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THE IMMUNITY-INFECTION ARMS RACE: AN ISLAMIC PHILOSOPHICAL AND EDUCATIONAL PERSPECTIVES

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Abstract

This article explores the interdisciplinary nexus between the Islamic philosophy of science and immunology, explicitly focusing on the immunity-infection arms race. Using COVID-19 as a case study, the paper elucidates the complex interplay between the immune system and pathogens, serving as a primer for Islamic scholars and non-scientists. It pioneers the Islamic philosophical perspectives into the understanding of this arms race, arguing that Islamic teachings not only align with but also enrich the ethical dimensions inherent in immunological studies. The article further delves into the educational applications of Islamic perspectives, advocating for a multidisciplinary approach that synergizes scientific rigor with Islamic ethical considerations. Methodologically, the article employs logical, theological, and philosophical analyses of extensive scientific and religious literature. The study offers a robust framework congruent with scientific and Islamic principles. The article holds practical significance beyond academic discourse by: (1) fostering potential collaboration among Islamic scholars, scientists, and educators, and (2) contributing to global health initiatives, particularly in Muslim-majority countries. Overall, it serves as a novel contribution to the interdisciplinary dialogue,

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revolutionizing the education of science and Islam related to the health and well-being of the Muslim community.

Keywords: Islamic philosophy of science; immunology; immunity-infection arms race; science and Islam; Islamic education.

Khulasah

Artikel ini meneroka perhubungan interdisiplin antara falsafah sains Islam dan imunologi, dengan fokus khusus pada persaingan adaptasi imuniti-jangkitan. Menggunakan COVID-19 sebagai kajian kes, makalah ini menjelaskan interaksi kompleks antara sistem imun dan patogen, dan berperanan sebagai sumber pemula untuk sarjana Islam dan bukan-saintis. Objektif kajian adalah untuk memperkenalkan perspektif intergrasi falsafah Islam dalam pemahaman mengenai persaingan ini, dengan menekankan bahawa ajaran Islam selari dalam memperkayakan dimensi etika melibatkan kajian imunologi. Artikel ini juga menyelami aplikasi pendidikan dari perspektif Islam, menyeru kepada pendekatan multidisiplin yang mensinergikan ketelitian saintifik dengan pertimbangan etika Islam. Bersandarkan metode analisis logik, teologi, dan falsafah dari sorotan sains dan agama, kajian ini menawarkan rangka kerja yang selaras dengan prinsip sains dan Islam. Artikel ini juga bermanfaat di luar wacana akademik: (1) mendorong potensi kerjasama antara sarjana Islam, saintis, dan pendidik sains, dan (2) menyumbang kepada inisiatif kesihatan global, terutamanya di negara-negara majoriti Muslim. Secara keseluruhannya, artikel ini memberi sumbangan baru kepada dialog interdisiplin, di samping merevolusikan pendidikan sains dan Islam berkaitan kesihatan dan kesejahteraan ummah.

Kata kunci: Falsafah sains Islam, imunologi; persaingan adaptasi imuniti-jangkitan; sains dan Islam; pendidikan Islam.

Introduction

The intersection of religion and science has been a topic of interest in various philosophical and theological traditions. Islam, as a comprehensive way of thought and life, encompasses various aspects of human experience, including the pursuit of knowledge of the biological self. One crucial part of this is the Islamic philosophy of science. It is part of the broader Islamic philosophy, which covers a wide array of inquiries outside natural sciences, such as metaphysics, philosophy of religion, logic, and other fields. As a subset of Islamic philosophy, the Islamic philosophy of science focuses its explorations on scientific ideas and integrates them within Islamic beliefs, teachings, and values[1].

Islamic scholars have approached the integration of natural sciences into Islamic philosophy in different ways. Prominent scholars, such as Syed Muhammad Naquib al-Attas and Osman Bakar emphasize the harmony of science and religion, seeing them as complementary rather than contradictory[2]. They aim to bridge the perceived gap between Islamic teachings and scientific knowledge, recognizing that the gap is illusory in understanding reality. Islamic philosophy holds a rich tradition of exploring questions related to the nature of human self. In this regard, Islam can offer insightful philosophical and educational perspectives on various scientific disciplines, including immunology.

Immunology studies the immune system and its role in protecting the body from harmful infections and diseases.

[1] Osman Bakar, "Islamic Science, Modern Science, and Post-Modernity towards a New Synthesis through a Tawhidic Epistemology," *Revelation and Science* 1(3) (2011), 13–20.

[2] Syed Muhammad Naquib Al-Attas, *Prolegomena to the Metaphysics of Islam: An Exposition of the Fundamental Elements of the Worldview of Islam* (Kuala Lumpur: Universiti Teknologi Malaysia Press, 1995); Osman Bakar, "From Secular Science to Sacred Science: The Need for a Transformation," *Sacred Web* 33 (2014), 25–49.

It is distinct from immunization or vaccination. While vaccination is indeed an important application within immunology, it represents just one small aspect of this extensive scientific discipline. Immunology encompasses studying all aspects of the immune system in all organisms, more than just humans. It includes diverse topics such as how the body combats infections (most of the time without vaccines) and what happens when errors occur (leading to allergies or autoimmune diseases unrelated to vaccinations).

Many works have been contributed to Islamic medical history and biomedical ethics. However, there is a philosophical divergence in how natural scientists and Islamic scholars approach their respective disciplines. This gap primarily manifests in ontological and epistemological perspectives, which often remain unbridged in immunology. To exemplify this, a literature search can be performed using Google Scholar with a Boolean search for 'Islamic philosophy AND immunology'. It yields limited results on the Islamic ontological and epistemological perspectives. Instead, it predominantly directs attention to Islamic medical history and biomedical ethics. In contrast, equivalent searches within the realm of physics, 'Islamic philosophy AND physics', reveal robust dialogues encompassing Islamic physics, existence and quiddity in Islamic philosophy, and *Daqiq al-Kalam* among others.

One reason is that Islamic scholars may not be familiar with specialized scientific knowledge, such as immunology, to complement their great theological expertise, despite active interactions with online sources[3].

[3] Rusli Rusli, Muhammad Syarif Hasyim & Nurdin Nurdin, "A New Islamic Knowledge Production and Fatwa Rulings: How Indonesia's Young Muslim Scholars Interact with Online Sources," *Journal of Indonesian Islam* 14(2) (2020), 499–518, doi:10.15642/JIIS.2020.14.2.499-518.

Similarly, scientists are generally unfamiliar with the Islamic philosophical principles pertinent to immunology.

This article seeks to take a small step in alleviating those problems. It addresses both the Islamic scholars and scientists. On the one hand, it will equip Islamic scholars with a scientific understanding of a key philosophical view in immunology. On the other, it familiarizes scientists with Islamic principles relevant to that view. A balance between scientific rigor and philosophical considerations is essential in the complex healthcare landscape. This article explores how Islamic principles provide unique perspectives that connect the scientific and philosophical aspects of immunology. Additionally, the Islamic philosophy of science holds valuable guidelines that offer insights into health education. It provides a framework that is not only congruent with scientific education but also enhances its inherent ethical dimensions.

This article aims to achieve three main objectives: first, to elucidate the concept of immunity-infection arms race; second, to explore Islamic philosophical perspectives in interpreting that concept; and third, to unearth the educational applications of such perspectives. The methodology employed for this study includes the logical, theological, and philosophical analyses of extensive scientific and religious literature and case studies. That methodological approach allows for an in-depth analysis of the topic, drawing from both historical and current sources.

This article is structured into multiple sections to ensure clarity and thoroughness. In the initial section, we will delve into the immunological dynamics of the immunity-infection arms race. We will use the familiar Coronavirus Disease 2019 (COVID-19) as an illustrative example to enhance clarity. Next, the following sections will inquire into vital Islamic principles relevant to the immunity-infection arms race, and the educational considerations in dealing with diseases.

It is important to note that this article is not just about Islamic responses to specific medical interventions like COVID-19 vaccinations. COVID-19 is mentioned as an illustrative example and is not the main topic. Such examples demonstrate broader principles within the Islamic philosophy of science, specifically relating to understanding immune system dynamics.

Essentially, this article holds significance beyond academic interest. It can foster collaboration by being a source of reference among Islamic scholars, scientists, and science educators, especially in relation to immunology and Islam. Moreover, it contributes to global health initiatives by presenting a framework that is scientifically and Islamically sound, especially in Muslim-majority countries.

The Immunity-Infection Arms Race: An Example from COVID-19

Before unpacking the Islamic perspectives of the immunity-infection arms race, it is critical to first understand its underlying dynamics. This section will provide a scientific overview of that philosophical concept. While we can use other diseases to support that concept, we will use Coronavirus Disease 2019 (COVID-19) as an illustrative example because it is familiar to a broader audience. This section is written for both scientists and non-scientists, such as Islamic scholars. For scientists, this section discusses recent evidence that comprehensively showcases the dynamics of the immunity-infection race. For non-scientists, having an extremely detailed technical understanding of the immunological mechanisms is unnecessary. To benefit from this section, the non-scientists can focus on summary paragraphs which give a helpful general understanding, preparing us to probe into their philosophical implications in the later sections.

As a starting point, the arms race between immunity and infection is an analogical representation of a philosophical concept in immunology. It refers to the

ongoing competition between the immune system and pathogens. This competition arises because the immune system and pathogens constantly strive to survive and exceed each other. It creates a cycle of adaptation and counter-adaptation, similar to the arms races seen in military conflicts, where opposing sides continuously develop new weapons in an attempt to gain an advantage in warfare. In our context, this warfare involves two sides. The first side is the immune system, which acts as the body's defense force. It comprises cells, tissues, and organs that work together through various mechanisms.

In principle, these defensive mechanisms operate in two stages. In the first stage, the immune system attempts to recognize invading pathogens. The highest priority during this stage is distinguishing pathogens from our own cells. This ensures that our healthy cells are not mistakenly targeted. In the second stage, the immune system aims to eradicate the invading pathogens, both to prevent infections and maintain overall health, also known as immunological homeostasis[4]. The second side of this warfare is the pathogens. Infection occurs when pathogens, such as viruses, enter the body to multiply themselves. These pathogens deploy strategies to incapacitate, or at least evade the immune system. Such strategies have been continuously developed over millions of years. What incentivizes such development is that the very survival of a pathogen depends on its success in avoiding the immune system. When this avoidance is achieved, the pathogens can then replicate themselves undetectably within an organism.

To express it another way, the arms race is the ongoing competition for adaptation. The immune system

[4] Valentina Carlini et al., "The Multifaceted Nature of IL-10: Regulation, Role in Immunological Homeostasis and Its Relevance to Cancer, COVID-19 and Post-COVID Conditions," *Frontiers in Immunology* 14 (2023), https://www.frontiersin.org/articles/10.3389/fimmu.2023.1161067.

continuously adapts to recognize and eliminate new pathogens, while pathogens adapt and develop strategies to evade the immune system. This dynamic interaction between the immune system and pathogens is well documented in scientific literature.

One striking example is the SARS-CoV-2 virus, proficient at evading the human immune system. SARS-CoV-2 is the pathogen behind COVID-19. The COVID-19 pandemic has vividly shown the arms race between our immune system and this viral pathogen. This global health crisis has highlighted the importance of understanding the intricate dynamics of immunity and infection. In December 2019, the SARS-CoV-2 virus emerged during an outbreak in Wuhan, China[5]. It then swiftly spread across the world. The observable effects of COVID-19 were inconsistent[6]. Some infected individuals experience severe respiratory illness, while others only present mild to moderate symptoms or remain asymptomatic. These varying effects of COVID-19 and the speed of SARS-CoV-2 transmission highlight the complexities of the interplay between the immune system and infection. This interplay has had profound consequences, with millions of lives lost globally[7]. It exemplifies the impact when pathogens secure an advantage in the arms race against the immune system. To understand this further, the following paragraphs will analyze how SARS-CoV-2 gains such an advantage.

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[5] Kristian G. Andersen et al., "The Proximal Origin of SARS-CoV-2," *Nature Medicine* 26(4) (2020), 450–52, doi:10.1038/s41591-020-0820-9.

[6] Manfred S. Green et al., "Sex Differences in the Case-Fatality Rates for COVID-19—A Comparison of the Age-Related Differences and Consistency over Seven Countries," *PLOS ONE* 16(4) (2021), e0250523, doi:10.1371/journal.pone.0250523.

[7] Peter Bager et al., "Conflicting COVID-19 Excess Mortality Estimates," *The Lancet* 401, no. 10375 (2023): 432–33, doi:10.1016/S0140-6736(23)00115-0.

An appropriate place to begin is the role of the immune system in combating viral infections. The immune response against viruses involves multiple components. These components can be broadly categorized into the innate immune system and the adaptive immune system[8]. The innate immune system includes white blood cells, which play a role in the initial defense. They can detect the presence of viral particles and take immediate action to prevent the infection from spreading. The innate immune system protects the body in various ways. For example, protection can be achieved through the activation of genes called interferon-stimulated genes (ISGs)[9]. These genes stimulate interferons, which are a group of signaling proteins. Host cells produce and release them in response to the presence of viruses. When a cell is infected with a virus, the cell releases interferons to signal other cells to enhance their defenses.

Interferons function in two ways: Firstly, they hinder the replication of the virus within our cells by disrupting specific stages of its replication cycle[10]. Secondly, interferons stimulate the overall immune response, helping white blood cells to clear viral infections[11]. Part of this stimulation includes the stimulation of the ISGs mentioned before. Some ISGs have direct antiviral activity against SARS-CoV-2, including interferon-simulated gene 15

[8] Benjamin Ruf, Tim F. Greten & Firouzeh Korangy, "Innate Lymphoid Cells and Innate-like T Cells in Cancer — at the Crossroads of Innate and Adaptive Immunity," *Nature Reviews Cancer* 23(6) (2023), 351–71, doi:10.1038/s41568-023-00562-w.

[9] Lucky Sarkar, GuanQun Liu & Michaela U. Gack, "ISG15: Its Roles in SARS-CoV-2 and Other Viral Infections," *Trends in Microbiology* (2023), doi:10.1016/j.tim.2023.07.006.

[10] Ram Savan & Michael Gale, "Innate Immunity and Interferon in SARS-CoV-2 Infection Outcome," *Immunity* 56(7) (2023), 1443–50, doi:10.1016/j.immuni.2023.06.018.

[11] Kavita Raniga & Chen Liang, "Interferons: Reprogramming the Metabolic Network against Viral Infection," *Viruses* 10(1) (2018), 36, doi:10.3390/v10010036.

(ISG15)[12]. ISG15 inhibits viral replication and promotes the destruction of infected cells. It improves immune signaling after the recognition of the viral RNA molecule. ISG15 accomplishes this by tagging viral proteins for degradation and facilitating their removal from the body.

To complement the innate immune system, the human body also has an adaptive immune system. Here, it is important to point out that the arms race between immunity and infection hinges on the adaptive immune system, rather than the innate immune system. The reason for this is the innate immune system provides a quick but generalized defense. In other words, it attacks different pathogens in generally similar ways. The adaptive immune system, on the other hand, provides specific defense. It learns, remembers, and adapts to target specific pathogens. This specificity relies on immune cells called lymphocytes. Lymphocytes are found in the blood and encompass B cells and T cells. B cells initiate antibody-based immunity while T cells initiate cell-based immunity[13]. Compared to the innate immune system, the adaptive immune system responds slower during the first encounter with a virus. Nevertheless, the adaptive immune system responds with higher accuracy and speed in subsequent encounters. Part of the reason is lymphocytes possess receptors on their surface that recognize distinct molecules known as antigens[14].

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[12] Pedro H. Gazzinelli-Guimaraes et al., "Antigenic Determinants of SARS-CoV-2-Specific CD4+ T Cell Lines Reveals M Protein-Driven Dysregulation of Interferon Signaling," *Frontiers in Immunology* 13 (2022), https://www.frontiersin.org/articles/10.3389/fimmu.2022.883159.

[13] Ryosuke Hiwa et al., "NR4A Nuclear Receptors in T and B Lymphocytes: Gatekeepers of Immune Tolerance," *Immunological Reviews* 307(1) (2022), 116–133, doi:10.1111/imr.13072.

[14] Lauren B. Rodda et al., "Imprinted SARS-CoV-2-Specific Memory Lymphocytes Define Hybrid Immunity," *Cell* 185(9) (2022), 1588-1601.e14, doi:10.1016/j.cell.2022.03.018.

The identities of antigens are unique to each pathogen. By recognizing and targeting these antigens, the adaptive immune system can mount a tailored response against pathogens such as SARS-CoV-2. The adaptive immune system helps prevent severe COVID-19 through antibodies produced by B cells[15]. This response involves the binding of those antibodies to the viral particles and neutralizing them to prevent further infection. The exact duration of the adaptive immune system to SARS-CoV-2 is unclear. A reason for this is the relative newness of the disease. However, studies have shown that B cell memory and T cell immunity against SARS-CoV-2 can last for a significant period, suggesting that immunity could be long-lasting[16].

We have so far discussed the role of the immune system in fighting SARS-CoV-2. Next, we will describe how SARS-CoV-2 gains an advantage and overtakes the defense provided by the immune system. The arms race between immunity and infection is constant, where both sides adapt their strategies to gain an upper hand. Like other viruses, SARS-CoV-2 has developed ways to evade and manipulate the immune response. These strategies include inhibiting the production of antiviral proteins, blocking the activation of immune cells, and manipulating host signaling pathways[17]. In the arms race between our immune system and SARS-CoV-2, the virus has found ways to disrupt both innate and adaptive immune responses. To evade the innate

[15] Endeshaw Chekol Abebe and Tadesse Asmamaw Dejenie, "Protective Roles and Protective Mechanisms of Neutralizing Antibodies against SARS-CoV-2 Infection and Their Potential Clinical Implications," *Frontiers in Immunology* 14 (2023), https://www.frontiersin.org/articles/10.3389/fimmu.2023.1055457.

[16] Antti Hurme et al., "Long-Lasting T Cell Responses in BNT162b2 COVID-19 mRNA Vaccinees and COVID-19 Convalescent Patients," *Frontiers in Immunology* 13 (2022), https://www.frontiersin.org/articles/10.3389/fimmu.2022.869990.

[17] Mariem Znaidia et al., "Characterization of SARS-CoV-2 Evasion: Interferon Pathway and Therapeutic Options," *Viruses* 14(6) (2022): 1247, doi:10.3390/v14061247.

immune system, SARS-CoV-2 employs multiple mechanisms. One such mechanism is the delay of the interferon-related innate immune response[18].

For example, earlier in this section, we mentioned ISG15, a protein that inhibits viral replication. Studies have shown that SARS-CoV-2 counteracts ISG15 in infected cells[19]. The virus does this through an enzyme called the SARS-CoV-2-PLpro protease. This protease detaches ISG15 from key immune proteins. These key immune proteins include Interferon Regulatory Factor 3 (IRF3) and Melanoma Differentiation-Associated Gene 5 (MDA5)[20]. IRF3 and MDA5 signal the production of defensive molecules such as interferons that help combat viral infections, and they require ISG15 for this signaling. Therefore, when the virus detaches ISG15 from IRF3 and MDA5, the virus prevents the activation of antiviral pathway signaling involving IR3 and MDA5. This signal disruption impedes the production of interferons mentioned earlier. Such impediment to interferon production allows the virus to evade the initial innate immune response and replicate unchecked within host cells[21].

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[18] Jordan M. Meyers et al., "The Proximal Proteome of 17 SARS-CoV-2 Proteins Links to Disrupted Antiviral Signaling and Host Translation," *PLOS Pathogens* 17(10) (2021), e1009412, doi:10.1371/journal.ppat.1009412.

[19] Caleb D. Swaim et al., "Modulation of Extracellular ISG15 Signaling by Pathogens and Viral Effector Proteins," *Cell Reports* 31(11) (2020), 107772, doi:10.1016/j.celrep.2020.107772.

[20] Raul S. Freitas, Tyler F. Crum, and Kislay Parvatiyar, "SARS-CoV-2 Spike Antagonizes Innate Antiviral Immunity by Targeting Interferon Regulatory Factor 3," *Frontiers in Cellular and Infection Microbiology* 11 (2022), https://www.frontiersin.org/articles/10.3389/fcimb.2021.789462.

[21] Xiaoming Sun et al., "Immune-Profiling of SARS-CoV-2 Viremic Patients Reveals Dysregulated Innate Immune Responses," *Frontiers in Immunology,* 13 (2022), https://www.frontiersin.org/articles/10.3389/fimmu.2022.984553.

Apart from evading the innate immune response, SARS-CoV-2 also develops strategies to target and bypass the adaptive immune system. One way SARS-CoV-2 avoids the adaptive immune response is by mutating its spike protein[22]. The spike protein is an antigen, which is the target for neutralizing antibodies produced by B cells. As mentioned earlier, these antibodies play a crucial role in the adaptive immune system. They do so by recognizing and binding to the spike protein, preventing the virus from entering human cells. By stopping this viral entry into the human cells, the antibodies effectively neutralize the ability of the virus to infect. To bypass this adaptive immune component, SARS-CoV-2 undergoes mutations in its spike protein. Mutations have been observed in two regions of the spike protein: the receptor binding domain and the N-terminal domain[23]. These mutations change the structure of the spike protein in a way that reduces the effectiveness of antibody binding. This change is immunologically important. Antibodies need to recognize the spike protein with precision to perform antiviral functions. By mutating the spike protein, the virus stops the antibodies from recognizing its spike protein. This failure of recognition allows the virus to escape neutralization by antibodies.

As we have seen in both the innate and adaptive immune responses, the manipulation by SARS-CoV-2 reveals the intricate nature of the ongoing arms race between our immune system and the infection it tries to combat. This constant struggle between our immune system

[22] Md Mohsin and Sultan Mahmud, "Omicron SARS-CoV-2 Variant of Concern: A Review on Its Transmissibility, Immune Evasion, Reinfection, and Severity," *Medicine* 101(19) (2022), e29165, doi:10.1097/MD.0000000000029165.

[23] Dhiraj Mannar et al., "SARS-CoV-2 Variants of Concern: Spike Protein Mutational Analysis and Epitope for Broad Neutralization," *Nature Communications* 13(1) (2022), 4696, doi:10.1038/s41467-022-32262-8.

and SARS-CoV-2 also highlights the complex mechanisms employed by both sides to gain a survival advantage.

Moreover, it is essential to point out that the immunity-infection arms race in relation to SARS-CoV-2 is more complicated than what has been discussed in this section. For instance, the severity of COVID-19 infection is influenced by an interplay between how much virus is present in our body (known as viral load) and the ability of our immune system to mount a timely response. When exposed to a high viral load of SARS-CoV-2, the COVID-19 infection tends to be more severe because our adaptive immune system requires a longer time to recognize the virus and produce specific antibodies[24]. To explain this in another way, the arms race is not just affected by the strategies employed by the immune system and the virus; it is also affected by the size of both armies (the number of immune cells versus the number of viruses), as well as the speed of the immune response.

To conclude this section, the COVID-19 pandemic has served as an example of how immunity and infection engage in an ongoing arms race. The SARS-CoV-2 virus with its capability to evade both our innate and adaptive immune responses, has demonstrated some of the sophisticated strategies employed by pathogens in this ongoing struggle. On the human side of this struggle, there is remarkable resilience and adaptability of the immune system, evident in its ability to combat this unprecedented virus. The ongoing battle between immunity and infection is far from static. It is a process marked by continuous adaptation and counter-adaptation. This is marked by the emergence of new strains of SARS-CoV-2, such as the Omicron variant, which present new challenges for our

[24] Janeri Fröberg et al., "SARS-CoV-2 Mucosal Antibody Development and Persistence and Their Relation to Viral Load and COVID-19 Symptoms," *Nature Communications* 12(1) (2021), 5621, doi:10.1038/s41467-021-25949-x.

immune systems[25], adding another layer in this ever-changing process. Having laid the scientific groundwork for the immunity-infection arms race, in the following section, we will explore the philosophical perspectives of the ongoing battle between immunity and infection from Islamic principles.

Interpreting the Immunity-Infection Arms Race through Islamic Principles

In this section, we will introduce three Islamic principles relevant to interpreting the immunity-infection arms race. We will then expand on how these principles relate to other principles and can be applied to our understanding of this fascinating scientific phenomenon. In the realm of Islamic philosophy of science, several key principles stand out as particularly pertinent to our discussion on the immunity-infection arms race. These principles include the concept of balance (*mizan*), the sanctity of life (*hurmat al-hayat*), and the pursuit of knowledge (*tahsil al-ʿilm*). Before delving deeper, we will briefly explain these three principles.

The concept of *mizan* is a crucial principle derived from many Quranic verses such as "And the heaven He raised and imposed the balance" (al-Rahman 55:7). This principle underlines the importance of maintaining equilibrium in all aspects of life, whether it be in our physical bodies, social interactions, or relationship with the natural world. In immunology, this principle can be seen in the delicate balance that the immune system must maintain in responding to pathogens. While an underactive immune response can result in unchecked infections, an overactive response can lead to autoimmune diseases. Thus, the immune system is constantly striving to achieve a state of balance, or homeostasis, in protecting the body from harm.

[25] Md Mohsin & Sultan Mahmud, "Omicron SARS-CoV-2 Variant of Concern."

Hurmat al-hayat is another key principle based on the Quranic verse, "And We have certainly dignified the children of Adam" (al-Isra' 17:70). It underscores the inherent value and dignity of all human life. It also serves as a moral and ethical guide in many areas, including the fields of medicine and healthcare. In the context of the immunity-infection arms race, *hurmat al-hayat* stresses the prominence of the immune system's role in preserving life by warding off harmful pathogens. Another valued Islamic principle is the pursuit of knowledge (*tahsil al-ʿilm*), based on numerous Quranic lessons that encourage Muslims to seek knowledge and understanding. This principle is not limited to religious knowledge but extends to all forms of beneficial knowledge, including natural sciences such as immunology. In the context of our discussion, *tahsil al-ʿilm* encourages the understanding of the dynamics of the immunity-infection arms race. It urges ongoing study into the mechanisms of the immune system and the strategies employed by pathogens, with the goal of elevating human well-being. These principles of balance, the sanctity of life, and the pursuit of knowledge provide a unique lens through which we can interpret and understand the immunity-infection arms race. In the following paragraphs, we will delve deeper into how these principles can be applied to our understanding of this complex immunological dynamic.

The principle of balance (*mizan)* provides a compelling framework for understanding the immunity-infection arms race. This principle emphasizes the importance of maintaining equilibrium in all aspects of life[26]. It is a concept that resonates profoundly with the dynamic interplay between the immune system and pathogens. The principle of balance is mirrored in the immune system's constant striving for homeostasis. The

[26] Muhammad Ashfaq, "Scientific Study of Balance (al-Mizan) in the Light of Surah Al-Rahman," *Journal of Islamic and Religious Studies* 1(1) (2016), 1–17, doi:10.36476/JIRS.1:1.06.2016.13.

immune system, in its complexity, operates on a delicate balance. On one hand, it must mount a robust response to invading pathogens. On the other, it must avoid overreacting to such threats, as an overactive immune response can lead to self-defeating autoimmune diseases. This delicate balance is a testament to God's intricate design of the immune system and reflects the broader Islamic principle of balance in the natural world. Within this context, the immunity-infection arms race can be seen as a dynamic equilibrium, where both the immune system and pathogens are continuously adapting and counter-adapting in response to each other. Indeed, this ongoing competition is a form of balance in itself. The immune system continuously changes to recognize and eliminate new pathogens, while pathogens adapt to evade the immune system and survive within the host. This dynamic balance is a key feature of the immunity-infection arms race and reflects the broader principle of balance in Islamic thinking. Such a principle of balanced thinking is vital in educating the self of a Muslim, as highlighted by scholars such as al-Zarnuji[27] and al-Attas[28].

The Islamic principle of *hurmat al-hayat* (the sanctity of life) underscores the inherent dignity of human life. It asserts that every life is sacred and therefore must be protected[29]. The principle resonates profoundly with the immune system's role in safeguarding the body against harmful pathogens. The immune system, in its essence,

[27] Khairul Nizam bin Zainal Badri, "Balanced Education According to Imam Al-Zarnuji," *Tafkir: Interdisciplinary Journal of Islamic Education* 3(2) (2022), 135–47, doi:10.31538/tijie.v3i2.177.

[28] Syed Muhammad Naquib Al-Attas, *The Concept of Education in Islam: A Framework for an Islamic Philosophy of Education*, 4th Impression (Kuala Lumpur: Ta'dib International, 2018).

[29] Mansoureh Ebrahimi & Kamaruzaman Yusoff, "Islamic Identity, Ethical Principles and Human Values," *European Journal of Multidisciplinary Studies* 2(6) (2017), 325–36, doi:10.26417/ejms.v6i1.p325-336.

serves as the body's biological mechanism for *hurmat al-hayat*. Just as this principle calls for preserving life, the immune system strives to maintain health and prevent disease, thereby protecting life. The immune system operates through a series of coordinated responses designed to neutralize and eliminate pathogens. These responses range from the immediate, non-specific defenses of the innate immune system to the highly specific and memory-informed responses of the adaptive immune system. Each cell and organ of the immune response serves a critical role in maintaining the health of the body, mirroring how each person and community should serve the broader Islamic imperative to preserve life, providing a moral outline for responding to infections. It calls attention to seeking illness treatment and protecting oneself and others from harm.

This moral imperative can be seen in the concerted efforts of scientists and healthcare professionals to understand the immune system, develop treatments, and improve public health measures in response to diseases like COVID-19. For example, it is applied in practices of masjids during the pandemic to prevent disease transmissions[30]. Moreover, the principle of the sanctity of life also informs the ethical considerations in research. It emphasizes the importance of respecting human dignity, ensuring informed consent, and prioritizing patient welfare. These ethical considerations are particularly relevant in the context of immunology research, where the development and testing of new treatments and vaccines must be conducted with utmost respect for human dignity.

The third principle, *tahsil al-ʿilm* refers to the Islamic emphasis on the pursuit of knowledge. It permeates all aspects of life, including the scientific study of the immune

[30] Moh Dahlan et al., "The Islamic Principle of Hifz Al-Nafs (Protection of Life) and COVID-19 in Indonesia: A Case Study of Nurul Iman Mosque of Bengkulu City," *Heliyon* 7(7) (2021), e07541, doi:10.1016/j.heliyon.2021.e07541.

system and diseases. *Tahsil al-ʿilm* encourages the acquisition of knowledge as a means to benefit humanity. It is a principle that resonates profoundly with the ongoing research into diseases and the workings of the immune system. The pursuit of knowledge in Islam is not merely an intellectual exercise. It is also a holistic endeavor that integrates the spiritual, moral, and practical dimensions of life. It is a journey that seeks to understand the signs (*ayat*) of God in the universe and within us, as stated in the Quran "We shall show them Our signs upon the horizons and within themselves till it becomes clear to them that it is the truth." (Fussilat 41:53). This holistic approach to knowledge is reflected in the interdisciplinary nature of immunity-infection arms race, which integrates various fields of study, including immunology, microbiology, and biomedicine.

In the context of the COVID-19 pandemic, the pursuit of knowledge has been at the forefront of global efforts. Scientists worldwide have been working tirelessly to unravel the mysteries of the SARS-CoV-2 virus, understand its interaction with the immune system, and develop effective vaccines and treatments. This concerted effort reflects the Islamic value of *tahsil al-ʿilm* to benefit humanity. The pursuit of knowledge in the study of diseases and the immune system also involves the development of innovative technologies. Examples of this include the use of genomic sequencing to track the virus, the development of novel vaccine platforms like mRNA vaccines, and the use of big data analysis in disease surveillance. These advancements are a testament to the power of knowledge, resonating with the Islamic emphasis on innovation and the application of knowledge for the benefit of humanity[31].

[31] Reda Ibrahim Ibrahim Elsayed Abdelgalil, "The Philosophy of Creativity, Innovation, and Technology from an Islāmic Perspective," *Journal of Islamic Thought and Civilization* 13(1) (2023), doi:10.32350/jitc.131.16.

Moreover, the pursuit of knowledge in the context of diseases and the immune system is not limited to the scientific community. It extends to the public, who are encouraged to learn about these topics to protect their families and contribute to public health efforts. This public engagement in science reflects the Islamic principle that the pursuit of knowledge is a responsibility shared by all members of society.

To reiterate our philosophical discussion so far, the detailed analysis of three Islamic philosophical principles: *mizan, hurmat al-hayat,* and *tahsil al-ʿilm* provides a rich and nuanced framework for understanding the immunity-infection arms race. *Mizan* highlights the significance of maintaining equilibrium, both in the functioning of the immune system and in our broader response to infections. *Hurmat al-hayat* aligns closely with the protective role of the immune system and provides a moral framework for understanding and responding to infections. *Tahsil al-ʿilm* frames the moral virtue of ongoing research into pandemic diseases and accentuates the consequence of knowledge, innovation, and ethics in the fight against infectious diseases. To expand on this point, these Islamic principles present a unique lens through which we can interpret the constant adaptation and counter-adaptation in the immunity-infection arms race. This is valuable to both science and religious educators because, from this lens, other Islamic principles can be philosophically connected.

For example, the adaptation and counter-adaptation dynamic can be connected to the Islamic understanding of life as a test (*al-hayat ibtila'*), with challenges that require continuous adaptation. In Islam, life is a journey filled with trials and tribulations, designed to test our resilience and adaptability. This perspective is encapsulated in the Quranic verses "We have certainly created man into hardship" (al-Balad 90:4) or, more directly in "Does mankind suppose that they will be left to say, 'we believe'

and that they will not be tried, though We have indeed tried those who were before them?" (al-Mulk 67:2-3). Through this Quranic lens, the immunity-infection arms race is a biological manifestation of this divine test, where the human body and pathogens are engaged in continuous trials and tribulations, each adapting in response to the other's strategies. The concept of *fitrah* further enriches this interpretation. *Fitrah* can be understood as the inherent nature of all living beings, which guides their responses to their environment as guided by God. In the context of the immunity-infection arms race, the immune adaptive recognition of new pathogens and the evasive adaptation by pathogens is an expression of their inherent natures.

Furthermore, the Islamic principle of *tawakkul* (reliance on God) provides a precious perspective on the immunity-infection arms race. While human beings are encouraged to strive in the face of challenges, they are also reminded that the ultimate control lies with God. This principle encourages a balanced approach to dealing with diseases, where research and interventions are pursued vigorously, but always with the understanding that the final outcome is in God's hands. Over time, it enhances the combined *ʿilm* (science) and *fahm* (deep understanding of the science) of the immunity-infection arms race as part of the natural world. The Quran encourages the study of the natural world as a means to ponder God's wisdom, such as in "Truly in the creation of the heavens and the earth and the variation of the night and the day are signs for the possessors of intellect" (Ali 'Imran 3:190). The ongoing intellectual research into the continuous adaptation observed in the immunity-infection arms race reflects this Quranic encouragement.

Additionally, Islam emphasizes social responsibility (*al-mas'uliyyah al-ijtima'iyyah*), preservation of life (*hifz al-nafs*), and the pursuit of treatment (*tahsil al-'ilaj*). These principles can guide both public measures and individual

behaviors during a pandemic, mitigating its impact and protecting the vulnerable members of society. The principle of social responsibility or *al-mas'uliyyah al-ijtima'iyyah* is deeply ingrained in Islamic thoughts. It brings to the fore the collective responsibility of society to ensure the well-being of all its members. In the context of a pandemic, this principle translates into the need for collective action to curb the spread of the virus, such as adhering to public health guidelines and practicing social distancing. It also features the responsibility of the authorities to provide equitable healthcare for all, particularly in times of crisis.

The sanctity and preservation of life, or *hifz al-nafs*, is another key principle which emphasizes the value of every life and the duty to protect it. In the context of a pandemic, *hifz al-nafs* underlines efforts aimed at protecting lives, such as implementing infection control measures, ensuring the availability of medical care for those infected, and prioritizing high-risk groups for vaccination. The preservation of life is also associated with the pursuit of treatment or *tahsil al-'ilaj*. It encourages the seeking of medical treatment, aligned with global efforts, including the development of therapeutics, and the implementation of evidence-based preventive measures. Remarkably, these two principles are philosophically nested in the perspective where life is seen as a test (*al-ibtila'*). This resonates with the challenges posed by pandemics as it encourages resilience, patience, and continuous adaptation in the face of adversity. Such a rich Islamic perspective can help individuals and societies navigate the uncertainties and hardships of a pandemic, while also fostering a sense of hope and resilience.

In this section, we have explored the immunity-infection arms race through the lens of the Islamic philosophy of science. We have discussed how key Islamic principles, such as the concept of balance (*mizan*), the sanctity of life (*hurmat al-hayat*), and the pursuit of

knowledge (*tahsil al-ʿilm*), provide a unique perspective on the dynamics of immunity and infection. We began by introducing three key principles: The concept of balance (*mizan*) relates to the importance of maintaining equilibrium in all aspects of life. This principle resonates with the immune system's role in maintaining health and warding off disease while maintaining a delicate balance between attacking infectious cells and protecting our own.

Next, we discussed the sanctity of life (*hurmat al-hayat*) and its implications for understanding the role of the immune system. The function of the immune system aligns with the Islamic imperative to preserve life, as it serves as the body's primary defense against harmful pathogens. We then explored the Islamic emphasis on the pursuit of knowledge (*tahsil al-ʿilm*), as well as its application to the scientific study of the immune system. The ongoing research into pandemic threats and the immune system reflects the Islamic value of seeking knowledge to benefit humanity, highlighting the value of scientific inquiry in combating diseases. Subsequently, in discussing the constant adaptation and counter-adaptation in the immunity-infection arms race, we interpreted this dynamic from an Islamic philosophical perspective. This dynamic connects to the Islamic understanding of life as a test (*al-ibtila’*), with challenges that require continuous learning and adaptation. It is also associated with the concept of *tawakkul* (reliance on God). Finally, we discussed how Islamic principles can inform the response to pandemics. Islamic principles such as social responsibility (*al-mas'uliyyah al-ijtima'iyyah*), preservation of life (*hifz al-nafs*), and seeking treatment (*tahsil al-ʿilaj*) can guide public health measures and individual behaviors during a pandemic, helping to mitigate its impact and protect the most vulnerable members of society.

In conclusion, the Islamic philosophy of science provides an insightful framework for understanding the

immunity-infection arms race. Its theological principles echo the biological dynamics of immunity and infection, offering unique perspectives on the challenges and opportunities in this field. As we transition to the next section of the article, we will discuss Islamic educational considerations in dealing with infections and diseases, continuing our exploration of the interplay between Islamic philosophy and the science of immunology.

Islamic Educational Perspectives on Dealing with Infections

Education plays a pivotal role in the prevention and control of infections. In Islam, education transcends mere information dissemination. Rather, it is an integrative process that aligns information with moral, social, and even environmental dimensions of human existence [32]. The importance of education in Islam is highlighted by the very first revelation, which began with the command to "Read in the Name of your Lord Who created," (al-'Alaq 96:1). This foundational emphasis on reading and learning permeates all aspects of Islamic thought, including the understanding of health and well-being. Building on the philosophical principles in the previous sections, the current section transitions to the realm of educational perspectives. The objective is to explore how Islamic principles can guide educational strategies in dealing with infections.

The holistic approach in Islamic education promotes a comprehensive understanding of health that encompasses physical, spiritual, and social well-being. This approach aligns with the multifaceted nature of immunity and infections, requiring an interdisciplinary perspective that integrates immunology, microbiology, and religious

[32] Masturin Masturin, Mhd Rasid Ritonga, and Siti Amaroh, "Tawhid-Based Green Learning in Islamic Higher Education: An Insan Kamil Character Building," *QIJIS (Qudus International Journal of Islamic Studies)* 10(1) (2022), 215–52, doi:10.21043/qijis.v10i1.14124.

sciences. For example, the Islamic emphasis on cleanliness (*taharah*) is not limited to ritual practice in Islamic jurisprudence (*fiqh*)[33]. It is also a preventive measure against infections, grounded in immunological principles. Islamic education promotes an understanding of health that transcends the purely physical aspect and encompasses the well-being of psychospiritual and social interactions. This integrative perspective allies with the principle of *Tawhid* (Divine Unity) which unites all aspects of life, including health[34]. Within it, the human body is viewed not as an isolated entity but as part of a beautiful structure interwoven with the intellect, soul, and society.

This emanates from the Quranic teachings: "[Remember] when your Lord said unto the angels, 'Behold! I am creating a human being from clay. When I have proportioned him and breathed into him of My Spirit, fall down before him prostrating'" (Sad 38:71-72). Here, human beings are not perceived as merely biological beings (from clay). Instead, human beings are also psychospiritual beings (from breathed Spirit). This comprehensive approach resonates with advanced perspectives on health that acknowledge how various biological and psychological factors interact with one another.

Within immunology, this holistic perspective aligns with psychoneuroimmunology. This specialized field explores the relationship between the mind, nervous system, and immune response[35]. It recognizes the interconnectedness between the immune system and other

[33] Stella Eme Osim & Nzeyo Gabriel Eteng, "Women and Ritual Purity in Islam," *Indonesian Journal of Social and Educational Studies* 2(1) (2021), doi:10.26858/ijses.v2i1.22956.

[34] Osman Bakar, *Tawhid and Science: Islamic Perspectives on Religion and Science*, 2nd ed. (Shah Alam: Arah Publications, 2008).

[35] Chun-Pai Yang et al., "Long COVID and Long Chain Fatty Acids (LCFAs): Psychoneuroimmunity Implication of Omega-3 LCFAs in Delayed Consequences of COVID-19," *Brain, Behavior, and Immunity* 103 (2022), 19–27, doi:10.1016/j.bbi.2022.04.001.

physiological systems as well as the environment. For instance, psychological stress, a mental factor, can affect immune responses, while social factors like community support can enhance overall well-being. In line with this concept, Islamic principles provide an ethical framework for guiding behaviors in healthcare. Key relevant principles include compassion (*rahmah*), honesty (*sidq*), and responsibility (*amanah*). In the following paragraphs, we will expand on each concept in detail.

In terms of compassion (*rahmah*), the Prophet himself is described in the Quran as "a mercy unto the worlds" (al-Anbiya' 21:107). This compassion or mercy extends to healthcare, where empathy and kindness are paramount. In the context of infectious diseases, compassion motivates efforts to alleviate suffering through research, treatment, and care. The historical example of the Bimaristan, Islamic hospitals in the medieval period, showcases the application of compassion in providing healthcare to all, regardless of social or religious background[36]. Compassion in healthcare is not merely an emotional response. It is a moral duty, a faded reflection of the divine light of the Compassionate (*al-Rahman*). This principle resonates with the patient-centered approach in medicine, emphasizing empathy, understanding, and personalized care. In the context of infections, compassion guides healthcare providers to alleviate suffering and ensure dignity, even in the face of highly contagious diseases.

That principle of compassion is counterbalanced by the principle of honesty (*sidq*). In Islamic healthcare, honesty extends beyond truthfulness in speech. It also includes integrity in research, diagnosis, and treatment. It prohibits deceit and exploitation, ensuring that medical practices are grounded in evidence. For example, honesty

[36] Ahmed Ragab, *The Medieval Islamic Hospital: Medicine, Religion, and Charity* (Cambridge: Cambridge University Press, 2015), doi:10.1017/CBO9781316271797.

in reporting clinical trials, especially in vaccine development, is crucial for global health security. It guides research practices, patient communication, and public health messaging. A historical example is the Plague of Amwās in 639 CE, where the truthful reporting of the situation by commanders and the honest implementation of quarantine measures reflected this principle[37].

Another important principle is responsibility (*amanah).* This entails being accountable to both God and other human beings[38]. It promotes quality care while adhering to standards and conducting medical research ethically. Developing and distributing vaccines requires an approach that takes into consideration aspects such as efficacy, safety, and accessibility. Moreover, responsibility in Islamic healthcare encompasses personal, communal, and societal obligations. It includes personal responsibility for maintaining health, community responsibility for supporting vulnerable populations, and societal responsibility for ensuring equitable access to healthcare. Incorporating these principles into health education promotes a culture of ethical awareness, sensitivity, and dedication within the healthcare community. It supports the professional codes of conduct, builds patient trust, and contributes to the overall integrity of healthcare services.

Next, we will investigate the specific educational strategies that translate these principles into practical applications for the prevention and control of infections. The focus will be on preventive measures, community engagement, and the integration of Islamic perspectives into vaccination and treatment campaigns.

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[37] Musferah Mehfooz, "Understanding the Impact of Plague Epidemics on the Muslim Mind during the Early Medieval Period," *Religions* 12(10) (2021), 843, doi:10.3390/rel12100843.

[38] Mohd Hasrul Shuhari et al., "Concept of *al-Amanah* (Trustworthiness) and *al-Mas'uliyyah* (Responsibility) for Human's Character from Ethical Islamic Perspective," *Journal of Legal, Ethical and Regulatory Issues* 22 (2019), 1.

In terms of preventive measures, Islam emphasizes cleanliness (*taharah*), moderation in eating, and proper hygiene. The concept of *taharah* in Islam is not merely physical cleanliness. It also extends to spiritual purity as emphasized by the Prophet, "Cleanliness is half of faith"[39]. This includes regular ablutions, bathing, and maintaining a clean environment. As behavioral support to our immunity, these Islamic practices can be seen as effective means to control the spread of infectious microorganisms. These practices align with hygiene standards that are essential in infection control, such as the framework established by the European Committee for Standardization (CEN)[40].

Moderation in eating is another preventive measure emphasized in Islamic teachings. The Prophet advised eating in moderation, saying, "It is sufficient for a person being to eat a few mouthfuls to keep his spine straight. But if he must, then one-third of food, one-third for drink and one-third for air" [41] . This principle aligns with an understanding of metabolic processes and avoidance of overconsumption, which can lead to obesity and related health issues.

Another aspect of Islamic educational strategies is community engagement. Community religious leaders, masjids, and Islamic schools play a vital role in promoting healthy practices. Masjids serve as centers for community gathering and education, where Imams provide guidance on

[39] Muslim, Sahih Muslim, Merit of Wudu', The Book of Purification, Chapter the Virtue of Wudu', hadith no. 223, https://sunnah.com/muslim:223

[40] Astrid Bolten, Verona Schmidt & Katrin Steinhauer, "Use of the European Standardization Framework Established by CEN/TC 216 for Effective Disinfection Strategies in Human Medicine, Veterinary Medicine, Food Hygiene, Industry, and Domestic and Institutional Use – a Review," *GMS Hygiene and Infection Control* 17 (2022), Doc14, doi:10.3205/dgkh000417.

[41] Ibn Majah, Sunan Ibn Majah, Chapters on Food, Chapter Being Economical with Food and the Undesirability of Eating One's Fill, hadith no. 3349, https://sunnah.com/ibnmajah:3349

health matters in light of Islamic teachings. During the COVID-19 pandemic, many masjids around the world educated the community about preventive measures, physical distancing, and vaccination. For example, Islamic scholars played a critical role in educating Muslims regarding congregational prayers during a pandemic[42]. Islamic schools and educational institutions can integrate health education into their curricula, emphasizing Islamic principles of cleanliness, nutrition, and ethical behaviors. Collaboration with health professionals ensures that the information is scientifically accurate and culturally relevant.

The third strategy relates to vaccination and treatment. Islamic perspectives on seeking medical treatment, including vaccination, are grounded in the encouragement to seek knowledge and utilize available means for healing. The Prophet Muhammad (peace be upon him) said, "Make use of medical treatment, for God has not made a disease without appointing a remedy for it"[43]. This perspective supports the integration of vaccination into educational campaigns as a means of disease prevention. The collaboration between Islamic authorities and health organizations has been instrumental in successful vaccination campaigns, such as the polio eradication efforts in various Muslim-majority countries[44]. However, it is also

[42] Sardjuningsih Sardjuningsih, "Portrait of Indonesian Religious Communities Attitudes toward the Government Policies Restriction on Congregational Worshipping," *QIJIS (Qudus International Journal of Islamic Studies)* 10(2) (2022), 443–78, doi:10.21043/qijis.v10i2.8221.

[43] Abu Dawud, Sunan Abi Dawud, Book of Medicine, Chapter A Man Should Seek a Remedy, hadith no. 3855, https://sunnah.com/abudawud:3855

[44] Hadil Alahdal, Fatemah Basingab & Reem Alotaibi, "An Analytical Study on the Awareness, Attitude and Practice during the COVID-19 Pandemic in Riyadh, Saudi Arabia," *Journal of Infection and Public Health* 13(10) (2020), 1446–52, doi:10.1016/j.jiph.2020.06.015; Nouar Qutob & Faisal Awartani, "Knowledge, Attitudes and Practices

essential to recognize and address the misconceptions and stigmas that may exist within some Muslim communities. Therefore, our subsequent analysis will focus on the challenges of challenging misconceptions and combating stigmas associated with certain diseases, emphasizing the role of Islamic teachings in fostering dignity, empathy, and non-discrimination.

Within some Muslim communities, misconceptions about infections and diseases may arise from misunderstandings of religious texts or cultural beliefs. For example, some may erroneously avoid vaccines, fearing that they contain prohibited (*haram*) substances or cause other health issues. This can happen despite the scientific evidence to the contrary[45]. Such misconceptions can be addressed through education that integrates Islamic principles with scientific knowledge. Scholars and healthcare professionals can work together to clarify Islamic teachings on disease and healing, emphasizing that illness is a natural part of human life and that seeking treatment, including vaccination, is not only permissible but encouraged. By aligning religious teachings with scientific evidence, such as the immunological basis of vaccines, communities can be empowered to make informed health decisions[46].

On the other hand, stigmas associated with certain diseases can lead to social isolation and reluctance to seek

(KAP) towards COVID-19 among Palestinians during the COVID-19 Outbreak: A Cross-Sectional Survey," *PLOS ONE* 16(1) (2021), e0244925, doi:10.1371/journal.pone.0244925.

[45] Ahmed R. Alsuwaidi et al., "Vaccine Hesitancy within the Muslim Community: Islamic Faith and Public Health Perspectives," *Human Vaccines & Immunotherapeutics* 19(1) (2023), 2190716, doi:10.1080/21645515.2023.2190716.

[46] Kosim Kosim, "Understanding Islamic Law in the Context of Vaccination: Reducing the Doubt Cast on COVID-19 Vaccines," *HTS Teologiese Studies / Theological Studies* 78(4) (2022), 7, doi:10.4102/hts.v78i4.7308.

treatment. Stigmas contradict Islamic teachings that emphasize dignity, empathy, and non-discrimination. Evidence for this can be found in the Quran, "O mankind! Truly We created you from a male and a female, and We made you peoples and tribes that you may come to know one another" (al-Hujurat 49:13). This verse stresses the importance of recognizing the inherent dignity of every individual, regardless of their health status. Combating stigmas requires a multifaceted approach that includes religious guidance, community engagement, and collaboration with healthcare providers. Muslim medical communities, such as nurses serve as frontline examples of compassion, fostering an environment of acceptance and support[47]. In the next segment, we will explore specific case studies to illustrate how these principles have been applied in real-world scenarios.

The COVID-19 pandemic is an illustrative case study where the response within Muslim communities has demonstrated the application of Islamic principles. Islamic scholars and community leaders have played a crucial role in disseminating accurate information about the virus and preventive measures against it. For example, masjids have been used as vaccination centers, merging religious and healthcare services[48]. Islamic organizations have also utilized online platforms and social media campaigns to reach a broader audience, leveraging technology to provide culturally relevant and scientifically sound information[49].

[47] Jalal Alharbi & Lourance Al Hadid, "Towards an Understanding of Compassion from an Islamic Perspective," *Journal of Clinical Nursing* 28(7–8) (2019), 1354–58, doi:10.1111/jocn.14725.

[48] Hitomu Kotani, Hirofumi Okai & Mari Tamura, "Mosque as a Vaccination Site for Ethnic Minority in Kanagawa, Japan: Leaving No One Behind Amid the COVID-19 Pandemic," *Disaster Medicine and Public Health Preparedness* 16(6) (2022), 2683–85, doi:10.1017/dmp.2022.78.

[49] Emma Rachmawati et al., "The Roles of Islamic Faith-Based Organizations on Countermeasures against the COVID-19 Pandemic

These efforts have been instrumental in addressing misconceptions and promoting adherence to preventive measures within Muslim communities.

Historically, education has played a role in dealing with pandemics in the Islamic world. The Plague of Amwas, which occurred in the 7th century CE, provides a notable example[50]. During this plague, the Caliph 'Umar ibn al-Khattab implemented quarantine measures, restricting movement to and from affected areas. He applied the Prophet's guidance, "If you hear of an outbreak of plague in a land, do not enter it; but if the plague breaks out in a place while you are in it, do not leave that place"[51]. This historical response reflects an understanding of contagion and the importance of containment, resonating with modern epidemiological principles[52].

Islamic scholars also contributed to the preservation of medical knowledge, translating Greek and Roman medical texts, and integrating them with Islamic jurisprudence. Infrastructurally, the Bimaristans served as centers for both treatment and education, fostering a holistic approach to healthcare that included physical, mental, and spiritual well-being[53].

These case studies clarify how Islamic principles have been applied in educational campaigns to address pandemics. They underline the synergy between religious teachings and scientific knowledge, emphasizing

in Indonesia," *Heliyon* 8(2) (2022), e08928, doi:10.1016/j.heliyon.2022.e08928.

[50] Mehfooz, "Understanding the Impact of Plague Epidemics."

[51] Al-Bukhari, Sahih al-Bukhari, The Book of Medicine, Chapter What has been Mentioned about the Plague, hadith no. 5728, https://sunnah.com/bukhari:5728

[52] Krish Seetah et al., "Global Health Needs Modernized Containment Strategies to Prepare for the Next Pandemic," *Frontiers in Public Health* 10 (2022), https://www.frontiersin.org/articles/10.3389/fpubh.2022.834451.

[53] Ragab, *The Medieval Islamic Hospital*.

prevention, compassion, and community engagement. Moving forward, we will explore how technology and innovation can further enhance Islamic health education, including the use of digital platforms. This exploration will provide insights into how Islamic principles can continue to guide and enrich health education in an increasingly interconnected world.

Technology has become integral to modern education, and Islamic health education is no exception. Leveraging digital platforms and innovative teaching methods can enhance the dissemination of Islamic principles related to health, aligning with contemporary needs and opportunities. Online webinars and conferences can bring together scholars, healthcare professionals, and community members from diverse geographical locations[54]. These platforms allow for real-time interaction and collaboration, fostering a global community of learners. Many Islamic organizations utilize online platforms to educate the public about Islamic ethical and practical considerations[55]. Mobile apps designed with Islamic guidelines on health and hygiene can provide accessible and user-friendly

[54] Shalini Shah et al., "The Technological Impact of COVID-19 on the Future of Education and Health Care Delivery.," *Pain Physician*, 2020, S367–80; Yongdong Shen, Yuan (Daniel) Cheng & Jianxing Yu, "From Recovery Resilience to Transformative Resilience: How Digital Platforms Reshape Public Service Provision during and Post COVID-19," *Public Management Review* 25(4) (2023), 710–33, doi:10.1080/14719037.2022.2033052.

[55] Mahfud Junaedi, Nasikhin Nasikhin & Silviatul Hasanah, "Issues in the Implementing of Online Learning in Islamic Higher Education During the Covid-19 Pandemic," *Ta'dib* 25(1) (2022), 33–46, doi:10.31958/jt.v25i1.5365; Nurdin Nurdin, Nurliana Nurliana & Saepudin Mashuri, "Online Islamic Religious Education Learning During Covid-19 Pandemic," *International Journal of Contemporary Islamic Education* 4(1) (2022), 38–53, doi:10.24239/ijcied.Vol4.Iss1.46.

resources[56]. Telemedicine provides the public with daily health tips, reminders for hygiene practices, and interaction with experts[57].

Social media campaigns further amplify the reach of Islamic health education. By engaging with followers through posts, videos, and live sessions, scholars and healthcare providers can address misconceptions, share evidence-based information, and promote healthy practices in line with Islamic teachings[58]. The integration of technology and innovation in Islamic health education reflects the dynamic nature of Islamic scholarship and its adaptability to contemporary contexts. It resonates with the Islamic tradition of seeking knowledge and embracing beneficial innovations, as reflected in, "Wisdom is the lost property of the believer; wherever he finds it, then he is more worthy of it"[59]. By leveraging digital platforms and innovative methods, Islamic health education can reach diverse audiences, engage learners in meaningful experiences, and contribute to global health efforts.

In summary, education emerges as a linchpin in the discourse on Islamic perspectives on dealing with immunology and infections. It transcends beyond the

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[56] Hamid Reza Saeidnia et al., "Development of a Mobile App for Self-Care Against COVID-19 Using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model: Methodological Study," *JMIR Formative Research* 6(9) (2022), e39718, doi:10.2196/39718.

[57] Esmaeil Mehraeen et al., "Telemedicine Technologies and Applications in the Era of COVID-19 Pandemic: A Systematic Review," *Health Informatics Journal* 29(2) (2023), 14604582231167431, doi:10.1177/14604582231167431.

[58] Wadd Mohammed et al., "Usage of Social Media for Health Awareness Purposes among Health Educators and Students in Saudi Arabia," *Informatics in Medicine Unlocked* 23 (2021), 100553, doi:10.1016/j.imu.2021.100553.

[59] Al-Tirmidhi, Jami' at-Tirmidhi, Chapters on Knowledge, Chapter What Has Been Related about the Superiority of Fiqh Over Worship, hadith no. 2687, Grade: Da'if, https://sunnah.com/tirmidhi:2687

simple sharing of facts and incorporation of moral, social, and environmental lessons. Islamic holistic approach aligns with interdisciplinary fields and imbues Islamic principles such as compassion (*rahmah*), honesty (*sidq*), and responsibility (*amanah*) into healthcare education and practices. Islam offers a robust philosophical framework that complements scientific rigor in its educational perspectives. This synergy fosters a comprehensive understanding of health, encompassing physical, psychospiritual, and social well-being.

Conclusion

This article has explored the scientific concept of the immunity-infection arms race, the Islamic philosophical perspectives in interpreting it, as well as the educational applications of such perspectives. The initial section clarifies the immunity-infection arms race. By using COVID-19 as a case study, it elucidates the complex dynamics between the immune system and pathogens such as SARS-CoV-2. The section serves as an essential primer for Islamic scholars and non-scientists, outlining the perpetual cycle of adaptation and counter-adaptation between the immune system and pathogens. The use of COVID-19 as an illustrative example adds a layer of contemporary relevance, making the discussion immediately applicable to current global health challenges.

The next section is a pioneering endeavor to interpret the immunity-infection arms race through the lens of Islamic principles. We argue that the Islamic philosophy of science provides a beneficial cognitive frame for understanding this scientific phenomenon. The section explores how Islamic teachings can enrich our comprehension of the arms race, offering ethical dimensions that are often overlooked in purely scientific discussions. We also argue that Islamic principles not only align with but also enhance the ethical considerations inherent in immunological studies. The final section

transitions into the realm of education, discussing how Islamic principles can guide educational strategies in dealing with infections. It emphasizes the role of Islamic philosophy of science in shaping educational policies, particularly in Muslim-majority countries. The section underscores the need for a multidisciplinary approach that integrates scientific rigor with Islamic ethical considerations, thereby fostering a more holistic educational experience.

In conclusion, this article serves as a novel contribution to the transdisciplinary dialogue between Islamic philosophy of science and immunology. So far, Islamic scholars have richly contributed to the philosophical dialogues on the broader field of medicine and the narrower discussion of vaccination. This article invites other immunologists to contribute to the scholarly space in between the two, exploring ontological and epistemological issues related to immunological phenomena. As such, this article holds significant value for Islamic scholars, scientists and science educators, providing them with a framework for the immunity-infection arms race that is both scientifically rigorous and Islamically sound. It has the potential to revolutionize how we understand and educate about health and well-being in Muslim-majority countries and beyond.

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https://www.frontiersin.org/articles/10.3389/fimmu.2023.1055457.

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