Volume 1 Issue: 3 February 2023

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Al-Quds Journal for Acdemic Research
NATURAL SCIENCES

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Front Cover Picture

Internet of Things (IoT) is a new direction for future internet, where anything embedded with sensors, software, and transceiver can access the Internet. The applications of IoT technology include home automation, smart city, smart grid, intelligent transportation system, smart industry, smart robots, smart healthcare, environmental monitoring and geologic disaster forecasting.

Al-Quds Journal for Natural Sciences

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Aims And Scope

Al-Quds Journal for Academic Research is a peer reviewed multidisciplinary journal covering wide areas of research in the fields of natural sciences, Medical and Biological sciences, Humanities, Arts and Social sciences. The journal publishes reviews in hot fields of research. The journal issued on biannual basis; on January the issue will cover research in natural, medical and biological sciences and on June the issue will publish research in Humanities and Arts. Al-Quds Journal for Academic Research accepts research in both English and Arabic Languages for arts and humanities fields and only in English for natural, medical and biological sciences.

Journal Standards

Al-Quds Journal for Academic Research implemented open access policy and accepts high quality research. All submitted manuscripts are subjected for peer review process that include three reviewers working closely in the research field. Authors should aware that manuscripts should describe the research carried by the main author and his team and followed the ethical standards of research. Submission of the manuscript to Al-Quds Journal for Academic Research means that all authors have read and agreed to the Al-Quds Journal for Academic Research policy.

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All manuscripts submitted to Al-Quds Journal for Academic Research should be original and not submitted for publication if full, in part or not under consideration by any other journal. Al-Quds Journal for Academic Research will assess any overlapping or co-submission and have the right to reject any redundant publication. All manuscripts submitted to Al-Quds Journal for Academic Research will be checked against plagiarism and violation of publication rules using the appropriate software and tools available and in service at Al-Quds Journal for Academic Research. When submitting a manuscript to Al-Quds Journal for Academic Research the authors endorse their compliance to Journal’s rules and policies and accept the publication agreement.

Al-Quds University

Founded in 1984, is a Palestinian university, and the only university in the world to be situated by a separation wall. The main campus of the University is located in Abu Dis with four further campuses in Jerusalem, Sheikh Jarrah, Beit Hanina and Rammalh (al-Bireh). AQU provides higher education and community services within the Jerusalem area as well as the neighboring towns, villages and refugee camps in the West Bank. With over 13,000 students, AQU is wide reaching with members from all over the West Bank, including from the districts of Bethlehem, Hebron, Jenin, Jericho, Nablus, Ramallah, Tulkarem, and Qalqilia. With fifteen academic faculties including Arts, Medicine, Dentistry, Law, Qur'an and Islamic Studies and Engineering, AQU has huge academic diversity and offers something for everyone. AQU is a hub of creativity and offers a vibrant learning environment by encouraging an exchange of ideas and freedom of expression, as well as leading innovative research. This allows for the highest standard of education for our students, as well as encouraging them to be active engaged citizens, who are open and cooperative, as well as well informed and interested in world cultures. In order to stay at the forefront of academia, AQU has international partnerships with American and European universities. It is also affiliated with over 30 institutes and engaged in innovative research around the world.

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Tawfik Canaan: A Pioneer Leishmaniologist from Palestine

BIOGRAPHY

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Tawfik Canaan1882-1964

Early life, study and work

Tawfik Canaan was born in 1882 in Bet-Jala near Bethlehem in Palestine. He finished his schooling at Schneller School and traveled to Beirut in 1899 to complete his study in Medicine at the Syrian Protestant Collage. He graduated as a physician in 1905. Then, returned back to Al-Quds (Jerusalem) and worked in the German Hospital. In 1910 he became the director of the clinic of Al-Quds (Jerusalem) municipal hospital, Schaare Zedek. In 1912 he was married to a German and moved to Musrara neighborhood in Al-Quds (Jerusalem) where he established his own clinic in 1913. He specialized in tropical medicine and microbiology in Germany between 1912 and 1914. In 1914, he was appointed as a physician in the Turkish army in Nazareth and head of the Turkish army medical laboratories in Nablus, Beer al-Saba', Gaza and Al-Quds (Jerusalem). At the beginning of his carrier, Canaan became responsible for preparing vaccines and antibiotics at the health office in Al-Quds (Jerusalem). He was later appointed as the head of Malaria research branch. He got more and more involved in the medical activities and community health and therefore became director for the Leprosy Hospital in Talbiyyah in Al-Quds (Jerusalem) in 1919 and, later, in 1956, participated in building a new one near Birzeit near Ramallah. Following the 1948 political turmoil (Nakba), Canaan was appointed as head of the Lutheran World Federation medical operations to cope up with the efflux of refugees by mobilizing mobile clinics and building others.

Later on his efforts succeeded in convincing UNRWA (United Nations Relieving and Works Agency for Palestinian Refugees) and the Lutheran World Federation to establish Al-Muttala' Hospital at the Augusta Victoria Hospice on At-Tour (Mount of Olives) in Al-Quds (Jerusalem). He was the first medical director until 1955 (Nashef, 2006). Canaan died in 1964 at his premises in the Al-Muttala' (Augusta Victoria) Hospital which he helped to establish and was buried in Bethlehem (Nashef, 2006).

Academia

Canaan was a member and the secretary of the Palestine Oriental Society from 1920-1939. He contributed regularly to its journal, The Journal of the

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Palestine Oriental Society by publishing a significant amount of his research therein. He was also a member of the American School of Oriental Studies.

In 1944 he, with other colleagues, founded the Palestine Arab Medical Association. He headed the society and became a member of editorial board for its journal *al-Majallah at-Tibbiyyah al-'Arabiyyah al-Filastiniyyah* in Arabic and English which was issued in December 1945. (Nashef, 2006). The journal ceased to exist in 1948.

Scientific Research

Canaan's first publication in health and medicine was in 1905 (Canaan, 1905). However, his real start in research was with Dr. Muellens, the director of the health office in Al-Quds (Jerusalem) in the field of tropical diseases in 1912. He also conducted research on tuberculosis under the supervision of Hans Much and on dengue fever (Canaan, 1913). He was successful in building a vast network of relationships with many scientists and medical professionals.

Apparently, Canaan extensively focused on building relationship with German scientists starting from Dr. Gruendorf, head of the German Hospital and Dr. Adolf Einzler in Al-Quds (Jerusalem). Others included Dr. Moritz Wallach, Director of Scharee Zaedik Hospital, professors Mühlens, Ruge, Much, and Huntemüler as well Saul Adler, a prominent leishmaniologist in Palestine. These extensive relationships bore fruits for about 94 publications starting from 1905 till 1964, out of which 36 were medical articles. These were published in Arabic German or English journals.

Leishmaniasis, Jericho boil

During his career life, Canaan had made significant contribution to the study and understanding of the epidemiology and diagnosis of leishmaniasis (Jericho boil) in Palestine either by conducting the research or helping those who intended to do so. Canaan was consulted by visiting scientists and sometimes shared clinical specimen with them. This scientific collaboration was meant to drive health research in Palestine.

A shear example is the collaboration with Huntemueller, a German physician, who mentioned Canaan in his publications. Huntemueller visited Canaan's clinic in Jerusalem who showed him some Leishmania cases from natives attending his clinic (Huntemueller, 1914). Two years later and in 1916 Canaan published his first work on leishmaniasis entitled "Die Jerichobeule" or "The Jericho boil" in a German journal. In this article he mentioned that he helped Huntemuller with his research in1913 by verifying Leishmania cases for him through microscopic examination.

Canaan reported that he observed Leishmania cases mainly from Jericho and neighboring areas like Duke and al-A'uja villages. He insisted that leishmaniasis was restricted to Jericho (Ariha) only, not to places nearby like wadi quilt, and to people who visit Jericho such as tourists and soldiers. Canaan described some of the epidemiological features of the infection such as affecting all ages, body sites of infections, incubation period, number of lesions observed on some patients, effect of dress on location of infection, type and characteristics of lesions, being transmitted by insects, diagnosis of lesions, and morphology of the observed parasite. Canaan described the geographical and topography of the area where Leishmania prevails. He also denied Huntemueller's claim of finding new parasite called *Plasmosoma jerichoense* and insisted that it was simply *Leishmania* parasite. Finally, Canaan presented the treatment of *Leishmania* at that time which was mainly Neosalvarsan, a chemical agent used against syphilis before inventing antibiotics in 1940s (Canaan, 1916).

In 1929 Canaan published his second article entitled 'The Oriental Boil: An epidemiological report in Palestine' in an English journal (Transactions of the Royal Society of Tropical Medicine and Hygiene). In this work he showed a change in the distribution of leishmaniasis in Palestine in which he reported cases outside Jericho such as Ein Karim, an Arab village near Al-Quds (Jerusalem), A'rtuf, Amman, Beit-Sahour and Beit-Jala. In this work he compared the Jericho focus with that of Aleppo in terms disease characteristics. In the 1929 article, the medical terminology has developed and became more technical reflecting better understanding of the disease behavior and determinants. For instance, using Leishman-Donovan bodies to designate the parasite form infecting the host, the involvement of *Phlebotomus papatasi* sand fly as a vector, sand fly infection rate, seasonality of infection, night biting habits of sand fly, infection sites of the host in which exposed sites namely limbs and face are more prone to infection, age group of hosts as children are more exposed to infection and incubation period. Canaan confirmed the absence of mucocutaneous leishmaniasis in Palestine. Within a decade from his first publication on leishmaniasis in 1916, he became more experienced in the field. He built more relations with the leishmaniologists of his time such as Destrowsky, Adler and Theodor, Katzellenbogen,

Huntemueller and others. He was already aware of their work and efforts in the field. Visceral leishmaniasis (VL) which Canaan designated as leishmaniasis vesceralis (Kala-azar) was first reported by him in Al-Quds (Jerusalem) in 1931 and by Ostrovsky in Haifa in 1930. He even mentioned that cases were present even before these dates but never on an epidemic scale (Canaan, 1931, 1937 and 1945).

In 1945 Canaan published his third article on leishmaniasis in Palestine. The article is overwhelming and reports both cutaneous and visceral forms of leishmanisis in the Mediterranean basin including Sudan. Canaan reported 67 cases of VL in 51 sites in Palestine. Al-Quds (Jerusalem), Jaffa, Burkin, Yazur, Bet A'tab, Birzeit, Beit Iksa, Haifa, Nablus, Tulakrem, Lyddah (al-Lidd) and Halhul near Al-Khalil. VL was recorded in the mountainous and coastal areas and affecting all age groups with children comprising more than half of the cases. Arabs and Jews were infected alike. One Jewish girl who had a *leishmania infantum* case showed lesion on the cheek.

This article traced the change of epidemiology of cutaneous leishmanisis (CL) in Palestine (Figure 1).

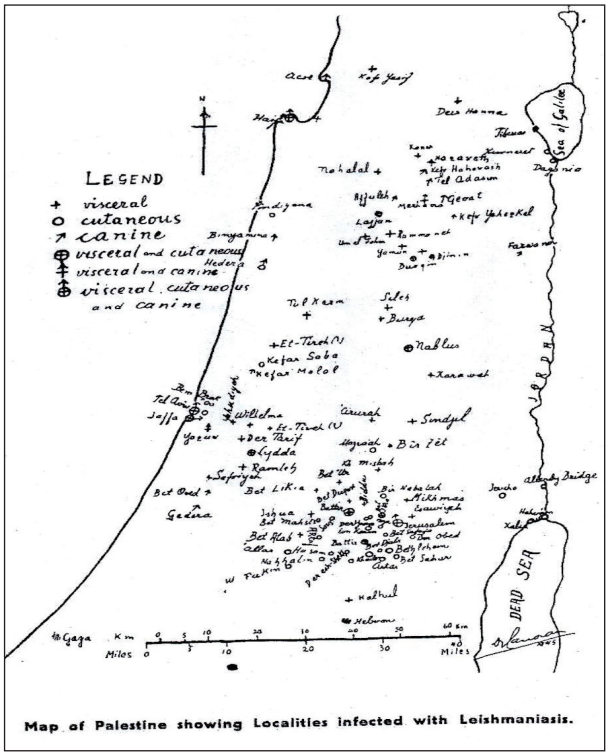

Figure 1: Map of Palestine showing localaties infected with leishmaniasis as drafted by hands of Tawfik Canann (Canann, 1945)

Before the World War I, leishmanisis was restricted solely to Jericho (Ariha), but in the 1930s and 40s cities like Beit-Jala, Beit-Sahur, Bethlehem and Irtas, a village nearby, became active CL foci. Canaan explains this spread as contamination arising from Jericho, Jewish immigrants and Egyptian Army. He, in the article, traced the epidemics of CL and VL in Palestine prior to World War I till 1945 and tried to find differences between the two forms of infection in terms of vectors and hosts including dogs. He described canine leishmaniasis and infantile leishmaniasis in the village of Yazur near Jaffa and other Jewish settlements in 1943 based on work done by Adler. At the end of his work he proposed ways to control the disease such as adopting a reporting system that classifies leishmaniasis as an obligatory reportable infection, killing all infected and suspected animals (Canaan, 1945).

In general, Tawfik Canaan was the first Palestinian scientist to show interest in leishmaniasis as an infection affecting Palestine and other neighboring countries since his graduation in 1910. From his first publication on leishmaniasis in 1916 to his last in 1945, the scope of his research showed to be developing fairly well but remained as descriptive epidemiology based on his own findings, official statistics and data from his colleagues like Adler and Katzellenbogen. It's only after many years to come starting from 1970s that other Palestinian scientists started to pay attention to leishmanaisis.

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Developing Institutions that Serve National Goals: Case Study of the Palestine Institute for Biodiversity and Sustainability

REVIEW

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A B S T R A C T

Biodiversity conservation and sustainable use of natural resources are difficult to manage in light of global and local threats ranging from climate change to Israeli colonization activities. Yet there is increased national awareness of the need to tackle the threats while also engaging in resistance and simple survival activities (sumud). We also must expand research in those areas and bridge the science-policy-practice gaps. These issues are discussed using the case study of the Palestine Institute for Biodiversity and Sustainability (PIBS) at Bethlehem University, an institute that serves national goals of respecting and protecting nature through research, education and conservation. Recommendations are made for establishing more institutions and better networking and prioritization based on national strategies.

Keywords: Palestine, biodiversity, sustainability, insitute for biodiversity and sustainability

Introduction

Most people now have come to realize what biologists and demographers have been saying since the 1950s: that the trend of relationship of humans to nature is unsustainable. In the late 20th century, the conservation of biological diversity became an urgent issue for humanity. This is largely due to the scientific observation of the significant decline in biodiversity accompanying the industrialization that spread widely in the 19th and 20th centuries. The Convention on Biological Diversity (CBD) adopted in 1992 highlighted three key principles: conservation of biological diversity, sustainable use of nature, and fair and equitable sharing of the benefits. Biodiversity is considered at various levels: species diversity, genetic diversity, and ecosystems diversity. Both human diversity and biodiversity are key to stability of human and natural communities. Yet, threats to biodiversity expanded from human population expansion, misguided economic policies, rampant consumerism, and a culture of unsustainable growth, among others resulting in lack of sustainability (Montgomery, 2002). Responding to threats require strong institutions that work in context of the national situation. Here we wanted to highlight a one such institution but drawing more general lessons about sustainability in Palestine.

Case Study

Most of the modern scientific knowledge of nature (fauna and flora) of Palestine was developed by Europeans and later Israeli scientists (e.g. Tristram 1884; Zohary 1966). In the 1960s a young scientist by the name of Sana Atallah (my maternal uncle) became the first Palestinian to get a PhD in Biology. He used to take me as a child to the field to explore nature. Part of his collection was used in the 1970s to educate school students (over 60 school groups visited 1978 and 1979) and was loaned in 1998 to the Lutheran school to help start an environment education center (by my late

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uncle Yaqoub Qumsiyeh, brother in law of Sana). This small snowball grew to several NGOs and institutions engaged in children education and awareness about nature. But there was a deficit in research and conservation related to biodiversity both globally (Liu et al. 2011; Fazey et al. 2020) and locally (Qumsiyeh and Isaac 2012; Isaac et al. 2019). The Applied Research Institute-Jerusalem (ARIJ) was founded in 1990 with a mission of "promoting sustainable development in the occupied Palestinian territories and the self-reliance of the Palestinian people through greater control over their natural resources." But there was a need for better integration of research and increased focus on biodiversity. Conservation and sustainability can not be managed without baseline data on biodiversity. Thus, some fellow researchers, volunteers and students embarked on careful planning for a national institute that addresses this need.

PIBS was started with land and a building provided by Bethlehem University and donations from Prof. and Mrs. Qumsiyeh and from other individuals to provide essential initial infrastructure (Figure 1).

Figure 1: The botanic garden is for both in situ and ex situ conservation and has 382 species of plants

In the transitionary period from 2014-2017, PIBS relied heavily on volunteers and on the generosity of individuals and continued to welcome theirs and your support. The institute grew rapidly and achieved its first five-year plan (2014-2019) earlier (2017) and then reset a new five year strategy which was just concluded (2017-2022). The accomplishments can be seen in the annual reports posted at (https://www.palestinenature.org/annual-reports/). These included three main areas:

Research

We cannot do education or conservation without proper research. For example, educating children on climate change required first doing studies on the available data of climate change and testing best modules for transmitting data on climate change (Qumsiyeh et al. 2022a). Over 100 research papers were published in five years ranging in areas of agriculture, biodiversity, taxonomy, genetics, and education. The research is done collaboratively for example with master students (two masters' students published over 15 papers between them even before graduating). Many interns and volunteers did significant research at PIBS that contributed to our understanding of Palestinian biodiversity (e.g. Adawi et al. 2017; Sawalha et al. 2017; Thaler et al. 2020; Mourad Hanna et al. 2021; Pahl and Qumsiyeh 2021; Al-Sheikh and Qumsiyeh 2021; Sanchez 2022)

Education

Tens of thousands of youth (both school and university students) benefitted by visiting PIBS's Palestine Museum of Natural History (including botanic garden) and through hundreds of activities and workshops covering areas like reducing waste, recycling, composting, respecting nature, biodiversity, critical thinking, science, anthropology, ecotourism, and more. PIBS developed multiple interactive educational modules to use in these activities and collaborated with the ministry of education to review the curricula, as well as extracurricular activities (e.g. environmental clubs and field trips). PIBS also used a mobile educational unit (museum on wheels) to reach to marginalized communities across the West Bank (Figure 2).

Figure 2: Mobile educational unit

Conservation

An animal rehabilitation unit was created that managed to treat or rescue and release over 20 injured animals including hyenas, eagle owls, golden eagle, snake, kestrels, and foxes among others. The most

important aspect of conservation is working with national authorities and other stakeholders to provide effective area-based management including both in situ and ex situ conservation thus bridging science-policy-practice (this is covered in the section below).

Serving the national interest

The National Policy Agenda for the state of Palestine emphasized three themes: working towards independence, improving public service, and sustainable development. In 2015, the state of Palestine signed a number of conventions and treaties related to the environment and sustainable development including the Convention on Biological Diversity (CBD) and the Climate Change Convention (UNFCC). PIBS developed strong relationship with key governmental bodies related to biodiversity and sustainability. The Environment Quality Authority (EQA) is the focal point for the CBD and responsible for the preparation and updating of the National Biodiversity Strategy and Action Plan (NBSAP) and submitting the national reports. The NBSAP helps integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs, strategies and policies. The first NBSAP was written in 1999 but Palestine, like other countries failed to achieve the set targets (called Aichi targets). PIBS led the effort in 2022 to create a new NBSAP that is realistic and achievable. It includes 17 targets and 76 action plans.
PIBS worked with the International Union of Nature Conservation (IUCN) in 2014 to develop the first management plan for a protected area in Palestine, Wadi Al-Quff. The resulting data were published in a special issue of the Jordan Journal of Natural History (Al Sheikh & Mahassneh 2016; Khalilieh 2016; Qumsiyeh, 2016a,b; Qumsiyeh et al. 2016). In the 1990s, a list of supposed "protected areas" were turned over to the nascent Palestinian authority. The designated 51 areas from 2000-2021 were reduced to 50 (49 in West Bank and one in Gaza). Due to limited capacity and involvement of many external actors in the process, there was never a real (re)evaluation of these areas or attempts at studying other potential areas worthy of conservation. In an analysis carried out on the ground in 2022 PIBS partnered with IUCN and the EQA to examin all 50 areas plus 8 more potential areas. Criteria were developed with stakeholder consultation. Twenty-two did not receive a high score to be included. These included 10 that were apparently designated by the Israeli authorities for political purposes, nine that offer no biodiversity value (small patchy remains or plant covers of no significance to PAN), and three that are of similar habitat to other areas (other areas allow for a strong PAN without those). As a result of that analysis, some areas were combined and others were adjusted for borders to arrive at a list of 27 areas worthy of real protection. The total protected land mass increased from 9% to 11%. We then commenced intensive surveys (currently five of the 27 have management plans). If managed well, the new areas would help protect the most vulnerable fauna and flora of Palestine while also contributing to the local population via ecosystem services. On the ground, we succeeded in protecting some areas based on research. For example, the first micro reserve to protect endangered Syrian spade-foot toad and plants in a vernal pool (Qumsiyeh et al. 2022b) and new laws are being drafted now as well as better enforcement mechanisms based on the new NBSAP.

Conclusions and Recommendations

Institutions like PIBS are critical for environmental conservation especially in developing countries (Qumsiyeh 2017; Qumsiyeh et al. 2017). The brief review above highlights role of PIBS in national strategies and action plans including in protected area management and in response to both global threats (like Climate change) and local threats (like Israeli occupation and colonization, socioeconomic deprivation). This is the essence of bridging the science-policy-practice gap. Adaptation and mitigation of threats like climate change and pollution is not merely a technical issue but is also an issue connected to socio-political challenges (Jarrar, 2015; EQA 2016).

Recommendations based on the above:

1) Implement the new NBSAP which has SMART action plans in it
2) Strengthen other existing institutions (NGOs, governmental and academic centers) in areas of biodiversity and network all together
3) Build similar institutions in other parts of Palestine
4) Leverage the new rich available resources for dealing with global and local threats (Climate Change, Habitat Destruction, Pollution, Invasive Species, Overexploitation, and Colonization/ Occupation)
5) Palestine should sign Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Wetlands (RAMSAR), and Convention on Migratory Species (CMS, Bonn Convention) among others. However, there should be consideration of both benefits and obligations of all signed treaties (Jaradat anfd AwadAllah 2015)

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Low Earth Orbit Satellite Communications for Internet-of-Things Applications

EDITORIAL

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A B S T R A C T

Internet of Things (IoT) is a new direction for future internet, where anything embedded with sensors, software, and transceiver can access the Internet. The applications of IoT technology include home automation, smart city, smart grid, smart industry, E-health, environmental monitoring, and geologic disaster forecasting, to name a few. As the demand for high data rate increases due to the huge number of IoT devices, the so-called Low Power Wide Area Networks (LPWAN) have emerged. These LPWAN are designed to cover wide terrestrial areas. Nevertheless, in open areas such deserts, forests and coastal waters of seas, rivers and oceans, there are cost and practical limitation in constructing LPWAN. Therefore, to enable LPWAN in such remote areas, Low Earth Orbit (LEO) satellite communications for IoT have recently attracted considerable interest from researchers. Among the open research issues are interference mitigation, Doppler spread estimation, LEO satellite constellation structure, efficient spectrum allocation, and access and routing protocols. In particular, as the satellite IoT system shares the same frequency band with the existing terrestrial IoT networks and other wireless systems, this results in multiple access interference issue. In addition, the high speed motion of LEO satellites induce a Doppler shift, resulting in inter-carrier interference problem.

Keywords: Satellite, comunication, internet-of-things, low earth orbit

Introduction

Internet of Things (IoT) is a new direction for future internet, where anything embedded with sensors, software, and transceiver can access the Internet (Atzori et al., 2010). The applications of IoT technology include home automation, smart city, smart grid, smart industry, E-health, environmental monitoring, geologic disaster forecasting, to name a few (Asghari et al., 2019). As the demand for high data rate increases due to the huge number of IoT devices, the so-called Low Power Wide Area Networks (LPWAN) have emerged (Mekki et al., 2019). These LPWAN are characterized by low power consumption, wide coverage area, high number of low complexity devices. The main worldwide standardization bodies of LPWAN are the third Generation Partner-ship Project (3GPP) and the Institute of Electrical and Electronic Engineers (IEEE). Therefore, some of these LPWAN are part of 5G mobile cellular networks and include Machine Type Communication (MTC), and Narrowband IoT (NB-IoT) (Rastogi et al., 2020). While the other LPWAN are non-cellular and include Sigfox, Long Range (LoRa) networks, etc. These LPWAN are designed to cover wide terrestrial areas. Nevertheless, in open areas such deserts, forests and coastal waters of seas, rivers and oceans, there are cost and practical limitation in constructing LPWAN. Therefore, to enable LPWAN in such remote areas, satellite communication for IoT has emerged (Chu and Chen., 2021; Kodheli et al., 2021). Indeed, satellite IoT system has covering advantages over terrestrial IoT in the case of extreme topographies such as cliff, valley, and steep slope, where geologic disasters are more easily to happen. In addition, satellite IoT provides a cost-efficient solution with respect to other terrestrial networks in such remote areas. Furthermore, as an extension to the terrestrial IoT network, satellite IoT system is the only approach to achieve global IoT service covering. A Low Earth Orbit (LEO) satellite system consists of a constellation of many satellites in circular orbits at altitudes ranging from 500 km to 2000 km (Kodheli et al., 2021). The satellites can

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either have inclined, or polar orbits, or a combination of the two. The coverage area and duration depend essentially on the number of satellites in the constellation, their altitudes and their orbit inclinations. Nevertheless, many other parameters must be considered to implement a viable system. Such satellite constellations can achieve either global or regional coverage, either real time or delayed communications.

Flexibility, robustness to failure, true global coverage and capability to reuse frequency more effectively than the Geostationary Earth Orbit (GEO) satellite are key advantages of LEO systems. In addition, due to the lower orbit altitude of LEO satellite constellation, it has lower propagation delay as measured by a round trip time (RTT). Furthermore, the propagation path loss will be smaller, results in lower energy consumption from the energy-constrained remote terminals. The main characteristic of LEO systems lies in the use of a large number of small satellites easily designed and launched. The renewed interest in multi-satellite communication systems is not prompted by a motive of competition with conventional GEO and the highly elliptical orbit system HEO systems, but more by the arising demand for satellite IoT coupled with the advance in LEO satellite technology and low-cost launchers. LEO satellites can provide local, regional or global communications. LEO satellite system can be well adapted to providing real-time local and regional communications but only delayed global communications. Several authors have recently investigated LEO satellite communications for IoT applications. Indeed, in Qu et al., 2017, the authors provide an overview of the architecture of the LEO satellite constellation-based IoT including the following topics: LEO satellite constellation structure, terrestrial-satellite IoT interference analysis, efficient spectrum allocation, heterogeneous networks compatibility, and access and routing protocols. In Cluzel et al., 2018, coverage extension of a LPWAN using a LEO satellite constellation is discussed. The authors in Chu et al., 2021 adopted non-orthogonal multiple access (NOMA) scheme to support massive IoT distributed over a very wide range, where two beamforming algorithms are proposed for minimizing the total power consumption. In Lin et al., 2021, the authors provide a survey on the state of the art in LEO satellite access, including the evolution of LEO satellite constellations and capabilities. The authors in Wei et al., 2021, present a comprehensive survey on hybrid satellite-terrestrial maritime communication networks with focus on enhancing transmission efficiency and extending network coverage. In Kodheli et al., 2022, the authors considered the use of LEO satellites to provide the NB-IoT connectivity to terrestrial user equipment's. They proposed a resource allocation strategy for the uplink data transmission which mitigates differential Doppler shift encountered in a LEO satellite. In Fraire et al., 2022, key open research challenges are pointed-out to achieve a successful space-terrestrial IoT integration.

Among the open research issues in LEO satellite communications for IoT applications are interference mitigation, Doppler spread estimation, LEO satellite constellation structure, efficient spectrum allocation, and access and routing protocols. In particular, as the satellite IoT system shares the same frequency band with the existing terrestrial IoT networks and other wireless systems, this results in multiple access interference issue. In addition, the high speed motion of LEO satellites induce a Doppler shift, resulting in inter-carrier interference problem.

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COVID-19 outbreak In Palestine: Early Response and National Strategies Implemented in Confronting the Epidemic

REVIEW

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A B S T R A C T

The early response and management of the coronavirus disease 2019 (COVID-19) and the outbreak in Palestine is summarized in this report. Since the WHO announced the pandemic, COVID-19 has rapidly extended globally within a short period of time putting health systems in many countries on alert. This report aims to provide an overview of the national strategies implemented to contain the ongoing COVID-19 epidemic in Palestine, highlighting the main steps implemented in etiology, epidemiology, vulnerability, social and economic impacts. Containment of the disease was very successful at the early outbreak by legally enforced lockdown which proved a golden strategy to tackle the disease. Community outreach and raising awareness, and implementation of legally enforced preventive measures were essential to contain the spread of the epidemic in Palestine. Monitoring the outcome of health and preventive measures are important to live the epidemic and minimize its unintentional negative impacts.

Keywords: COVID-19, Corona virus, Palestine, Epidemic

Introduction

Severe acute respiratory syndrome coronavirus (SARS-CoV) reported in November 2002 and Middle East Respiratory Syndrome coronavirus (MERS-CoV) reported in September 2012, which emerged as zoonosis in human population from animal reservoirs and caused severe respiratory illness with high mortality rates. Another Sever Acute Respiratory Syndrome coronavirus-2 (SARS-CoV-2) has been emerged for the first time in Wuhan, China in December 2019 causing highly contagious and severe illness; identified as Coronavirus Disease 2019 (COVID-19) (Du Toit, 2020). SARS-CoV-2 is classified as a novel Betacoronavirus belonging to the Sarbecovirus subgenus of Coronaviridae family. This virus has never previously been identified in humans (Cyranoski, 2020). Millions of people around the World have been infected, and more than a hundred thousand deaths. The World Health Organization (WHO) declared COVID-19 a global pandemic spread in 213 countries and territories, United States of America, Italy, Germany, France, United Kingdome, China, Iran, Canada, Brazil are among the highly affected countries (Organization, 2020d). Countries in the Middle East where less affected and most of the cases reported were imported from other countries especially European countries, United States and China (Karamouzian and Madani, 2020; Organization, 2020b, d).

The origin of coronavirus-19 (SARS-CoV-2), is still unknown, SARS-CoV virus has been identified in many animals including raccoons, dogs and Chinese ferret-badgers (intermediary source) and in live animal markets, bats species (horseshoe bats) which are the primary reservoir of coronaviruses (Benjamin-Chung et al., 2019; Guan et al., 2003; Wu and McGoogan, 2020). The transmission cycle of COVID-19 is not fully understood, recent studies have reported human-to-human transmission through the droplets generated from the infected person by coughs or sneezes, which

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could potentially infect others remaining in close contact and by touching contaminated surface with the virus (Chan et al., 2020; Huang et al., 2020; Lai et al., 2020; Tey et al., 2020). WHO declared that SARS-CoV-2 may transmitted from person to person via air particularly indoors with poor ventilation (Organization, 2020c). The severity of the virus appears to be lower than that of SARS and MERS (Petrosillo et al., 2020). Among the symptomatic COVID-19 patients, 81% developed a mild to moderate disease characterized by dry cough, fever, or unspecific symptoms such as headache, and fatigue. Only 5% of the patients were critically ill with dyspnea and pneumonia, respiratory failure, sepsis, and may lead to multi-organ failure (Guan et al., 2003). Some Palestinian patients with COVID-19 claim sudden loss of smell and taste (Palestinian Ministry of Health, 2020). People of all ages are affected, however the severity of the disease is different with age, old people and immunocompromised are under high risk. Children are considered asymptomatic carriers of the virus. However, their potential to transmit the virus has not been ruled out even if they do not show clinical manifestations (Dong et al., 2020).

In the absence of clinically approved drug or pharmacological treatment to treat COVID-19, public health measures are adopted in countries who early suffered from the disease like China, Germany and Italy. These measures include isolation, social distancing, and quarantine of positive cases in specialized health care facilities for treatment and management, and isolation of symptomatic from non-symptomatic patients (Linton et al., 2020; Rothe et al., 2020). Complete lockdown was also implemented in many countries including Palestine.

Effect of environmental conditions are important in the spread of SARS-CoV-2 virus and should subject for more investigation; ambient temperature and humidity are an important factors in the transmission and survival time of the coronaviruses on surfaces (Casanova et al., 2010; Morse et al., 2020; van Doremalen et al., 2013).

As the first outbreak began, different countries start containment of the disease and take strict health measures including lockdown, social distancing and quarantine. Palestine ,like other countries in the world, put strategies and measures for confronting the disease outbreak but differs from other countries in having highly populated refugee camps and crowded areas like Gaza strip which is considered the highest populated territory worldwide (AlKhaldi et al., 2020). The Palestinian management of this health crises is worthy and inspiring. This report aims to provide an overview of strategies implemented nationally to contain the ongoing COVID-19 epidemic in Palestine, highlighting the main steps implemented in etiology, epidemiology, vulnerability, social and economic impacts. This report may be used as starting point in Palestine for further studies and research involving COVID-19.

Palestinian early response

The first Palestinian response expressed from Palestinian Authority president who declared state of emergency on March 5th 2020, initially for one month, the declaration gives the Palestinian prime minister responsibilities to put measures for containment of the outbreak. The outbreak started in Bethlehem where seven patients confirmed positive for SARS-CoV-2 by RT-PCR. The health measures employed entitled in complete closure of schools including kindergartens, daycares and nurseries, universities and colleagues and other higher education facilities, gym and sport facilities, public and governmental businesses except services were shut down. People were advised to stay home and avoid contacts with others (social distancing). Palestinian National COVID-19 response plan released by the Palestinian government on March 26, outlines the strategic measures from a number of key sectors, including health, economy and social protection to contain the outbreak, the government call for combined and complemented efforts of private sector, non-governmental organizations and Palestinian Red Crescent Society (PRCS) and private healthcare providers to contain the outbreak (Agency, 2020; AlKhaldi et al., 2020).

Diagnosis

Patients with COVID-19 were diagnosed in the laboratory using real-time reverse-transcriptase polymerase-chain-reaction (RT-PCR) assay of the nasopharyngeal swabs. Tests were carried out in accordance with World Health Organization interim guidance (Organization, 2020a), and Palestinian Ministry of Health special protocols (Li et al., 2020). Patients found positive for SARS-CoV-2 infection were repeated for confirmation and tagged as a positive result. Chest X-ray is being used for patients with positive result to evaluate the condition and seriousness of the patient especially the functionality of lungs. RT-PCR testing is performed of asymptomatic or mildly symptomatic contacts for the assessment of individuals who have had contact with a COVID-19 patient.

Treatment

Due to the absence of clinically approved treatment of COVID-19 disease, there were no approved

antiviral therapy against SARS-CoV-2. Clinical studies revealed the usefulness of antiviral agents, antibiotic to control secondary complications, corticosteroid, intravenous immunoglobulins especially from COVID-19 recovered patients, and oxygen support (Bhumbra et al., 2020; Huang et al., 2020; Morse et al., 2020; Romani et al., 2020; Wang et al., 2020). Depending on the severity of the case and whether the patient developed mild or sever pneumonia; COVID-19 patients in Palestine are treated according to Palestinian Ministry of Health protocoles, which include the use of Lopinavir - Ritonavir, Hydroxychloroquine, and Azithromycin (Palestinian Ministry of Health, 2020).

Outbreak in Palestine

The number of infected and confirmed cases in Palestine vary from one region to another. Some areas in particular showed higher incidence than other regions. This variation in disease incidence between different areas may be related to rapidly spread of the infection and the obligation and commitment to the preventive measures than other areas and it is an interesting field of further study. The outbreak in Palestine is started in Bethlehem in March, 2020 with seven cases infected after having contacts with SARS-CoV-2 positive visitors from different countries, later on, other outbreaks from Palestinian workers in Israel who returned back and transmit the infection to their families. On May, 2020 Palestinian government declared that outbreak of COVID-19 is under control and manageable and decided to go back to normal life and instruct the public to keep on health and safety measures. On June, 2020 a second wave of COVID-19 outbreak was recorded in Hebron governorate, southern West Bank, where tens of cases reported every day. This recent outbreak alerted Palestinian health system and considered a catastrophic health crises, which required immediate intervention, the highest number of cases were reported by July 16, 2020 (4604 confirmed cases) and the lowest was in May, 2020 (Figure 1). The high shift in number of cases is probably due to many factors including; emergence of a second wave of SARS-CoV-2 transmission worldwide (Organization, 2020c), and the unprogrammed lift of lockdown without considering gradual return to normal life where people did not follow the health and safety rules strictly (Alaraby, 2020). The infected cases in the second wave of transmission (June-July) characterized by severe symptoms and high death rate; three deaths were in March-May while 49 deaths reported by July16, 2020. The recovery rate was higher in March-May compared to Jun and July. The total number of cases by July 16, 2020 was 8617; while the active cases are 7086 (82.2%), the recovered cases were 1482 (17.2%), and deaths were 49 (0.57%) (MOH, 2020).

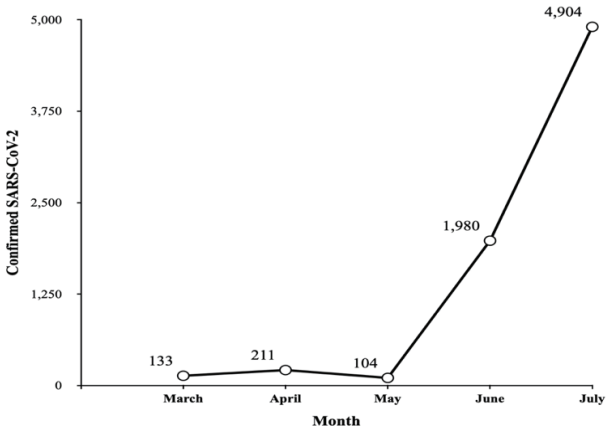

Figure 1: Number of confirmed SARS-CoV-2 cases in Palestine by July 16, 2020. Data were obtained from Palestinian Ministry of Health COVID-19 surveillance system ((MOH), 2020; Palestinian Ministry of Health, 2020).

Preventive health and safety measures

Quarantine

Individuals tested positive for SARS-CoV-2 were quarantined by Palestinian preventive health services in Hugo Chavis COVID-19 hospital, Turmosayya, Ramallah, Palestine. COVID-19 patients received treatment, and medical and psychological follow up free of charge by specialized medical personnel. According to Palestinian COVID-19 protocols, patients are remained isolated for 14 days in the COVID-19 hospital, retested for the presence of the virus. If found negative, they are released for home quarantine for another14 days. Others who contacted patients are legally enforced quarantined either in specialized quarantine facilities or at home for 14 days, depending on the type of the contact circle (AlKhaldi et al., 2020). Preventive health services developed map of contact circles (Figure 2); primary contact circle include individuals who directly and for prolonged time contacted a COVID-19 patient confirmed positive for SARS-CoV-2, others; secondary and tertiary circles include individuals who contact individuals in the primary circle. Individuals in the contact circles are followed up during the quarantine by medical staff, if tested positive, they admitted to COVID-19 hospitals, otherwise released for home quarantine for another 14 days. Depending on the degree of spreading of the disease and how long it took for preventive health services to build map of contacts for each confirmed SARS-CoV-2 patient, the breakdown of the cycle of contacts and contain the spread of the disease.

Quarantine of patients and contacts is proved

effective for containment of the disease and prevent the spread of the SARS-CoV-2 virus to other healthy individuals (Flumignan et al., 2020; Reddy et al., 2020). Mapping circles of contacts is very intensive work performed by medical and security staff and involved legally enforced investigation.

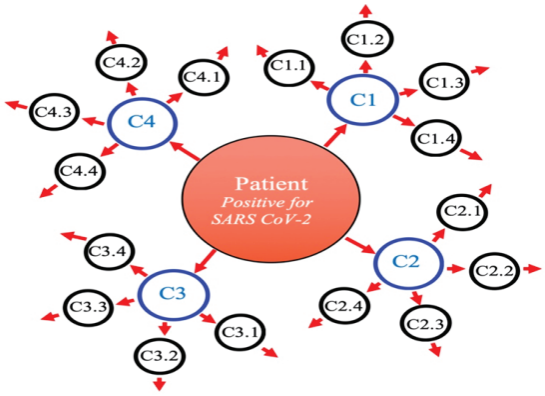

Figure 2: Mapping the circles of contacts. A patient with COVID-19 in the center of the map, C1- C4: primary contact circles, Cx.1- Cx.4: secondary contacts circles. Numbers inside the circles denotes contacts with COVID-19 patient or contacts of contacts. Arrows show the direction of transmission and spread of the disease between patient and contacts

The rapid response in identifying circles of contacts may be effective and crucial to stop the spread cycle of the infection. To perform that; in certain cases Palestinian health authorities ordered to Palestinian Police for mobility restriction of people in newly identified foci for 36-48 hours to have free access to these foci without disruption and carry on health investigation with infected people and with their primary contacts to develop a complete map of contact circles, which will limit the growth of the circles and eventually limit the spread of the virus.

Lockdown and community outreach

Strict preventive measures were implemented and aimed to contain the outbreak of the disease and mitigate the spreading to other areas in the country. The lockdown was legally enforced to all businesses (public and private). However, food shops, groceries, pharmacies and bakeries were excluded from lockdown. People were instructed to stay home and mobility were restricted to emergency or to obtain food and medication in an area not exceeding one kilometer away from home. Police officers were deployed on main roads and junctions for legally enforce inter-city mobility restriction.

Stay home strategy and mobility restriction were combined with community outreach using media especially Palestinian national TV where representative of Palestinian ministry of health and government spokesman appear for morning and evening updates and update the public for new reported cases and consequent regulations and instructions. These updates impacted positively on the majority of Palestinian public, social media were also used extensively by health experts to educate the public about prevention measures that should be taken, concentrating on social distancing, hand wash, and wearing mouth and nose masks. Lockdown were combined with legally enforced regulations, complete shutdown of holy places and mass prayers were prevented for the first time since centuries; mosques and churches were closed.

Outcomes

The outcomes of lockdown and preventive measures were evaluated based on the number of daily new positive cases, mortality rates, and feedback support from the public. The incidence of the COVID-19 was shown to be on very low levels and the epidemiology of the disease kept under control. Only five deaths were recorded and almost all have health problems, most patients infected with SARS COV-2 were asymptomatic or developed mild symptoms and were responsive to treatment. With the implementation of strong prevention and control measures by the Palestinian government, the containment of the epidemic has been achieved, but the global situation is still out of control and confirmed infected cases are rapidly increasing each day.

Gradual return to normal life

On May 26th 2020 the Palestinian government took the decision to lift the mobility constrains, reopening all private and public business. The government insisted and instructed the public to persist keeping the preventive measures of social distancing and wearing masks. The government took the decision to return to normal life after evaluation of the socioeconomical situation. The unintentional negative impacts of this decision were appeared by June 15, 2020 where new confirmed positive cases emerged in multiples at the beginning and then increased to reach hundreds of cases each day in certain areas in the country. By July 15, 2020, the cumulative numbers recorded in Hebron governorate were 5366, Nablus 244, East Jerusalem 1697, and Ramallah 497. The total number of cases from March to May in the country were 448 and after lifting the lockdown by June 2020 the total number of cases shifted up to reach 4904 cases by July 16, 2020. Gradual recovery and returning to normal life slowly appeared a key issue to live with

COVID-19 epidemic in Palestine. Gradual reopening the public and private business, keeping the legally enforced measures of social distancing and preventing social gatherings especially wedding celebrations are key issues to prevent the transmission of the disease massively in the society. Palestinian government in the light of the new COVID-19 outbreak or the second wave of the outbreak, took new preventive measures of lockdown, mobility restriction and social outreach to stop the spread of SARS-CoV-2 in the country especially in highly endemic areas like Hebron, East Jerusalem, Ramallah and Nablus.

Negative impacts

Although, quarantine and other health measures can have adverse negative effects, strict prevention and control measures undertaken are more effective in containing the COVID-19 outbreak. These effects include, psychological effects such as anxiety, posttraumatic stress symptoms, confusion and anger, which can lead to adverse long-term psychological problems, social and economic consequences on communities that have been subjected to extended periods of social distancing and other prevention and control measures might also lead to an increase in the burden on health overall. In order to maintain the best possible balance of measures, decision makers must constantly monitor the outbreak situation and the impact of the health measures implemented (AlKhaldi et al., 2020; Baloch et al., 2020). Quarantine alone as only measure is considered a key issue but not enough to control the outbreak of the disease, the identification of asymptomatic individuals is very important and this could be done by expanding the screening system to include samples from possible contacts in the third and fourth circle and screening random samples from different areas especially from regions with high death rates. The increase in number of tests is challenged and compromised by the availability of testing kits and the complexity of importing necessary swabs and materials due to limitations on international trade and the high global demand on testing kits.

Discussion

COVID-19 continues to spread all over the world, with increasing morbidity and mortality, preventive health measures have been taken in many countries of the world (Feng et al., 2020; Leung et al., 2020). It was proved that the swift measures imposed by the governments have been effective in containment the transmission of SARS-CoV-2 in many countries including Palestine and saves a lot of lives (Chan et al., 2020; Dong et al., 2020; Gualano et al., 2020; Lai et al., 2020; Zu et al., 2020). Governments should monitor the outcomes of the health measures undertaken and manage COVID-19 health crises in a way to save lives and minimizing the unintentional bad effects on society and economy. Gradual recovery of the community and gradual reintroducing the people to their normal daily life is very important to avoid re-emergence of the outbreak and help people to coexist with the disease until a treatment or vaccine become available. The quick and swift reaction and legally enforced preventive measures taken by Palestinian government substantially helped to control the outbreak of COVID-19 across the country. The measures successfully contain the disease outbreak in Bethlehem.

Although, the management of the COVID-19 crises by Palestinian government was very useful and saves lives of many Palestinians, the effect of lockdown was very costly on national economy; many private businesses were severely affected and the national income was substantially decreased. Strict lockdown measures were proved effective in many countries including Palestine, keeping on preventive measures by the public is essential. The high number of cases in June-July 2020 in Palestine are concentrated in Hebron Ramallah, Jerusalem and Nablus which is due to extensive social contacts through gatherings without taking into consideration social distancing, and other preventive measures like masks, this results in massive spread of the infection among people. Preventive and safety measures were not practiced by customers of many businesses or business owners did not care of using these measures for their customers. Crowded shops and markets were prominent and aided in the spread of the disease. To keep on the safety measures and economy running without any negative impacts of COVID-19 epidemic, the following measures should be considered in Palestine; flexible working schedules for employees, introducing distance working or remote working, using email and video or audioconferencing to reduce close contacts, legally enforced distancing between customers in shops and markets, using counter shields and personal protective measures and preventing mass gathering weather social, religious, or political. On personal level, community outreach on personal safety and hygiene should be continuously announced by Palestinian media which include washing hands with soaps and water for 20 seconds, avoid touching nose and eyes with the hands, putting on masks when going out of homes and in public places and continuously disinfect surfaces in home and workplaces. By writing this report the number of cases in Palestine is escalating which necessitate putting on

strict preventive measures once again after three weeks of lifting it (Alaraby, 2020).

Conclusion

The Palestinian government took strict health measures at the beginning of the outbreak, and succeeded in containing the outbreak. The serious effects on national economy affected the Palestinian society, forced the government to lift the lockdown. The public unawareness on keeping preventive health measures recommended by the government caused escalating in the spread of the disease in many areas of the country. Community outreach is essential to follow the strict health recommendations, this proves that any strict measures implemented by the government will not tackle the spread of COVID-19 unless public awareness is raised. More research should be carried out on the impacts of COVID-19 epidemic on Palestine national security, economy, health, and education. Recommendations from experts in various fields to put innovative ideas on how to treat the unintended negative impacts on community level in order to recover all sectors from the epidemic.

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The Impact of COVID-19 Pandemic on Medical Imaging Workers: Infection Sources, Awareness and Commitment to relevant Safety Guidelines

REVIEW

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A B S T R A C T

COVID-19 virus disease is an infectious disease caused by SARS-Cov-2 virus, as the diagnostic imaging department play a remarkable role in detecting and diagnosing of COVID-19 in early stages, therefore, medical imaging workers should be aware of infection control guidelines to prevent the transmission of the disease. A cross-sectional descriptive study survey design was conducted from July 15, 2020 to September 15, 2020, in diagnostic imaging departments in Palestine, aimed to evaluate the impact of COVID-19 pandemic on medical imaging workers; in terms of infection sources, awareness and commitment to relevant safety guidelines. From a 205 valid responses, there was 54.5% governmental, 27.2% private, and 18.3% from NGOs sector. Female were 26.8% and 81.9% holding BA degree, about 41.2% are less than five years of experience. 36.1% had a previous positive COVID-19 result, of them there was 61.6% due to nosocomial infection. Only 63.2% were confidence of their hospital preparedness for COVID-19, 65.1% felt that their department is capable of dealing with COVID-19 patients, 43.3% revealed that they had training on handling COVID-19 patients, 58.7% reported that self-reading was their source of information about COVID-19, inadequate training or knowledge about hand hygiene and proper use of PPE was noted. Our findings emphasize the vital need of expanded COVID-19 pandemic training for medical imaging workers, as well as related protective measures.

Keywords: COVID-19, SARS-Cov-2, Medical Imaging, Infection Source, Knowledge & Awareness

Corona virus disease (COVID-19) is an infectious disease caused by the Severe Acute Respiratory Coronavirus 2 (SARS-Cov-2) that was first discovered in December, 2019, in Wuhan, China. In March, 2020 World Health Organization (WHO) declared COVID-19 as a global pandemic (WHO, 2020). Reverse Transcription Polymerase Chain Reaction (RT-PCR) molecular test is the most commonly test used to detect COVID-19 infection (WHO, 2020). But it suffers from low sensitivity (e.g. 60% - 70%) in the early detection of COVID-19, due to the false negative rate and the long time for results to show up with respect to the need for rapid decision-making for patients with clinically noticeable pneumonia (Ai et al., 2020; Fang et al., 2020; Li et al., 2020; Yang et al., 2020; Diao et al., 2020). Rapid Diagnostic Test (RDT) is cheaper and quicker than PCR, but it has a disadvantage of less accuracy (WHO, 2020).

Diagnostic imaging examination, mainly high resolution chest computed tomography (HRCT) and chest X-ray (CXR) play a remarkable role in detecting coronavirus disease, chest computed tomography is preferred over CXR because of its accuracy, improved contrast resolution, high sensitivity and ability to diagnose the disease in early phase of development (Zu et al., 2020; Diao et al., 2020; Shi et al. 2020). In detecting pulmonary abnormalities, HRCT is more sensitive than CXR (Ng et al., 2020). Due to their rule in COVID-19 pandemic medical imaging workers (MIWs) should be aware of infection control measures and trained in

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the use of personnel protective equipment's (PPE) to prevent the transmission of disease. According to the Palestinian Ministry of Health, until 25 September 2021 there is 426035 total infected cases and 4286 deaths in Palestine. Among those, 6116 infected cases were health care workers (HCWs) (1.53%) (Health, 2021). The total number of infected medical imaging technologists (MIT) in Palestine was 85 MITs; 65 in governmental sector and 20 MITs in private sector, according to Palestinian Association of Medical Radiographic Technologists (PAMRT).

In this study, we aim to evaluate the impact of COVID-19 pandemic on MIWs; infection sources, awareness and commitment to relevant safety guidelines. Also, compare between the components of Palestinian's health care system (Governmental private and NGOs) in terms of the preparedness of Infection Control and Prevention (ICP), PPE availability, team training, confidence of the team in hospital's preparedness for COVID-19 and number of infected MIWs in Palestine and source of knowledge about ICP..

Materials and Methods

We conducted an institutional based cross-sectional descriptive study design, from July 15, 2020 to September 15, 2020, in diagnostic imaging departments in Palestinian health system (including governmental, private and NGOs hospitals).

Ethical approval obtained from the Research Ethics Committee (REC) at Al-Quds University. Data for this study were collected from all diagnostic imaging departments in the Palestinian health system, including government and private hospitals and NGOs. All MIWs (Radiologist, Radiology Residence, Radiologic Technologists and Radiology Nurses) worked in diagnostic imaging departments during the COVID-19 pandemic were included in the study. We developed a questionnaire of 39 questions in addition to the demographic data section; Demographic information's, Hospital environment and preparedness (HEP), Department environment and preparedness (DEP), Staff preparedness and capability (SPC), this divided into two sections: (Staff knowledge/awareness (SPCA) & Staff practice/skills (SPCB)).

However, due to the large number of MIWs in departments with different shifts, the questionnaires were distributed in the department head's office for at least one week and then the filled-in questionnaires were collected. Five hundred questionnaires were distributed to all hospitals, 207 completed questionnaires were collected, and other two were excluded due to missing the demographic data.

Statistical Analysis

The 205 valid questionnaires were exported to IBM SPSS Statistics for windows, version 23 for analysis. Descriptive statistics were used to describe the study variables. Statistical significance was considered for $P < 0.05$. The chi-square and Kruskal-Wallis Tests were used in the analysis. Reliability of knowledge, awareness and commitments to relevant safety guidelines were determined using Cronbach's alpha, which revealed scores HEP = 0.72, DEP = 0.79, SPCA = 0.70 and SPCB = 0.77.

Results

Results showed that 54.5% of respondents were from the government sector, 27.2% from private sector, and 18.3% from NGO sector. Female were 26.8%, majority of participants (49.8%) were less than 30 years' old which may explain that also the majority were less than 5 years in practice (41.2%), 81.9% of all participants holding a bachelor degree. 36.1% of all respondents were have positive COVID-19, 61.6% of those were due to nosocomial sources (Table 1).

Table 1: Demographic Data and source of infection

		N (%)
Gender	Male	150 (73.2)
	Female	55 (26.8)
Age	20-30	102 (49.8)
	31-40	71 (34.6)
	41-50	22 (10.7)
	≥ 51	10 (4.9)
Education	Diploma	9 (4.4)
	Bachelor	167 (81.9)
	Master	26 (12.7)
	PhD	2 (1)
Years in Practice	0-5	84 (41.2)
	6-10	69 (33.8)
	11-15	22 (10.8)
	≥ 16	29 (14.2)
Occupation	MITs	175 (85.4)
	Radiologist	17 (8.3)
	Rad. Residence	7 (3.4)
	Rad. Nurse	6 (2.9)
Do you had a previous COVID-19 positive result?	Yes	74 (36.1)
	No	131 (63.9)
If "YES" where did you get the infection from?	Nosocomial	45 (61.6)
	Home	12(16.4)
	Social Activity	7(9.6)
	Don't Know	9(12.3)

Only 50.5% of participants in governmental sector were confident with their hospital preparedness compared to 70.9% and 89.2% in private and NGOs sectors, respectively. Nearly, the same response in governmental sector in relation to the capability of medical imaging departments in dealing with COVID-19 patients, it was 52.9% which is too low compared to other sectors (Table 2).Medical imaging departments in governmental sector were allocate a separated x-ray room for suspected/confirmed COVID-19 cases, as 53.8% of participants revealed, while in private and NGOs sectors were 40.4% and 27.6% respectively (Table 2). Medical imaging departments in governmental sector were allocate a separated x-ray room for suspected/confirmed COVID-19 cases, as 53.8% of participants revealed, while in private and NGOs sectors were 40.4% and 27.6% respectively (Table 2). In their response to whether they had received training in dealing with COVID-19 patients, only 43.3% of all participants reported that they had received training, with a high correlation between the three sectors, and the lowest was in the government sector where only 29% had received training (Table 3).

Table 2: Measurements of hospital / department environment and preparedness

Hospital/Department Environment & Preparedness		Hospital Sector				*P*-Value
		Govermential	Private %	NGOs %	Total %	
Are you confidence in hospital preparedness for COVID-19?	No	49.5%	29.1%	10.8%	36.8%	< .001
	Yes	50.5%	70.9%	89.2%	63.2%	
Does your department is capable of dealing with COVID-19 patients?	No	47.1%	30.8%	11.1%	34.9%	0.001
	Yes	52.9%	69.2%	88.9%	65.1%	
Supplies necessary for hand hygiene are readily accessible in department	No	13.5%	0.0%	5.6%	7.8%	0.012
	Yes	86.5%	100.0%	94.4%	92.2%	
Hospital has made available adequate PPE during COVID-19 Pandemic	No	16.0%	6.3%	3.0%	10.9%	0.059
	Yes	84.0%	93.8%	97.0%	89.1%	
Your department allocates a separated x-ray room for suspected/confirmed COVID-19.	No	46.2%	59.6%	72.4%	54.4%	0.033
	Yes	53.8%	40.4%	27.6%	45.6%	
We clean all radiological equipment on a routine basis (e.g. weekly).	No	12.0%	2.0%	0.0%	6.9%	0.02
	Yes	88.0%	98.0%	100.0%	93.1%	

Table 3: Measurements of staff preparedness and capability

Staff Preparedness & Capability		Hospital Sector				*P*-Value
		Govermential	Private %	NGOs %	Total %	
Have you had any training for handling suspected/ infected COVID-19 patients?	No	71.0%	40.4%	42.4%	56.7%	<0.001
	Yes	29.0%	59.6%	57.6%	43.3%	
COVID-19 is transmitting via; Droplet	No	71.6%	58.2%	62.2%	66.2%	0.197
	Yes	28.4%	41.8%	37.8%	33.8%	
COVID-19 is transmitting via; Contact	No	63.3%	61.8%	78.4%	65.7%	0.194
	Yes	36.7%	38.2%	21.6%	34.3%	
I have knowledge about types of disinfectants, how to prepare and use them.	No	16.9%	2.4%	9.1%	11.6%	0.048
	Yes	83.1%	97.6%	90.9%	88.4%	
Your source of information about Infection Control and Prevention was from In-Hospital Training	No	73.4%	50.9%	51.4%	63.2%	0.005
	Yes	26.6%	49.1%	48.6%	36.8%	
I already trained on hand hygiene	No	34.9%	12.7%	8.1%	23.9%	<0.001
	Yes	65.1%	87.3%	91.9%	76.1%	
I already trained on correct use of PPE (Donning & Doffing)	No	45.7%	23.6%	8.3%	32.7%	<0.001
	Yes	54.3%	76.4%	91.7%	67.3%	
Before putting on gloves, I wash my hands or disinfect with alcohol.	No	10.9%	23.6%	5.4%	13.4%	0.022
	Yes	89. 1%	76.4%	94.6%	86.6%	

Discussion

Healthcare workers (HCWs) and Medical Imaging Workers (MIWs) were at higher risk than other people, as they work at frontlines facing this new pandemic. In 2020 researcher in China reported 3,387 infections among HCWs (4.4% of all cases) (Zhan et al., 2020). The Italian National Institute of Health also reported that 17,000 HCWs have been infected (about 10% of all cases) (Disease, 2021), and the US Centers of Disease Control and Prevention (CDC) reported that more than 9,200 HCWs were diagnosed with COVID-19 in the US between February 12 and April 9, 2020 (Burrer et al., 2020). A positive COVID-19 test was reported by 36.1% of all respondents, with 61.6% of those resulting from nosocomial sources, in terms of source of infection, similarly a study held in Helsinki University Hospital (HUS) in Finland, 53.7% of 4.7% infected persons were due to nosocomial (Oksanen et al., 2021). Also a study in Milan, on 172 HCWs with positive COVID-19 results, there was 60% due to nosocomial (Mandic-Rajcevic et al., 2020). In other study in Ontario, Canada, which was aimed to describe and compare HCWs and non-HCWs COVID-19 cases as well as the frequency of COVID-19 among HCWs, there were 4230 (17.5%) HCWs, 108 (3.1%) of them due to nosocomial infection and the majority; 2718 (76.9%) were missed due to unknown infection source (Schwartz et al., 2020).

In comparison to 89.2 % of NGOs sector and 70.9% in private sector, only 50.5 % in the government sector remains confident in hospital preparedness for the COVID-19 pandemic. In addition, nearly the same difference emerged between governmental and non-governmental participants when it came to their department's capability in dealing with COVID-19 patients, with 52.9 % of governmental participants stating that their department was capable of dealing with COVID-19 patients compared to 88.9% and 69.2% of NGOs and private, respectively. Although, our results somewhat disappointing in governmental sector, but in Libya, a study was conducted among HCWs working in emergency (ER), Intensive Care Unit (ICU) and infectious diseases departments in 21 hospitals, only about 13.4% of them reported that their hospital was prepared for COVID-19 pandemic (Elhadi et al., 2020), where only14.8% of all participants reported that they confidence and highly confidence in management of COVID-19 patients (Elhadi et al., 2020). In a study conducted in Menoufia University isolation unit, 206 HCWs, 91.7% of them were feel safe in their work environment against COVID-19, this is supported by a low infected rate among targeted HCWs (5.8%, 12 out of 206 HCWs was infected) (Ghonaim et al., 2021). Also, significant differences (P = 0.012) were noted between health care sectors in the participant's revelations about the readily accessible of supplies necessary to hand hygiene in department, with 100% of responses in the private sector compared to 94.4% in NGOs and 86.5% in governmental.

Not faraway, of this study results about staff training on handling COVID-19 patients, which were only 43.3% of all participants, a study held in UK reported that 48.3% of respondents had training on handling COVID-19 patients (Akudjedu et al., 2020). In a study on radiology workforce (RWF) conducted by Elshami et al., (2021), only 58% of RWF had received training on infection control for handling COVID-19 patients.

The main mechanism of transmission for the COVID-19 has been established as human-to-human transfer via droplets and contact (Zu et al., 2020). Our results are very low compared to an Indian study on medical imaging professionals MIPs, were 98% of participants answered correctly about the transmission mode of SARS-CoV-2 (Kotian et al., 2020) and low also compared to Elshami et al., (2021) study were 93.6% of respondents understood the mode of coronavirus transmission.

PPE is also an important part of infection control techniques for protecting HCWs because it is designed to prevent infections in the particular HCW as well as secondary spreading to other HCWs and patients (Reddy et al., 2019). Hospitals in Palestinian health care system had made available adequate PPE in all sectors with no significance difference, but the most were in NGOS sector (97.0%). While, the majority of respondents in a study conducted by Coppola et al., (2021) stated that they had difficulty finding PPE, and this percentage was lower in hot areas than in other areas (64.7% vs. 71.9%, P = 0.0009), and also in another study by Huang et al., (2020) reported that only 21.2% of all respondants revealled that PPE availability was abundant and 28% responded about sufficient and available PPE. Acourding to Huang et al., (2020) a hospital's absence of PPE significantly raises anxiety levels. In addition to the risk to their mental and physical health, health care employees' work passion and efficiency would definitely suffer if they are unable to ensure their own safety. In order to appropriately protect employees and to allay their fear, each hospital should work to guarantee that the supply of protective supplies is adequate, especially in local hospitals.

About 88.4% reported that they have knowledge about types of disinfectants and how to prepare

them. This is similar to study held in Sudan among radiology staff were 90% of respondents reported that the disinfectant should be used after contact with every suspected/confirmed COVID-19 patients (Elgyoum et al., 2020). While in a study among HCWs in radiology departments in Saudi Arabia, there were 67.2% of participants have knowledge about the types of disinfectants and how to prepare them (Aljondi et al., 2020). More than half (58.7%) of all participants reported that their source of information about COVID-19 was due to their self-reading, while only 4% of them revealed that university curriculum is the source of information. The university's involvement in teaching ways of prevention and protection from infectious diseases is regrettably limited.

Assessments of the level of knowledge about COVID-19 among HCWs in public hospitals and primary healthcare centers in Jeddah and Najran regions in Saudi Arabia, showed that the majority of HCWs had inadequate or intermediate level of basic knowledge about COVID-19. This means that government agencies, such as the ministry of health, hospital administrations, universities and others, should plan and implement initiatives to promote HCWs knowledge (Alharbi & Mandoura, 2021; Al Sulayyim et al., 2020). Availability of a representative person for the infection control in the diagnostic imaging department has an effect on SPCB among health care sectors with a significant of $P = 0.028$ (Figure 1).

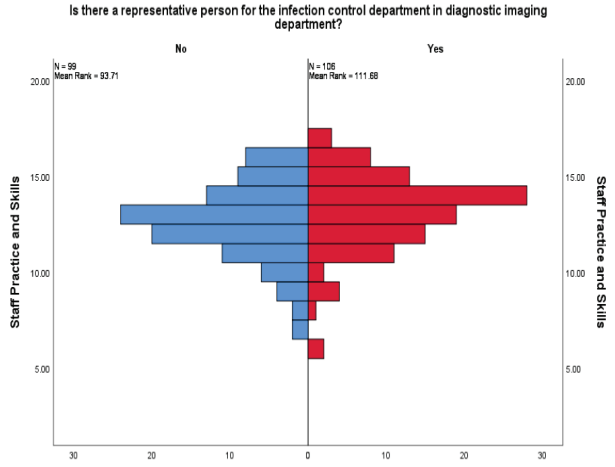

Figure 1: Effect on SPCB according to availability of representative person for the ICP in diagnostic imaging department.

While SPCA was not the same across health care sectors ($P = 0.030$) (Figure 2), this was measured by using Independent-Samples Mann-Whitney U Test. There was a significant difference ($P = 0.003$) in the effect of HEP across Health care sectors (Figure 3), and also in the effect of DEP ($P = 0.040$) (Figure 4), this was also calculated by Independent-Samples Kruskal-Wallis test, by using Kruskal-Wallis test to measure the relationship between SPCA & SPCB from a side and gender and ages of MIW, level of education, years in practice, and occupation. From other side, we find no correlation between them.

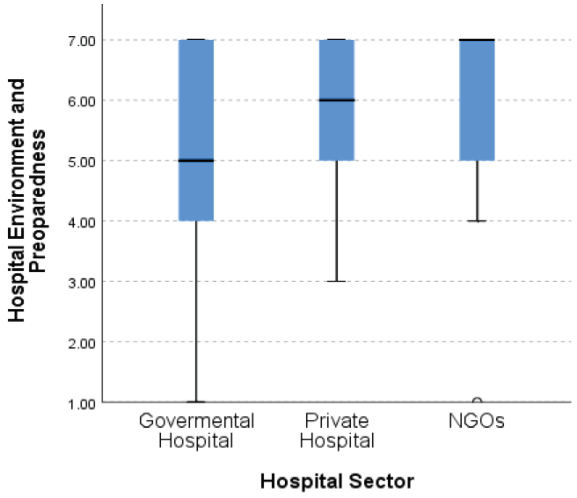

Figure 3: Distribution of HEP in relation to Hospital Sector, $P = 0.003$

Hand Hygiene means cleaning your hands by using: Any of the soap and water or Antiseptic hand wash or Antiseptic hand rub, findings could indicate that MIWs have limited understanding of ICP strategies, where only 39.7% answer that hand hygiene could be achieved by any one of these actions.

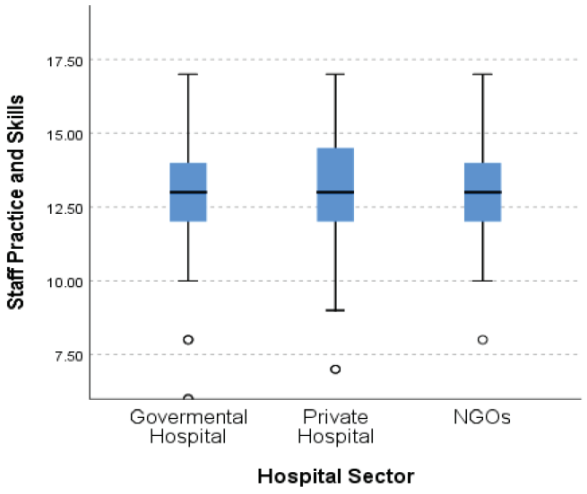

Figure 4: Distribution of DEP in relation to Hospital Sector, $P = 0.040$

While in Jeddah, Saudi Arabia, a study among students and staff of Alghad College revealed that

96.6% of participants said yes that they aware and know hand hygiene (Osman, 2020). On the other hand, 67.3% reported that they trained on the correct use of PPE, governmental participants were the least team among all sectors that they had training on PPE (54.3%). Where NGOs provided a high percentage of training on hand hygiene and PPE use, the government should expand its educational and training programs for employees. This is similar to the findings of a study, in Sudan, where 65% of MIWs reported that they had training on hand hygiene, and 75% of them had knowledge about hand hygiene (Elgyoum et al., 2020). While in another study in Libya, only 54.3% of overall participants showed that they were prepared to utilize PPE properly (Elhadi et al., 2020).

Conclusion

Findings among Palestinian MIWs revealed a moderate level of confidence in hospital preparedness and diagnostic imaging department capability in dealing with suspected or confirmed COVID-19 patients, absence of an ICP representative in diagnostic imaging department, poor training on handling COVID-19 patients, a low level of hand hygiene, lack of knowledge and training on proper PPE use and lack of understanding about COVID-19 transmission mode. In addition, the data revealed that self-reading was the most common source of information for MIWs, with little in-hospital training and a near-complete lack of external training in the curriculum. To increase the level of MIWs knowledge and practices towards COVID-19 or any other infected pandemic in future; we recomend the followings; (1) the infection control department's role should be expanded in terms of providing continuous education and training to hospital employees, there should be a representative of it in every department of the hospital, including the diagnostic imaging department. (2) Infection control and prevention educational course, should be added to the curriculum of medical imaging programs at the universities.

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Conflict of interest declaration

The authors declared that there is no conflict of interest

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Author's contribution:

Data collection, analysis and writing was performed by the author. Corresponding author was supervising and manage the whole work step-by-step with the author.

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Cloning and Expression of SARS COV-2 Surface Protein and its Use in Detecting Corona Viral Infections

RESEARCH

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A B S T R A C T

The main aim of this study was to develop indirect enzyme linked immune sorbent assay based on the use of bacterial cloned SARS CoV-2 spike protein as a cheap and continuously available source of antigen. This test was proved to be useful for a quantitative measurement and evaluation of antibody immune response among SARS-CoV-2 infected individuals. Standard cloning procedures had been used in cloning two different segments of the spike gene and its expression. The size of the two cloned segments were of 700 base pair and of 500 base pair, which were named clone 8 and clone 105, respectively. These DNA segments were cloned in pET28a plasmid and then expressed in Bl21 *E. coli*. Different serum samples were tested from: current, previous infection, vaccinated and non-vaccinated patients using the amplified expressed proteins in enzyme linked immune sorbent assay. The expressed proteins from each clone were responded with varying degrees of sensitivity against COVID-19 positive human sera, and we attempted to validate which of the two recombinant proteins is the best to be used in Corona IgG and IgM antibody detection. Based on the results of indirect enzyme linked immunoassay, most of the tested samples had greater antibody titers with clone 8, which was found to have a higher similarity (99% resemblance) to the severe acute respiratory syndrome coronavirus 2 surface protein using BLAST search. We recommend clone 8 with high potential to be used for large-scale screening for COVID-19 outbreak; nevertheless, it requires greater sensitivity and specificity validation.

Keywords: COVID-19, SARS CoV-2, ELISA, Cloning, Surface protein, Immunity

Introduction

COVID-19 disease devastated health and economy worldwide, challenged scientists for research and develop a fast and cheap diagnostic tests, in order to reduce the pandemic through proper diagnosis, medication and clinical quarantine (Chan et al., 2020). Serological tests are important for detection of the virus as well as detection of serum antibodies of infected people, especially for plasma donors, it could be used as qualitative and quantitative assay for the human immunity to COVID-19 (Amanat et al., 2020). Serological tests detect the existence of antigens as well as the detection of antibodies to SARS-CoV-2 as well as previous SARS-CoV-2 infection (IgG), and might help to confirm the presence of the current infection (IgM). For the detection of antibodies against SARS-CoV-2, several commercial and in-house serological tests based on recombinantly produced viral proteins nucleocapsid (N), surface (S), or epitope forms of the S protein have been developed. Despite the fact that different assays are applied, studies comparing multiple viral antigens in similar assays concluded that the S1 of the surface spike protein is an ideal antigen for SARS-CoV-2 diagnosis (Krähling et al.,

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2021). To develop a sensitive serological assay for COVID-19 there is a need to produce antigens in large quantity, thus using recombinant proteins expressed in prokaryotes like *E. coli* was vital in this experiment, which is characterized as quick and low-cost strategy. The developed serological test could be of great importance as a complementary diagnostic strategy to the well adapted Polymerase Chain Reaction (PCR) and mainly for follow-up of recovered patients, in addition to identification the asymptomatic individuals. In the present study, we reported the cloning and expression of COVID-19 spike protein segments, and the use of these segments in developing an indirect ELISA serological test for detecting SARS CoV-2 Spike protein IgG and IgM antibodies in serum samples.

Materials and Methods

Biological samples

Twenty nasopharyngeal samples of SARS CoV-2 confirmed infected individuals were collected from Bethlehem area. These samples were used to prepare cDNA material that was used for cloning purposes. Serum samples were collected from previously infected or vaccinated individuals. In general, pre-identified serum samples were obtained from Beit Jala Governmental Hospital, Beit Jala, Bethlehem. Ethical approval for the study methods were obtained from Al-Quds University Ethical Committee.

Cloning of SARS CoV-2 surface protein

The cDNA of positively identified samples were used as a source of SARS CoV-2 genetic material. The main cloning strategy was to amplify a segment of the surface protein using two designed primers and ligation of the amplified segment in a plasmid (pET-28a bacterial expression vector) according to the standard protocols that were provided by the plasmid manufacturing company (Novagen, USA). In short we designed two PCR systems in each two DNA primers (Table 1), that enabled amplification of two different regions in the COVID-19 surface genes (Tregoning et al., 2020).

Table 1: PCR systems used in cloning, the designed primers sequences and the used annealing temperature in PCR amplification

PCR System	Primer Name	Primer sequence	Annealing Temp
System 1	Cov19-1	Fwd-GAGCTCATGGCAGATTCCAACGGTACTATTAC Rev-GTTAATTTTCCTCTGGCTGTTATGGCC	53 °C
System 2	Cov19-2	Fwd-GAGTTTAATTTATAGTTGCC Rev-CTGTACAAGCAAAGCAATATTGTC	53 °C

PCR conditions

PCR reactions were carried out in 25µl reaction volume containing (2x ready mix *Taq* DNA polymerase mixture (Takara, Japan), and 10 pmoles of forward and reverse primers from each PCR system (Table 1). The amplified PCR product was analysed on 1.5% agarose gel electrophoresis.

Ligation and transformation of surface gene in pET-28:

Ligation of the amplified DNA surface protein segments was done in pET-28a expression vector at the restriction site XhoI available in the plasmid poly-linker cloning region. For this purpose, the amplified gene segments and the expression plasmid were cut by XhoI restriction enzyme (Thermo-Fisher Scientific, USA) and according to the manufacturer instructions. This was followed by ligation using T4 DNA ligase and according to standard kits and previously known standard methods (Thermo-Fisher Scientific, USA). The ligated products between the amplified DNA fragments and the pET-28a plasmid were transformed in *E. coli* bl21 using standard heat shock transformation method. The cloned gene segment was subsequently expressed as a fusion protein consisting hexa-histidine tag (His6-g gene-pET-28a) in *E. coli* BL21 cells. The transformed cells were grown on LB-agar plates containing 100 µg/mL kanamycin antibiotic. In order to check the presence of the cloned DNA segment in the plasmid vector and in the transformed bacterial cells, about 20 different bacterial cells were picked from the LB agar plate and transferred into 15ml tube containing 5ml LB media plus 50 µg/ml of Kanamycin antibiotics. The tubes were left to grow for overnight and the next day, 0.5ml of the bacterial cells were lysed by boiling and the clone was used in PCR reaction using T3/T7 universal primers in order to amplify the inserted segment if present in that specific tested recombinant clone.

Protein purification

The recombinant His-tagged surface recombinant protein of SARS-CoV-2 which expressed in *E. coli* was purified by two ways, one is by sonication, protein determination was carried out for the extracted proteins using spectrophotometer at 280nm. The other by Nickle beads affinity chromatography to purify His-tagged recombinant proteins. Histidine residues in the His tag

attached with great specificity and affinity to the empty sites in the coordination sphere of the immobilized nickel ions.

ELISA preparation:

ELISA assay started by plate coating with 100µl of 100 µg/ml nickel purified expressed surface protein diluted in phosphate buffer saline (PBS), plates were kept for overnight at 4°C. The tested serum samples were subjected to serial dilution in buffer (PBS, containing 5% foetal calf serum, and 0.1% Tween-20). The tested antibodies were incubated for two hours at room temperature followed by the addition of a secondary antibody (anti-human IgG or IgM conjugated with Horse-radish peroxidase (HRP)). The bound secondary antibody was detected by the addition of HRP enzyme ABTS substrate and later measuring the colour change using ELISA reader at 405 nm wavelength.

Results

Cloning of surface spike CoV-2 DNA segments: Initially five PCR systems were examined for the purpose of CoV-2 genes cloning, the primers of these PCR systems were covering about 500-800 bp segments from CoV-2 region located in a range of 25,000-27,000 of the genome, and that mainly code for the surface CoV-2 genes. Out of five different PCR systems; only the two above mentioned systems in Table 1 showed a successful gene amplification. These primers were able to amplify different positive CoV-2 cDNA material. The amplified bands by these two systems were grouped and used for the cloning in pET-28a plasmid. Cloning of PCR amplified DNA segments in pET-28a plasmid: As indicated in materials and methods, the successfully amplified DNA segments were ligated in pET-28a plasmid vector at XhoI site. After transformation in *E. coli* bl21 cells; different recombinant clones were obtained, which were indicated by successful growth of the transformed bacterial cells on LB agar plates containing Kanamycin antibiotic. Figure 1 shows the results of the amplified DNA segments that were successfully cloned in the plasmid vector, after their amplification using a universal primers (T3 and T7) located on both sides of the poly-linker cloning region in pET28a expression plasmid. In order to confirm the result and the presence of these inserts in the plasmid and without contamination by non-recombinant plasmid, some of these clones were streaked on LB agar plates with Kanamycin and Ampicillin and single colonies were obtained. The colonies were grown another time on LB media for overnight and retested for the presence of insert in these selected clones (Figure 2).

Figure 1: Agarose gel electrophoresis analysis showing the PCR products targeting different recombinant plasmids containing Cov-2 DNA insert segments. M: Size marker of 100bp ladder

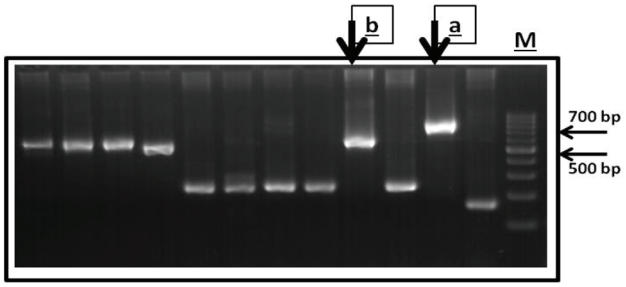

Figure 2: Agarose gel electrophoresis of some retested clones to check the purity of the recombinant plasmid in the bacterial cells. M: Size marker of 100bp ladder.

DNA sequence analysis of recombinant clones 8 and 105: The DNA segment in clone 8 and 105 were amplified and the PCR product was cleaned and subjected to DNA sequencing. The obtained DNA sequences were alignment with Cov-2 DNA segment (Wuhan-Hu-1), which part of the original Sars Cov-2 genome initially identified at the beginning of the current Cov-2 pandemic shows more than 95% homology between the sequenced clones 8 and 105 with reference DNA segment. Also, the obtained DNA sequence of both clones 8 and 105 were analysed by BLAST DNA analysis against different nucleotide entries in the GenBank. The analysis shows that both clones showed similarity with Cov-2 genome entries, the first identified hit namely was: (Severe acute respiratory syndrome coronavirus - 2 isolate SARS-CoV-2/human/USA/CA-LACPHL-AF08895/2021, complete genome / Sequence ID: ON422081.1).

Utilization of the expressed Cov-2 surface proteins in screening of corona related serum samples by Enzyme Linked Immunosorbent Assay (ELISA): Microtiter ELISA plates were coated with purified expressed and induced surface antigen protein. In each analysis; one plate was coated with surface antigen expressed by clone 8 and another plate coated with surface protein antigen expressed by clone 105. These ELISA plates were tested for their reactivity with serum samples that were used after applying serial

dilutions of the tested sera (1:50 1:100 1:200 1:400), negative control samples were used as well from freezing serum sample in Al-Quds University before the current pandemic. In each ELISA run, the cut-off value was determined by calculating the mean value of SARS Cov2-negative serum samples plus three standard deviations, readings above the cut-off value were considered as positive and were used to calculate the antibody titers Based on the obtained ELISA result readings, the results were used to illustrate the antibody titer results of each clone (8 and 105) as histogram, and this was in general according to the following criteria (current infection, previous infection, vaccinated and non-vaccinated). As can be seen from figure 3 and figure 4, that represents the average percentage reading of antibody titers for the different tested groups, it can note that the use of the expressed proteins from clone 8 showed more sensitivity than the use of expressed protein from clone 105 (Figure 3 and 4).

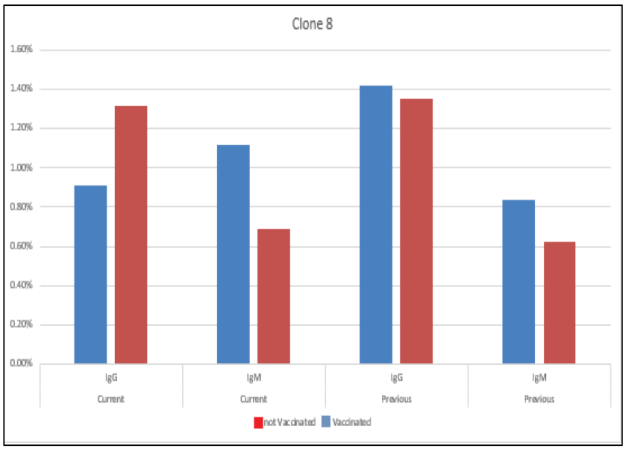

Figure 3: antibody titer results of clone 8 in general according to the following criteria (current infection, previous infection, vaccinated and non-vaccinated).

Also, it is possible to note that the produced antibody responses shown by this ELISA test for the previously infected individuals was much higher than the produced antibody responses seen among current infected individuals. This may relate to that: whether if patient may have vaccinated or not, or if the were previously infected and then they will produce more antibodies than those individuals whom were being recently infected and this is true especially with the IgG antibody (the main antibody class in secondary humoral immune response). Beside this, the data indicate that vaccination plays a major role to induce antibody production against the virus in both current and previously infected individuals, as it was noted that previous infection provides more immunity indicated by higher antibody titers of IgG antibodies compared to immunity with IgM antibody immune response (Figure 4).

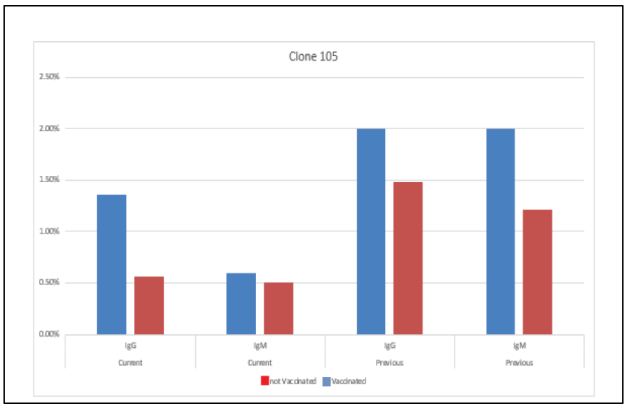

Figure 4: antibody titer results of clone 8 in general according to the following criteria (current infection, previous infection, vaccinated and non-vaccinated).

Discussion

The present study was performed to develop a suitable SARS CoV2 immunological test based on testing SARS CoV-2 IgG and IgM antibodies qualitatively and quantitively and to provide a continuous source of SARS CoV-2 surface protein antigenic material in sufficient quantities by using cloning technique to be used in our developed indirect ELISA tests. S protein is the most significant viral structural protein in terms of SARS CoV-2 pathogenesis because it promotes receptor binding and virus–cell membrane fusion and is rich in antigenic and neutralizing epitopes , so it was the most suitable antigen for such test (Dong et al., 2021). This study was also performed due to the public health concern about COVID-19 as the disease has been reported in almost all over the world. The results of the current antibody titers; utilizing the developed ELISA test; showed high IgG and IgM antibody titers among the Palestinian hospitalized population. The study also performed because of some imported commercial IgG/IgM test kits for COVID-19 had problems with sensitivity, resulting in high rates of false-negative test results, as the sensitivity and specificity of a fast antibody test for screening healthcare workers were studied in a prior study. In a certain study, serum of 389 health-care personnel who had been exposed to COVID-19 patients or who had symptoms was tested. All personnel were tested for SARS-CoV-2 on a monthly basis, with virus RNA detected by RT-PCR in nasopharyngeal swabs. After a median of 7.6 weeks, the Chemiluminescence Immunoassay (CLIA) and the Rapid test (KHB diagnostic kit for SARS CoV-2 IgM/IgG antibody) were used to identify IgG antibodies in serum. In COVID-19 positive persons, those with only

SARS-CoV-2 IgG antibodies, and those negative for both tests, the fast test was positive in 31/132 (23.5%), 16/135 (11.8%), and 0/122 instances, respectively. Specificity was 100 percent (CI95 percent 97-100) and sensitivity was 17.6 percent (CI95 percent 13.2-22.7) and 23.5 % (CI95 % 16.5-31.6). As a result, whether comparing Rapid test vs CLIA IgG or Rapid test vs SARS-CoV-2 positive RNA detection, Rapid test is not suitable for screening workers with past COVID-19 infection (CI95 % 97-100) (Filon et al., 2021). Our developed ELISA technique was used to determine the immunity by measuring the IgG and IgM antibody titers of the different tested serum samples against SARS CoV-2 crude antigen, these samples were collected from current positive infected patients (vaccinated and not vaccinated), negative infected patients (vaccinated and not vaccinated), and previous infected patients (vaccinated and not vaccinated), and the test had been reported to demonstrate high sensitivity and specificity when compared to other serological assays like western blot and chemiluminescence assay. The enzyme linked immunosorbent assay (ELISA) measures antibodies, antigens, proteins, and glycoproteins. Diagnosis of HIV infection, pregnancy testing, and detection of cytokines or soluble receptors in cell supernatant or serum are only a few examples. Because they rely on a pair of antibodies for capture and detection, immunometric ELISAs are highly selective. They are also thought to be compatible with a wide range of complicated materials, as they do not require sample extraction prior to analysis. The indirect ELISA method has a higher sensitivity than the direct ELISA method because it uses fewer labelled secondary antibodies to bind the main antibody. It is also less expensive than the direct ELISA approach since it uses less labelled antibodies (Butler, 2000). The immune system creates a wide range of antibodies in response to an illness, rather than simple one. Some of these antibodies attach strongly to an antigen, whereas others do not. Neutralizing and non-neutralizing antibodies are both types of antibodies. Antibodies known as neutralizing antibodies can "neutralize" viruses, as the name suggests. In reaction to SARS-CoV-2, certain neutralizing antibodies bind tightly to the coronavirus spike protein and prevent it from infecting the cell. Non-neutralizing antibodies don't accomplish this - or only do it in a restricted way - but they can nevertheless aid in the fight against viruses. Non-neutralizing antibodies do not protect infected cells against infection, but they can recognize viral antigens that are exposed or exhibited on infected cell's surfaces. Other elements of the immune system can come along and kill the infected cells when non-neutralizing antibodies bind to these surface antigens. COVID-19 neutralizing antibodies are tested in most labs because they are a good indicator of infection prevention. However, we don't know how high neutralizing antibody levels needed be to protect COVID-19 patients from infection or severe disease (Chvatal-Medina et al., 2021). Simple monitoring and assessing vaccine effectiveness studies has shown that as neutralizing antibodies decline, the chance of a breakthrough infection rises. Meanwhile, scientists rely on other signs to establish the efficacy of vaccines. Examining vaccination effectiveness in the real world, both in specific populations and across time, is part of this. When it comes to deploying COVID-19 boosters in the summer of 2021, Israel chose this technique. According to data from the country, infections detection were more likely among people who had been vaccinated earlier in the year than those who had been vaccinated more recently. You can't take an antibody test to see how well you're protected against the coronavirus after vaccination or a spontaneous infection because there is no connection of protection for COVID-19, taking into account the importance of cellular immune response in viral infections. (Krammer, 2021). ELISA test is considered a simple diagnostic immunological test that can be performed in many laboratories; not only in hospital and main health care laboratories but even it is used in many private laboratories. The only limitation of this specific ELISA tests is the production of pure recombinant antigen using nickel purification. Large amount of bacterial cultures is needed for this purpose and special technical efforts are needed from well trained individuals to perform such purification protocols.

Conclusion

A recombinant SARS-CoV-2 surface proteins were cloned and expressed and then used in the current investigation to show the design and development of a low-cost in-house ELISA. The assay could offer information about COVID-19 seroprevalence, which could be useful for disease prevention and control at the population level. Serological tests are essential for establishing SARS-CoV-2 exposure and protective factors. From the two clones that were constructed in the current study, it was noted that, the used expressed protein based on Clone 8 is likely more sensitive than the expressed protein based on clone 105. We recommend that this clone be utilized for large-scale screening of covid19 in any future outbreak in our nation; nevertheless, it requires more sensitivity and specificity validation. Despite we used a positive pool serum but we recommend to use positive known antibody titer from any other laboratory as positive

control next time, and we recommend to use both clones as combination in next study for validation or to use surface protein with other types of protein like nucleocapsid as it is more conserved gene with less mutations. We recommend as well to test specificity of our developed test by using other types of Corona viruses to increase validation.

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Author Contribution

Rasmi Abu-Helu: supervising the study and manuscript writing, Hana Al-Khatib conducting the experimental research and writing the manuscript, Tamer Shabana, Aseel Eqneiby, Rawan Ajlouni, all helped in sample collection and part of the conducting part of the experimental work. Ibrahim Abbasi: supervising the study and manuscript writing.

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Reverse Osmosis Membrane Scaling Inhibition using Kinetic Degradation Fluxion Media

RESEARCH

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A B S T R A C T

Membrane fouling can lead to reduced efficiency, increased operating costs, and shorter membrane life, which can ultimately impact the quality of potable water produced from seawater. The use of Kinetic Degradation Fluxion (KDF) media as a pretreatment method is promising because it can potentially reduce fouling caused by $CaCO_3$ scaling and improve the performance of RO membranes. The study's methodology, which involves comparing two identical reverse osmosis systems with and without KDF pretreatment, is appropriate and well-designed. By comparing the salt rejection and permeability flow of the two membrane systems, the study can provide valuable insights into the effectiveness of KDF media in reducing fouling caused by CaCO3 scaling. The explanation of how KDF media works to prevent the formation of mineral hardness scale by altering the morphology of the insoluble Ca and Mg carbonate and sulfate crystals and creating a redox environment is helpful in understanding the potential mechanism behind the effectiveness of KDF media as a pretreatment method. By controlling the formation of mineral scale and other contaminants, KDF media can potentially lead to improved efficiency of the RO membrane. Results suggest that KDF media can be an effective pretreatment method for reducing fouling caused by mineral scaling in RO systems. The potential mechanism behind the effectiveness of KDF media is explained, and the observation that only a small number of KDF discs were degraded over the 40-hour period indicates that KDF media can be used for multiple cycles of RO operation, reducing the frequency of media replacement and associated operating costs. The finding that the RO-KDF membrane remained healthy and efficient for 40 hours while fouling was observed in the RO system within 20 hours is also promising, as it indicates that the KDF media can effectively reduce membrane fouling caused by scaling, leading to improved efficiency and extended membrane life. However, further studies can explore the optimal conditions for using KDF media in RO systems to maximize its effectiveness in reducing fouling and extending the lifetime of RO membranes. Investigating the potential for KDF media to reduce fouling caused by other contaminants, such as organic matter or silica, would also be interesting.

Keywords: Kinetic Degradation Fluxion, RO-KDF membrane, fouling

Introduction

Reverse osmosis (RO) is a widely used water treatment technology based on a semi-permeable membrane to remove impurities from water. However, fouling is a major problem that can affect the efficiency and lifespan of reverse osmosis membranes. It is important to implement effective pretreatment methods to remove or reduce potential sizing of materials and other contaminants in the feed water (Mulyawan and Muarif, 2021). Reverse osmosis membrane scaling may occur when poorly soluble salts in the reverse osmosis element are concentrated beyond their solubility limits (Robinson, et. al 2016). Calcium carbonate ($CaCO_3$) is a common source of measurement in reverse osmosis membranes, due to its rapid sedimentation rate and the fact that many natural water sources are saturated with respect to $CaCO_3$. When water with high concentrations of sparingly soluble salts, such as calcium carbon-

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ate, is passed through an RO membrane, the salts can become concentrated beyond their solubility limit, leading to the formation of solid deposits on the membrane surface. This can reduce the effectiveness of the membrane and lead to decreased permeate flow, increased pressure drop, and other related issues that can affect the performance and lifespan of the RO system. In order to prevent scaling and maintain the performance of the RO membrane, it is important to implement effective pretreatment methods to remove or reduce the concentration of scaling potential substances from the feed water. This can include physical, chemical, or biological methods to remove suspended solids, dissolved organic matter, and other contaminants that can contribute to scaling. It is also important to carefully monitor the performance of the RO system and take appropriate measures to address any $CaCO_3$ scaling or fouling issues that may arise (Eisheh, and Shoqier, 2017). Fouling is a common problem in membrane technology, including reverse osmosis, and can occur due to various factors such as the feedwater quality, membrane material and structure, and operating conditions. $CaCO_3$ fouling occurs when particles or contaminants in the feedwater accumulate on the surface of the membrane, while internal fouling occurs when these particles or contaminants accumulate within the membrane structure, reducing its permeability. The schematic diagram figuring the surface and internal fouling are shown in Figure 1.

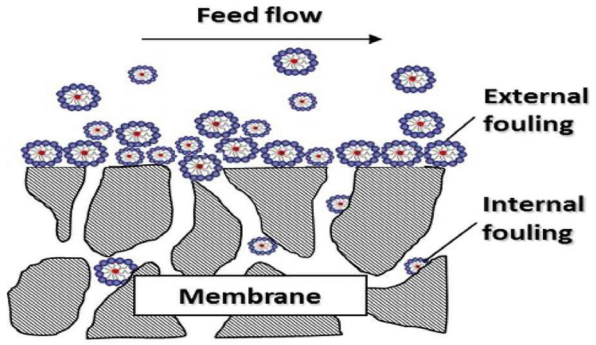

Figure 1: Schematic diagram of reverse osmosis process (SHAMS, 2013)

Fouling can have a significant impact on the performance of the membrane, reducing its permeation flux and salt rejection, and increasing the need for maintenance and cleaning. To address fouling, various pretreatment and cleaning techniques can be used, such as prefiltration, chemical cleaning, and backwashing. In addition, researchers are continually developing new materials and technologies to improve the performance and lifespan of membranes and reduce fouling (Lin, et al, 2016 and She, et al 2016). Fouling can have a range of negative effects on the performance and efficiency of membrane technology, including decreased productivity, lower permeate quality, increased energy demand, the need for additional pre-treatment steps, and increased operating and maintenance costs. Additionally, fouling can shorten the lifespan of the membrane, leading to the need for more frequent replacement and further adding to operational expenses. Therefore, it is important to develop effective fouling control strategies to minimize the negative impact of fouling on membrane technology. In order to avoid $CaCO_3$ scaling and fouling, the pH of the concentrate stream in an RO system should be lower than the pH of saturation (pHs) where the water of the concentrate stream is in equilibrium with $CaCO_3$. This relationship is expressed by the Langelier Saturation Index (LSI) for brackish waters and Stiff and Davis Saturation Index (S&DSI) for sea waters (de Souza et al., 2018 and Robinson et al. 2021). Water treatment professionals often use the index to monitor the potential for scaling and adjust treatment processes to prevent scaling and ensure optimal water quality. Water treatment professionals patented a chemical compound called Kinetic Degradation Fluxion media (KDF). KDF media is a high-purity alloy of copper (Cu) and zinc (Zn) that is used as a prefilter in water purification systems. As water passes through the KDF bed, a redox reaction takes place, which helps to remove impurities such as minerals, metals, dissolved oxygen, and organic materials. KDF is often used in combination with other filtration technologies, such as reverse osmosis, to improve their performance and reduce the need for expensive chemical treatments. KDF media has been found to be effective in reducing chlorine in water, which is important in water treatment, particularly in industrial settings. By reducing chlorine and other impurities, KDF can help prevent fouling and scaling in reverse osmosis water treatment plants, improving their efficiency and lifespan (Eisheh, R., and Shoqier, 2017 and Majdi, et. al., 2019). The study will examine the performance of the two membranes, one with KDF pretreatment and the other without, to determine if KDF media is effective in reducing fouling caused by $CaCO_3$ scaling in reverse osmosis systems. The comparison will be based on the salt rejection and permeability flow of the two membranes.

Materials and Methods

TW30-1812-50 FILMTEC™ RO membrane was used for all experiments. This type of membrane is specifically designed for home drinking water systems and is capable of high salt rejection rates up to 99% with a permeate flow of up to 200 L per day. Addition-

ally, a CuZn filter using KDF-media was used for the study. This filter contains 11 patented reticulated discs with a diameter of 5 cm and a thickness of 1.3 cm for each disc. The discs are flexible, oversized, lightweight, and environmentally friendly. They also have a porous nature, making them easy to install.

For each test in the study, two membranes were used: a reference and a control membrane where the feed water was directed straight through without passing through the KDF media, and a pretreatment membrane where the feed water was passed through the KDF media first. A simplified schematic of the experiment design and layout is shown in Figure 2.

indicated by Eq(1).

$$LSI = pH - pHs \quad Eq(1)$$

The tap water used in the experiments had an average concentration of 45 mg/l for Ca and 300 mg/l for HCO_3, but these levels increased to 174 mg/l for Ca and 600 mg/l for HCO_3 in the supersaturated feed solution. The initial pH values for the experiments were in the range of 7-7.5 to achieve a critical LSI value in the range of 0.5-1, indicating a high potential for scaling. The feed tank was kept fully closed to maintain a constant LSI level throughout the experiment.

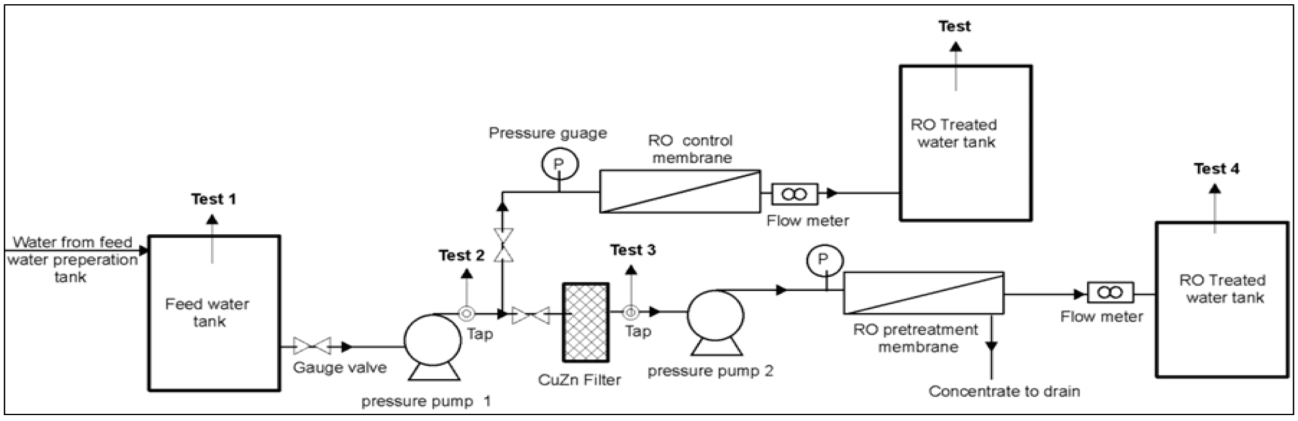

Figure. 2: Experiments schematic design for RO system

The study focused on measuring the effectiveness of KDF media in reducing fouling on RO membranes. Since fouling can lead to a decline in salt rejection and flux rate, these parameters were used to determine the effect of KDF media on reducing fouling. By comparing the salt rejection and permeate flow rate of the RO membrane with and without KDF media, the effectiveness of KDF media in reducing fouling could be roughly assessed. Prior to the experiment, the feed water was analyzed to ensure that the potential for fouling due to factors such as biofouling and mineral fouling was very low.

Results

RO membrane performance parameters in $CaCO_3$ experiments

To prepare a supersaturated $CaCO_3$ feed solution with high scaling potential for the experiments, 16 grams of $CaCO_3$ were dissolved in 50 liters of tap water with rapid mixing. Since CaCO3 is a major source of Ca, adding it to water increases the levels of both Ca and HCO_3, which are fundamental parameters that control the Langelier Saturation Index (LSI) value, as

Salt rejection

RO-only salt rejection

The study found that the optimal salt rejection for the membrane was 96.8%, which was achieved after running the membrane for 3 hours with tap water as the feed solution. When the feed solution was switched to the $CaCO_3$ supersaturated solution, the salt rejection decreased slightly to 95.2% in the 4th running hour and remained relatively constant thereafter (figure 3). Overall, the salt rejection in the RO-only system with the supersaturated $CaCO_3$ solution was in the range of 94.1%-96.8%, which is considered high. The $CaCO_3$ supersaturated solution did not have a significant chemical effect on the material and composition of the polyimide membrane, allowing the system to operate for 40 running hours with a high salt rejection capability.

RO-KDF salt rejection

The KDF media used in the RO-KDF system was effective in reducing fouling and maintaining the performance of the RO membrane. Despite being exposed to a supersaturated $CaCO_3$ solution, the salt re-

jection remained relatively constant for the rest of the 40-hour running period with a range between 95.8% and 96.8% and only a 1% reduction in salt rejection overall. This indicates that the KDF media was successful in reducing fouling caused by the $CaCO_3$ solution and maintaining the performance of the RO membrane.

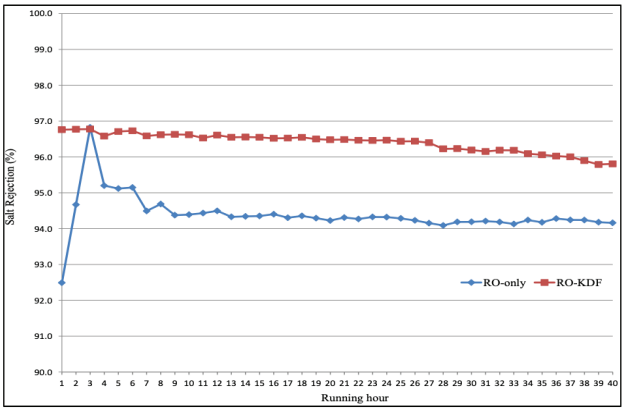

Figure 3: Salt rejection obtained by RO-only and RO-KDF systems.

Permeate flow

Permeate flow is affected by temperature, with higher temperatures generally resulting in higher permeate flow. The experiments in this study were conducted over a range of temperatures from 12.2°C to 28.7°C. The proper permeate flow at each temperature was determined by plotting the typical permeate flow at 60 psi, in accordance with company recommendations.

RO permeate flow

The maximum permeate flow rate of 12 L/h was obtained in the first hour of running using tap water with negative LSI. However, after switching to the $CaCO_3$ supersaturated solution, the maximum permeate flow rate was reduced to 11 L/h in the 7th hour of running. A backwashing operation was performed in the 13th hour of running, which increased the permeate flow rate to 12 L/h by partially removing precipitation and deposition within the membrane. After 22 hours of running, the permeate flow rate decreased to 9 L/h, and backwashing was performed again in the 23rd hour, leading to better performance and an increase in permeate flow rate. However, after 33 hours of running, backwashing became ineffective due to the strong attachment of the particles, resulting in reversible fouling being transformed into an irreversible fouling layer that cannot be removed by physical cleaning methods. In the $CaCO_3$ experiments, the minimum permeate flow rate was 7 L/h, which represents a 41% reduction in permeate flow compared to the maximum permeate flow rate achieved in the first hour of running. This reduction in permeate flow is a strong indicator of fouling, specifically scaling caused by the $CaCO_3$ supersaturated solution used as the feed solution. It is important to note that this reduction in permeate flow is significant, as a 15% reduction in permeate flow is enough to suggest fouling. Additionally, since the feed water analysis indicated low potential for other types of fouling such as metal fouling, microbial fouling, and colloidal fouling, scaling caused by the $CaCO_3$ supersaturated solution is the most likely culprit for the fouling. The total passing feed solution of 1250.5L was processed by the RO system during the 40 running hours. Of this amount, 393.5L was produced as permeate flow, while the remaining amount was the concentrate. The average permeate flow for the running hour was 9.8L, while the average concentrate was 21.4L. This suggests that the system was able to produce permeate flow at a rate of approximately 44% of the feed flow. It also suggests that the system was able to concentrate the feed solution approximately 2-fold.

RO-KDF permeate flow

The RO-KDF system was able to maintain its maximum permeate flow of 12 L/h for the first 18 running hours (figure 4) , despite being exposed to a supersaturated $CaCO_3$ solution. This is likely due to the KDF media's ability to reduce fouling and maintain the performance of the RO membrane. However, after 22 running hours, an 8% reduction in permeate flow was observed, indicating some level of fouling. Fortunately, the second backwashing operation was able to restore the system's maximum permeate flow again to 12 L/h, suggesting that physical cleaning methods like backwashing can be effective in removing fouling and restoring system performance.

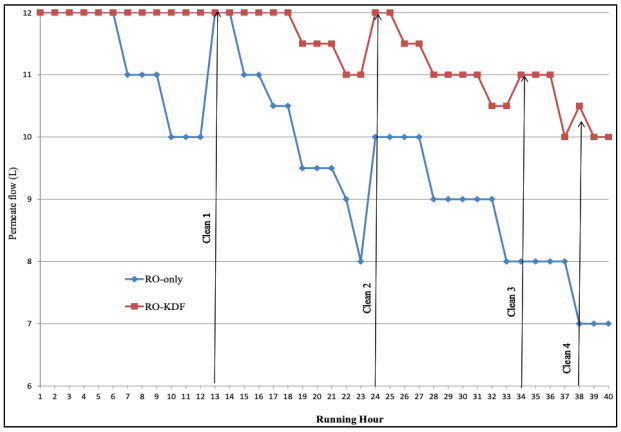

Figure 4: Permeate flow produced by RO-only and RO-KDF systems.

Based on the results, the RO-KDF system was able to maintain its maximum permeate flow of 12 L/h for the first 18 running hours, and despite experiencing an 8% reduction in permeate flow after 22 running hours, the second backwashing operation was able to restore the system's maximum permeate flow again to 12 L/h. The maximum reduction of permeate flow in the RO-KDF system was only 16% with 10 L/h, and this value was measured in the last 2 running hours, indicating that fouling was still reversible. The experiments ended after 40 running hours, with a total passing feed solution of 1382L, 458L were permeate flow and 924L were concentrated. The average permeate flow for the running hour was 11.5L, while it was 22.2L for concentrate. These results suggest that the RO-KDF system was able to produce permeate flow at a rate of approximately 33% of the feed flow and concentrate the feed solution by approximately 2-fold.

Scaling inhibition by KDF

The KDF media was able to prevent the formation and accumulation of mineral hardness scale, which is primarily composed of $CaCO_3$, by altering the morphology of insoluble Ca and Mg carbonate and sulfate crystals to relatively small, evenly shaped, and rounded grains and rods. As a result, there was no change in the water composition and the permeate flow results showed that the KDF media improved the efficiency of the RO membrane. This change in crystal morphology is due to the redox reaction that occurs on the surface of the KDF media , which results in the formation of small, spherical crystals that are less likely to adhere to surfaces and form scaling. The KDF media is able to achieve this through its unique combination of copper and zinc, which creates a redox environment that helps control the formation of mineral scale and other contaminants in the water. This is why the KDF media was effective in preventing fouling and maintaining the performance of the RO membrane, even when exposed to a supersaturated $CaCO_3$ solution.

Discussion

The use of KDF media as a pretreatment step in RO systems has shown promising results in preventing fouling and scaling caused by $CaCO_3$. The redox environment created by the combination of copper and zinc in the KDF media has been found to alter the morphology of the insoluble Ca and Mg carbonate and sulfate crystals, resulting in small, evenly shaped, and rounded grains and rods that are less likely to adhere to surfaces and form scaling. The $CaCO_3$ experiments demonstrated that the RO-KDF membrane was able to maintain high efficiency and prevent fouling for a longer period of time than the RO-only system, with the KDF media extending the lifetime of the membrane for at least one cycle. Additionally, the concentrate produced by the RO-KDF system had less scaling potential, indicating that the fouling in the whole plant could be minimized. However, it should be noted that the KDF media has a limited ability in $CaCO_3$ inhibition, and 11 discs were required to extend the lifetime of the membrane once only. This suggests that KDF media may not be a cost-effective solution for long-term use in RO systems for $CaCO_3$ inhibition. Overall, further studies are needed to explore the effectiveness of KDF media as a pretreatment step for other types of fouling and scaling in RO systems and to evaluate its cost-effectiveness in comparison to other pretreatment methods.

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