
#ECR2019: Impact of AI on medical imaging access



[Girish Srinivasan](#)

*****@***phenomx.co

Co-founder & Chief Technology
Officer Technology Solutions
Leader / Bio & Computer Engineer
- PhenoMx, Inc Palatine, IL, USA

[LinkedIn](#) [Twitter](#)



[Mark Punyanitya](#)

*****@***phenomx.co

Biomedical Engineer Co-founder &
Chief Executive Officer - PhenoMx,
Inc. New York, USA

[LinkedIn](#) [Twitter](#)

Noninvasive MRI digital physical exam provides a Whole Body approach for personalised health.

The scarcity of radiologic expertise and resources (hardware, personnel, quality, and other radiology services) impacts up to 4.7 billion people worldwide. Unfortunately, two-thirds of the world's population has no access to basic radiologic services. When it is available, both the quality and safety of the procedures may be questionable or even dangerous, both to the patient, the health care worker and the public. The gap in the access between high-income and low-middle-income countries is also significant (who.int). In the case of Computer Tomography (CT) for example, 14% of low-income countries have at least one CT equipment per million population (pmp) as compared to 100% in high-income countries. Nearly all African countries have reported less than 1 MRI scanner relative to Denmark's 14 per million inhabitants. A similar divide exists for the availability of appropriate medical personnel.

Although the role of radiology is profound in patient screening, diagnosis, treatment guidance, monitoring and follow-up, due to the challenges with access, the application has remained primarily in diagnosis. The tremendous potential to use imaging as a preventative tool in healthcare remains largely untapped. Amongst the various imaging modalities, Ultrasound (US) and Magnetic Resonance Imaging (MRI) do not use any ionising radiation for acquiring data from the body. While US is a portable versatile modality, it suffers from limited image resolution. The image quality also varies significantly based on technologist expertise.

MRI provides excellent soft tissue contrast with high quality images. Access to MRI is limited due to its large footprint, high cost and complexity in operation. The global MR scanner density (pmp) plotted as a function of (a) population and (b) life-expectancy is shown in Figure 1. These demographics and countries represent the unmet need for accessible MRI (Geethanath, Vaughan 2019). Digital healthcare solutions can revolutionise patient-to-provider encounters. Based on a study (Kapral et al. 2013), after the implementation of a digital care delivery system for stroke patients, the proportion of patients who received appropriate care increased from 40.0% to 46.5%, the 30-day mortality after stroke decreased from 38.3% to 34.4%. Also, the median wait time for treatment procedures decreased from 50 days to 22 days.

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Digitisation allows for utilisation of automated processing and analysis techniques including Artificial Intelligence (AI) to transform the data into meaningful results. For imaging data, AI-based processing and analysis yields simplified workflows, definitive diagnosis as well as predictive disease biomarkers. Figure 2 shows the addition of a quantitative imaging biomarker workflow to traditional radiological workflow.

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Factors impacting imaging (particularly MRI) access

The W.H.O. definition of access in healthcare includes availability (availability of imaging solutions in the market), affordability (cost effectiveness for patients and healthcare providers), geographical accessibility (reachable distance for patients), appropriateness (scientifically validated, addresses local needs), acceptability (culturally acceptable to patients) and quality (meets national standards for safe and effective use). Access to care solutions can be perceived based on five dimensions namely: geographical, temporal, financial, cultural and digital (Fortney, et al. 2011). A representative set of features for each of the dimensions of access for an MRI system is shown in Table 1.

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Based on current state-of-art technology, Ultra Low Field (<10 mT) and Very Low Field (10 – 100 mT) MRI systems have been primarily directed
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towards geographical and financial access, while the higher-field systems have relatively focused more on temporal, cultural and digital accesses (Geethanath, Vaughan 2019). The inherent digital nature of the data from most imaging modalities (if not all in the near future), allows for the application of automated analysis to obtain valuable information beyond raw images. Medical image analysis till the 1990s involved low-level pixel processing and mathematical modeling to construct compound rule-based systems that solved particular tasks. Today AI-based solutions, particularly deep learning techniques have permeated the entire field of medical image analysis. A breakdown of papers based on a survey conducted in 2017 (Litjens et al. 2017) classified according to deep learning architecture, area of application, imaging modality and anatomical region is shown in Figure 3. The application of deep learning methods for MRI data analysis was the highest.

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Phenotyping the human body for precision medicine Normally people associate precision medicine with genotyping – identifying an individual's DNA sequence (Ritzer-Ross 2015). But that is not the complete picture. Just looking at an individual's genome will not necessarily create cohorts, mainly because of epigenetics, or the cellular trait variations that are caused outside of the changes to the DNA sequence and other sources of variation in gene expression. While genotyping can create a baseline view of an individual's physical makeup, imaging observes or phenotypes the physical manifestations of disease (Bonner 2015). An accessible MRI solution with deep data analytic capabilities creates the ability to peer into an individual's body to evaluate health status, understand behavioral characteristics and predict disease risks. PhenoMx Inc., is a digital health company, that has created a digital physical examination, using noninvasive MRI, to measure the major vital organs and tissues from a Whole Body approach, for personalised health, wellness, and longevity. This enables the use of MRI as a comprehensive screening tool (Ladd 2009), paving way for affordable and actionable annual health exams. With a mere 20 – 30 minute scan, a detailed fingerprint of the body's structure, composition and function in health and disease can be determined. Figure 4, shows a whole body composition map highlighting the distribution of different tissues (bones, organs, muscle, fat etc.) across the body.

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Tracking, monitoring and evaluation of the tissue distribution with respect to an individuals' own baseline or a demographic population can provide insights into metabolic anomalies, which can serve as a biomarker for diseases such as obesity (Shah, Braverman 2012), diabetes, cachexia, etc. Body mass index (BMI) is commonly used to determine adiposity, which serves as an indicator of obesity for practical reasons. However, BMI presents as an inaccurate obesity classification method that underestimates the epidemic and contributes to failed treatment. For example, older adults have a particular body size, shape, and composition, and they tend to lose fat-free mass and increase fat mass. Furthermore, Asians have a higher proportion of body fat for a given BMI than Caucasians. The BMI does not consider composition (lean mass vs fat mass). Athletes / wellmuscled individuals will thus fail a BMI test due to the density of muscle. Alternatively BMI does not identify under muscled individuals (skinny fat), a growing segment of the population whereby, scale weight may fall within the approved BMI healthy ranges yet compositionally the individuals have excessive body fat levels with dangerously low amounts of lean tissue to support healthy aging. For these reasons, the Lean Mass Index (LMI), calculated from the MRI-based body composition information has been proposed (© Grant Roberts, Granite Gym). This purports to promote a positive spin to assist in revolutionising mindsets. Anatomy specific image acquisition followed by AI-based automated processing can be useful in phenotyping various diseases. Multi-parametric MRI for eg can provide a macroscopic picture of the Alzheimer's Disease (AD) phenotype and its environment that is ideally suited to quantifying the onset of the disease phenotype before, during, and after treatment (Petrella 2013). For Alzheimer's automated tools to segment brain sub-regions and track volumetric changes in these regions have been created. Population cohort analysis and demographic clustering models developed using deep learning techniques help in databased understanding of cognitive impairment and decline. An AD solution workflow (© PhenoMx Inc.) is described in Figure 5.

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Conclusion

Successful adoption of this solution at scale would provide an opportunity to test multiple hypotheses on biomarkers of health and disease, to facilitate paradigms of affordable and accessible, preventive and interceptive healthcare. This would lead to critical discoveries in healthcare and the globe, decisions in policy and significant impact on lifestyle.

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