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Sustainable chemical preventive models in COVID-19: Understanding, innovation, adaptations, and impact

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A R T I C L E I N F O

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Sustainability

A B S T R A C T

COVID-19 is considered as a major public health problem caused by the SARS CoV-2. This Viral infection is known to induce worldwide pandemic in short period of time. Emerging evidence suggested that the transmission control and drug therapy may influence the preventive measures extensively as the host surrounding environment and pathogenic mechanism may contribute to the pandemic condition earlier in COVID-19 disease. Although, several animals identified as reservoir to date, however human-to-human transmission is well documented. Human beings are sustaining the virus in the communities and act as an amplifier of the virus. Human activities i.e., living with the patient, touching patient waste etc. in the surrounding of active patients or asymptomatic persons cause significant risk factors for transmission. On the other hand, drug target and mechanism to destroy the virus or virus inhibition depends on diversified approaches of drugs and different target for virus life cycle. This article describes the sustainable chemical preventive models understanding, requirements, technology adaptation and the implementation strategies in these pandemic-like situations. As the outbreak progresses, healthcare models focused on transmission control through disinfections and sanitization based on risk calculations. Identification of the most suitable target of drugs and regional control model of transmission are of high priority. In the early stages of an outbreak, availability of epidemiological information is important to encourage preventive measures efforts by public health authorities and provide robust evidence to guide interventions. Here, we have discussed

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the level of adaptations in technology that research professionals display toward their public health preventive models. We should compile a representative data set of adaptations that humans can consider for transmission control and adopt for viruses and their hosts. Overall, there are many aspects of the chemical science and technology in virus preventive measures. Herein, the most recent advances in this context are discussed, and the possible reasons behind the sustainable preventive model are presented. This kind of sustainable preventive model having adaptation and implementation with green chemistry system will reduce the shedding of the virus into the community by eco-friendly methods, and thus the risk of transmission and infection progression can be mitigated.

1. Introduction

SARS-CoV-2 is a coronavirus that causes COVID-19, is very contagious and has now infected nearly a more than 10 million people across the globe. SARS-CoV-2 is a spherical surrounded particle containing nucleoprotein-associated single-stranded (positive-sense) RNA inside a capsid consisting of a matrix protein, where the envelope bears club-shaped glycoprotein projections [Fig. 1] [1]. Some of the corona viruses are with hemagglutinin-esterase protein. In the membrane of corona virus, the membrane (M) glycoprotein is the most abundantly available structural protein which spans the membrane bilayer three times. It leaves a short NH_2-terminal domain outside the virus and a long COOH terminus (cytoplasmic domain) inside the virion.

There are four types of corona viruses: alpha, beta, delta, and gamma, among them only alpha and beta transmissible to humans [2]. Coronaviruses impact the respiratory systems of mammals and acute respiratory distress syndrome (ARDS), which can lead to patient deaths [3]. SARS-CoV-2 was first reported to the World Health Organization on December 31, 2019 since then, highest number of deaths has occurred in the United States, India and Brazil respectively. Fig. 2 Shows the deaths cumulative total per 1 million people as per the data reported by WHO globally (5:58pm CET, December 21, 2020). Among all other countries the first ten countries in the list (United States of America, India, Brazil, Russia, France, United Kingdom, Italy, Spain, Argentina, Germany) having more no. of deaths have been given here. It shows that the maximum no. of countries has reached to the community transmissions.

2. Covid-19

2.1. Understanding of COVID-19

People's respiratory disorders vary from common colds to more serious cases, such as severe acute respiratory syndrome (SARS). It can spread by respiratory droplets from person to person through coughs or sneezes of infected individuals [3]. The common symptoms range from fever, cough, and shortness of breath, where it can start to show up anywhere from 2 to 14 days after exposure to the virus. The best preventative action to avoid getting COVID-19 illness is based on social distancing and keeping sanitize environment. You should frequently wash your hands with soap and alcohol-based sanitizers and try to avoid contact with infected people. Covering face with masks is highly necessary for protection against a COVID-19 infection. Various protective and adaptation methods and suggestions are recommended at time to time by public health organizations as below:

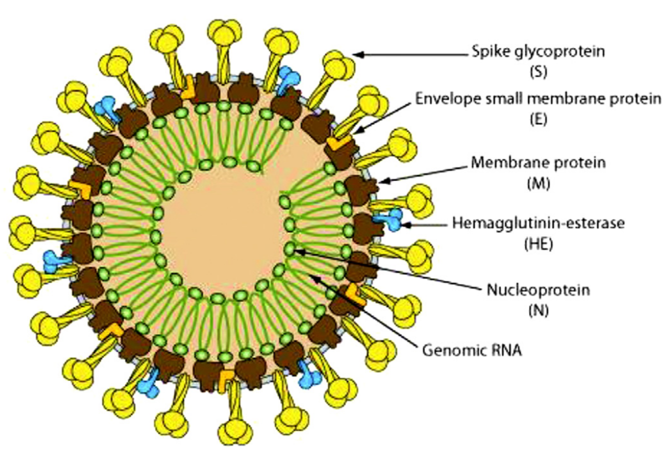

Fig. 1. Schematic representation showing structure of a Corona Virus. This figure has been adopted from Ref. [1].

- The Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/about/symptoms.html Accessed Feb. 28, 2020.
- https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public

According to the CDC, the symptoms of COVID-19 can include:

- Cough
- Difficulty in breathing
- Fatigue
- Runny nose
- Fever
- Chills
- Muscle pain
- Sore throat
- Loss of smell or taste
- Nausea or vomiting
- Diarrhea

According to literature, SARS-CoV-2 appears to be more contagious than other coronaviruses (Like SARS and MERS). Scientists are working on ideas for the development of treatment and prevention strategies to contain disease spreading [4].

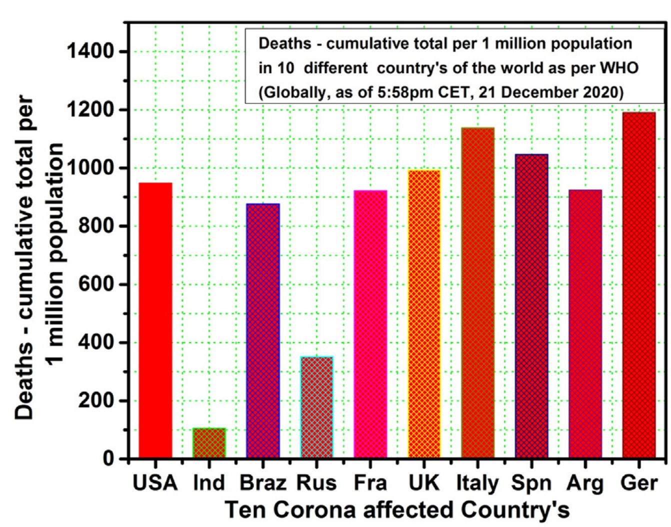

Fig. 2. Deaths - cumulative total per 1 million population in 10 different countries of the world as per WHO (Globally as of 5:58pm CET, December 21, 2020).

2.2. Structure of SARS-CoV-2

The corona virus is made up of an unusually large RNA genome which is surrounded by proteins and lipids (fats) and characterized by club-like projected spikes on their surface [5]. When the virus enters your cells, it uses unique replication strategy through RNA genome. The SARS-CoV-2 has four main structural proteins contain spike (S), membrane (M), envelope (E), and nucleocapsid (N) proteins. Electron micrograph study shows that S glycoprotein forms the large glycosylated peplomers M. The *trans*-membrane protein spans the membrane three times and highly hydrophobic in nature, while E, a membrane-spanning protein, like a envelop [6]. Some other viruses express different glycoprotein called as hemagglutinin-esterase (HE), which makes smaller spikes [6].

2.3. Functional aspects of corona virus proteins

Corona virus proteins bears several functional aspects which are responsible for virus severity and pathogenesis [6]. Understanding of such mechanism and functional and structural characteristics of proteins is important for designing drug and treatment strategies.

Spike protein: Helps in viral entry, cell, and tissue-oriented spreading.

M protein: Helps in viral assembly and host interactions. Due to glycosylation condition, M protein helps in virus-host interaction. Condition may be O glycosylated for groups I and III or N glycosylated for group II.

N protein: Responsible for transcription and inducing a cell cycle arrest (i.e.in the G2/M phase) possibly by cytokines inhibition of cytokines and play role in pathogenesis.

E protein: Responsible for viral assembly and production of infectious virus either by expressing alone or together with M protein.

Replicase proteins: Responsible for enhancing viral replication and affecting tropism and pathogenesis. This protein interacts with the viral genome in non-coding 5 and/or 3UTR sequence regions along with specific factors, or with elements of the immune response.

SARS-CoV-2 Genome: Among all known RNA viruses, coronaviruses have the largest genomes (26.4–31.7 kb) and SARS-CoV-2 is positive-sense RNA virus belonging to the genus Beta coronavirus in the *Coronaviridae* family. This virus has two untranslated regions (UTRs) at both 5′ and 3′ ends flanking the coding region (5′-cap structure and 3′-polyAtail) and an open reading frame (ORF) encoding a polyprotein structure [7].

A typical CoV contains, in its genome, at least six ORFs. The soluble g RNA (sgRNAs) of CoVs is translated from both structural and accessory proteins [**1**] . The Open Read Frame ab (ORF1ab), spike (S), envelope (E), membrane (M) and nucleocapsid are in the coding area (N). There are also some other ORFs between genes S and N. The largest of the genes is ORF1ab and is subdivided further into ORF1a and ORF1b. More than 15 nonstructural proteins are encoded by the ORF1ab gene, including RNA-dependent RNA polymerase (RdRP) and helicase [3].

Different coronaviruses encode special structural and accessory proteins, such as HE protein, 3a/b protein, and 4a/b protein. These mature proteins are responsible for several important functions in genome maintenance and virus replication [1,8].

Clinical and laboratory findings of patients with SARS-CoV-2 infection are defined by earlier literatures. The difference of proteins on the gene sequence between viruses may account for the pathogenesis of the virus. The released complete viral genome analysis indicated the 88% sequence identity with bat-derived SARS-like corona viruses. Genetic analysis is very useful for phylogeographic study and understanding pathogenic mechanism and severity of SARS coronavirus [9,10].

Timeline: Important COVID-19 timeline described as below incidences:

- Dec. 31: China report pneumonia like cases in Wuhan, China, to the World Health Organization.
- Jan. 11: China informs the WHO that the coronavirus outbreak is linked with exposure to the seafood and live animal market in Wuhan.
- Jan. 12: China shared the genetic sequence of the novel coronavirus
- Jan. 25: The WHO confirms 1320 cases globally. Australia, Nepal, and France report their first cases.
- Feb. 11: The WHO names the illness COVID-19, and the coronavirus that causes it.
- March 11: The WHO declares COVID-19 a pandemic.

3. Analysis of COVID-19

3.1. Analysis of pathogenic mechanism

The SARS CoV-2 structure has information about pathogenic mechanism and its variation is responsible for disease severity. Understanding of anatomic pathology in terms of disease progression and clinical features is most important to make strategies for diagnosis and treatment plan. Study shows clinical complexity and differentiation about pathology knowledge and importance of genetics and immunology in better understanding of pathogenic mechanism [11].

3.2. Analysis of disease progression

Disease progression in SARS CoV-2, consists of several steps where viral replication, transmission, immune reaction and organ destruction leads to severe conditions and sometime deaths. The duration of SARS-CoV-2 is significantly longer in stool samples than in respiratory and serum samples, and virus persists longer with higher load and peaks later in the respiratory tissue of patients with severe disease [12].

SARS pathogenesis of the multi organ shows certain clinical symptoms such as:

- Lung: lymphopenia and hemophagocytosis
- Spleen: white-pulpatrophy

Symptoms

- Cytokine deregulation
- Pneumonia
- Gastrointestinal cases,
- Splenic atrophy
- Diarrhea

Utilization of specific and targeted drugs at suitable regions and identification of pathogenic mechanism for better diagnosis and treatment strategies is ultimate goal of disease progression.

3.3. Analysis of coronavirus replication

Coronavirus replication refers to the release of new virions through vesicles by the cell secretory mechanisms. The synthesis of virus-specific RNA and proteins via virus and cell plasma membranes fusion is completed in the cytoplasm. Translation of two polyproteins, pp1a and pp1ab started to form replicase complex, proteins are translated from the 5th of each mRNA, transcribing a 3coterminal set of nested subgenomic mRNAs, as well as genomic RNA, with a common 5′ leader' sequence derived from the 5th of the genome [6].

3.4. Analysis of infection and transmission progress

SARS-CoV-2 transmits via respiratory droplets (2 m) helps to protect from getting infection by maintaining a distance of at least 6 feet. SARS-CoV-2 is highly transmissible with a broad tissue tropism and immune antagonism [13]. Coronavirus infection begins through ACE2 receptors of the human nose or mouth (during breathing and talking process). Then virus proceeds through other body parts where ACE2 is present such as the lungs, intestines, kidneys, brain and heart. After hijacks the body's own systems, it can upregulate ACE2 receptors in other organelles. Upon high severity this condition leads to multiorgan failure. Clinical studies of SARS-CoV-2 infected patients indicate that multiple infection-related characteristics and disease severity (i.e., older age, hypertension, diabetes, cardiovascular disease) share a variable level of ACE2 deficiency, thus the pivotal link between ACE2 deficiency and SARS-CoV-2 infection reported [14]. The term R_0 refers to how many other people one sick person is likely to infect on average in a group that's susceptible to the disease. COVID-19 is currently believed to have an R_0 between 2 and 2.5.

3.5. Analysis of virus production

The folded structural proteins enter the endoplasmic reticulum (ER) and then transported to the ER Golgi for translational mechanism. Assemble of the progeny virions occur due to replication of synthesized structural proteins. Due to occupation of the RNA genome encoding of the structural proteins (like S, M, and N etc.) possible. Understanding of SARS-CoV-2 infection throughout the intracellular viral life cycle and relating that to our knowledge of coronavirus biology is important for analysis of virus production [15].

3.6. Analysis of conserved domain showed information as below

i. Envelope protein (E), Nucleocapsid phosphoprotein (N) and ORF3a are hemelinked locations. The retained domains of human cytochrome C reductases and bacterial EFeB proteins also contain ORF3a. All three domains were strongly overlapping, allowing ORF3a to dissociate the heme iron to form porphyrin. The study shows that E protein hemelinked sites may be important to high infectivity, while N protein may be correlated with virus replication [16].

ii The results of the docking showed that orf1ab, ORF10, and ORF3a proteins were organized to attack the hemoglobin 1beta chain, and porphyrin could be bound by certain structural and nonstructural viral proteins. Deoxyhemoglobin was more susceptible than oxidized hemoglobin to virus attacks. As for the attack, less and less hemoglobin that could hold oxygen and carbon dioxide will cause symptoms of respiratory failure and coagulation reaction, harming many organs and tissues [16].

4. Diagnosis

The recent research trends were mostly focused on the effective diagnosis, where experts suggest that both cost effectiveness and sensitivity are associated with COVID-19 diagnosis. Individuals under exposed conditions are more likely to get diseases due to higher risk of COVID-19 exposure. Under such conditions, diagnosis has very important role in segregating individuals based on their clinical condition and stop any further possibilities of infections. Valid and international guidelines are available for better diagnosis approaches in COVID-19 as below:

- https://www.who.int/publications/i/item/diagnostic-testing-for-sars-cov-2
- https://www.cdc.gov/coronavirus/2019-ncov/hcp/testing-overview.html

Several studies are available with updated information about selection of specimens and various diagnostic methods for the laboratory diagnosis of SARS-CoV-2 infection [17].

There were several methods applied in public health based on disease type, infection type and individual type. Molecular and immunological diagnostic tests are used for detection of either the virus (SARS-CoV-2) or virus-induced immune responses and their working mechanisms and compare their analytical performances [18].

i. **Serological tests**

It can quantify antibodies or proteins against COVID-19 infections. It is a symbol of body's immune response to the infection. Its significance lies in population or community infection status.

ii. **Biochemical test**

It can measure biochemical markers of virus infections. Various pathological examinations done to ensure the infection possibilities. However, for exact confirmation not in use.

iii. Immunological tests

In case of early infection when the body's immune response is building, antigens test ensures virus pathogens detection while antibodies of host may not be detected in early stage. Host antibody test also indicates presence of infection; however, sensitivity and specificity are the major associated limitations, so for confirmatory test genetic tests are highly recommended.

All above mentioned tests have limit of effectiveness for diagnosing COVID-19 that's why it should not be used as the confirmatory diagnosis test for COVID-19. Although for general indication of infection, and with other clinical phenotype similarities these are used extensively by public health authorities due to easy to use and cost-effective purpose.

The literature review and stakeholder feedback indicate that risks associated with COVID-19 transmission, morbidity, and mortality can be exacerbated by the housing.

iv. Genetic tests

This test for the viruses' genetic material in suspected persons. Here, cotton swab is used to collect a virus sample from the back of nose or throat. RT-PCR test used to detect COVID-19 genetic material RNA. In RT PCR test firstly, viral RNA converted into DNA with the enzyme reverse transcriptase then by using chemicals amplification of the DNA, completed by the PCR instrument. The RT-PCR test detect live or very recently dead virus and as the infection finished the test become quickly negative, so RT PCR considered as the gold standard for diagnosis of SARS-CoV-2. Several SARS-CoV-2 genetic sequences was uploaded to the Global Initiative on Sharing All Influenza Data (GISAID) platform, so research professionals can develop a diagnostic kit-based on choice of candidate genes for COVID-19 by designing of primers and probes [19].

5. Treatment

Treatments for COVID-19, depends on exact drug action on disease pathway. Worldwide researchers are engaged in developing an effective drug for COVID-19 treatment. Various therapeutics will be approved to treat COVID-19 by authorities at time to time in different countries based on their own experimental data and understandings.

Tocilizumab (TCZ), a monoclonal antibody against interleukin-6 (IL-6), emerged as an alternative treatment for COVID-19 patients with a risk of cytokine storms recently [20]. Chemoprophylaxis (including Traditional Chinese Medicine (TCM) agents), therapy (including lopinavirritonavir, umifenovir, favipiravir, interferon, remdesivir, antiviral drug combination, hydroxychloroquine/chloroquine, interleukin-6 inhibitors, interleukin-1 inhibitors, glucocorticoid, qingfei paidu decoction, lianhua qingwen granules/capsules, convalescence-6 inhibitors, chemoprophylaxis oxygenation (ECMO)), and recommendations to help and support healthcare workers caring for COVID-19 patients [21,22]. Hydroxychloroquine (HCQ) is being recommended as chemoprophylaxis drug for asymptomatic healthcare personnel handling COVID-19 cases, frontline workers, and asymptomatic contacts of the confirmed cases, while hydroxychloroquine-azithromycin combination for patients with serious sickness [23].

Use of drugs and variation in effects at various clinical patients give chance to medical authorities to use and research on different targeted drugs, which can demonstrate its efficacy and appropriate uses.

5.1. New drugs and their targets

All drugs are currently used in treatment of COVID-19, have some effects and influence on pathway of virus progression or virus life cycle. They work on targeted regions and enhances the immunity, inhibit virus production. Target on virus is better option in compared to host targeted drugs due to high severity and deaths risk of corona virus. Few very common drugs are mentioned below:

- Veklury (remdesivir), in Japan and Australia
- Dexamethasone, in the U.K. and Japan.
- Hydroxychloroquine and chloroquine in USA and other countries.
- Convalescent plasma in USA, Europe and India

5.2. Drug discovery

Drug discovery and development is related to research and technology associated with progress from large molecule to small molecules drugs treatments and now focused on precision medicine level. AI based drug discovery and machine-learning approaches are helpful in identifying drug potential regions in millions of compounds in a short time period [24]. Using advanced tools for computational & cloud, researchers can be able to screen suitable candidates with software's, analytics, image processing, AI and ML application in drug discovery [25].

4.2.1. Vaccine

Currently, all the nations have started vaccinations in their respective countries. There are many types of vaccines are available, namely RNA Vaccines (Example: Pfizer–BioNTech COVID-19 vaccine and the Moderna COVID-19 vaccine); Adenovirus vector vaccines (Example: Oxford–AstraZeneca COVID-19 vaccine, the Sputnik V COVID-19 vaccine, Convidecia, and the Janssen COVID-19 vaccine); Inactivated virus vaccines (Chinese CoronaVac, BBIBP-CorV, and WIBP-CorV; the Indian Covaxin; Russian CoviVac and the Kazakhstani vaccine QazVac), Subunit vaccines (Example: peptide vaccine EpiVacCorona and ZF2001) and some other types (Example: DNA plasmid vaccines, at least two lentivirus vector vaccines are in clinical trials).

4.2.2. Risk and control

The focus of control response is to identify top risk associated with COVID-19 transmission or progression. The control strategies should be adapted based on regional risk and behavior requirements.

4.2.3. Behavior risk

- Cleaning: washing with detergent cause skin irritation and disruption so soap and saline water is another option for sanitization.
- Handling mask: wearing mask is one of challenging task where we have to avoid touching mask and face and use of regular hand washing.
- Social distancing: physical distancing, and shelter-at-home at your location.
- Quality of mask: wearing high quality mask having filters to stop the transfer of virus particles is need in hospital and containment zones. In normal places, people can wear surgical mask for protection. Mask made up of cotton can be washed with precautions. N-95 respirators mask is costly and are reserved for medical personnel on priority.
- Promotion of preventive measures: set up public hand washing platforms at common places, and distributing mask, soap, protection kits, gloves, sanitizers are best strategies.
- Supporting health systems: surveillance and monitoring health status through thermometers, blood pressure, oximeter and identification of infected persons and share their information to regulatory health authorities is best public health system.
- Knowledge sharing: Education enhances current understanding about pathogen and required protection from them.

4.2.4. Risk in society

People in high risk are advised to take preventive measures, by ensuring self-protection strategies mentioned above.

- Old age persons (60 and over).
- Complex disease persons (such as cardiovascular disease, diabetes, chronic respiratory disease, and cancer).
- Houses nearby hospitals or contentment zone
- Crowded places such as railway stations, airports, shopping malls, religious places etc.
- Biochemical Research Progress
- Transmission and Risk of Progress

The virus can spread during cough, sneeze, speak, etc. in form of liquid droplets of various sizes.

https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19-how-is-it-transmitted. A study paper on SARS-CoV-2 transmissions in Phuket, Thailand's, the second most visited tourist destination explore that during sharing accommodation with an infected case, and exposure to a case with several documented secondary transmission, increased the SARS-CoV-2 infection probability [26]. Some confirmed cases do exhibit a higher risk of spreading SARS-CoV-2 to their contacts compared to other confirmed case.

- Drugs Formulation and antiviral agents
- Therapeutics and Chemotherapy

6. Advanced technologies and adaptations

Technology enables to make the process easy and faster, which further helpful for early diagnosis. Technology can contribute to disease prevention by stopping the spread of virus, release early warning etc.

Several new age technologies empowered the healthcare field extensively such as AI, IoT, cloud computing, data-analytics, robotics etc. by contributing to diagnosis and preventive systems.

Digital health technology provides successful solutions such as for population screening, tracking the infection, allocation of resources, and designing targeted responses (https://www.who.int/news/item/03-04-2020-digital-technology-for-covid-19-response).

Digital revolutions have major impact on the healthcare [27]. COVID-19 pandemic enhances several new innovation and technology that were already well underway before the pandemic, these technologies were mentioned below:

6.1. Artificial intelligence

Artificial Intelligence (AI) is playing an important role in analyzing large datasets based on specific algorithms. This technology is helpful in forecasting of persons health status, which became difficult to predictable, and to help effective public health logistics. Early diagnosis of infection, medication and vaccine production and the reduction of the workload of healthcare staff are the key applications of AI [28]. Through AI tools, one can understands large amount of data through underlying patterns, thus enabling computer systems to make decisions, predict human disease, and recognize images and human health etc. AI-enabled systems work continuously based on data inputs by any stakeholders, so these capabilities will be valuable to confront and adapt for set of disease models. AI is playing important role in suggesting disease biomarkers, vaccine components, understanding viral protein structures, and 3D structure of a protein based on its genetic sequence [29]. The human cells and virus spike protein could be more understandable in terms of configuration and functional aspects.

6.2. Internet of things (IoT)

IoT also accelerate computing system, thus data transfer and storage and computation algorithm become easier in actions. IoT transform the user experience profoundly, providing device options, that makes healthcare models better and monitor daily health status more comfortable can become quite easy to use. This is useful in monitoring movement and tracking subjects and transfer data (Fig. 3).

6.3. Data-analytics technologies

The data-analytics technologies identifies trends and results easily and accurately. Such technologies can be easy in analyzing large data sets of people and thus helped in pandemic management. Through technology integration of AI, Cloud computing, IoT, data analytics it becomes easy and fast to identify and monitor individuals, track them, alert them for risk behaviors associated with virus transmissions associated with infected and quarantined persons.

- Biosensors and Bioelectronics
- Genomics

Our understanding of the advanced genomics improved much due to advent of next generation sequencing technologies. Understanding relationship between viral RNA load kinetics and disease severity is quite challenging. Angiotensin-converting enzyme (ACE2) serves as the receptor binding site for SARS CoV-2 in hosts. Angiotensin receptor 1 (AT1R) blockers, such as losartan, can be used as therapeutics for reducing the severity of SARS CoV-2 infections [30].

In a ferret model of H1N1 infection, the loss of viral culture and the absence of viral RNA coincided with the end of the infectious period, here RT PCR results remained positive 6–8 days after the loss of transmissibility [31]. For SARS corona virus, viral RNA is detectable in the respiratory secretions and stools of some patients after onset of illness for more than 1 month, but live virus could not be detected by culture after week 3 [32]. The inability to differentiate between infective and non-infective (dead or antibody-neutralized) viruses still challenging by RT PCR.

- Proteomics
- Statistical and Mathematical Modeling
- Nanotechnology and Effectiveness
- Chemi-informatics
- Drug Mechanism and Treatment

6.4. Nanotechnology in COVID-19 detection and treatment

The small size of nanoparticle (1–100 nm) is the main reason for achieving the exceptional behavior than that of its bulk form. Nanoparticle exhibits unique chemical, physical and electronic properties, which leads to its diverse application in various fields [33–37]. There are different nanoparticles which include some organic molecules (e.g., dendrimers, DNA, lipids, viruses, and micelles), and inorganic molecules (e.g., iron oxide, gold, quantum dots, carbon nanotubes, and fullerenes) [38]. Nanoparticles have played a great role as a sensing material in electrochemical and bio-sensing. Metal nanoparticles, oxide nanoparticles, semiconductor nanoparticles and even composite nanoparticles have widely used in sensing of the biomolecules. Generally, in electrochemical sensing the basic function of nanoparticles may involves step by step process as immobilization of biomolecules, catalysis of electrochemical reactions, enhancement of electron transfer, labeling biomolecules and acting as reactant. Nanoparticles were also used as a drug carrier in targeted drug delivery and drug loading applications. By using the unique luminescent properties of the nanoparticles in MRI, researchers have studied the cancer cells. The large specific surface area and high surface free energy of the nanoparticle adsorbs the biomolecules strongly which immobilizes the biomolecule for biosensor constructions. The possibility of modifying the surface of gold nanoparticle has opened the door of its application in cancer treatment. A good biocompatibility and controllable bio-distribution patterns were observed for functionalized gold nanoparticles. Hence, nanoparticles have become fine candidates for the basis of innovative therapies [39]. Looking these advantages and performance of nanoparticles in medical field, researchers are trying to solve the current problems caused by the

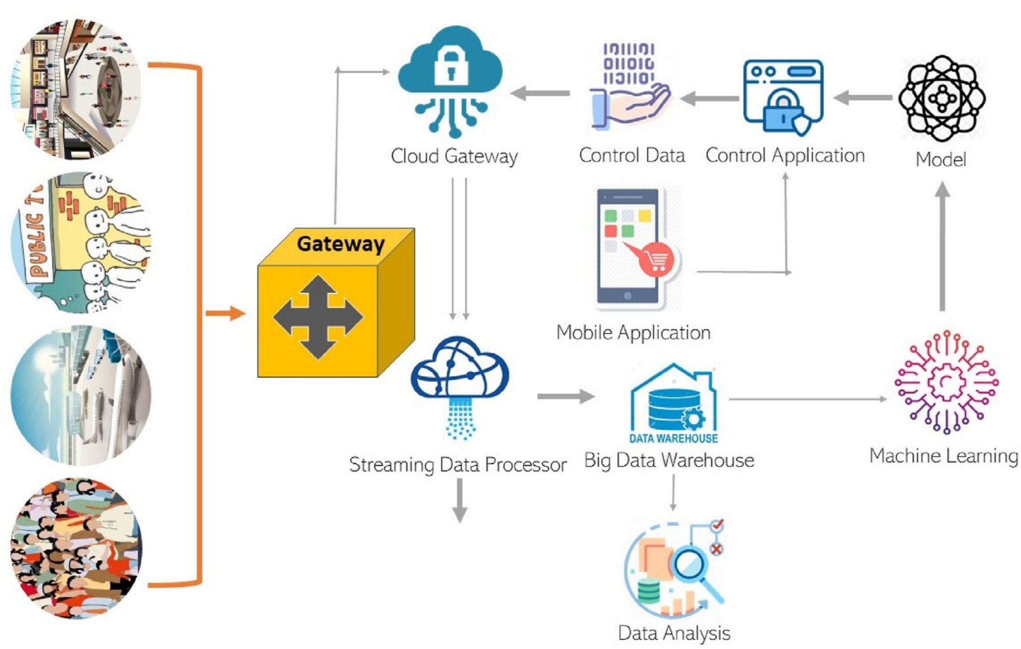

Fig. 3. Proposed digital architecture for COVID-19.

SARS-CoV-2 virus.

To fight against the COVID-19, nanotechnology-based approach should be attempted. Not only for COVID-19 but also for any future pandemic, the nanotechnology can be employed in number of ways. Nanotechnologies can be used in the development of vaccines and drugs, designing of highly specific, rapid, and sensitive kits to detect infections or immunity. Nanotechnology can be also employed in making of superfine filters for face mask or blood filtering, designing of surface coatings which will offer resistant to virus adhesion as well as inactivate its toxic nature, and the improvement of tools for contact tracing [40]. Moitra et al. have performed a selective naked eye detection of SARS-CoV-2 virus by developing a colorimetric assay. They have capped gold nanoparticles (AuNPs) with suitably designed thiol-modified antisense oligonucleotides (ASOs) which is specific for N-gene (nucleocapsid phosphoprotein) of SARS-CoV-2. This experiment resulted with the diagnosis of positive COVID-19 within 10 min.

Fig. 4 shows the detail procedure and techniques followed to detect the SARS-CoV-2 virus. The viral sample was collected, and the viral RNA extraction was performed. This RNA added to the ASO-capped gold nanoparticles. After 5 min incubation the thiolated ASO-capped AuNPs gets agglomerated. This agglomeration only occurs in presence of its target RNA sequence of SARS-CoV-2. It exhibits a change on its surface plasmon resonance. Again, RNaseH was added and incubated for 5 min and at a temperature of 65 °C. Finally, precipitation of gold nanoparticles was visually detected [41].

Fig. 5 (A) shows the absorbance study of the Au-ASO mix nanoparticles tested against the SARS-CoV-2 RNA. A large redshift of about 40 nm in the aggregation band was observed. Different Au-ASOmix nanoparticles were individually dispersed in the sample in absence of viral load. In presence of SARS-CoV-2 RNA, it tends to agglomerate by forming large clusters and which was confirmed from the increase in absorbance of the aggregation band at 660 nm. The hydrodynamic diameter of the Au-ASOmix nanoparticles increases largely with the addition of its target RNA containing SARS-CoV-2 {Fig. 5 (B)}. Fig. 5 (C) shows the minimal change in the hydrodynamic diameter when the individual ASO capped Au nanoparticles were mixed with each other. A significant amount of clustering was obtained from the TEM images of the Au-ASO mix nanoparticles with its target viral RNA {Fig. 5 (C–F)}. Fig. 5 (G) shows an optimum sensitivity for the 4–6 min incubation of the nanoparticles with the total RNA (1 ng/μL) extracted from the vero cell infected with SARS-CoV-2.

Shan et al. have developed a nanomaterial-based sensor array having capability of detecting the COVID-19 from exhaled breath. The nanomaterial-based sensor has been designed by linking different gold nanoparticles to organic ligands, which provides excellent sensing layer that can swell and shrink upon exposure to volatile organic compounds. It causes change in electrical resistance which leads to sensing. They have conducted the study by observing 49 confirmed COVID-19 patients, 58 healthy controls, and 33 non-COVID lung infection controls [42]. G. Qiu et al. have used a dual functional plasmonic biosensor for clinical diagnosis of COVID-19. The biosensor becomes excellent with the combining effect of the plasmonic photothermal (PPT) effect and localized surface plasmon resonance (LSPR). The two-dimensional gold nanoislands (AuNIs) functionalized with complementary DNA receptors can perform a sensitive detection of the selected sequences from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) through nucleic acid hybridization. The biosensor exhibits a high sensitivity with a limit of detection of 0.22 pM toward the selected SARS-CoV-2 sequences [43].

7. Impact of innovation and technology in preventive measure

Impact of innovation is reflected in public health models extensively due to slight change in results. Small change can influence extensively at broad scale and develop more sustainable healthcare models. Below subheadings will discuss important area where innovation can play role in shaping COVID-19 prognosis models. Solid hypothesis of innovation and technology in research exploration, planning for prognosis models need to be emphasized on certain field.

7.1. Innovation in diagnosis and drug research

Innovation in research brings unique information about the

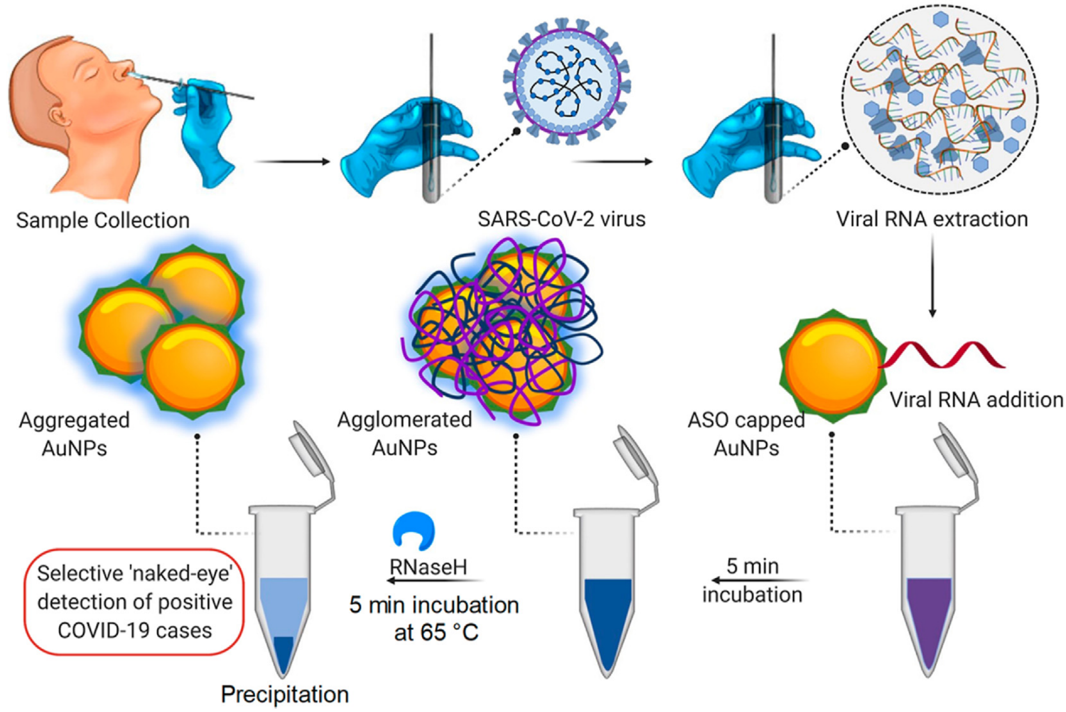

Fig. 4. Schematic representation for the selective naked-eye detection of SARS-CoV-2 RNA mediated by the suitably designed ASO-capped AuNPs. This figure was adopted from Ref. [41].

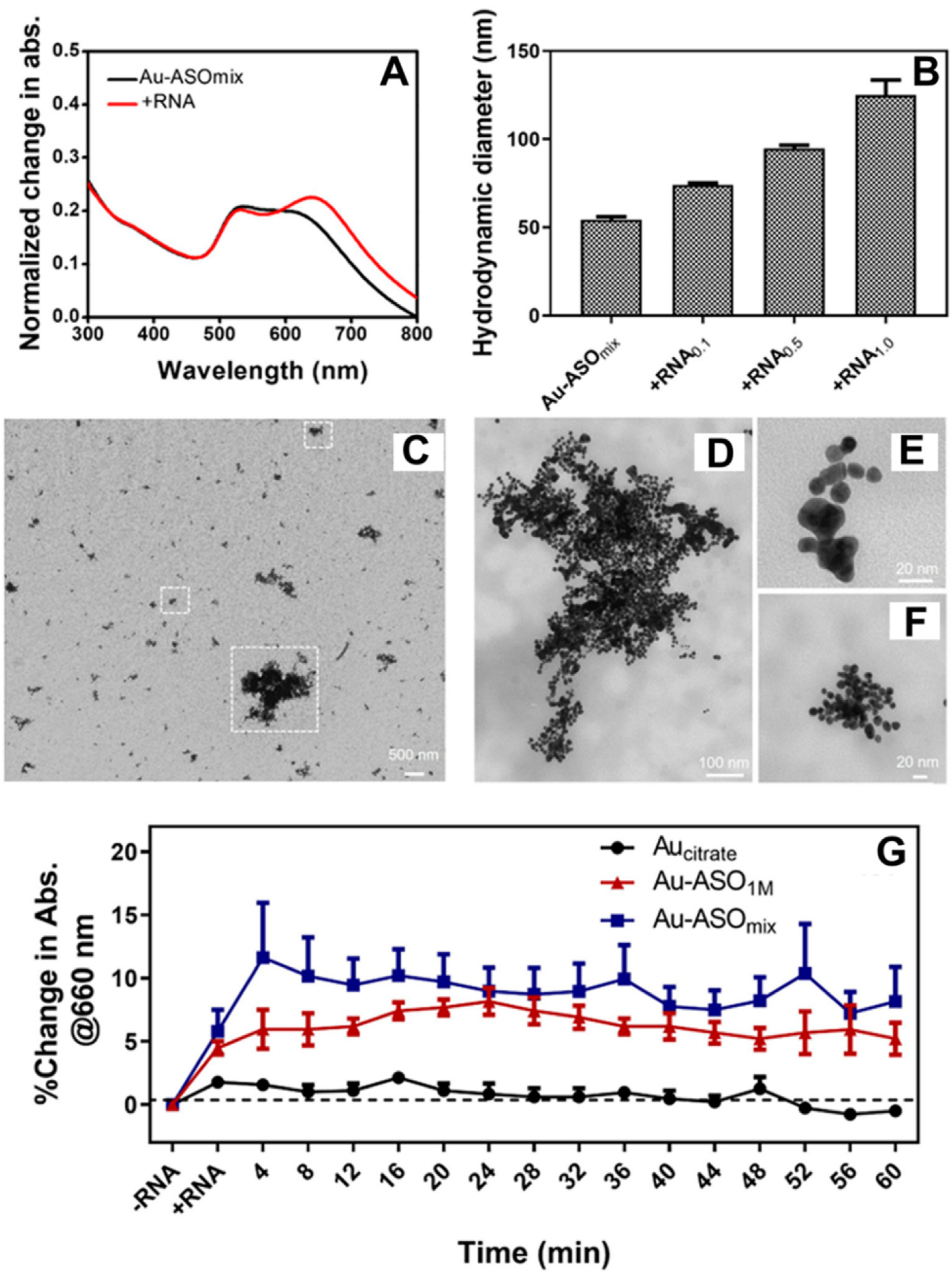

Fig. 5. (A) Change in absorbance of the gold nanoparticles before and after the addition of total RNA containing the SARS-CoV-2 viral load. (B) Comparative change in average hydrodynamic diameter of the composite of Au-ASOmix before and after the addition of RNA (0.1–0.5 and 1 ng/μL) containing SARS-CoV-2. (C–F) TEM images of the Au-ASOmix nanoparticles after addition of RNA containing SARS-CoV-2. (G) The percent change in absorbance at 660 nm of the ASO-capped gold nanoparticles at different incubation time points with a definite concentration of 1 ng/ml RNA. This figure was adapted from Ref. [41]. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

biomarkers and drug development policy. Ideal drugs and diagnostics are suitable for patient, healthy and populations differentiation. Artificial intelligence and genome-based technologies have currently potential to bring new information for diagnosis and drug research. The biological meaning and suitable drug therapy need to understand based on genomic medicine perspective. Molecular basis of human diseases, targeted drugs therapies through Nano technology is best for preventive measures. Research has shown that RBDeACE2 blockers, S cleavage inhibitors, fusion core blockers, neutralizing antibodies, protease inhibitors, S protein inhibitors, and small interfering RNAs are design-based S protein antiviral therapies [30,44].

7.2. Innovation in genomics and gene sequencing

Enormous genetic information contributes to better knowledge about disease mechanism. All genetic variants are important and lead to influence the characteristics through the correlation between genetic sequences and environmental components. More importance has been given to the whole-genome sequencing, which facilitates exclusive genetic information for better knowledge of disease mechanism and thus drug development.

7.3. Innovation in personalized healthcare

The extensive source of genomic information about single individuals and their utilization in the healthcare development leads to establishment of new field called as personalized healthcare. From whole genome to single cell genomics approaches, every information and understanding substantially makes strength of the diagnosis and treatment area and thus personalized healthcare field. Additional technologies such as statistical, computational and mathematical modeling field provide a solid diagnostic and therapy hypothesis, for patient disease control. The personalized healthcare is straightforward path to disease control based on specific information's, although costly but able to deliver fast and accurate healthcare model.

7.4. Innovation in technologies

The use of advanced technologies and their innovative utilization for required work is used extensively for product-based technologies in healthcare gadgets. IoT, AI, cloud computing and machine learning in the drug developing and disease surveillance's projects continue expanding day by day. These technologies having innovative orientation has the potential to drastically reduce the cost, time and outreaching to facilitate complete healthcare package due to fast development of new drug and diagnostic strategies. Innovations will occur drug discovery, biochemical assays developments, clinical trial models etc. Virtual drug trials, and discovery make it easy to reduce costs extensively.

7.5. Innovation in preventive measures

Self-protection is best strategies. Certain precautionary measurement is helpful for neutralizing virus or keeping our-self protect from contact and spread of viruses.

- Washing: frequently hand wash with soap and disinfectant having chemical effects on virus surface.
- Distancing: keeping at least 6 feet distance from everyone and use mobile technology.
- Avoiding: don't touch unknown surface by wearing light weight disposable polythene gloves.
- Using: While coughing or sneezing use disposable tissue.
- Cleaning: clean all house floors with hypochlorite solutions once a day.
- Discarding: all used disposables should be buried inside earth near know places of garden with NaCl (eating salt).
- Keeping: alertness for health by monitoring ourselves, keep warming and eating heathy and warm food and soups.
- Neglecting: avoiding guest and relatives visits and shopping malls unnecessarily cause unknown risk.

7.6. Innovation in chemical science and environment

Target on environment friendly procedure or process through making plan with non-hazardous chemicals to use every time for sanitization and cleaning process will be helpful for sustainable environment. Green chemistry eliminates the hazardous substances by replacing better chemical products and the by-products through this process should be less toxic and ecofriendly [45]. This will be achieved through manufacturing and selecting of eco-friendly chemicals via modification in the mechanism of chemical synthesis, the process, and the management of discarding toxic products. Adaptation of green chemistry helps in protecting the environment and transfer benefit to the diverse biological communities. The guiding principles of green chemistry based on framework for designing ecofriendly materials, products, processes, and synthesis for sanitization and stop virus transmission is major goals [46–48].

8. Road map of chemical science and technology

Authorities works on specific objectives and progress map commonly followed for standard community healthcare system [49]. This roadmap covers the below objectives (Fig. 6):

i. Control coronavirus transmission through non-hazardous methods.
ii. Diagnosis coronavirus through non-invasive methods.
iii. Treat coronavirus without side effects.

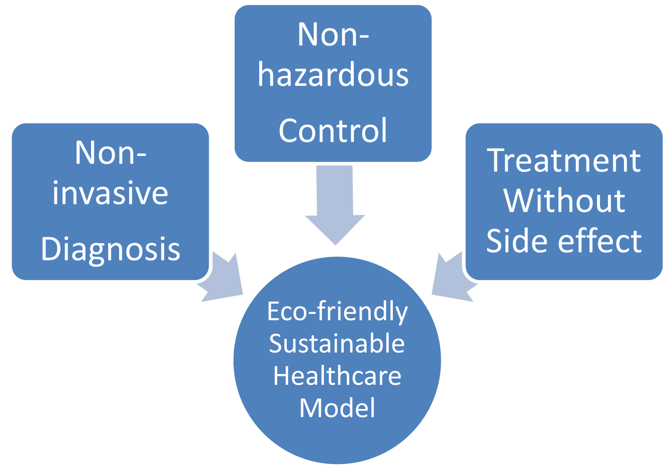

Fig. 6. The sustainable roadmap model of healthcare based on utilization of eco-friendly green chemicals. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

iv. Develop sustainable models of Green Chemical for health.

This roadmap runs on the objective of utilization of eco-friendly green chemicals, at every step of healthcare models. Although in some cases it is difficult to find suitable compounds but through advanced tools of nanotechnology and artificial intelligence and genomics, now it is possible for establishing sustainable model of healthcare. This road map identifies a set of priorities in diagnosis and treatment models, which has certain evidence-based, directions to act on immediately, which further improve the overall health of community. They include:

- Contribution: Cleaning and Protection
- Action: Resource productions and Endless supply
- Monitoring: Regulation and penalty system
- Implementation: Management and Technology
- Analysis: Transdisciplinary platform analyzed for whole structure
- Sustainability: Understanding the input and output resources

Above system will ensure primary requirement of community for cleaning, protection through face covering, diagnosis through non-invasive and treatment through targeted drug mechanism.

- Healthcare Management and Chemical Engineering
- Drug industry and commercialization

The process of bringing a targeted drugs and effective treatment plan of action through innovative drug or therapy in the public health policy is real need of the market. Such kind of framework will develop commercialization aspects and improve industry for real impact.

Innovative ideas and inputs in drug research and technology give highest pace in medicine and health. Several such kind of efforts have revolutionized the current things:

- Artificial kidney for renal patients
- Artificial pancreas for diabetes patients
- Gene editing therapy for genetic diseases

For industry it is important to have commercialized potential of any technologies such as innovators bring suitable, relevant, and cost-effective treatment policy on floor.

Sustainable Chemical Preventive Models: With the adoption of the Global Public Health Plan and coming vaccines options for several countries are leading towards COVID-19 elimination. However, this needs well developed sustainable models having globally verified approaches. This study highlights an overview of advanced technologies and required area of coronavirus, where our control strategies should be focused on eco-friendly chemical free healthcare model. The role of green chemistry is highlighted, and the possible sustainability models discussed in context of host-pathogen prognosis system. Overall, *trans*-disciplinary approaches are essential for sustainable coronavirus control and elimination [50].

9. Conclusion and future prospective

To guide decision-making system for COVID-19 control programs, the aim of this study is to summarize the available information, challenging risk and the actions required to decrease the harmful impact in the environment. Evidence-based control strategies is an imperative process for the development of virus control. This article identifies an absence of sustainable model in control of virus transmission and treatment. Preventive measures along with diagnosis and drugs therapy that target the virus control and stop further transmission have the negative impact on environment due to use of hazardous substances. There is an urgent need in research to screen high-throughput methods, introduce new eco-friendly sanitization chemicals, advanced techniques for monitoring to solve risk behaviors and challenges and open unique avenues, with an innovative eco-friendly compound having virus inhibitory activity. The advanced field of technology will be helpful in prognosis mechanism in a more sustainable way, and act as more transformative to all objectives for eradicating COVID-19.

Author declaration

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

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