Pandemic Resilient Ecosystem for Business Continuity

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It has been a year since the global fight against COVID-19. The world has travelled through the anxious phase to a new fearless phase of pandemic response. During the initial months, there was fear and panic among the masses. With the awareness of wearing masks, hand hygiene and social distancing, the world population entered a more confident place where the economies slowly rebooted. Although this "new normal" promised low disease transmission, it was challenging in population dense areas with another wave of infection upsurge. It is no illusion that COVID-19 is here to stay for a while. Each country's mitigation response, its preparedness regarding detection, isolation, testing, surveillance and contact tracing will help combat the current pandemic as well as prepare for future unforeseen pandemics.

Biologically, SARS-CoV-2 is different from SARS-CoV and MERS-CoV, which made it difficult to understand its features and transmission pattern. Moreover, its faster spreading capacity created havoc across the globe. Although the mortality rate in India is 1.45%, the severe symptoms such as breathlessness, high fever, excessive body ache, vomiting, amplified by the social stigma attached with the disease has had physical and mental effects on victims. With high transmission rates and low fatality rates, our medical institutions have been able to form an effective mitigation response for the current pandemic. The downside though, is, that the "Pandora box" of notorious options and ideas is now open. The world has to be prepared for worst case scenarios of extreme biological emergencies. For instance, Ebola Viral Disease outbreak of 2014 in Africa had an exuberant fatality rate of 59%, however, it was not easily transmissible. Infected people were not capable of spreading the infection until they started showing symptoms, and even the virus was hard to catch because it spread through direct contact with bodily fluids of infected people, such as blood, sweat, urine or semen. This is fairly contrasting to the coronavirus which is easily transmitted when someone coughs, sneezes or even speaks! With genetic engineering and notorious mindsets, it is not impossible that novel viruses be developed in the future with extreme traits of high transmissibility and high fatality rate. Moreover, humans are social animals, and human-human interaction cannot be stopped. Further, generating vaccines within a short-span of time is far-fetched owing to the various phases of trials. Considering all these factors, the world needs to be effectively prepared for unpredictable viruses and severe biological emergencies. In addition to building smart cities, the administrative authorities ought to build Pandemic Resilient Cities. The world cannot afford more lockdowns, as the countries need rotational incomes and expenditures. Thus, we need Pandemic Resilient Ecosystems at all levels, be it homes, shops, offices, schools, universities etc. to save human lives and world economics.

Pandemic Resilient Ecosystems rest on three major bases - social distancing, personal protective equipment, and

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disinfection. Such systems must be self-sustaining with low recurring cost. Considering the current circumstances of escalated infections and decline in businesses, Institute of Nuclear Medicine & Allied Sciences (INMAS), Defence Research & Development Organisation (DRDO) has developed some products to help combat the situation. These technologies have been developed for personal use as well as commercial use. Few of these are discussed herewith.

PPE Suit, Protecton - DRDO developed a body suit using "smart textiles" which is washable and reusable, without compromising on its protective ability. It contains a layer of activated charcoal which wards off infections effectively. The regular PPE kits which are available commercially are generally for single use. This could lead to higher manufacturing rates, high bearing costs to common man as well as greater environmental load.

Tri-netra Hand Sanitization Unit - Tri-netra hand sanitization unit is a portable wall-mounted device which contains an ozone generator cathode maintaining the concentration up to 5 ppm, and converts water into hand sanitization medium. Half-life of ozone is 30 minutes, thus, simple ozonated water would not be suitable to carry while traveling. Thus, a herbal formulation called "Triyogani" was developed which does not get oxidized with ozone and provides sanitization comparable to alcohol. In fact Triyogani hand sanitizer demonstrated up to > 99.99% reduction in microbial cell count within 15-30 seconds of application, which is equivalent to an alcohol based sanitizer with at least 75% alcohol content. Alcohol based hand sanitizers are associated with some long term side effects viz. (a) skin dryness which results in itching, flaking or cracks, skin irritation on prolonged usage, (b) toxicity by accidental ingestion by children resulting in subsequent hospitalization, (c) fire hazard as they are classified as Class 1 flammable liquid substances due to low flash points, are risky to use near flame or high temperature environments. Moreover production of alcohol sanitizers relies on industry which does not make it self-sustaining compared to zero recurring cost of ozonated water. Also, there is a possibility of growth of new variants of microorganisms resistant to existing disinfecting chemicals. In such situations, ozonated water can be produced and used on site, using air; while alcohol requires complete set up and raw material from agriculture sector.

Ozonated Radical Confined Space (ORCS) Sanitization Unit, Poorn Swachh - ORCS Disinfection Unit is a portable and mobile machine that generates ozonated fog and penetrates into various parts of room or vehicle (confined space) neutralizing microbes, viruses, bacteria etc. This system also produces ozone on its own with the help of a generator cathode at the bottom of the device. The ORCS unit produces ozone at 0.03 ppm x 10 hours, which is fairly less than the permitted occupational dose of 0.1ppm x 8 hours. To compensate the excess time required to thoroughly sanitize a space, a herbal formulation called Triyogani fumigant is added to this device, which produces ozonated fog. It is a safe option that enhances the impact of ozone in synergistic manner while disinfecting the confined space. Existing UV-C based counterparts are extremely effective in sterilizing the surfaces in their line of path. However any slight deviation or obstacle in path (or shadow areas) significantly reduces the efficacy leading to surface disinfection only. Moreover, the time and energy required to achieve UV-C based room sterilization is higher, including delayed timer for the safety of personnel performing the disinfection. Poorn Swachh with Triyogani on the other hand, performs comprehensive sterilization and is not restricted with obstacles in path.

Safe Passage Patient Transfer System, Taaran - This specialized Patient Transfer System (PTS) is a modified wheel chair with isolation cover and an assembly that absorbs all the exhaled air of the patient, sterilizes it through HEPA filters and UV-C, and re-circulates the cleansed air. It provides safe passage for victim passing through contaminated environment and/or prevention of spread of infection in

health care settings or public areas. PTS can be used in designated hospitals, where suspected persons can pass through the screening process at triage area wherein interaction between doctors and patients, or doctors and patient's attendants, or medical staff and paramedics takes place, thus minimizing the chances of infection transfer. Also, transferring the suspected patients from hospital parking to OPD, or, from home/ office to the ambulance, or, airports/ railway stations which are the first places to encounter suspects with symptoms. Even though N-95 masks provide adequate protection, but they reduce in efficiency after 36 hours. Moreover, patients are continuously rushed between test centers and isolation wards and a closed space for transfer is always better. Inside Taaran, the flow rate of air being sucked from the lower part of PTS and back into two suction apparatus on either side of patient creates a continuous directional flow of exhaled air. As per guidelines for isolation precaution, >12 ACH (air exchanges per hour) or 80-160 liters/ second/ patient is required for isolation in high risk areas. PTS supports 15 air changes per hour, ensuring complete safety. Furthermore, it is rechargeable. So the only recurrent cost is of electricity.

Fruits and Veggies Wash - Majority of the food produce is waxed to increase its shelf life. Also, pesticide residues are present on fruits and vegetables' surfaces, whose prolonged exposure has been associated with increased risk of several autoimmune and degenerative diseases such as cancer and autism. Additionally, washing with plain water will not remove food-borne pathogens which affect people with weaker immune systems such as elderly, infants, pregnant women etc. Therefore, the team of scientists at INMAS, DRDO developed a disinfectant, Triyogani - Fruits and Veggie Wash, which is composed of organic acids and naturally derived plant based compounds especially citrus ingredients, with proven efficacy in killing microbes. They strip off the waxy layer, pesticide residues, and dirt trapped on the surfaces and pathogenic contaminants. All components of Triyogani are food grade and free from alcohol, chlorine or sulphates, thus safe for consumption.

Ultra Swachh Personal Protective Equipment Disinfection - Ultra Swachh PPE Disinfection Unit is an advanced oxidative process based disinfection unit comprising multiple barrier disruption approach. It works using Ozonated SPACE and Aqua-Ozonated SPACE. This technology is based on Tri-netra mechanism, translating to three step sterilization, where the radical dispenser generates a mist of aqueous ozone as microbial neutralizer (1), UV sterilizes the surface (2), UV further transforms ozone back to oxygen and water (3). Moreover, DRDO has developed multi-layered convertor to absorb residual ozone leftover, if any, after completion of the cycle. This technology has been tested and validated using standard biological indicators having bacterial spores of volcanic origin, which are one of the most resistant micro-flora and used worldwide to obtain Sterility Assurance. The spores were killed instantaneously within an effective contact time of 50 seconds. This ascertained its utility in killing fragile Corona RNA virus, and is also promising for any resilient future bioagent. In case of an unforeseen circumstance where the new bioagent cannot be degraded with this technology, there is a provision of adding Triyogani fumigant making the sterilization process excessively effective. In another situation if there is a need of chemical sterilant, hydrogen peroxide can be added in the radical dispenser. Ultra Swachh can be used to disinfect wide range of material, fabric, PPEs, hard plastic tools, radios, mobile phones, bluetooth devices, watches etc. For hard surface items, only UV-C cycle can be used; for PPEs sterilization Ozonated SPACE cycle can be used and so on. Regarding running cost, there are two models, base model and an advanced version. For both, there is no recurring cost other than operational electric cost at 220V, 50Hz for base model and minimum cost imperative for advanced model.

Ati Swachh Heat Sensitive Medical Device Disinfection Unit - Ati Swachh is a disinfection/ sterilization unit based on advance oxidative process, for multiple barrier disruption. It works on the same Tri-netra principle explained above for Ultra Swachh. The additional feature of this system is that it works on heat-sensitive materials, mostly medical instruments. Presently, single sterilant technologies do exist like Hydrogen Peroxide vaporized sterilization solution, Ethylene Oxide (EtO) or Steam based systems. However, each has a few problems: (a) higher recurring cost; (b) not environment friendly; (c) non-compatibility with range of fabrics; (d) lesser oxidative potential of single sterilants technology as compared to Ati Swachh's dual/ tri-technological combinations and; (e) standardization and development outside the country and generally imported. All these methods are highly specialized, dedicated facilities require special trainings and operational instructions to operators due to their associated hazard. Thus, the present solution was developed with respect to advent of COVID-19 spread and as technological solution towards "self-reliant Indian mission". Also, the current demand of medical device disinfection has escalated many folds which requires quick, sterilization-in-place (SIP) approach of medical device disinfection. The practice of disinfection is already in place in hospitals for management of patients (including infected ones), they generally follow conservative and conventional methods of disinfection (autoclave) which may not be sufficient and suitable for re-utilization to many of the heat sensitive medical devices such as plastic applicators, lumens, endoscopes, brachytherapy applicators, surgical implants, hydrogel based systems etc. This technology has a promising future in dental operations. DRDO has developed and validated the process of sterilization cycle by using globally accepted biological indicator, Geobacillus stearothermophilus (thermophile with the ability to survive up to 130 degC). Similar to Ultra Swachh, there is no recurring cost other than the operational electric cost at 220V, 50Hz for the basic model; with minimum cost inclusion for advanced model.

In the end, what goes up must come down. The sudden upsurge in the use of sterilants, disinfectants and the compulsive habit of over-sanitization could cause greater problems to human immunity in the future. A study from the University of Ireland in 2010 concluded that Pseudomonas bacteria exposed to disinfectants that were either improperly mixed or excessively used, caused the bacteria to become resistant to the disinfectant, but far more alarmingly, 240 times more resistant to the antibiotics used to treat an infection of the bacteria. There is evidence that misuse of disinfectants may be contributing to bacterial antibiotic resistance. This could be aggravated when dealing with viruses and other bioagents. Thus, all sterilization techniques should be used only in extreme adverse conditions such as the current COVID-19 pandemic. We, as a humanity need enhanced cleaning (sanitization), not sterilization, to keep our immunities high.

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