sample volumes, and enhance standardization of microbiological processes**.

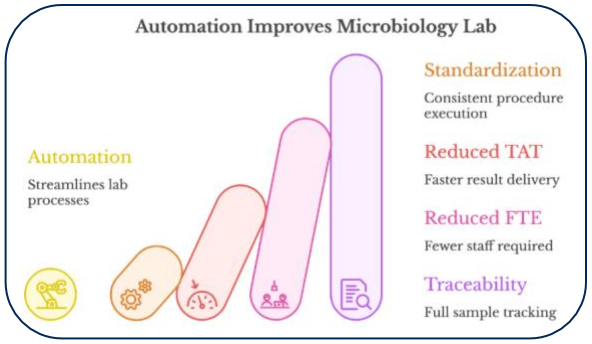

Figure 1: Major benefits of full automation in the microbiology laboratory

Full automation in the microbiology laboratory, defined as the integration of automated processes from sample reception to post-analytic result reporting, has now emerged as a key strategic driver for modern diagnostic workflows. Its primary benefits include improved **standardization of procedures** (historically challenging in microbiology due to heterogeneous sample types, analytes, and volumes), **reduction of turn-around time** (TAT) and **full-time equivalents** (FTE), and **complete traceability** from sample check-in to final result delivery, eliminating manual paperwork and minimizing the risk of errors.

This review examines the **principles of full microbiology laboratory automation (FLA)**, identifies **key metrics** for evaluating automated workflows, analyzes **selected studies** on the implementation of automation in clinical microbiology, and outlines **future developments**.

Principles of full microbiology laboratory automation

Full microbiology automation embodies the concept of end-to-end workflow automation, in which manual procedures are minimized to the lowest possible level. Copan has translated this concept through a modular architecture that physically connects distinct automated systems: from the **automated plate streaker (WASP®) to the incubator–imager platform (WASPLab®), to the automated colony picker (Colibrí™) and AST module (Radian® In-Line Carousel and Radian Expert System®), all supported by an AI-driven decision-support software suite (PhenoMATRIX®).**

Figure 2: Copan Full Microbiology Laboratory ecosystem

This architecture has its roots in a critical milestone achieved years earlier: the standardization of the pre-analytical phase through the development of flocked swabs and, in particular, their elution into liquid transport media, a concept known as **Liquid-Based Microbiology (LBM®)**. This has been the starting point for every mechanical development. Together, these components define Copan's paradigm for full microbiology automation: **a process that is continuous, fully traceable, and reproducible**. In this model, human intervention shifts from manual, repetitive manual tasks to high-skilled supervision and decision-making.

What to measure to determine whether FLA is impactful

Assessing the impact of Full Microbiology Laboratory Automation (FLA) requires measuring relevant operational parameters before and after automation, ideally using comparable time intervals to control for seasonal variability in specimen volume and workload. According to Culbreath et al. (2021), the most commonly evaluated metrics include:

- **FTE number** (Full-time equivalent number): It represents an employee's workload relative to a full-time schedule. For example, 1.0 FTE is equivalent to the workload of one full-time worker, e.g., 8 hours per day, while 0.5 FTE equals 4 hours per day.
- **Productivity**: is the volume of cultures processed or the volume of cultures worked up/number FTE required on peak day to complete the work.
- **TAT** (Turn-around time): is the elapsed time between a clearly defined starting point and the moment a result is sent to the clinician. Given that microbiology workflows are complex, the starting point must be pre-defined. Common starting points are

specimen collection time, specimen receipt, or specimen registration (check-in).

- **HOT** (hands-on time): is the amount of human labour time required to perform a task, during which the operator must be engaged. Examples of HOT in the microbiology laboratory include the time required for sample streaking, sample reading, or performing workup (e.g., ID and/or AST) for a batch of plates.

Additional complementary metrics, some derived from the parameters above, include:

- **Labour cost per specimen**: total daily labour cost/total number of culture specimens processed on peak day.
- **Total productivity percentage**: (post-FLA productivity – pre-FLA productivity)/pre-FLA productivity.
- **FTE needed without FLA**: theoretical FTE needed to complete the work if FLA was not in place.
- **FTE savings**: FTE needed without FLA – Pre-FLA FTE.
- **Direct savings FLA**: Pre-FLA FTE – Post-FLA FTE.

These metrics, together with those related to workforce and consumable costs, capital investment, and amortization, provide a comprehensive framework for quantifying the operational and economic impact of FLA.

SCIENTIFIC EVIDENCE

The following chapter presents a selection of s**cientific studies evaluating the impact of Full Microbiology Laboratory Automation (FLA)** using the WASPLab® ecosystem and, in one case, the PhenoMATRIX® software. These studies assess the performance by measuring turnaround time (TAT), standardization, and other common operational metrics.

Benefits Derived from Full Laboratory Automation in Microbiology: a Tale of Four Laboratories

K. Culbreath, H. Piwonka, J. Korver, M. Noorbakhsh

Scope and study setup

This multicenter study quantifies the operational and economic benefits of FLA by measuring the **impacts of Copan automation on workforce (FTE) and efficiency (TAT)**.

The study included four microbiology laboratories in North America, differing in size, patient mix, acuity, and geography: Willis-Knighton Laboratory (WKL), TriCore Reference Laboratories (TC), Hamilton Regional Medicine Laboratory Program (HRMLP), and Sutter Health Shared Laboratory (SHSL).

Data were collected 6 months to 1-year pre-FLA and again post-FLA, using identical metrics in both periods. The analysis focused on specimens and workflows handled by automation, excluding blood cultures, by including sample processing (e.g. streaking, reading) and culture work-up (e.g. rapid test, ID, and AST).

Instrument configuration by site

- **WKL**: 2 WASP®, 1 WASPLab® with three incubators.
- **TC**: 1 WASP®, 1 WASPLab® with two incubators. AI algorithm on urine specimens.
- **HRMLP**: 2 WASP®, 1 WASPLab® with three incubators. AI algorithms on urine, MRSA, VRE and MRSA/VRE biplate.
- **SHSL**: 3 WASP®, 2 WASPLab® with three incubators each. AI algorithms on urine and

MRSA. Pre-FLA measurements include the use of two stand-alone WASP® instruments.

Main results and operational metrics

Key results across sites included:

Productivity increase: combined gains ranged from 18% to 93% across sites.

FTE savings and cost avoidance ($/year):

- **WKL**: total savings 5.6 FTE, around 322,000.
- **TC**: total savings 3.9 FTE, around 268,000.
- **HRMLP**: total savings 13.6 FTE, around 1,19 million.
- **SHSL**: 7.4 FTE saved despite adding staff, around 663,000.

Reduction in labour cost per specimen ($):

- **WKL**: from 5,75 to 3,03 (-47%).
- **TC**: from 3,86 to 3,19 (-17%).
- **HRMLP**: from 5,50 to 3,41 (-38%).
- **SHSL**: from 7,19 to 6,09 (-15%).

TAT improvements:

- **WKL**: urine culture average TAT was reduced from 30,8 h to 23,0 h (-7,8 h).
- **TC**: median TAT decreased stepwise from 35 h (no automation) to 31 h (WASP®), 29 h (WASP® and WASPLab®), and 21 h (with PhenoMATRIX®), a decrease of -14 h with a growth in sample volume of around 24%. The majority of TAT improvement is attributable to FLA adoption, while only 7% of TAT improvement could be directly linked with extended culture reading hours.

Conclusions

The study concludes that **FLA using Copan's WASPLab® ecosystem provides substantial, scalable benefits across different laboratory types by optimizing workforce**, improving productivity and TAT, and reducing costs. FLA can help laboratories "do more with less," that is, deliver standardized results while facing constraints such as increasing sample volumes and workforce shortages.

Impact of Total Laboratory Automation on Turnaround Times for Urine Cultures and Screening Specimens for MRSA, ESBL, and VRE Carriage: Retrospective Comparison with Manual Workflow

A. Cherkaoui, G. Renzi, R. Martischang, S. Harbarth, N. Vuilleumier and J. Schrenzel

Scope and study setup

This study from the University of Geneva **compared TAT for urine samples and screening ESwabs for MRSA, VRE, and ESBL between 1 year pre-FLA** (January-December 2017) **and post-FLA** (January-December 2019). The dataset included more than 98000 specimens (48000 in 2017 and 50000 in 2019). The laboratory moved for a manual setup to the adoption of WASP® and WASPLab®.

Main results and operational metrics

Post-FLA period highlighted a substantial TAT reduction for *negative samples* across all specimen types:

- **Urine**: from 52,1 h to 28,3 h (-46%, $p < 0.001$)
- **MRSA screening**: from 50,7 h to 26,3 (-48%, $p < 0.001$)
- **ESBL screening**: from 50,2 h to 43,0 h (-14%, $p < 0.001$)
- **VRE screening**: from 50,6 h to 45,7 h (-10%, $p < 0.001$)

This effect is due to earlier plate imaging and the ability to sort negative plates without waiting for the next reading cycle.

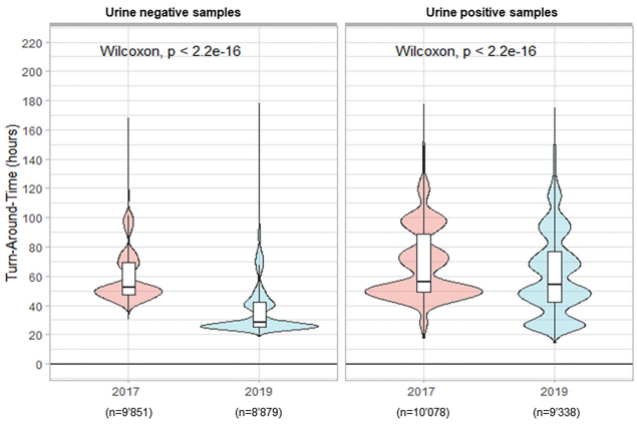

Figure 3: Turn-Around Times (from reception of samples to delivery of the culture results) for urine analysis. (Cherkaoui et al. 2020)

For a positive culture, TAT reduction is limited or not statistically significant. The authors attribute this to unchanged laboratory working hours and workload organization.

Conclusions

The authors stated **that FLA contributes to a significant reduction in TAT for negative samples, whereas for positive samples, the reduction largely depends on automation adoption and laboratory reorganization.**

Laboratory Automation in Microbiology: Impact on Turnaround Time of Microbiological Samples in COVID Time

C. Fontana, M. Favaro, M. Pelliccioni, S. Minelli, M.C. Bossa, A. Altieri, C. D'Orazi, F. Paliotta, O. Cicchetti, M. Minieri, C. Prezioso, D. Limongi and Cartesio D'agostini

Scope and study setup

The last study evaluates the **impact of FLA (WASP®, WASPLab®) on TAT** at Policlinico Tor Vergata in Rome during the COVID-19 pandemic. The laboratory moved from a 12-hour shift to a 24/7 service during the pandemic, even without sufficient staffing for blood culture monitoring during night shifts. Different from the other studies previously taken into consideration, TAT was measured for blood cultures (BC) and biological fluids (BF). Three periods have been considered: pre-automation (2019), installation phase (2020), and full automation (2021).

Main results

The use of automation brought substantial improvement in TAT reduction:

- **BC**: TAT decreased from 97 h (2019) to 53,5 (2021), (- 43,5 h without staff changes, p < 0.03).
- **BF**: TAT decreased from 73 h (2019) to 58 h (2021), (- 20 h without staff changes, p < 0.008).

The study highlights the added value of digital imaging, which helped earlier recognition of target colonies and speculates possible further improvement by the implementation of PhenoMATRIX® software.

Conclusions

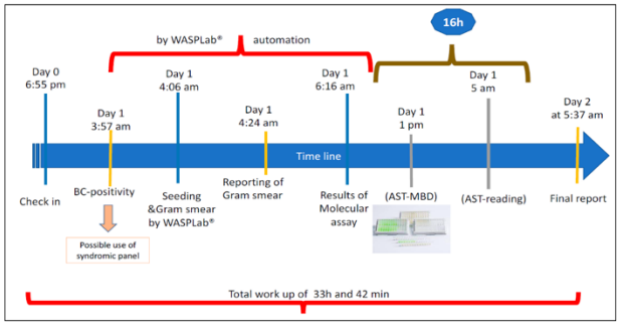

Figure 4 Workflow on blood culture during night shift (Fontana et al. 2023)

The study shows that **WASPLab® significantly improved reporting times for BC and BF**, even under the workload pressure of COVID-19.

ENVISIONING THE FUTURE

The progressive adoption of FLA is laying the foundation for a fully digital, data-driven diagnostic ecosystem.

Copan is strategically positioned to lead this transformation. More than a decade ago, the company pioneered the integration of machine learning within microbiology, combining high-quality sample collection (LBM) with information derived from plate digital imaging, LIS data, and laboratory decisional trees.

Copan's commitment to innovation continues to advance the field. Disk diffusion, for example, is evolving toward increasingly sophisticated levels of interpretation supported by artificial intelligence.

Looking ahead, Copan's AI is expected to move beyond a plate-centered perspective and adopt a holistic approach that integrates heterogeneous data to support infection risk assessment and diagnostic decisions.

AI of the future will evolve from a supportive tool into the coordinating "brain" of full automation, guiding analytical workflows. This shift signifies a structural change in diagnostic practice and reflects the principle of "*creative destruction*," introduced by economist Joseph Schumpeter in 1942, which describes **how innovative technologies replace outdated methods and reshape entire systems**.

Copan Wasp S.r.l.
c/o Libera Technology Park
Via Achille Grandi, 32
25125 Brescia

t | +39 030 2687218
@ | info@copangroup.com
www.copangroup.com