WhitePaper

Molecular Information Management Systems (MIMS):

Pathologists are Using MIMS To Revolutionize Personalized and Predictive Medicine

Author: Mark Terry

Editors: Lisa-Jean Clifford, Brian Keefe

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Introduction

As molecular technology and personalized medicine increasingly becomes the default position for clinical diagnostics laboratories, these modalities place significant demands on laboratory information systems. Although hospitals and healthcare institutions often focus on an enterprise-wide electronic medical records system that includes a laboratory information system (LIS), those LIS's do not typically have the functionality needed to handle current molecular testing needs, let alone those expected in the near future.

"...As personalized medicine becomes 'standard medicine,' diagnostic laboratories and clinical pathologists will be the control point of that extensive clinical data."

And it's important that they do. Not only are clinical diagnostic laboratories revenue drivers for healthcare institutions, but as personalized medicine becomes "standard medicine," diagnostic laboratories and clinical pathologists will be the control point of that extensive clinical data. These same lab testing technologies increasingly position the pathologist or geneticist to offer guidance to physicians about the most appropriate therapies for their patients.

Pathology's forward thinkers define molecular diagnostics and genetic testing as both the future of pathology and the number one opportunity to add clinical value while earning appropriate reimbursement.

But for pathologists to realize this potential and convert it into reality, they must have the right tools in place, including the ability to collect, store, retrieve, analyze, and report the data from molecular assays and genetic tests. That is where MIMS comes in… and one example is NucleoLIS, a MIMS developed by Psyche Systems, Milford, MA.

This special White Paper is your key to unlocking the potential of molecular diagnostics to the benefit of your laboratory, and the contribution you make to patient care. In the pages that follow, you'll be provided with:

- An overview of the current state of the MIMS industry
- What a MIMS is and What a MIMS is not
- What a Pathology Lab needs to do to acquire and use a MIMS to advance patient care and increase revenue
- Smart ways to purchase MIMS and get the best ROI
- How to evaluate key factors for calculating ROI on MIMS.

Chapter 1:

Molecular Pathology's Increasing Role in Personalized and Predictive Medicine and How It Creates Opportunities for Pathology Groups

"The typical laboratory information system is not well-designed to handle the wealth and complexity of information created by molecular tests and personalized medicine."

Molecular pathology currently plays a substantial role in clinical diagnostics and in the nascent personalized medicine arena. An October 2014 market research report[1] published by Markets and Markets, stated that the molecular diagnostic laboratory segment was expected to grow at the highest CAGR from 2014 to 2019 "owing to the increasing acceptance of personalized medicine amongst patients, which in turn increases the usage of molecular diagnostic and genetic testing in the coming years. Furthermore, molecular diagnostic laboratories are moving from paper-based systems to laboratory information systems to handle the increasing volume of molecular tests; thus driving the growth of the market."

This increasing use of molecular testing techniques as the world moves steadily into personalized medicine, creates challenges and opportunities for pathologists, geneticists and clinical diagnostic laboratories.

The challenges revolve around an excess of data and how to corral that data — the typical laboratory information system is not well-designed to handle the wealth and complexity of information created by molecular tests and personalized medicine. A MIMS — a molecular information management system — is a specially

designed LIS/LIMS to handle the demands of molecular test data. As molecular diagnostics and personalized medicine moves to the forefront of healthcare, a MIMS will become increasingly important.

As healthcare moves more and more toward the utilization of extensive, comprehensive, individual molecular data, the area of healthcare that generates, manages and interprets that data — pathologists and clinical laboratories — becomes the center of personalized healthcare. Pathologists and clinical laboratories will essentially own the keys to the personalized healthcare kingdom.

"Pathologists and clinical laboratories will essentially own the keys to the personalized healthcare kingdom."

The U.S. Food and Drug Administration (FDA) provides lists of nucleic acid-based tests that have been cleared or approved by the Center for Devices and Radiological Health. As the website says, "These tests analyze variations in the sequence, structure, or expression of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) in order to diagnose diseases or medical conditions, infection with an identifiable pathogen, and determine genetic carrier status."

The FDA website[2] lists 57 approved Human Genetic Tests and 158 approved Microbial Tests. Under a separate list dubbed In Vitro Companion Diagnostic Devices, the FDA lists 12 that have been Cleared or Approved. The FDA's definition of a companion diagnostic device is an "in vitro diagnostic device or an imaging tool that provides information that is essential for the safe and effective use of a corresponding therapeutic product. The use of an IVD companion diagnostic device with a particular therapeutic product is stipulated in the instructions for use in the labeling of both the diagnostic device and the corresponding therapeutic product, as well as in the labeling of any generic equivalents and biosimilar equivalents of the therapeutic product."

And those numbers are just the tip of the iceberg. Since the inception of molecular diagnostic testing, laboratory developed tests (LDT) have been a prominent feature of clinical diagnostics. The FDA's definition is "a type of in vitro diagnostic test that is designed, manufactured and used within a single laboratory." It is estimated that there are 100,000 LDTs in the U.S.[3]

Chapter 2:

What You Need to Know about MIMS, the Molecular Information Management System

"Although these enterprise-wide systems generally provide some form of LIS module specific to the needs of the general clinical diagnostic laboratory, they are most often insufficient for the complexities of specific laboratory modalities..."

Modern healthcare is all about data — collecting it, creating it, collating it, organizing it, interpreting it, storing it, and transferring it. The widespread implementation of electronic health records (EHR), electronic medical records (EMR), laboratory information systems (LIS) and laboratory information management systems (LIMS) has made this increasingly possible — and necessary.

Often, larger institutions like hospitals and healthcare systems invest significant time and money into an enterprise-wide EHR. These enterprise-wide systems are typically excellent at providing a "big picture" application for a system. However, they are often inadequate or even ignore the specific needs of the clinical diagnostic and pathology laboratories.

Although these enterprise-wide systems generally provide some form of LIS module specific to the needs of the general clinical diagnostic laboratory, they are most often insufficient for the complexities of specific laboratory modalities, such as anatomic pathology, cytogenetics/genetics, blood bank, microbiology, and molecular pathology. Those shortcomings are often in the area of workflow, data mining, imaging and report formats.

As a result, vendors are developing best-of-breed LIS's for specialty laboratory areas. By utilizing an enterprise-wide EHR augmented with a best-of-breed LIS — in the context of this report, a MIMS — laboratories can have the best of both worlds.

Specimen Type

A typical hospital chemistry laboratory primarily performs tests on blood and urine. In some cases they might do tests on other body fluids, such as saliva, or from a swab, or on a stool sample.

"Typically, generic enterprise-wide systems are not designed to handle the variety of information captured."

Many types of genetics laboratories and molecular testing laboratories perform tests on a far wider spectrum of sample and specimen types. For example, a typical cytogenetics laboratory will perform testing on blood, bone marrow, tumor samples, amniotic fluid, chorionic villus samples (placenta), products of conception, skin biopsies and pleural effusions.

Data Volume

The advantage and challenge of most molecular testing, especially in the context of personalized medicine, is the amount of data it provides, as well as the different types of data.

An anatomic pathology report will include a spectrum of information such as gross appearance, microscopic descriptions, and diagnoses. The content of that report will include free text, structured data, pre-written responses, dictation, images, diagrams, tables and disclosures. Often, to provide clarity, there will be a full page or more of formatted text with highlights that include supporting materials such as images, tables and diagrams that assist in communicating the diagnostic conclusion to the patient by the clinician.

Typically, generic enterprise-wide systems are not designed to handle the variety of information captured.

One of the tools increasingly used in the molecular laboratory are microarrays. This technology produces vast amounts of data. A recent technical note[4] by Illumina, one of the major vendors of microarray

technology, said, "Illumina's whole-genome genotyping BeadChips have dramatically grown in complexity, with the latest ones providing nearly 5M (million) markers per sample, leading to a substantial increase in the amount of data being processed. Such large data sets can significantly increase the import and processing time required by the analysis pipeline."

"A single day's worth of cases in a pathology practice can require multiple terabytes (TB) of data."

Another increasingly utilized technology is **next-generation sequencing (NGS)**. NGS is essentially a way to sequence genes and entire genomes of individuals. The amount of data delivered ranges from 300 kilobytes up to 1 terabyte in a single run.

Digital Imaging

Anatomic pathology, molecular pathology, FISH, SKY, spectral imaging, cytogenetics and many other molecular-based techniques require digital images. These images and results must be incorporated into patient reporting in a seamless way.

This produces storage problems and places significant demands on an LIS. It's not as much of a problem as it used to be even five or six years ago due to the exponential growth of computer storage, but it's still a consideration. A single pathology slide, when digitized, can take up to 50 gigabytes (GB) or more, depending on magnification levels and number of focal planes. A single day's worth of cases in a pathology practice can require multiple terabytes (TB) of data. The better LIS's allow digital images to be attached or embedded in final test reports.

Reporting

Traditional clinical diagnostic laboratory tests provide a value range or a yes/no answer that is all the clinician needs to know. That is generally not the case with molecular testing, genetic testing, anatomic pathology testing, or personalized medicine. They typically require complex analysis and interpretation based on the data and patient history, and often the clinician will write or dictate a test-based analytical report.

"An effective MIMS can assist the clinician in integrating all the variety of complex information into a coherent, streamlined report."

This has several implications. One is time. Although molecular platforms are increasingly automated, there is often a paper-based component to it. The paperless hospital is a concept that has been around for at least a decade, and a MIMS can assist in managing complex molecular protocols, electronic activity logs, instrument interfaces, and automated quality control.

An effective MIMS can assist the clinician in integrating all the variety of complex information into a coherent, streamlined report. If necessary, for additional or enhanced functionality, it should also be able to integrate with software that specializes in molecular, genomic or pharmacogenomic interpretation, such as Translational Software's software-as-a-service solution.[5]

Translational Software's services, for example, "when integrated with a partnering MIMS, such as Psyche's NucleoLIS, allow the MIMS to automatically transfer genetic test results and patient demographics to Translational Software. It can then transmit that resulting data directly to the MIMS to be incorporated in a comprehensive, single report.

In short, in order to fully leverage the value of personalized medicine and molecular-based tests, another step beyond the standard LIS is necessary. "In general, the traditional LIS can provide a good

solution for billing and reporting, but it won't handle the workflow of molecular lab testing — identifying the paraffin block, doing nucleic acid extraction on the sample, quantitating DNA/RNA, and handling complex bench workflow, with quality control parameter integration," said Mark J. Routbort, MD, PhD, director of computational and integrational pathology and medical director of laboratory informatics for the University of Texas MD Anderson Cancer Center in a CAP Today[6] article.

"In general, the traditional LIS can provide a good solution for billing and reporting, but it can't handle the workflow of molecular lab testing..."

Chapter 3:

MIMS as a Bioinformatics Resource: Understanding Automated Molecular Test Data Analysis and Its Role in Identifying Essential Factors as Pathologists Create Personalized Treatment Plans

"A lot of work needs to be done to connect a new biomarker to actionable healthcare."

Personalized medicine is already presenting challenges in terms of data storage, analysis and interpretation. The solution is going to come from the field of translational bioinformatics (TBI), which the American Medical Informatics Association defines as "the development of storage, analytic and interpretive methods to optimize the transformation of increasing voluminous biomedical data into proactive, predictive, preventative and participatory health."[7]

Casey Overby and Peter Tarczy-Hornoch outlined four challenges to implementing genomics applications related to personalized medicine in their article[7] "Personalized medicine: challenges and opportunities for translational bioinformatics." They are:

1. **Validating correlations between genetic markers and disease and identifying actionability.** The key issue here is that every day, it seems, a research paper is published citing the correlation between a new biomarker and/or genetic mutation and its effect on an individual's health or a specific disease or disorder. A lot of work needs to be done to connect a new biomarker to actionable healthcare.

"Personalized medicine is going to increase the need for genetic counselors and clinical geneticists."

2. **Addressing concerns over the return of results and privacy that limit patient acceptance.** This revolves around two areas. First, this level of genetic information on an individual can often exceed the stated purpose of a test — in other words, if a patient comes in to be tested for A and B, but the genetic information obtained for that also contains information about C through Z, how long is that data stored and what level of information is provided to the patient? Overby and Tarczy-Hornoch write, "In light of these concerns we foresee additional demands on already burdened clinical geneticists and genetic counselors to assist with individualized interpretation of test results. … Relevant areas for TBI inquiry may include investigating automation and tailoring of test interpretation and communication for healthcare providers and patients to mitigate this burden."

   Also wrapped up in this area is information and data security related to the Health Insurance Portability and Accountability Act (HIPAA) and the Genetic Information Nondiscrimination Act (GINA).

3. **Educating patients and healthcare providers on the use and limitations of personalized medicine.** As mentioned above, personalized medicine is going to increase the need for genetic counselors and clinical geneticists. It is also going to require that healthcare providers at all levels become more familiar with genetic and genomic information and how to interpret data and provide complex, variable and highly risk-based statistical data to patients in a meaningful way.

4. **Addressing the absence of robust scalable electronic health record (EHR)-linked decision support tools.** The point of personalized medicine isn't just to present interesting biological information — it's to present useful, actionable healthcare information, or clinical decision support (CDS). In the context of this paper, it's not enough to just store all this information, personalized medicine requires that it be accessible and usable.

"The laboratory-centered functionality of a traditional LIMS, focused on managing lab data, sample tracking workflow and results, needs to merge with the more typical functionality of an LIS..."

Which is where a best in breed MIMS plays a significant role. The laboratory-centered functionality of a traditional LIMS, focused on managing lab data, sample tracking workflow and results, needs to merge with the more typical functionality of an LIS, which handles administration, billing, and private patient information.

And to make it truly valuable in an era of personalized medicine, it will need to integrate with modules or information systems that provide bioinformatics abilities.

Chapter 4:

MIMS in Support of Multi-Faceted Analysis: Unique and Specific Use of Molecular Test Data Elements Provide a Specific Combination of Unique Specialized Treatment Regimens

"Personalized medicine based on genomic testing has the potential to identify health problems in individuals before they happen..."

Traditional drug development has been based on averages — what dosage of a drug works best for the average population. Molecular testing and personalized medicine, specifically pharmacogenomic testing, is contrary to that. Pharmacogenomics (PGx) is the study of how an individual's genetic makeup affects their unique response to drugs.

However, in the wider population, there's a great deal of variability in how individuals respond to medications. Anywhere from 20 to 95 percent of patient variability to medications has a genetic basis.

Personalized medicine and molecular testing is useful for this type of drug-response analysis on a patient-by-patient basis. The same thing applies in cancer treatments. Researchers have increasingly found specific biomarkers in tumors that provide significant information to clinicians about disease progression, survival and response to various therapies.

Personalized medicine based on genomic testing has the potential to identify health problems in individuals before they happen, as well,

with cardiovascular risk, testing for Alzheimer's and a variety of other disorders. But to do so depends on data — a lot of it.

The human genome has 3 billion base pairs. Not all mutations in genes are created equal, and need to be put into a context of a patient's medical history, what is known about those mutations, and how they respond in the population.

"Part of this trend is the need to track data concerning patient health, data that is typically tied up in the EHR, and in the clinical laboratory."

The Accountable Care Trend

There is a shift away from fee-for-service toward fee-for-quality or basically, flat fees. This has been coupled with the concept of an Accountable Care Organization (ACO). One of the things the Affordable Care Act (ACA) has as a priority is to reduce healthcare costs by encouraging doctors, hospitals and other healthcare stakeholders to form networks to coordinate better care, which has the potential to reduce costs.

An ACO is a network of healthcare providers that share responsibility for providing care to patients. In addition to the various regulations governing ACOs, The Centers for Medicare and Medicaid Services (CMS) added a requirement that ACOs use Electronic Health Records (EHR) as a quality measure.

One of the objectives for the development of ACOs was to save money and achieve quality goals for the Medicare Fee-For-Services beneficiaries. The idea was to eliminate duplicate services and coordinate patient care. In addition, it is hoped to increase preventive efforts that would, in the long-term, cut the need for high-cost medical services like hospital stays.

Part of this trend is the need to track data concerning patient health, data that is typically tied up in the EHR, and in the clinical laboratory.

It is generally cited that about 70% of healthcare decisions are based on clinical laboratory testing — and that data is pushed directly into an LIS, or in the context of molecular diagnostics and personal medicine, into a MIMS. From there it is transferred into the EHR of the applicable healthcare provider, whether that is a hospital, health system, medical practice, reference laboratory, etc.

"Keeping in mind that a single patient's genome containes 3 billion pieces of data, and multiply that by a minimum of 5,000 patients, along with all the interpretive, analytical and non-genomic data, the scope and complexity of personal medicine becomes obvious."

One step further in thinking is required — ACOs and healthcare networks are increasingly in the business of handling a healthcare population, not just an individual. If an ACO is accountable, by definition, for a minimum of 5,000 patients in which it's managing not only healthcare, but flat fees, it needs a deeper understanding of population trends. This requires not only the data from an individual contained in a patient medical record, but the enormous quantity of data within a population — which is contained within a MIMS and LIS, as well as EHR.

Parsing that data, making it useful on an individual scale and on a population scale, requires computing power, data storage, and "big data." Keeping in mind that a single patient's genome contains 3 billion pieces of data, and multiply that by a minimum of 5,000 patients, along with all the interpretive, analytical and non-genomic data, the scope and complexity of personal medicine becomes obvious.

Interestingly, pathologists and clinical diagnostic laboratories have become both the generators and the keepers of that data.

Chapter 5:

MIMS' Role with Automated Molecular Testing Systems and Next-generation Middleware

"As molecular techniques, sequencing and arrays become integral to clinical diagnostics, laboratories are looking for and demanding automated systems that can integrate with their LIS's and MIMS's."

Molecular diagnostics as a separate entity from clinical diagnostics hasn't been around all that long — probably only a few years prior to the completion of the Human Genome Project in 2003. Personalized medicine, as such, has been around only a few years and is still in its infancy. As a result, laboratory information systems in general are still developing to handle molecular data, let alone genomic data.

The LIS industry is somewhat fragmented, tied as it is to large institutional EHR companies that commercialize EHRs for hospitals and healthcare systems, and tack on an LIS almost as an afterthought. This has left a number of small to medium-sized vendors to develop best-of-breed LIS's as well as specialized LIS's, LIMS's, and increasingly, MIMS.

As molecular techniques, sequencing and arrays become integral to clinical diagnostics, laboratories are looking for and demanding automated systems that can integrate with their LIS's and MIMS's. Discrete data must be analyzed, placed into formularies and algorithms, and then combined with a variety of other data sets such as radiology and pharmacy, to provide a holistic view of the patient's health.

One result of multiple vendors is the need for MIMS, LIS, EHR and molecular laboratory automation to interface with each other. The current standard for the lab community is Health Level Seven (HL7), which doesn't solve all the interface and interoperability problems

because it lacks conformity in terms of data structure. In short, it's not quite up to the "plug-and-play" level.

In order for analytics to be accurate, discrete data must be captured within the LIS, which needs to manage several different workflows from different areas of the laboratory, while also accommodating the various ways instrumentation interfaces. For example, not all of the instrumentation found outside a laboratory is sample ID-specific. Point of care (POC) devices are often patient ID-centric. It's important to that user certification and qualifications are evaluated and taken into consideration. Currently the industry often uses middleware as a stop-gap measure to handle POC testing. As POC and beside testing moves more mainstream, these need to be incorporated into the MIMS.

"The bottom line is that for laboratories looking for a MIMS to handle their current molecular, genomics and personalized medicine needs, interoperability and interfacing is a major consideration..."

The bottom line is that for laboratories looking for a MIMS to handle their current molecular, genomics and personalized medicine needs, interoperability and interfacing is a major consideration — as well as some anticipation of where this will be going in the near future.

Chapter 6:

Adopting MIMS for Clinical Use: A Buyer's Guide

"The LIS offered as part of an enterprise-wide EHR doesn't always offer the necessary functionality, let alone the optimal functionality."

The CIOs of hospitals and health systems often prefer the simplicity of a single EHR vendor — one vendor, one system, one bill, one database, one operating system. The problem with this is that the LIS offered as part of an enterprise-wide EHR doesn't always offer the necessary functionally, let alone the optimal functionality.

In addition, the EHR vendor may not provide focused support for the molecular diagnostics laboratory. Although CIOs and healthcare administrators may very well have well-defined reasons for insisting on an enterprise-wide EHR rather than the investment of a MIMS, that rationale doesn't solve the problems that molecular laboratories and laboratories utilizing a substantial amount of molecular diagnostic techniques face, especially when you take into account the net revenue generated from molecular laboratories and testing.

When comparing an enterprise-wide EHR's LIS compared to a best-of-breed MIMS, it is critical to evaluate the maximum total LIS functionality (T-LIS). The Association for Pathology Informatics (API) published a major report in 2013 titled "Use of the LIS Functionality Assessment Toolkit: A Methodology for Assessing LIS Functionality and Enabling Comparisons Among Competing Systems."[8]

The arguments for adopting a MIMS over an enterprise-wide EHR-based LIS include:

"The primary critical issue to evaluate when selecting an information system is the quality of support provided by the vendor."

- A MIMS will result in lower labor costs for laboratories that, as a result, will allow lower cost-per-test for the laboratory.
- A high-quality MIMS helps optimize laboratory workflow, which provides greater work efficiency, higher quality, and lower costs.
- Because of long-term and continuing shortages of medical technologists, laboratory automation in conjunction with a highly functional MIMS can serve as a substitute for labor.
- Additional concerns of laboratories include:
- Laboratories prioritize maximum computer functionality over system-wide integration.
- Enterprise-wide systems typically do not have capabilities for outreach laboratory business, which is a significant revenue generator for both laboratory and the institution.
- An integrated, single-vendor system may not have the flexibility necessary for the constantly changing business and technical conditions associated with personalized medicine and molecular testing.
- Integrated systems are not easily adapted for a multi-entity business model, such as the various components of a laboratory, pharmacy, etc., and are not easily modified when business or regulatory changes affect the entire integrated systems.

Selection of a MIMS

The primary critical issue to evaluate when selecting an information system is the quality of support provided by the vendor. System capabilities will evolve over time, but your partnership with a particular vendor will likely last 15 years or longer.

What level of support will that vendor provide?

Working with a vendor who provides stellar support to a system that is still evolving is desirable, rather than an "integrated" system that you can't get the vendor to repair or troubleshoot unsatisfactory aspects of the system.

"Working with a vendor who provides stellar support to a system that is still evolving is desirable..."

How to assess the vendor's culture of support? Start by asking the vendor for a list of current clients, then call and talk to them. If the vendor refuses to provide a list, it is appropriate to assume they have something to hide and you should look elsewhere.

Once you select a few vendors with excellent support records, it's time to look at current functionality.

The API report has an appendix with 850 functionality statements (FSs) related to all laboratory work that an ideal LIS would have. Various sections, such as Weights, provide a way of scoring (weighting) each of the FS's. "All of this should be taken to mean that most labs, particularly the larger and more complex ones, should seek to select best-of-breed LISs that provide all or most of the 2-4 weighted tasks and certainly all of the weight 3's and 4's."[8]

For example, FS's that are rated 3's and 4's include "Ability for staff to manually assign an accession number" and "supports lab-defined cast numbers and groups."

The report[8] states, "Installing an LIS with the maximum total LIS functionality (T-LIS) will generally result in lower labor costs for the laboratories which, in turn, will lower the cost-per-test. Systems with high functionality will also serve as a guide for achieving optimum workflow within the laboratories which results in greater efficiency."

An evaluation of "cost," however, should look at more than the price tag. Other factors to consider include:

- Impact on quality
- Productivity
- Improved competitiveness
- Service levels
- Workflow maximization

If the EHR vendor indicates that the specialty laboratory LIS is "free," request written assurance from the vendor that there will be no charge for hardware, implementation, maintenance, or ongoing support.

By carefully evaluating the functionality of the MIMS, both in terms of current needs, but future needs as personalized medicine becomes a broader reality, and by taking into account flexibility, quality, workflow, and productivity, it is possible to gain an understanding of the overall return on investment (ROI) a MIMS can provide to the cutting-edge clinical diagnostic laboratory.

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Chapter 7:

Molecular Technology Collaboration: The True Potential in Molecular Automation Will Not Evolve and Be Fully Realized Without Industry Participation

"Many laboratories continue to deliver test results on paper or through home-grown/ proprietary system formats."

There are approximately 225,000 CLIA-certified clinical diagnostic laboratories operating in the U.S. According to CLIA, they perform over 7 billion laboratory tests each year. More than half are performed by 6,000 different hospitals.

From a practical point of view, this means an enormous diversity among the types of data, EHRs, LISs, and MIMS. That's before even getting into the dramatic variations between the various automated instrumentation. Many laboratories continue to deliver test results on paper or through home-grown/proprietary system formats. This causes data backlogs, as well as presents a closed circuit of sorts — data gets to the hospital or institution's system and to the ordering physician, but without a health information technology network and LIS/MIMS, it may not make its way downstream to insurers, health plans, wellness providers, ACOs, etc.

Whether an LIS/MIMS is in-house or cloud-based, there are a number of challenges. They include:

Privacy/Security — Privacy and security of protected health information (PHI) is a major concern to healthcare networks. Those issues focus on potential system vulnerabilities that might be exploited by hackers and inappropriate user access.

"An interface is a connection that allows different computer systems whether an LIS/MIMS, EHR, or laboratory analyzer — to communicate with each other."

Interface Complexity — An interface is a connection that allows different computer systems — whether an LIS/MIMS, EHR, or laboratory analyzer — to communicate with each other. Numerous national and international organizations exist that oversee the development and implementation of standards related to healthcare technology interactivity. They include:

- HL7 (Health Level Seven International)
- CLIA (Clinical Laboratory Improvement Amendments)
- CCHIT (The Certification Commission for Health Information Technology)
- ANSI (The American National Standards Institute)
- HITSP (The Healthcare Information Technology Standards Panel)
- LOINC (Logical Observation Identifiers Names and Codes)

All are important to the HIT industry, but for healthcare users and LIS/MIMS users, HL7 and CLIA are of particular importance.

HL7 has members in over 55 countries, and determines standards for HIT interoperability. It is accredited by the American National Standards Institute (ANSI), and is one of a number of accredited Standards Developing Organizations (SDOs) involved in healthcare. Its primary focus is developing standards for administrative and

clinical healthcare data. Approximately 90% of information system vendors globally that serve healthcare are members of HL7.

CLIA is a component of the U.S. Department of Health and Human Services (HHS). All clinical diagnostic laboratories in the U.S. fall under the regulatory guidance of CLIA. In order to provide services in the U.S., clinical laboratories typically are required to be certified under CLIA (although there are exceptions). LIS/MIMS are typically designed with CLIA regulatory requirements in mind and are set up to facilitate compliance.

"What is clear, however, is that as the data needs of healthcare grow there is going to be increased demand on manufacturers and vendors..."

Although HL7 and other standards are reasonably effective at getting healthcare IT vendors' products to communicate with each other, challenges remain. Standards are revised regularly, but earlier standards remain. And healthcare institutions and laboratories typically have finite resources, so some instrumentation may be older and not up-to-date on standards — and the same thing applies to their computing systems and operating systems, let alone the software running on it.

What is clear, however, is that as the data needs of healthcare grow — and it is on a daily basis — there is going to be increased demand on manufacturers and vendors to develop "big data" applications, EHR, network viability, instrumentation interfaces, middleware and LIS/MIMS that can communicate and interface with each other as "personalized medicine" grows to a point where it is just called "medicine."

Conclusion

As personalized medicine and predictive medicine become a reality, the need for a molecular information management system will become increasingly important. Often a hospital or healthcare institution will purchase an enterprise-wide EHR that has a built-in LIS, but often these LIS's are inadequate for the needs of specific laboratory specialties, such as anatomic pathology, blood bank, cytogenetics or, increasingly, molecular diagnostics.

"What is needed are robust, best-in-breed MIMS that can handle the complex workflows of various molecular platforms and modalities, handle the large data volume, digital imaging and complex reporting needs that personalized medicine will require."

What is needed are robust, best-in-breed MIMS that can handle the complex workflows of various molecular platforms and modalities, handle the large data volume, digital imaging and complex reporting needs that personalized medicine will require. In addition, bioinformatics capabilities might to be required, either as part of the MIMS, or as a modular add-on to handle various specialized aspects of personalized medicine, whether for pharmacogenomic interpretation, "big data" analysis, or population genetics to assist accountable care organizations in managing patient populations in addition to individual patients.

This paper has discussed the trends in increasing use of genetic and molecular testing, the growth of big data in healthcare, and the challenges facing laboratories in handling the complexities of personalized medicine. It has outlined some of what they should consider in purchasing a MIMS and challenges for MIMS and other HIT vendors in terms of compatibility between various HIT technologies, including electronic health records, laboratory information systems, molecular information management systems, analytical instrumentation, and various middleware applications designed to improve communication between the systems.

"The multiple facets of molecular pathology testing can be incorporated into the business of the laboratory," wrote Lisa-Jean Clifford, chief executive officer of Psyche Systems, Inc. in an Advance for Laboratory Administrators[9] article. "Having the right LIS in a lab that offers these services to their providers enables that lab to capture the tests, results and codes necessary to thrive as this molecular pathology trend continues to grow. A flexible LIS designed to incorporate all clinical, pathology, molecular and billing information in a single database will separate a laboratory from its competition and ensure long-term profitability and a positive effect on its overall financial health."

"A flexible LIS designed to incorporate all clinical, pathology, molecular and billing information in a single database will separate a laboratory from its competition and ensure long-term profitability and a positive effect on its overall financial health."

Leighann Sheffield DLM(ASCP), CG(ASCP), Laboratory Manager at Genetics Associates, Nashville, TN, and user of one of the best-in-breed systems called NucleoLIS, offered by Psyche Systems, was recently quoted as saying, "For those who have multiple clients with multiple referring physicians, this system is wonderful. It allows for not only hard copy reports to be printed and/or faxed, but it also allows for distribution utilizing Outreach or secure email. These multiple reporting options ensure that the distribution needs of any client can be satisfied with the stroke of a key." She goes on to state, "Unlike many systems whose report formats are static or very limited to change, this system allows for very creative report formatting. If you can envision it, you can format it. It is obvious that this is a system created for cytogenetics by cytogeneticists. Awesome idea! Thanks!"

To find out more about specific MIMS solutions for your laboratory, contact Psyche Systems at sales@psychesystems.com or http://www.psychesystems.com/contact.html to speak with a sales representative.

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Appendices

A-1
About Psyche Systems

Psyche Systems Corporation is a private, profit-driven software company that has focused exclusively on delivering laboratory information software to hospitals, clinics, reference and private labs since 1976. It is this unwavering focus on serving our core customer base that has enabled Psyche to maintain strong customer loyalty and deliver on our commitment to high quality products and services. Psyche Systems' laboratory information software are best-of-breed products designed to meet the specific needs of molecular, toxicology, microbiology, anatomic pathology, cytology, histology, dermatopathology, and GI laboratories. We at Psyche work closely with our customer base during product development to ensure we are delivering the highest quality products and services at a competitive price.

For more information, visit www.psychesystems.com

A-2
About Mark Terry

Mark Terry is a freelance writer and editor specializing in clinical diagnostics, telemedicine, and biotechnology. He worked for 18 years in clinical genetics prior to turning to writing, and has published over 1,000 magazine and trade journal articles, 20+ books, and dozens of white papers and book-length market research reports related to the clinical lab industry. He is a member of the Association of Health Care Journalists and the Association of Genetic Technologists. For more information, visit his website at www.markterrywriter.com.

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About DARK Daily

"Dark Daily is a concise e-news/management briefing on timely topics in clinical laboratory and anatomic pathology group management. It is a solution to the dilemma facing anyone in the laboratory profession."

DARK Daily is a concise e-news/management briefing on timely topics in clinical laboratory and anatomic pathology group management. It is a solution to the dilemma facing anyone in the laboratory profession. New developments, new technology, and changing healthcare trends make it imperative to stay informed to be successful. At the same time, the Internet, cell phones, blackberries, laptop computers and wireless devices are overwhelming any one individual's ability to absorb this crushing Tsunami of data.

DARK Daily is a quick-to-read, easy-to-understand alert on some key developments in laboratory medicine and laboratory management. It has no counterpart in the lab world. Why? Because it is produced and written by the experts at THE DARK REPORT and The Dark Intelligence Group, who know your world, understand your needs and provide you with concise, processed intelligence on only those topics that are most important to you!

You will find DARK Daily to also be an exceptionally valuable resource in laboratory and pathology management. Some of the lab industry's keenest minds and most effective experts will be offering their knowledge, their insights and their recommendations on winning strategies and management methods. Many of these experts are unknown to most lab directors. As has proven true with THE DARK REPORT for more than a decade, DARK Daily will be your invaluable— and unmatched—resource, giving you access to the knowledge and experience of these accomplished lab industry professionals.

A-4
About The Dark Intelligence Group, Inc. and THE DARK REPORT

"Membership is highly-prized by the lab industry's leaders and early adopters. It allows them to share innovations and new knowledge in a confidential, non-competitive manner."

The Dark Intelligence Group, Inc., is a unique intelligence service, dedicated to providing high-level business, management and market trend analysis to laboratory CEOs, COOs, CFOs, pathologists and senior-level lab industry executives. Membership is highly-prized by the lab industry's leaders and early adopters. It allows them to share innovations and new knowledge in a confidential, non-competitive manner. This gives them first access to new knowledge, along with the expertise they can tap to keep their laboratory or pathology organization at the razor's edge of top performance.

It offers qualified lab executives, pathologists and industry vendors a rich store of knowledge, expertise and resources that are unavailable elsewhere. Since its founding in 1996, The Dark Intelligence Group and THE DARK REPORT have played in instrumental roles in supporting the success of some of the nation's best-performing, most profitable laboratory organizations.

The Dark Intelligence Group (TDIG) is headquartered in Austin, Texas. This location makes it very accessible for any laboratory organization seeking input, insight and support in developing their business operations, creating effective business strategies and crafting effective sales and marketing programs that consistently generate new volumes of specimens and increasing new profits. The Dark Intelligence Group, Inc. owns and operates two Web sites in the TDIG Website network:

THE DARK REPORT

http://www.DarkReport.com

DARK Daily
Clinical Laboratory and Pathology News/Trends

http://www.DarkDaily.com

A-5
About the *Executive War College on Laboratory and Pathology Management*

Every spring since 1996, the lab industry's best and brightest gather at the *Executive War College on Laboratory and Pathology Management* to learn, to share and to network. Many consider it to be the premier source of innovation and excellence in laboratory and pathology management.

Each year, a carefully selected line-up of laboratory leaders and innovators tell the story of how their laboratories are solving problems, tackling the toughest challenges in lab medicine and seizing opportunities to improve clinical care and boost financial performance. The *Executive War College* is the place to get practical advice and solutions for the toughest lab management challenges. A unique case study format brings participants face-to-face with their most successful peers. They tell, first hand, how their laboratory solved intractable problems and successfully used new technology.

Many lab management secrets are shared, along with specific "what-not-to-do's" gained from hard-won experience! It's not pie-in-the-sky theory, but useful knowledge that can be put to use in any lab. The *Executive War College* offers superlative networking, with lab administrators and pathologists attending from countries as far away as the United Kingdom, Germany, Brazil and Australia. It makes the *Executive War College* a melting pot for all the best ideas, new lab technologies and management strategies now reshaping the laboratory industry. It's also become a recruiting ground used by headhunters and major lab organizations.

In the United Kingdom, The Dark Intelligence Group and the Association of Clinical Biochemists (ACB) have co-produced a meeting every February since 2003. Known at *Frontiers in Laboratory Medicine* (FiLM), it attracts laboratory leaders and innovators in the United Kingdom. Also featuring a case study format, this meeting pioneered the international laboratory side-by-side case study, where a North American laboratory and a United Kingdom laboratory prepare a comparison of best practices and an operational assessment of their two organizations.

In September 2005, a laboratory management meeting called *Executive Edge* was conducted in Toronto, Ontario, Canada, by The Dark Intelligence Group and QSE Consulting. It provided pathologists and lab directors in Canada with a customized meeting devoted to the strategic and operational issues of laboratory management in Canada.

A-6
About Lisa-Jean Clifford

Ms. Clifford has over twenty years of experience in the high tech industry with over 15 of them specifically in health care high tech. Her experience includes strategy development and execution, general business administration and operations, marketing, business development, and product management. Ms. Clifford has been published and quoted in numerous publications including Forbes Magazine, has authored a book on XML, and has presented educational sessions at conferences. She is currently the Chief Executive Officer at Psyche Systems Corporation headquartered in Massachusetts.

About Brian Keefe, BS MT(ASCP), Director, Laboratory Product Management and Sales

Mr. Keefe has over 15 years of sales, marketing, and implementation experience in the medical laboratory informatics industry with first-hand applied experience in product planning, development, roll-out and management of medical laboratory informatics solutions, specializing in Clinical/Anatomic Pathology, Toxicology, Molecular/ Genetics and Outreach/EMR.

Born and raised in Massachusetts, Brian graduated from Quinnipiac University in Hamden, Connecticut with a Bachelor of Science in Medical Technology. Brian is celebrating his 17th year at Psyche Systems Corporation.

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Contact Information

The Dark Intelligence Group, Inc.
Customer Service
800-560-6363
21806 Briarcliff Drive
Spicewood, Texas 78669

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