Meeting the needs of Mediterranean nations: improving health with emerging technologies

The Journal of the International Federation of Clinical Chemistry and Laboratory Medicine

eJIFCC

New solutions for the sample transport and results delivery: a digital lab

Damien Gruson[1,2]

[1] *Department of Laboratory Medicine, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium*

[2] *Pôle de recherche en Endocrinologie, Diabète et Nutrition, Institut de Recherche Expérimentale et Clinique, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium*

ARTICLE INFO

Corresponding author:
Damien Gruson
Service de Biochimie Médicale
Cliniques Universitaires Saint-Luc
Tour Rosalind Franklin
10F Avenue Emmanuel Mounier
B-1200 Brussels
Belgium
Phone: +32-(0)2-7646747
Fax: +32-(0)2-7646930
E-mail: damien.gruson@uclouvain.be

Key words:
big data, automation, machine learning, augmented reality, blockchain, drones, robots, user experience

ABSTRACT

The consolidation of laboratories, the evolution to integrated care network as well as an environment of consumerization are disrupting laboratory services and operations. The switch to SMART (Speed Metrics Automation Remote Technologies) digital laboratories based health ecosystems depends on several prerequisites for successes. Intelligent processes, integration of big data and real-time data management, automation, blockchain, Internet of things and enhancement of user experiences are key element of the smart digital laboratory. Safety, security and cost-effectiveness are pillars for the credibility and transferability of such smart digital laboratory environment. This transforming ecosystem will also trigger novel human – machine interfaces and we will be the gatekeepers for this new "click to brick" ecosystem.

INTRODUCTION: TRANSPORTATION AND DELIVERY

At first sight, we could limit our discussion to "classical" pathways of laboratory transportation of samples and delivery of results to physicians.

Focusing on this perimeter, we can already observe that our laboratory environment is changing and consolidating (1,2). Laboratories and hospitals are operating as networks with some consolidated hubs for specialty testing. The complexity of these networks are increasing as well as the need to meet the accreditation requirements, leveraging the need for real-time monitoring, traceability, safety, temperature control and economy of scale (1-3). These networks and large size consolidated core-laboratories have triggered the evolution of transportation, supply chain management and current progresses are impacting the intra-laboratory / intra-hospital logistics but also the inter-laboratory / inter-hospital logistics (1,4). Emerging technologies offer clear gains for temperature control and monitoring, holistic supply chain management, inventory management, sample tracking, standardized connectivity between laboratory information systems, and for a broader control of whole healthcare facilities through the latest generations of electronic medical records (1,5). Innovations make processes more fluids and operations more cost effective, meeting the constraints coming from health care systems under stronger economical pressure.

However, broadening the vision led us to consider that our whole ecosystem is transforming. We are living in smart, inclusive and connected cities where the paradigms of mobility, motility and logistics are transforming (12). We are also citizens of an "accelerated world" where our relation to ordering and transport is influence by "uberization" of goods and services and wishes of "consumerization". Finally, we are actors of the ongoing digitalization wave and users of applications aimed to facilitate services, empowerment, tracking and monitoring. The efficiency of our transforming SMART (Speed Metrics Automation Remote Technologies) based health ecosystems will depend on several prerequisites for successes.

THE PREREQUISITES OF SUCCESS FOR A SMART DIGITAL LABORATORY

The processes and logistics will be integrated, intelligent and scalable

The effects of consumerization, competition and the switch to care pathways trigger real time reporting, integrated workflows, speed and cost-effectiveness (1,5). Solutions will need to take a greater control over the supply chain, to ensure fast and smooth processes, to guarantee quality and ISO requirements. Intelligent systems will analyze and sense demands, measure performances, monitor the status of systems and will respond in real-time to manage capacities, predict needs and avoid disruption and complains. An example of transformation could be the evolution from temperature maintenance to intelligent cold chain management.

The efficient use of big data will improve operations

Our new ecosystems are driven by data and our new healthcare systems are made of opportunities to harness new forms of data to improve practices (6-9). The use of big data to capture and analyze, to streamline the operations and optimize the supply chain will add tremendous value to laboratory logistics and services. The application of algorithms and machine learning to crunch data, unlocking insights and opportunities as never imagine before. The perspectives include a data based automation to optimize the use of resources, reduce waste and facilitate lean operation, an effective real time management, a comprehensive data base inventory and supply

chain management, the analysis of data to control carbon footprints and contribute to a greener environment and the use of machine learning to build actionable and intelligent network and services (6-9). The benefits of machine learning have already been demonstrated in electronic health records, omics and mobile data and wearables. The efficient use of data and data flows is essential to face our transforming biotope and provide a dynamic response to disruption.

Relying on automation and blockchain to improve security and safety

The recent reformation of the Global Data Protection Regulation bring to light for a safe and secure use and management of data, and this is clearly sensitive when considering healthcare data. Automation will continue to secure processes and reduce the rate of errors (6-9). The use of cognitive technologies will prevent mistakes and increase safety (13,14). Inventories, real-time supply chain management, transfer of results to caregivers will be stronger and more secure. Blockchain represent a way to improve the security and safety of data monitoring, sample transfer and results communication (16,17). Blockchain technologies have already demonstrated their benefits in the also sensitive field of economics and cryptocurrencies. Blockchain technologies are offering a decentralized network maintained by users and allowing the development of a stable and secure data set with which users can interact through transactions of various types. The opportunities offered by blockchain technologies to the clinical laboratory and biobanking fields seem therefore evident.

The use of tags and the internet of things to enhance operations

Intelligent, integrated and reactive systems require the capture of data. The applications of RFID and internet of things (IoT) allow this capture of data. Perspectives include connected and autonomous transportation solutions, accurate tracking and real time management of the supply chain and services. The science of cloud computing will be the glue to collect, transfer and agglomerate the data generated by all the smart sensors and IoT.

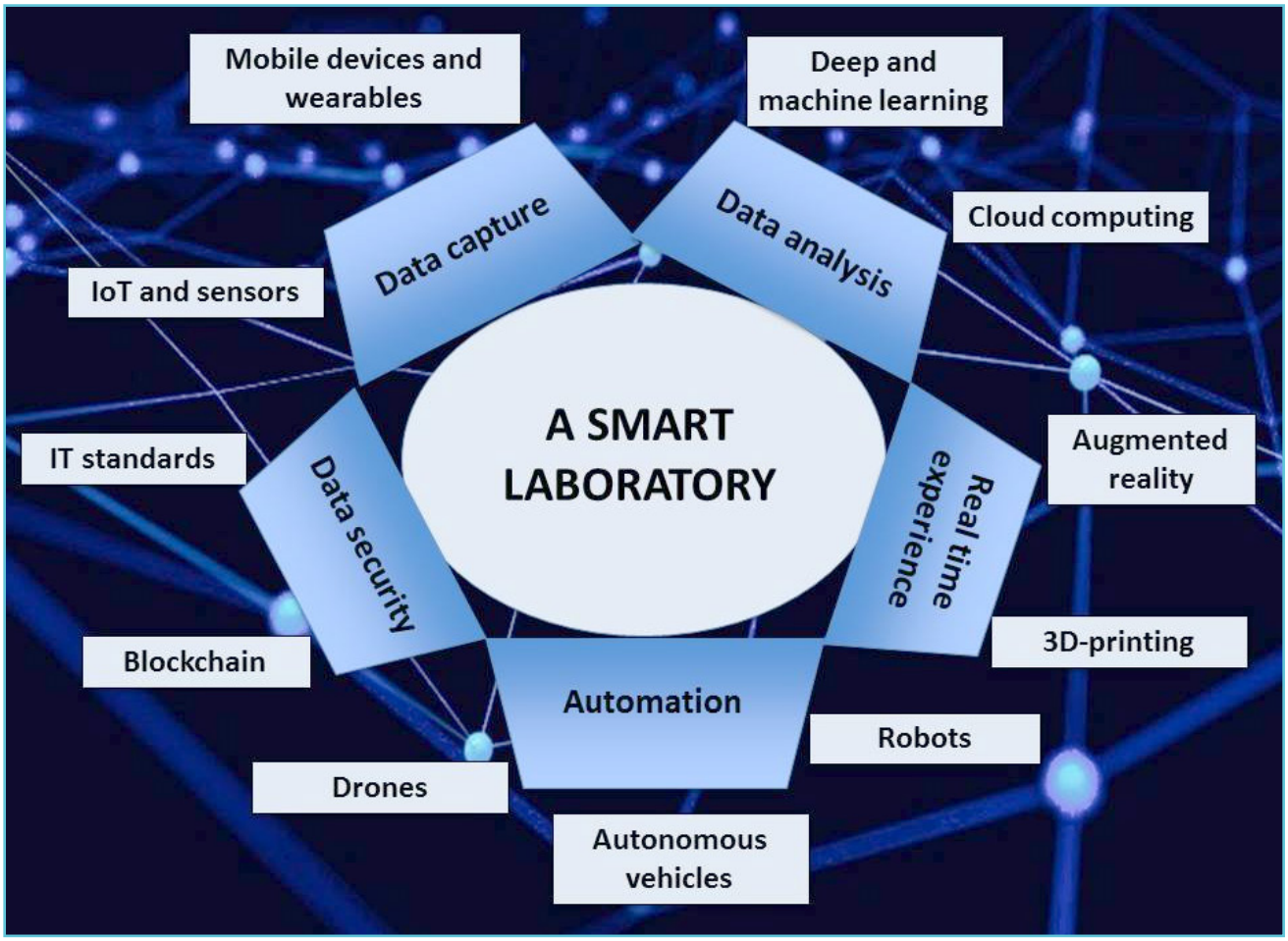
Emerging technologies to unlock new possibilities

Emerging technologies are helping us to transform the way (10,11). Even if the validation and harmonization of pneumatic tube systems remains a subject of discussion, this solution remains the preferred choice for hospital. Innovative pneumatic systems are carrier free, faster and could offer more options for mega-laboratories. The use of robots and drones are also tested in hospital and laboratory networks for human samples transportation and transfer. Like cars, these new transportation solutions are becoming more and more autonomous. Transportation is also a field where sharing vehicles and means is current practices and where public – private partnerships for a greener and cost-efficient ecosystem could stimulate.

Co-creation and user experience

Meeting the satisfaction and priorities of users is key and the evolution of the user experience is fundamental (15). Meeting the user's expectations means more personalized, faster and timeless services. The transcription of direct field observations to user-centered experiences is also an opportunity to improve patient safety. Our digital environment and hyper-connectivity reinforce the quest for more user centric experiences. Therefore the use of agile and users experiences methodologies will offer the possibility to re-design and co-create with the users themselves more users-centric solutions. The progresses of augmented reality will provide more option to sense the future experience and discover the benefits of future solutions, products

Figure 1 The prerequisites for a smart laboratory (IoT, internet of things)



or services. Augmented reality, defined as the expansion of physical reality by adding layers of computer generated information to the real environment, allow now to have the information at the right time at the right place and offer mixed reality simulations for exploring the virtual and the real.

CONCLUSIONS

The transforming ecosystem, the era of digitalization and the needs to improve efficiency and users experiences are disrupting laboratory services and operations. Such major ongoing changes allow us to implement emerging technologies into practices, develop integrated and intelligent solutions, streamline and standardize structures and processes, and provide more personalized and real-time experiences. The transformation will also offer us the digitalization and integration of vertical and horizontal value chains through cloud computing, mobile devices and IoT platforms. Safety, security and cost-effectiveness are pillars for the credibility and transferability of such smart digital laboratory environment. The future will also trigger novel human – machine interfaces and we will be the gatekeepers for this new “click to brick” ecosystem.

REFERENCES

1. Jonas Vollanda Andreas Fügenerb Jan Schoenfeldera Jens O.Brunnera. Material logistics in hospitals: A literature review. Omega Volume 69, June 2017, Pages 82-101 https://doi.org/10.1016/j.omega.2016.08.004

2. Nybo M, Lund ME, Titlestad K, Maegaard CU. Blood Sample Transportation by Pneumatic Transportation Systems: A Systematic Literature Review. Clin Chem. 2018 May;64(5):782-790. doi: 10.1373/clinchem.2017.280479.

3. Lippi G, Banfi G, Church S, Cornes M, De Carli G, Grankvist K, Kristensen GB, Ibarz M, Panteghini M, Plebani M, Nybo M, Smellie S, Zaninotto M, Simundic AM; European Federation for Clinical Chemistry and Laboratory Medicine Working Group for Preanalytical Phase. Preanalytical quality improvement. In pursuit of harmony, on behalf of European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working group for Preanalytical Phase (WG-PRE). Clin Chem Lab Med. 2015 Feb;53(3):357-70. doi: 10.1515/cclm-2014-1051.

4. Lippi G, Lima-Oliveira G, Nazer SC, Moreira ML, Souza RF, Salvagno GL, Montagnana M, Scartezini M, Picheth G, Guidi GC. Suitability of a transport box for blood sample shipment over a long period. Clin Biochem. 2011 Aug;44(12):1028-9. doi: 10.1016/j.clinbiochem.2011.05.028.

5. Zini A. Robots expand delivery options with seamless integration. A growing number of forward-thinking hospitals in search of greater efficiencies are embracing automated delivery robots. Health Manag Technol. 2011 Mar;32(3):10-2..

6. Matías JM, Taboada J, Ordóñez C, Nieto PG. Machine learning techniques applied to the determination of road suitability for the transportation of dangerous substances. J Hazard Mater. 2007 Aug 17;147(1-2):60-6.

7. Pashazadeh A, Jafari Navimipour N. Big data handling mechanisms in the healthcare applications: A comprehensive and systematic literature review. J Biomed Inform. 2018 Apr 12. pii: S1532-0464(18)30056-X. doi: 10.1016/j.jbi.2018.03.014.

8. Gibbons C, Greaves F. Lending a hand: could machine learning help hospital staff make better use of patient feedback? BMJ Qual Saf. 2018 Feb;27(2):93-95. doi: 10.1136/bmjqs-2017-007151.

9. Beam AL, Kohane IS. Big Data and Machine Learning in Health Care. JAMA. 2018 Apr 3;319(13):1317-1318. doi: 10.1001/jama.2017.18391..

10. Piva E, Tosato F, Plebani M. Pre-analytical phase: The automated ProTube device supports quality assurance in the phlebotomy process. Clin Chim Acta. 2015 Dec 7;451(Pt B):287-91. doi: 10.1016/j.cca.2015.10.010.

11. Lippi G, Plebani M. Laboratory applications for smartphones: risk or opportunity? Clin Biochem. 2011 Mar;44(4):273-4. doi: 10.1016/j.clinbiochem.2010.12.016.

12. Alvear O, Calafate CT, Cano JC, Manzoni P. Crowdsensing in Smart Cities: Overview, Platforms, and Environment Sensing Issues. Sensors (Basel). 2018 Feb 4;18(2). pii: E460. doi: 10.3390/s18020460. Review.

13. Cerruela García G, Luque Ruiz I, Gómez-Nieto MÁ. State of the Art, Trends and Future of Bluetooth Low Energy, Near Field Communication and Visible Light Communication in the Development of Smart Cities. Sensors (Basel). 2016 Nov 23;16(11). pii: E1968.

14. Cresswell KM, Mozaffar H, Lee L, Williams R, Sheikh A. Safety risks associated with the lack of integration and interfacing of hospital health information technologies: a qualitative study of hospital electronic prescribing systems in England. BMJ Qual Saf. 2017 Jul;26(7):530-541. doi: 10.1136/bmjqs-2015-004925.

15. Allyse MA, Robinson DH, Ferber MJ, Sharp RR. Direct-to-Consumer Testing 2.0: Emerging Models of Direct-to-Consumer Genetic Testing. Mayo Clin Proc. 2018 Jan;93(1):113-120. doi: 10.1016/j.mayocp.2017.11.001.

16. Yli-Huumo J, Ko D, Choi S, Park S, Smolander K. Where Is Current Research on Blockchain Technology?-A Systematic Review. PLoS One. 2016 Oct 3;11(10):e0163477. doi: 10.1371/journal.pone.0163477. eCollection 2016.

17. Roman-Belmonte JM, De la Corte-Rodriguez H, Rodriguez-Merchan EC. How blockchain technology can change medicine. Postgrad Med. 2018 May 10:1-8. doi: 10.1080/00325481.2018.1472996.