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Neurogenomics: An Egyptian perspective

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1. Introduction

In the beginning of the twenty-first century, the world celebrated the fiftieth anniversary of the discovery of DNA. The discovery has led to enormous amounts of new knowledge, including the fact that the human genome has a physical size of 3×10^9 base pairs that encode and regulate approximately 32,000 genes. It has also spawned new fields, such as Genomics, which was born in Europe (Goetz, 2004), and the sub-field neurogenomics, which examines the molecular mechanisms and the interplay of this molecular information and health interventions and environmental factors of neurological disorders. The West has been able to advance neurogenomics, establishing high quality research institutions and educating health care professionals to incorporate new knowledge into diagnosing and testing patients. Egypt, however, has been far less able. The genetic research and services disparity between developed countries and the developing ones, specifically Egypt, is huge. In Egypt, as with other developing countries, genomic research capabilities and basic genetic services are considerably limited by infrastructure deficits. Genetic screening, and counseling, is common practice in the West, but not so in Egypt and other developing countries. Prenatal genetic screening for hemoglobin disorders, for instance, exists in most developed countries, but not so in developing world. Furthermore, the disparity in terms of genetically literate healthcare professionals and cost of care is substantial (Skirton et al., 2010; Thurston et al., 2007). In high-resource countries, the treatment cost is covered by medical insurance, while in lower-income countries the cost falls directly on families.). These gaps between developed and developing countries have been discussed in detail by WHO expert groups (World Health Organization, 1999, 2000, 2002) and others (Alwan and Modell, 2003; James et al., 1998; Penchaszadeh, 2000; Wonkam et al., 2006) who recommended several steps for developing countries, including Egypt, that wish to incorporate molecular techniques into research and health systems. Here the small-scale efforts for Geneva-Yaounde cooperation to train Cameroonian medical geneticist that may serve as a useful model for developing health professional education because it is easy, affordable with direct benefits (Gerber, 2005). In sum, neurogenomics in Egypt lags far behind that in the better resourced of the world.

2. Why is neurogenomics more challenging to perform in Egypt?

There is no doubt that African populations have a complex evolutionary history and hence display genetic diversity. But, currently little is known about their genetic profile. Basic biomedical research is the cornerstone for medical development and discoveries but without research facilities and clinical researchers, neurogenomics cannot advance in Egypt. Like most of low- and middle-income countries, Egypt is struggling to establish affordable genetics capabilities and facing considerable obstacles in the process. For example, genetically defined mouse strains, (inbred, co-isogenic, cogenic, knockout and transgenic strains) have become invaluable in research, especially for neurogenomics because they can elucidate genetics vs. environment influences on a wide variety of traits and offer the means to test multiple genetically identical animals at one time. However, these strains are not available in Egypt. Researchers must import them, which entails navigating a very expensive and complicated process entailing a formidable bureaucracy and strict regulation. The work around is to use the fruit fly *Drosophila melanogaster* as an affordable model organism. Its advantages for neurogenomics analysis include the fact that about 50% of human genes have a *Drosophila* ortholog (Shulman et al., 2003). Moreover, because the life cycle of the fly is rapid, with the possibility of breeding thousands of genetically identical flies in less than a month, researchers can conduct neurogenomics research for less cost and short time. Further, *D. melanogaster* expresses complex patterns of behavior (Hall, 1994; Sokolowski, 2001), which enables researchers to explore the phenotype characteristics of genes. A superb genetic database of information has been collected over more than 80 years (Asburner et al., 2004) and its fully sequenced genome has many tools and a database (see http://flybase.bio.indiana.edu/ for database of the *Drosophila* genome and related tools) that enables researchers to access genetic data easily for less cost. Another cheap and affordable model to study genetics is the nematode *Caenorhabditis elegans* that has a rapid growth rate with small size of genome (100 Mbases) (Fire et al., 1998). However, without access to the mouse strains noted above and related tools, the Egyptian scientific community cannot develop a good neurogenomics database and the informatics tools requisite to identifying genetic variants implicated in neurological disorders, or embark on discovery and

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development of diagnostics and treatments. There is a great need to build a database of genes, genetic polymorphisms and phenotypes related to neurological disorders in order to then translate the information for clinical benefit. That is, the genetic mapping of Arab and African population is essential for the identification and interpretation of genetic variation in patients with specific neurological diseases in certain sub populations. At present, there is no any such initiative in Egypt and therefore no available data on familial types of diseases like PD (Parkinson's disease). Further while quantitative genetics can render valuable information to the neuroscientist's arsenal and may greatly enhance our understanding of the neurogenomics of many neurological disorders, Egypt's lack of resources hampers our ability to conduct important quantitative experiments, such as quantitative trait loci (QTL). Therefore, our research capacity is severely constrained. Egypt, like some of its sister Arab countries, is now using next generation sequencing (NGS), but to be able to advance neurogenomics in Egypt, it is imperative to establish an Arab and an African population specific NGS database on neurological disorders (Fokkema et al., 2011). We need to encourage researchers to conduct association studies that focus on the Egyptian population in order to provide powerful tools to identify genetic components in neuropsychiatric disorders. Indeed, open databases are crucial to enabling our neurogenomics research in Egypt. However, financial constraints pose a formidable obstacle to start such an initiative. The Gulf States and oil-rich countries allot only 0.1–2.5% of gross national product (GNP) for research and development (Giles, 2006). Egypt's ability to conduct neurogenomics research and advance clinical neurogenomics can only be done if greater funding is made available and the current system for importing genetically defined mouse strains for basic research made simpler and financially feasible. Otherwise, advancing biomedical basic research will suffer and may ultimately not be possible. The pace of neurogenomics application in Egypt, for the reasons discussed above, is quite slow. In high-resource countries, new genetic knowledge has been incorporated into medical curriculum, in Europe, by 1970–1980 (Brunner, 2000; Goetz, 2004; Dahl, 2010; Orstavik, 2001), and in the U.S. as early as 1955 (Waelsch and Nitowsky, 1990), with the majority of US medical schools (77% of the 112 schools) teaching medical genetics (Childs et al., 1981; Thurston et al., 2007). In Egypt where there is no uniform medical curriculum across all 22 Egyptian medical schools, it is hard to know to what extent medical genetics and neurogenomics are taught. Therefore, it is not surprising that the need for “genetically literate” healthcare professionals is low (Feero et al., 2014; Korf, 2002; Stephenson, 1997; Skirton et al., 2010; Thurston et al., 2007). Apart from the constrains discussed above, substandard clinical training (Skirton et al., 2010; Thurston et al., 2007), and the fact that health care professionals do not view such knowledge as clinically relevant serves to maintain this unfortunate state (Kemper et al., 2010; Phimister et al., 2012). Further, limited availability of competent neurogenomics teaching faculty, and a providers' preference for clinical specialties over basic biomedical specialties contribute to this deficit (Korf, 2002). High quality educational programs are needed to produce well-trained medical geneticists.

3. Hopes and perspectives

Understanding the neurogenomics of Egyptian population will lead to our understanding of African genomic variation, which in turn will be an invaluable resource for scientists across the world. It is crucial to recognize that the needs and priorities in developing countries are wholly different to that those in developed countries. Knowledge and skill commensurate with research and technological advances are necessary to establishing neurogenomics research. High quality research can ultimately lead to discoveries that translate into new knowledge about disorders, new diagnostics, new therapeutics and even prevention strategies. Without high quality education at all levels, including medical schools and other healthcare professional training programs, neither research nor clinical neurogenomics care can advance in Egypt. Preparing tomorrow's doctors to appropriate practice clinical neurogenomics in Egypt requires assessing identifying the core neurogenomics knowledge and skill set (Harden et al., 1999; Smith, 2009; Korf et al., 2014). It also requires continuous evaluation of whether educational programs achieve their objectives (Gaff et al., 2007). These programs should integrate the principles and application of medical neurogenomics and genetics into undergraduate medical curricula with many emphases on clinical practice. Physicians need to be aware of, for example, common neurological disorders, such as epilepsy, dementia, and neuromuscular disorders, be able to identify when genetic components are present and master how to diagnose their overlapping signs and symptoms. For instance, Dravet syndrome is rare catastrophic infantile epilepsy that ends with SUDEP (sudden unexpected death in epilepsy) and identifying its genetic defect enables physicians to treat with anticonvulsants. To achieve educational goals, medical societies and advocacy groups in Egypt should work together to educate primary care professionals and patients to value the neurogenomics tools for diagnosis and treatment. In sum, to advance neurogenomics in Africa and Egypt, the overall goal of scientific community should be focused capacity building and networking. I recommend the following for introducing and advancing neurogenomics services in developing countries: 1) Establish educational resources and online free courses, 2) Disseminate of knowledge and establish an African Journal of Human Genetics, 3) support and incorporate neurogenomics advocacy, 4) effectively and efficiently transfer technology, and 5) encourage collaborative neurogenomics research.

4. Conclusion

Neurogenomics information is essential for optimal patient care (Institute of Medicine, 2012). It can be helpful in diagnosis, treatment assessment, side effect prediction, and disease prevention as well as preventing drug–drug interactions in some patients. We, as Egyptian physicians, hope to have a clear conceptual framework for the application of clinical neurogenomics, mainly towards prevention, diagnosis and management (Korf, 2013). Woefully, science in Egypt is not viewed as a necessity and neurogenomics is not regarded as an important humanitarian conquest or requisite. Therefore, there is a need to rearrange our priorities in Egypt and establish policy initiatives to advance neurogenetics research. Moreover, Egyptian policymakers, media and the public need to work together to alleviate fears and concerns regarding neurogenomics research and create a friendly neurogenomics research environment with an acceptable legal, moral, ethical and cultural framework. The fears and concerns regarding neurogenomics research emerge from s a number of ethical challenges (Leng, 2002). For example, there are several relevant unanswered questions including: 1) Is it possible for human subjects to consent using their biological samples or genetic data regardless the aims of the research? 2) Do research ethics committees have sufficient knowledge and experience to handle authorization of neurogenomics research? 3) Neurogenomics research has the potential to medicalize normal human conditions and disability i.e., will research may be used inappropriately to further human development? 4) Will various devices used in neurogenomics research to collect human subject data be used in ways that violate privacy?, and finally 5) Which research and applications will be funded governmentally? How we can assess such research? Finally, there is a pressing need to address the aforementioned inequalities in order to develop a common minimum standard of competencies among medical professionals in developing countries. I hope that the neurogenomics technologies will soon be applied in Egypt within clinical practice. This will open the horizon for a new era of data centric clinical practice. However, the question is still the same Are Egyptians prepared for this new era yet?

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