

EDITORIAL

NEED OF OUR TIMES: IMPACT OF GENOME EDITING SCIENCES AND REQUISITE PREPAREDNESS FOR MOLECULAR BIOTERRORISM

1. The pace of human evolution has accelerated at an unprecedented rate in the last couple of decades. Never ever before the mankind could witness a global hostage situation by a tiny invisible RNA creature. While the global community struggles at large finding plausible solutions in the information replete era, there are serious lessons to be learnt. The tiny RNA monster has exposed the vulnerabilities of one the considered most intelligent creature posing a question mark about how to strike the intricate balance between preventive approaches and acquiring the post-exposure immunity¹. The rapidly improving genome editing methods along with synthetic genomics has emerged as a double-edged weapon where on one side it opens newer therapeutic avenues to cure disease, but also its malicious use could result in disasters of limitless magnitudes². The delicate boundaries nature may face terrorism in newer clothes at the hands of nano technological tools to modify genome and synthesizing newer life forms³. Unstoppable if it becomes can create man-made disasters with issues leading to emergence of black markets for cloning, designer humans ethnic-specific nucleotide editing for worse and possibly much more^{4,5}. The fiction we saw yesterday is today's science and can lead the human race to point of no return. "He Jiankui affair" is still one of the genome editing dilemma widely criticized for ethical concerns emerging from germ line editing two human embryos for HIV using Cluster Regularly Interspaced Short Palindromic Repeats (CRISPR) Cas technology⁶.

2. At the time of writing this editorial, we are already seeing evidence of unwarranted genome handling. Several countries have developed specific working groups including "American Society of Human Genetic (ASHG)" work group, British Society for Genetic Medicine, International Genetic Epidemiology Society and few others. ASHG in its 2017 position statement has not reco-

mmended germ line gene-editing with caution to exercise oversight and need for ethical justification⁷. Though regulations following the rapid surge of genome editing technologies, techniques like type-2 CRISPR/Cas⁹ has already been applied to create multiple knock-in and knock-out nucleotide sequence changes in *Escherichia Coli* and others with much greater efficiencies⁸. Provided concerns raised about the potential health hazards and possible use in bioterrorism Gao *et al* and Bernard *et al* have suggested the need of several legal measures while consuming/dealing with "Genetically modified food (GMF)" and "Genetically Modified Organism (GMO)"^{9,10}.

3. Provided our concerns the counter narrative seems stronger and probably can't be managed. We are already seeing the tremendous potential of CRISPR/Cas genome editing methods in development of organoids, cancer therapy, medicinal use in metabolic disorders and probably much more to justify its use in therapeutics and diagnostics¹¹. However, with every human plight the future remains susceptible to its eminent rancorous possibilities. Cloning of human organs, though being debated could actually help reduce burden on human organ providers, but with time the efforts may lead to possible "clone banks" and that could pave way to being a perfected human and designer humans¹². The possible use of human cloning seems desirable in medicinal context but how much and how many can cause ethical dilemma for the community¹³. Before the debate gets extended and unknowns caught us unaware, its time..... time to learn, understand and evolve to strategize actions which are needed to be taken. Before bio weapons, human cloning, GFOs and GMOs haunt the weak we have to start action for protection⁹. Newer genome editing methods and synthesis of genome is now possible due to development of novel genetic techniques like Zinc Finger Nuclease (ZFN), Transcription Activator-Like Effector Nuc-

lease (TALENs) and most recently CRISPR techniques⁸.

4. Following is recommended to address possible non-desirable proliferation of genome editing methodologies and synthetic genomics:

- a. A working group must be established under the ownership of a senior molecular pathologist to assess current risk assessment due to non-desirable aspects of the gene editing/developing methods in various set ups.
- b. Core objective of the working group should be to assess following:
 - i. Regular and continuous assessment of gene editing and related techniques in terms of methodologies use, efficiencies in terms of gene-edited product and futuristic research pathways.
 - ii. Delineate diagnostic, therapeutic and non-clinical usage of gene editing and synthetic genomic advances.
 - iii. Assessment of all possible human and animal genome editing on germ lines with background of "molecular bioterrorism" within our and global community.
 - iv. Understanding most possible risks related with genome editing and synthesizing new genomes for our population.
 - v. Develop national level regulatory guidelines for:
 - a) Using gene therapies for therapeutics in line with international guidelines and expert opinions⁷.
 - b) Guidelines for agriculture and food industry^{9,10}.
 - c) Oversight on newer and re-emerging infections¹⁴.
 - d) Oversight on current research and development programs related with synthetic genomics and genome editing
- c. Establishing a core laboratory facility to incorporate analytical facilities to assess various

categories of editing sciences as per currently established guidelines¹⁵.

- d. Research and development of all genetic methods used in various biological sciences
- e. Preventing efforts of illegal and non-ethical attempts of gene modifications in the shape of natural and man-made bio threats in humans, animals and other biological sciences⁷⁻¹⁰.
- f. Ensuring cyber security to protect illegitimate use of private genome data hacks and constant oversight on newer misadventures in genome editing sciences¹⁶.
- g. An initial core team above may possibly include an domain specialists with expertise in molecular pathology, genome editing methods, diagnostic sequencing methods, field epidemiology, non-clinical and clinical microbiology, virology, botanical sciences, industrial-scale development of food sciences, veterinary sciences, entomology, bio-informatics, cyber security and expertise in non-conventional threat assessment¹⁷⁻¹⁹.

The team may guide future course of action starting from human resource addition, professional developments, areas needing specific oversight, developing regulatory guidelines, mechanism to preempt threats and align our country with next-generational molecular level hazards.

5. The novelty associated with genome manipulation, which has surfaced over the last few decades remains undeniably useful if pursued with the laws of medicinal research and human betterment. Nonetheless the future may witness newer avenues in life forms as microorganisms, purpose-built human and animal kinds, and plant species. The real trepidation will always be the incalculable and infinite risks attached to these experimentation challenging the ways human beings has ever lived according to the laws of nature. A pushing obligation and need of our times remains to be prepared for curtailing and fine-tuning the use of these colossal genome modifying experiments and biotechnology by

timely developing regulations and domains to work within.

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