PERSONALIZED MEDICINE:
THE WINDS OF CHANGE IN LIFE SCIENCES AND HEALTHCARE
One of the oldest and most persistent challenges that the life sciences industry has been striving to contain is that of side effects from traditional drug treatment. The success of the human genome project and the subsequent introduction of pharmacogenomics has allowed the industry to make considerable progress in this direction through the development of personalized medicine. At the very heart of the concept of personalized medicine lies the accumulation and structuring of a massive patient data pool that contains physiological and genomic information. By accessing this data, clinicians can prescribe drugs that are tailored to meet the unique patient requirements.

This paper explores the implications that the advent of personalized medicine will have on various areas of the pharmaceutical and healthcare industries. Through innovative treatment models, personalized medicine (PM) promises to transform the industry at an infrastructural level and provide pioneering companies with first mover advantage.
The Current Scenario

According to a report published by the Personalized Medicine Coalition (PMC), nearly 35% of USFDA new drug approvals in 2017 were personalized medicines. Much of this observed growth in personalized medicine development initiatives can be attributed to technological advancements that have rapidly driven down computing and genome sequencing costs. This has allowed the healthcare industry to successfully identify patient subgroups and engineer drugs targeted towards them. However, simply identifying patient sub-populations and developing personalized medicine is insufficient without a sound model to accelerate and scale complete personalized medicine ecosystem.

In contrast to the voluminous batch-sized production of traditional medicine, personalized medicine production involves small-batch, and often on-demand, production of drugs. On a large scale, this requires major changes, including infrastructural transformation, and reimagined production models of largely traditional medicine manufacturers. Externally, it translates to a systematic transformation of supply chains, patient ecosystem understanding, healthcare management, and bridging of therapeutic gaps prevalent in conventional drug prescription. The associated investments with such a change, being quite extensive, hinder the personalized medicine adoption process for the healthcare ecosystem.

Another major impediment in the widespread production and distribution of personalized medicine is the lack of a clear overarching regulatory framework. The rapidly evolving gene and cell therapeutics make it further difficult for stakeholders to anticipate the kind of regulations required for personalized medicine. While regulatory authorities such as the United States Food and Drug Administration (USFDA) and European Medicines Evaluation Agency (EMEA) are in the process of developing regulatory frameworks for personalized medicine, the progress is measured.

Despite the slow pace of development of regulations for personalized medicine, various other regulations such as the 21st Century Cures Act enables advancing the medical product development and review to bring new products to patients in a timely manner. These regulations are encouraging novel clinical trial design and use of real world evidence (RWE) to support the approval of a new indication or post-approval study requirements.
The Forces behind Personalized Medicine

When it comes to the key drivers of the personalized medicine disruption in the healthcare sector, a large set of factors come to the fore. One such is the modified approach to drug discovery. With modern drug research increasingly focusing on comprehending disease biology and human genetics profiling, the isolation of smaller statistical patient pools has significantly improved test outcomes and could potentially reduce adverse drug reaction (ADR) incidents. Besides the scientific breakthrough in decoding the human genome, much of the advantage can be attributed to the rapid advancements in technology, data computing in particular. For instance, medical imaging has helped researchers generate valuable insights to treat chronic and critical diseases such as cancer. Moreover, the existing need to reduce patient morbidity and mortality is driving personalized medicine initiatives to achieve an efficient mode of therapy.

Another driver of personalized medicine as a practical replacement for traditional drug therapies is the availability of patient information. The use of smart devices and wearables has helped create a seemingly endless stream of data, which serves as the foundation for developing personalized medicine. In addition to publicly available information, patient-level data from EHR also provides great potential to the development and widespread use of personalized medicine.
Who are the Key Players?

The development and distribution of personalized medicine on a large scale requires the culmination of a large number of functions operating in tandem. From patient and genomic data accumulation and processing to integration into the electronic health record (EHR), the process forms an interconnected web of stakeholder responsibilities. This calls for an all-inclusive collaborative approach across the stakeholder structure. Such an effort would involve:

Providers studying available patient data, particularly the patients’ molecular information, and designing treatment protocols tailored to the needs of patient sub-populations. Providers play an important role in initiating efficient patient engagements, replacing existing tokenistic involvement, that yield information instrumental in developing personalized treatment methodologies. Providers can begin to look at various areas of personalized drug administration by studying their capacity for disease management, disease prevention, and best-fit drug procedures.

Healthcare Providers (HCPs) venturing into molecular treatment studies such as genetics and biochemistry in order to better gauge possible treatment methods. Additionally, they should take into account the most recent developments in the fields of gene and cell therapy in order to provide stakeholders with a comprehensive approach towards targeted treatment.

Patients assuming an end-user role and providing valuable disease data. Patients will also play an important role in development of a comprehensive test result database for disease sub-populations by proving consent to investigational diagnosis and test-phase prognosis.
Diagnostic partners providing cost-effective technology that mixes accuracy with speed in early diagnosis, allowing for increasingly effective go-to-market strategies. Furthermore, the model needs to be scalable to be able to process large volumes of diagnostic data.

Payers rethinking financial incentives with the introduction of risk-rated premiums. This would allow payers to effectively pool risks across entire patient sub-populations while still being able to offer customized coverage of diagnostics and treatment.

Regulatory bodies developing robust compliance protocols for specimen requirements that are jointly agreed upon by stakeholders.

EHR/IT partners storing and processing the relevant data in real-time and providing manufacturers and healthcare providers with pharmacogenomics insights on patient sub-populations. This includes integrating genomic and biomarker data in the standard patient records, making it a crucial tool in the prescription of personalized medicine. IT partners will be key in the incorporation of technologies like machine learning and big data analytics in the development of personalized healthcare programs. For instance, ML algorithms are capable of identifying patterns in large genetic data sets, allowing researchers to effectively interpret genetic variations. This would allow researchers to isolate abnormalities at a cellular level and predict the onset of disease.

Such collaborative effort will prove to be a key driver in the production and distribution of personalized medicine with stakeholders gaining the first mover advantage by tapping into substantial market shares. Moreover, the pro-active approach stands to eliminate the need for currently practiced ‘trial and error’ methods of conventional drug treatments leading to heightened quality of life (QOL) and subsequently reduce financial repercussions.
Personalized Medicine: A Big Shift Across Stakeholders in Healthcare

**Pharmaceutical Manufacturers**
- Before Personalized Medication: Manufactured large volumes for blockbuster drugs
- After Personalized Medication: Manufacture small batches on-demand for personalized drugs

**Healthcare Providers**
- Before Personalized Medication: Administered drug with minor supply chain connections
- After Personalized Medication: Administer personalized treatment with direct supply chain communication

**Patients**
- Before Personalized Medication: Purely consumer-ended
- After Personalized Medication: Early screening for disease and diagnostics for right treatment/drug

**EHR/IT Partners**
- Before Personalized Medication: Responsible for diagnosing ailments
- After Personalized Medication: Information sources and demand indicators for manufacturers and PM

**Diagnostic Partners**
- Before Personalized Medication: Participants in PM processes and providers of genomic data
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How is PM Impacting the Pharma Value Chain?

A recent survey of global pharmaceutical industry leaders revealed that 92 percent of respondents saw personalized medicine as an opportunity while 84% have a corporate agenda around it. The goal of bringing personalized medicine into the mainstream, however, requires rethinking the pharmaceutical and healthcare sector as we know it. The existing pharmaceutical value chain including production, distribution, and provision of medicine has been tailored, over the ages, to suit the conventional treatment system. This translates to disruption across various components of the value chain, the topmost of them being:

- **Manufacturing**: Manufacturing plays a fundamental role when it comes to widespread adoption of personalized medicine. Industry, thus, needs to innovate to address the changing business need. Life sciences industry is exploring newer technologies. As a result, evaluation of single use technologies such as continuous manufacturing, additive manufacturing, and portable manufacturing is beginning to mature.

Since the traditional production models are not the best fit to serve the purpose of small-batch multi-product requirements of personalized medicine, drug manufacturers need to look at different modes of production. One of the most promising technologies in the area of manufacturing precision drugs is that of 3D-printing (3D-P). Being a single-use technology, 3D-P offers the required flexibility for small-batch multi-product manufacturing of personalized medicine. Additionally, the approach of on-demand printing enables pharmacy-based production and holds the potential to revolutionize the ownership model across the life sciences sector.
3D-Printing can reduce small batch production costs to as low as a fifth of the original expense.

By leveraging 3D-printing techniques, drug manufacturers can focus on the precision of formulating and “printing” drugs with properties such as automated dosage control and tailored drug release profiles. The process is suitable for manufacturing both low and high dose concentrations. 3D-P drugs can be also be customized using the size and drug combinations to suit the needs of the patient sub-populations. This method of personalized medicine production allows a great deal of freedom to design oral dosage forms (ODFs) with respect to factors such as active pharmaceutical ingredients (API) dosage, distribution and absorption of ODFs, and excipient use.

3D-printing of personalized medicine involves three commonly used techniques: printing-based inkjet systems, nozzle-based deposition systems, and laser-based writing systems. While the laser-based writing system relies on the principle of photo polymerization, printing-based inkjet system involves two techniques, continuous inkjet printing (CIJ) and drop-on-demand (DOD). The most popular of these techniques, however, is the nozzle-based deposition system. The provision of mixing drugs and polymers prior to the printing process grants it a higher degree of flexibility in terms of dosing accuracy.

**Supply Chain:** The past decade has witnessed the optimization of healthcare supply chain to the purposes of mass distribution of drugs and centralized treatment methods. One of the ways that the sector achieved this was through consolidation of the supply chain components. Traditionally, the approach has been a “One supply chain executed many times”. However, the advent of personalized medicine demands completely new capabilities to support the scenario of “Hundreds of supply chain executed once (extreme – more likely is executed few times)”. The evolving personalized medicine ecosystem and the unique nature of customer distribution is forcing the supply chain industry to evolve and adapt to the personalized medicine market. It is not just the transformation of distribution models that holds the potential to disrupt the supply chain. The opportunity or need to customize treatment for individual patients further increases the complexities in supply chain.

The fundamental idea behind personalized medicine being the improvement in quality of treatment, it is safe to say that the timely, error-free delivery of the appropriate product is an important factor for such an achievement. This requires improving the supply chain control and visibility in frameworks.
Keeping these requirements in mind, pharmaceutical companies are increasingly adopting the practice of "complete chain of custody". By assuming an end-to-end responsibility of the supply chain, pharmaceutical companies can ensure that the products meet the customers' individual packaging and delivery needs. This holistic approach requires companies to possess seamless tracking of each individual product through each of the stages in the supply chain, from procurement to manufacturing to distribution. This would involve efficient management of the supply chain including monitoring details like temperature of products in transit or in storage using IoT sensors.

Personalized medicine distribution is also changing the way third-party logistics operate within the healthcare sector. One of the most noticeable trends is the introduction of 'pharmacists and patient coordinator' models that enable an integrated two-way process of personalized medication. For instance, coordinators collect blood or T-cell samples from the patient and deliver it to the manufacturer. The resulting treatment is then delivered to the patient.

Aside of the levers of the life sciences value chain, the other activities impacted by Personalized Medicine are:

**Companion Diagnostics:** Companion diagnostics form an integral part of patient sub-group identification and subsequent personalized treatment design. Companion diagnostics are carried out alongside the administration of a drug. These tools offer insights that help in identifying biological markers and provide vital information on the effectiveness of the corresponding drug. This is one of the fastest evolving avenues to develop innovative treatment protocols. In a bid to adopt companion diagnostics in mainstream treatment, the US FDA, in 2018, advanced a policy that backed the co-development of drugs and in vitro diagnostics. Research and exploration in this area, however, experiences a certain degree of stagnancy resulting from the reluctance of pharmaceutical companies. In fact, fewer than 5% of all in vitro diagnostics are companion diagnostics. The hurdle lies in the lack of a regulatory framework, insufficiency of data, and the ever-potent threat of data breach.
Taking Personalized Care Forward

The effects of personalized medicine will become increasingly visible in the prescribing pattern of pharmaceutical treatments. Healthcare providers will be required to refer to patient sub-population averages and prescribe customized therapies according to the bodily needs of each patient.

One may argue about the practicality of personalized medicine from a perspective of immediacy, but it would be difficult to refute the disruption it means for the healthcare industry. From the shift in the role of HCPs and transformation in manufacturing practices to a changing supply chain management approach, the effects of personalized medicine will be witnessed all across the sector. Coupled with a marked rise in personalized drug approvals, it is only a matter of time before personalized medicine enters the mainstream. While government bodies, manufacturers, and distributors have the opportunity to gain the first mover advantage, they also need to prepare for the impact that personalized medicine will have on the market, and by extension, themselves.
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About the Authors

Sanjeev Sachdeva
Sanjeev Sachdeva is the CTO for TCS’ Life Sciences unit and globally heads the unit’s advisory group. As part of his role, he is responsible for tracking industry trends, driving thought leadership, assisting in formulation of the unit’s strategy, business and IT advisory, industry collaboration, and technology innovation in life sciences. With over 24 years of experience in technology and business transformation, he assists various life sciences customers in their transformation journey by adopting new technologies and processes across the business value chain - R&D, Manufacturing, Supply Chain, and Commercial. He is a post graduate in computers application from Delhi University.

Dr. Rajgopal Srinivasan
Dr. Rajgopal Srinivasan heads TCS’ Life Sciences Research division. Dr. Raj holds a Ph.D. in Chemistry from the University of Illinois at Urbana-Champaign in the USA. Prior to joining TCS in 2003, he was a research professor at the Johns Hopkins University in the biophysics department. His expertise in bioinformatics includes genome analysis and interpretation, biomedical text mining, and protein analysis. Under his guidance, the Life Sciences Research group has collaborated with several leading academic institutions including the University of California, Berkeley, and the University of California, San Francisco.
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