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ARTICLE

Scientoons: The Comic Relief in the COVID-19 Science Saga!

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ABSTRACT

Communicating science to non-technical audiences has always been challenging for science communicators. Scientoons are cartoons based on science. They make people smile and laugh and provide scientific information in visual form. So, Scientoons are one of the visual ways of science communication. During the COVID-19 pandemic, scientoons are used as a medium of communication to spread awareness. This paper discusses the importance of scientoons and new scientoons related to the COVID-19 pandemic that has been created to develop awareness about COVID-19 and future pandemics among the general public. Here, we have drawn new scientoons related to all the aspects of COVID-19 i.e., awareness, prevention, risk management, infodemics, vaccines and their working principle.

KEYWORDS: Scientoon, Science Communication, Medium of Science Communication, Public Understanding of Science

Introduction

Good science communication during pandemics has always been a challenge. Today, the spread of information without proper verification is a serious concern. linguistic obstacles must be eliminated and the communicator must possess some scientific training. During a pandemic or epidemic like the swine flu or COVID-19, digital social media networks like Facebook, Twitter and Telegram *etc*. played a significant part in raising awareness of the environment and health hygiene issues by verifying dos and don'ts.

Katz *et al.* (2018) explained that scientists can educate the public through the Heuristic-Systematic Model of Information Processing, which involves two techniques: (1) systematic and (2) heuristic processing. Systematic processing happens when a person is motivated and able to understand information, so they pay close attention to the content. In contrast, when someone is less motivated or struggles to understand the information, they focus on contextual factors like visuals or presentation style to make judgments. Lahuerta-Otero *et al.* (2018) reported that heuristic processing is more common because it requires less cognitive effort. This shows the need for new methods in science communication to improve public engagement and understanding. According to Frohock *et al.* (2022), the human mind is highly receptive to visual communication, making it a more effective means of communication. The "one-size-fits-all" approach no longer works, as everyone has not the same level of scientific knowledge. Therefore, using innovative communication tools that make science interesting and easy to understand is essential.

One such tool is science-based cartoons, or "scientoons," which can reach a wide audience through cultural, verbal, digital, and visual channels. Scientoons are based on the Heuristic-Systematic Model of Information and are not only entertaining but also simplify complex scientific ideas. Jones *et al.* (2022) observed that scientoons have made science more accessible and engaging. During pandemics, especially with COVID-19, scientoons play a crucial role in making science understandable to the public.

Efficacy of Scientoons as Science Communication Tool

Keller *et al.* (2020) found that visual content effectively captures the audience's attention and increases engagement. Scientoons help audiences to remember information better than text alone, which can overwhelm them. Mayer (2009) reported that visuals improve memory recall, making remembering complex topics easier. Wang *et al.* (2021) reported that scientoons can bridge knowledge gaps and reach various audiences, including children and non-experts. Organizations like the Centers for Disease Control and WHO used scientoons in their messaging, such as the "COVID-19 for Kids" cartoon series, to teach children about safety measures during the pandemic. Smith *et al.* (2021) highlighted that scientoons gained popularity on social media platforms like Twitter and Instagram, where they quickly spread and engaged large audiences. Studies show that scientoons receive more shares and likes than infographics. However, Jones *et al*. (2022) pointed out that the humorous nature of scientoons can sometimes lead to misinterpretation, so the message must be clear. Lee *et al.* (2021) noted that humour's effectiveness varies across cultures, so careful consideration of the audience is necessary when creating scientoons. Patel & Shukla (2020) noted that science cartoons are more accessible to younger audiences who might avoid traditional health communication. Wang *et al.* (2021) found that groups who received visual humour had better recall than those who received text-based communication. This is important in a pandemic, where information needs to flow quickly. Many scientoons directly addressed and challenged myths about COVID-19, such as vaccine rejection and disease transmission. Lee *et al.* (2021) explained that scientoons can effectively debunk health myths and engagingly provide accurate information. However, humour is subjective and culturally specific, which can limit the impact of scientoons across diverse groups. Patel & Shukla (2020) highlighted that scientoons were very helpful in disseminating information about Zika virus transmission prevention. They were able to reach communities that might not embrace traditional health communication methods. Silva *et al*. (2018) noted that scientoons can quickly address and debunk common myths surrounding health issues. For example, Lee *et al*. (2021) mentioned that during the COVID-19 period, scientoons illustrated various myths and side effects of vaccines. This made it easier for people to access the most accurate information.

Representation of Scientoons as Preventive Measures

The COVID-19 pandemic was transformed into an infodemic. It brought scientists closer to the public. This underscored the importance of training in effective science and technology communication (Soterio *et al*., 2023). Since 2008, scientoons have gained popularity for illustrating concepts in chemistry and biology. Scientoons have made these subjects more accessible (Pandit *et al*., 2011). During the COVID-19 crisis, we could easily depict the chemistry of hand sanitisers, soap, medicines, and vaccines through scientoons. The WHO recommended hand sanitisers as essential protective measures in response to COVID-19. Alcohol-based hand sanitisers are widely used due to their affordability. They are also easy to prepare.

In response to increased demand, some companies have created their own formulations for hand sanitisers. However, these products have not been verified or licensed for use. Organizations like the United States Pharmacopeia (USP), FDA, and WHO have established guidelines to address this. These guidelines help manufacture and design such products (USP, N.F., 2020). Various countries have adopted these guidelines. Health regulatory bodies now require that all hand sanitiser formulations meet specific standards. Disinfectants come in hand rubs, rinses, foams, and gels. These products often contain isopropanol, n-propanol, and ethanol. The alcohol concentration in these products is typically between 85% and 95%. Research shows that isopropyl alcohol is more effective against a wider range of bacteria and fungi than ethanol. This is true within the 60%–100% concentration range. Adding benzalkonium to isopropyl alcohol sanitisers further enhances their effectiveness (Kapadia *et al*., 2015). This information related to the chemistry of sanitisers can be easily represented to the common people through scientoons, as shown in Figure 1.

Hand hygiene with soap has become the primary protective measure against COVID-19. Soaps are surfactants derived from either petrochemicals or natural sources. They work by lowering surface and interfacial tension between two phases. Camacho-Munoz *et al*. (2014) discussed that the most commonly used

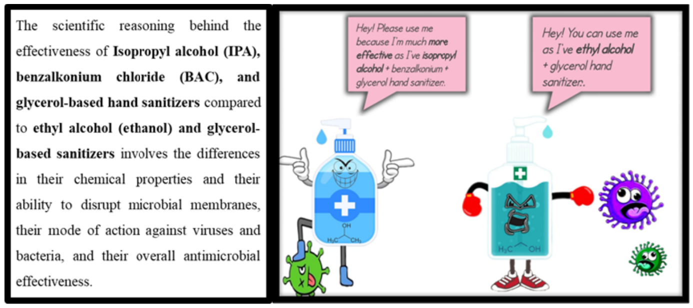

Figure 1. Scientoon is used to evaluate the effectiveness of isopropyl alcohol, benzalkonium, and glycerol-based hand sanitisers

surfactants in soaps, detergents, shampoos, and personal care products are linear alkylbenzene sulfonates (LAS). These LAS molecules have carbon chain lengths of C10-C14. Jing *et al*. (2020) studied the fact that medicated hand soaps often include antimicrobial agents. These agents include triclosan, triclocarban, chlorhexidine, and quaternary ammonium compounds like benzalkonium chloride. Reichert *et al.* (2019) mentioned a growing trend toward using natural product-based soaps. Natural soaps are non-toxic, biodegradable, and environmentally friendly. Borsanyiova *et al*. (2016) noted that nature-derived products, such as microbial biosurfactants and plant secondary metabolites, are effective against various viruses. For example, sophorolipid, a glycolipid biosurfactant, fights enveloped viruses like herpes, HIV, and influenza (Vollenbroich *et al*., 2017). They also found that surfactin, a cyclic lipopeptide biosurfactant, has antiviral activity. Surfactin works against both enveloped and non-enveloped viruses, such as transmissible gastroenteritis virus, Semliki Forest virus, porcine epidemic diarrhoea virus, vesicular stomatitis virus, and herpes simplex virus. The skin compatibility, antiviral and antimicrobial properties, low toxicity, and detergent capabilities of biosurfactants make them ideal for soaps.

Aloe vera gel, sourced from the Aloe vera plant, is used as a natural humectant and viscosity enhancer in soap. Aloe vera contains glucomannans, vitamins, lipids, sterols, and amino acids, and is mostly made up of water (99%). Aloe vera is known

Natural product-based soaps are **effective in combating viruses**, including **coronavirus**, through their **antiviral properties** from natural oils and essential oils. Additionally, they provide a range of **skin health benefits** such as reducing **irritation**, **itching**, and **burning** sensations, while keeping the skin moisturized and youthful-looking. In contrast, petroleum-based soaps often strip the skin of essential oils, leading to **dryness**, **irritation**, and **premature aging**. Therefore, natural product-based soaps offer both **antiviral protection** and **superior skincare** compared to their petroleum-based counterparts.

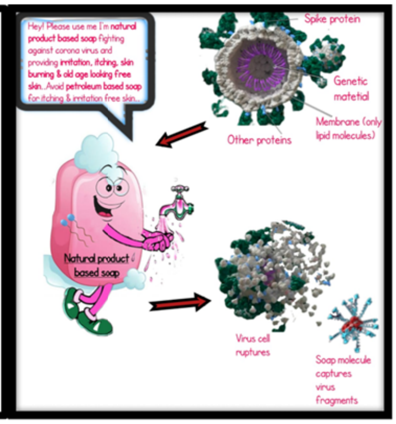

Figure 2. Scientoon for fighting against coronavirus through natural product-based soap

for its medicinal properties, including antiviral and antibacterial effects. Mpiana *et al*. (2020) mentioned that aloin and aloe-emodin are the primary compounds responsible for aloe vera's antiviral activity. These compounds target lipid-coated viruses like SARS-CoV-1, influenza, and HIV. These properties make aloe vera an appealing ingredient in soap formulations. In Uttarakhand's Kumaun region, 22 plant species have been traditionally used as soaps and detergents. Local communities use various plant parts—seeds, barks, leaves, roots, and ash—for washing and bathing. Herbal soaps and detergents offer a viable alternative to synthetic options. The simplified mechanisms of soaps, detergents, and alcohol-based hand sanitizers are presented in Figure 2 through scientoons.

Painter *et al*. (2021) mentioned in their study that the CDC and WHO have identified social distancing as an effective measure to limit the transmission of the novel coronavirus. Kraemer *et al*. (2020) also supported this view. Each infectious disease, such as SARS and MERS, has unique characteristics. Prevention and control strategies typically focus on three key factors, i.e., (i) transmission routes, (ii) pathogens, and (iii) susceptible populations.

Maintaining a distance of 1.5 meters between individuals is one of the most effective ways to reduce the transmission of coronavirus disease. COVID-19 spreads through respiratory droplets and aerosols. In aerosol science, an aerosol is defined as "a mixture of particles less than 100 μm suspended in a gaseous medium." The primary goal of social distancing is to minimize aerosol transmission of the SARS-CoV-2 virus. The transmission pathways of the virus can be categorized into two types: (i) direct transmission via surfaces, wastewater, and the air (e.g., through coughing and sneezing), (ii) indirect transmission through re-aerosolization, such as when flushing toilets (Yao, 2020). Although COVID-19 is primarily transmitted through airborne particles, the specific patterns of its transmission remain unclear. This information can be easily represented through a scientoon in Figure 3.

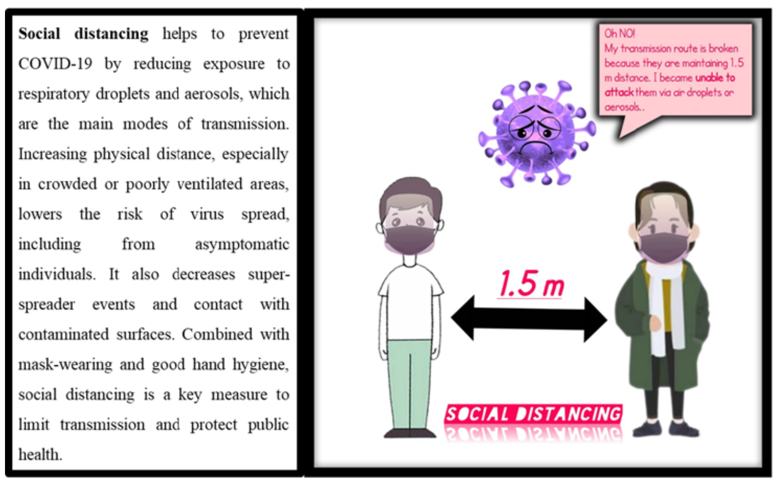

Figure 3. Scientoon for social distancing as a preventive measure of COVID-19

Scientoons related to COVID-19 variants

The COVID-19 outbreak arose in Wuhan, China, in December 2019. The primary symptom of the disease generated by the novel coronavirus SARS-CoV-2 is severe acute respiratory syndrome. Arora (2020). Mentioned in the study that on January 30, 2020, a Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) for COVID-19, and later, on March 11, 2020, it was designated as a pandemic, the second of the 21st century, following the Swine Flu outbreak in 2009. Humanity has previously faced several coronavirus outbreaks, including severe acute respiratory syndrome (SARS) caused by SARS-CoV-1 in 2003 and Middle Eastern Respiratory Syndrome (MERS) caused by MERS-CoV in 2015.

Viruses mutate over time by altering their genome sequences. This leads to the emergence of new strains. This has been observed in SARS-CoV-2. SARS-CoV-2 has accumulated mutations at a rate of about one to two per month. Various new mutants of SARS-CoV-2 have been identified in many regions, including Europe, the United States, Brazil, Nigeria, South Africa, India, and beyond. These variants are classified as: Alpha (B.1.1.7), Beta (B.1.351), Lambda (C.37), Mu (B.1.621), Gamma (P.1), Delta (B.1.617.2), Omicron (B.1.1.529). Scientoons for different variants of SARS-CoV-2 are represented in Figure 4.

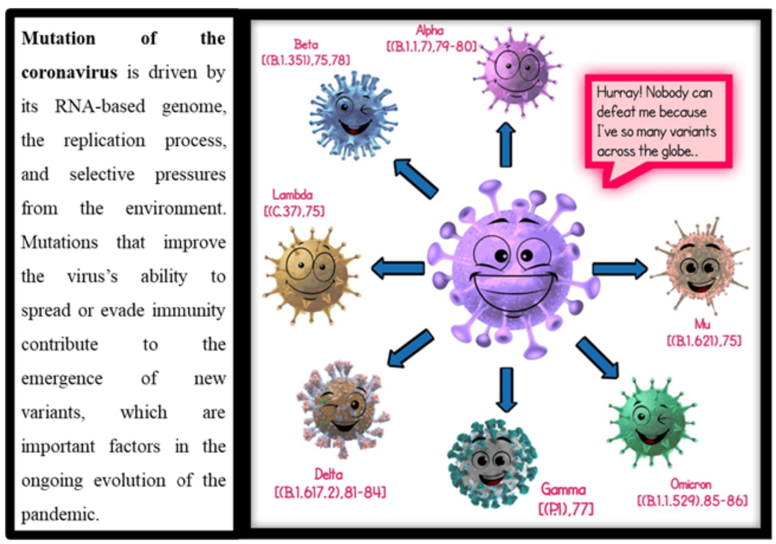

Figure 4. Scientoon for different variants of SARS-CoV-2

The Delta and Omicron variants put unprecedented strain on healthcare systems. These variants potentially caused more deaths. Both variants are highly transmissible (~2x). They also caused more severe disease, leading to increased hospitalizations and deaths. They are capable of evading the immune system.

They challenged existing diagnostics, vaccines, and therapeutics. The currently circulating variants of concern are primarily Omicron and its subvariants. These subvariants include BA.1, BA.2, BA.3, BA.4, BA.5, and their descendant lineages (WHO, Classification of Omicron, 2021).

Scientoons Related to Vaccines

COVID-19 continues to spread and impact over 200 countries and territories worldwide. As of January 2023, more than 663 million confirmed cases have been reported. Over 6.82 million related deaths have occurred globally. Scientific communities worldwide are actively seeking solutions to curb the disease's spread. Significant efforts are focused on vaccine development and related medical research utilizing modern technologies.

In their study, Dhama & Sharun (2020) mentioned that many authorized COVID-19 vaccines target the viral spike protein (S) as the primary antigen. This can either be on its own, in combination with other viral proteins, or as part of inactivated virus vaccines. SARS-CoV-2 contains 25–28 proteins, and research has focused on isolating mRNA from the spike protein. Various strategies are being explored to address the common challenges associated with mRNA-based vaccines. One of these challenges is mRNA instability compared to DNA. The detailed mechanism of action of genetic and protein-based vaccines is depicted in Figure 5.

An innovative approach has created a protein that safely triggers an immune response. This is done using genetically engineered DNA or RNA. The genetic similarities between SARS-CoV and SARS-CoV-2 may aid scientists in developing a universal and effective COVID-19 vaccine. This vaccine could protect against all coronavirus and safeguard us from future viral outbreaks.

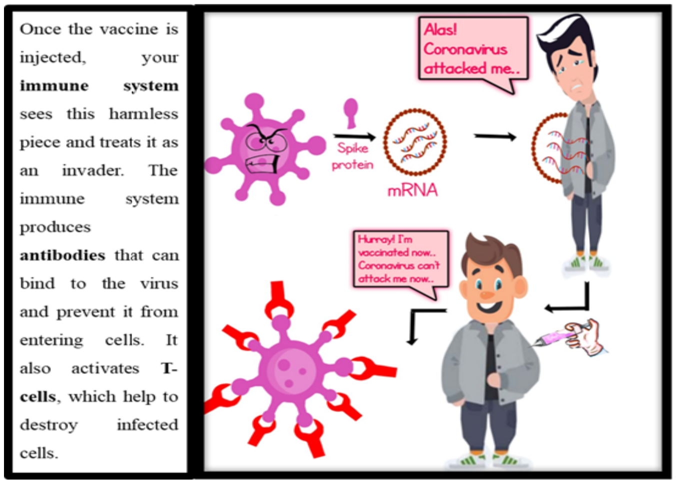

Figure 5. Scientoons for the mechanism of action of COVID-19 vaccines

The spike protein is generated by the current COVID-19 vaccines using different methods. These methods are classified into two main categories. The first category, genetic vaccines, includes mRNA, adenoviral vector (viral vector), and DNA vaccines. These vaccines contain genetic instructions for producing the spike protein in the cells of the vaccine recipient. They are designed with specific genetic sequences to ensure the proper formation and functioning of well-structured spike proteins that stimulate B cells.

In a study by Heinz & Stiasny (2021), it was discussed that the second category is classified as protein-based vaccines. This category includes innovative subunit vaccines and traditional inactivated whole virus vaccines. The spike protein is contained in various forms and combinations with adjuvants in these approaches. These adjuvants mimic SARS-CoV-2 to safely elicit an immune response.

During the early days of the COVID-19 pandemic, only three drug candidates were approved for treatment. These were Vekluri (remdesivir) in Japan and Australia, Avigan (favipiravir) in China, Italy, and Russia, and Dexamethasone in the United Kingdom and Japan. In addition to these medications, several other therapeutics have been authorized to treat COVID-19 in various countries. These include: Lagevrio (molnupiravir), Regkirona (regdanvimab), Olumiant (baricitinib), Ronapreve (imdevimab and casirivimab), Xevudy (sotrovimab), Romlusevimab, Amubarvimab (formerly BRII-198 and BRII-196), Kineret (anakinra), RoActemra/Actemra (tocilizumab), and Paxlovid (nirmatrelvir + ritonavir). Notably, Evusheld (tixagevimab and cilgavimab; AZD7442) has been approved in multiple countries for use as pre-exposure prophylaxis. It is shown in Figure 6.

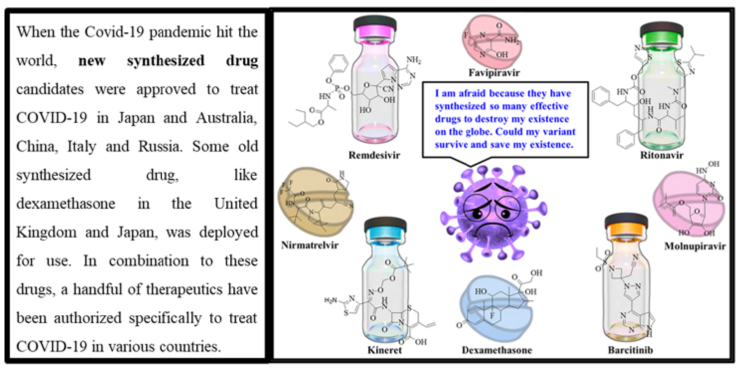

Figure 6. Scientoon showing scariness of coronavirus the drugs

Purified natural products and herbal medicines represent a promising avenue for developing new antiviral drugs. These natural agents have already been recognized for their antiviral mechanisms (Thorne *et al.*, 2022). They interact with various stages of the viral life cycle, including viral entry, replication, assembly, and release. They also target virus-host interactions. Baicalin is a flavonoid compound and the principal active ingredient in the Chinese herb *Scutellaria baicalensis*, commonly known as Baikal skullcap or Chinese skullcap. It has been reported to possess anti-tumor and antiviral properties, among other pharmacological effects (Ye, *et al.*, 2007). Research has demonstrated baicalin's antiviral activity against several viruses. These include the dengue virus, vesicular stomatitis virus, HIV, and influenza virus. Baicalin disrupts the viral replication process.

Calanolide A is recognized as the first natural product identified as an inhibitor of HIV-1 reverse transcriptase. Kinetic assays have shown that calanolides effectively inhibit HIV-1. Calanolide may offer clinical benefits when combined with ritonavir, saquinavir, UC781 (an NNRTI), AZT (an NRTI), and other anti-HIV agents. Currently, calanolide compounds, such as (−)-calanolide B, are in the preclinical and clinical trial phases (Fadus *et al*, 2016).

Curcumin is derived from the rhizome of *Curcuma longa* L., from the Zingiberaceae family. It exhibits antimicrobial activity against various viruses, including HBV. Curcumin works by down-regulating the gluconeogenesis gene coactivator PGC-1α. Notably, clinical trials have reported no significant dose-dependent toxicities associated with curcumin (Fadus *et al*.; 2016). The frightening impact of the coronavirus and the chemical structures of the natural products that act as antiviral drugs, is illustrated in Figure 7.

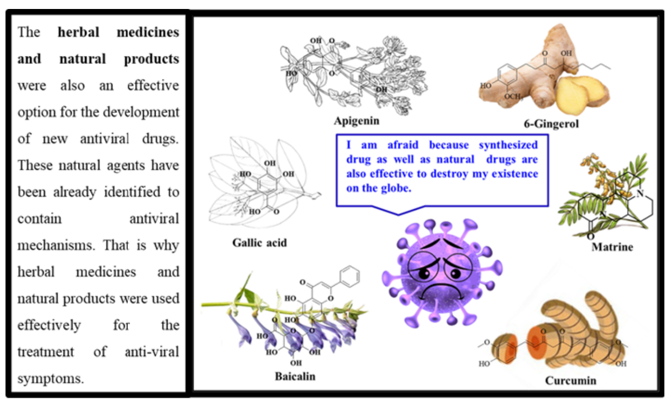

Figure 7. Scientoon showing the scariness of coronavirus to herbal medicines

Numerous readily available natural compounds, particularly phenolic acids, have demonstrated antiviral activity. These include gallic acid, chlorogenic acid, caffeic acid, and quinic acid. These compounds show antiviral effects against the DNA virus herpes simplex type 1 (HSV-1) and the RNA virus parainfluenza type-3 (PI-3).

Apigenin is a flavonoid chemically known as 4′,5,7-trihydroxyflavone. It is abundant in common fruits, plant-based beverages, and vegetables, including parsley, onions, oranges, tea, chamomile, wheat sprouts, and various seasonings. Chamomile, particularly, is a well-known source of apigenin. It is often consumed as a herbal tea made from the dried flowers of

Matricaria chamomilla. Studies have confirmed that apigenin possesses multiple properties. These include: Antiviral, Anticarcinogenic, Antioxidant, Anti-inflammatory, Antineoplastic proliferation, Antimutagenic, and Antineoplastic progression effects (Birt *et al*, 1986).

Matrine is a piperidine alkaloid herbal medicine derived from the roots of *Sophora japonica* (Sophora flavescens). Recent studies have highlighted various matrine activities. These include antiviral, anti-inflammatory, and anti-tumor effects (Wang *et al.,* 2015).

The primary pharmacologically active component of ginger is 6-gingerol. It is known for its wide range of biological activities, including anti-inflammatory, anticancer, and antioxidant properties. Due to its effectiveness in regulating multiple biological targets and its safety for human use, 6-gingerol has garnered interest as a potential therapeutic agent. It may serve as a potent antiviral compound for developing a vaccine against coronaviruses (Kumar & K *et al*, 2021).

Scientoons for Creating Belief in Science and Eliminating Infodemic/Myth

David Rothkopf, a writer for the *Washington Post*, coined the term "infodemic" in 2003. He used it to describe an overwhelming amount of information. This information includes accurate and misleading content, leading to public confusion. Disinformation is often spread with malicious intent. Several factors contribute to the rise of infodemics. One of these factors is low health literacy. Social media can amplify this issue (Ruffell *et al*, 2020).

Infodemics have become a significant concern during pandemics. The WHO also addressed this issue during the COVID-19 pandemic. On February 15, 2020, at the Munich Security Conference, WHO Director-General Tedros Adhanom Ghebreyesus stated, “We’re not just fighting an epidemic; we’re fighting an infodemic.” Daily, misinformation about COVID-19’s origins, prevention, treatment, and protective measures circulated online.

One tragic example of an infodemic occurred in Iran. There, 796 people died from alcohol poisoning. This was due to social media rumours claiming that alcohol could cure the virus (Spring, 2020). Numerous myths emerged during the COVID-19 pandemic. One such myth was the false belief that drinking alcohol could eliminate the virus from the body. In reality, consuming alcohol does not protect against COVID-19. It can, in fact, pose serious health risks.

Common types of alcohol include methanol, ethanol, and ethylene glycol. When methanol is ingested, it is metabolized into formaldehyde and formic acid. This makes methanol extremely toxic. It is associated with high morbidity and mortality. Ingestion can cause vision impairment, including blindness. It can also lead to metabolic, cardiac, and neurological disorders, even after hospital discharge (Mousavi-Roknabadi *et al*., 2021). Acute exposure to lethal doses of methanol may initially cause mild intoxication. This can be followed by unconsciousness, cardiac failure, and death.

Ethanol, typically consumed through the gastrointestinal tract, can also be absorbed as vapor through the lungs. It is metabolized more quickly than acetic acid. Ethanol has several acute effects due to central nervous system depression (Welle *et al*, 2021). A scientoon illustrating this infodemic is shown in Figure 8.

Figure 8. Scientoon about the myth related drinking alcohol and protection against COVID-19

A striking example is a research paper that claimed Vitamin D could combat COVID-19. This paper garnered over 100,000 views. Further investigation revealed that this assertion was nothing more than a myth (Henrina *et al.*, 2021).

Another widespread myth during the pandemic was that cow dung and cow urine were effective against COVID-19. However, there is no evidence supporting the efficacy of cow urine in this regard. Many rumours circulated during the COVID-19 pandemic that had no basis in reality. For instance, some believed that COVID-19 could not spread in hot and humid climates. They assumed that heat would kill the virus. In truth, the COVID-19 virus can be transmitted in all environments, including those with warm and humid conditions.

Some claims suggested that chanting and clapping could eliminate the virus. However, no scientific evidence supports this idea. These actions might only help alleviate stress and anxiety related to the pandemic. They may boost mood and calm the mind (Sahoo *et al*., 2020).

Additionally, reports suggested that newspapers, milk packets, and vegetables could transmit the virus. People believed the virus could survive on these surfaces for extended periods. However, there is no evidence to support this either. Some even thought that the mosquitoes could spread the coronavirus. Yet, the virus is primarily a respiratory virus that spreads through droplets expelled when an infected person coughs, sneezes or exhales (Sahoo *et al*., 2020).

Infodemics pose a significant barrier to effective risk communication. Numerous examples during the COVID-19 pandemic demonstrate how poorly crafted messages can lead to various misconceptions among the public.

Scientoons During, Post-COVID-19 and the Future Preventative Tool

Recognizing the importance of scientoons in pandemics, this paper creates new scientoons. These can be used as a medium to raise awareness among the general public for future COVID-19 cases. Figures 9-12 show scientoons illustrating the pandemic-appropriate behaviour that should be followed in future pandemics.

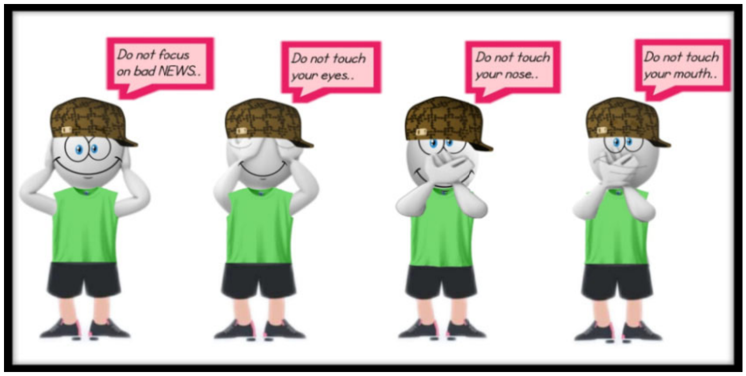

Figure 9. Scientoon for appropriate COVID-19behaviour

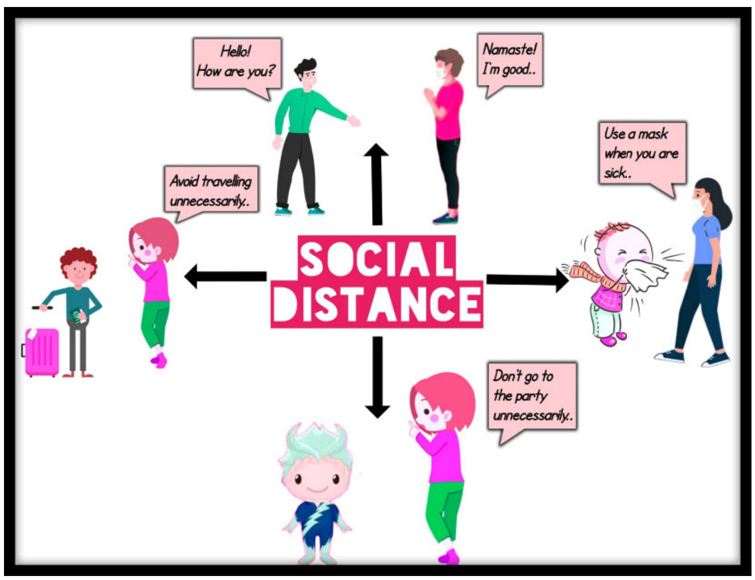

Figure 10. Scientoon for importance of social distancing during pandemics

Figure 11 illustrates the importance of quarantine and lockdown during the spread of pandemics. It shows the virus trying to convince a person to leave their home, but the person refuses. On the road, a cartoon representation of Yama (the Hindu god of Death in Indian belief) is shown. Yama tells the person that he will not take them if they follow the lockdown.

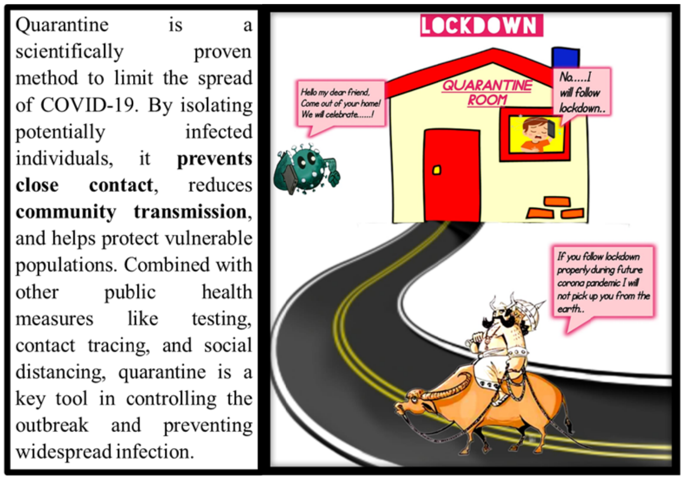

Figure 11. Scientoon depicting smart citizenship during the pandemic

Figure 12 features a scientoons created to highlight the importance of focusing on science communication, scientific temper, and scientoons during pandemic times. The losses during pandemics can be minimized in a world where people have a scientific temper. This can be achieved by combining science communication, scientific temper, and scientoons.

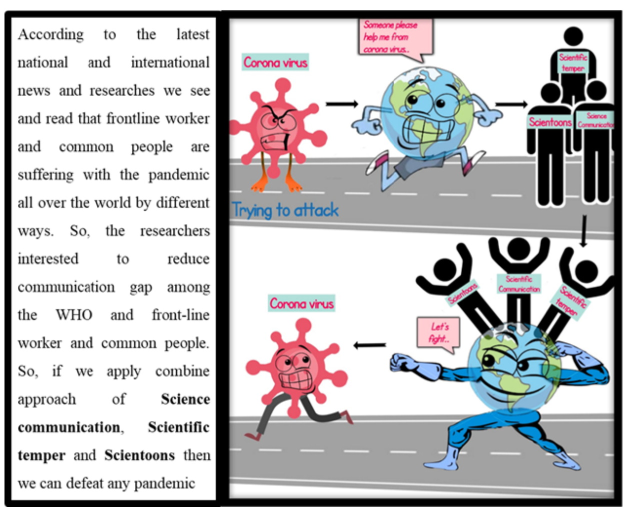

Figure 12. Scientoon for the combined approach of science communication, scientific temper and Scientoons in defeating any pandemic

Conclusion

We have created new scientoons related to different aspects of COVID-19 and related pandemics. Scientoons are an important part of science communication, especially during a pandemic like COVID-19. These scientoons make the language of science easy and interesting. They are also effective in spreading science communication. Scientoons enhance public engagement with science and improve public understanding of scientific concepts. Many scientists, science communicators, and the Indian government have used scientoons to inform and educate people about COVID-19. There are examples of scientoons being available during the COVID-19 pandemic, which highlight their importance. However, scientoons are still not used extensively. This limited use may hinder the effectiveness of science communication strategies. There is a need for more frequent use of scientoons in science writing, reports, and documentaries, especially during pandemics.

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Notes

Conflict of interest: None.

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