JAASP http://www.aaspjournal.org
Journal of Asian Association of Schools of Pharmacy 2023; 12: 38–46

Review

The role of higher education in pharmacy and pharmaceutical sciences in addressing global warming: A personal perspective

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Received April 21, 2023
Revised June 2, 2023
Revised July 12, 2023
Revised August 29, 2023
Revised September 29, 2023
Revised October 21, 2023
Revised November 2, 2023
Accepted November 8, 2023

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ABSTRACT

Climate change and global warming are critical issues facing humanity today, leading to rising sea levels, extreme weather events, ecosystem impacts, infectious diseases, and food crises. Over the past 130 years, human activities like deforestation and fossil fuel usage have steadily increased greenhouse gas emissions, resulting in global warming. High temperatures contribute to health risks including asthma-related deaths, infectious diseases, malnutrition, diarrhea, and mental disorders. Addressing these challenges necessitates prioritizing the development of human resources in higher education, including pharmacy and pharmaceutical sciences. This paper explains the current issues of global warming and proposes a few subjects tailored to pharmacy education. The integration of contemporary information technology, artificial intelligence, and digital tools is essential for pharmacy education for mitigating global warming. Additionally, low CO_2 emission drug development and therapies hold significance for the future. These endeavors will equip forthcoming generations to tackle climate shifts and construct a sustainable, robust world.

Key words: global warming, natural disasters, greenhouse gases, diseases, pharmacy education

1. Introduction

1.1. Global warming as a global imperative

In the first half of the 21st century, the global landscape is marked by significant challenges that encompass a range of critical issues: (1) global-scale population growth alongside simultaneous declines in birth rates and populations in developed countries, (2) diminishing economic disparities between developed and developing countries, but widening disparities within developed countries concerning economic and educational matters, (3) the increasing polarization of political systems worldwide, (4) the rapid advancement of the digital revolution, including information technology (IT) and artificial intelligence (AI), leading to rapid progress in digital transformation (DX), and (5) escalating concerns about climate change, global warming, and an increase in natural disasters around the globe, such as rising sea levels, more extreme weather events, impacts on the ecosystem, infectious diseases, and food crises (Amit, 2021; Lenzen, 2011). Extreme weather phenomena are being observed globally. In 2019 alone, a multitude of remarkable instances occurred: heatwaves spread across Europe, with a temperature of 45.9°C recorded in France; incidents of widespread flooding in Sichuan Province, southwest China; heavy rains on Kyushu Island, Japan; large-scale flooding resulting in over 70 deaths in Iran; heavy rains causing more than 20 deaths in Mumbai, India; massive hail in central Guadalajara, Mexico; and the dengue infection in Brazil spreading due to high temperatures (Japan Meteorological Agency, 2020).

1.2. Navigating global warming through higher education in pharmacy

This paper elucidates the impact of climate change and global warming on human lives and highlights the role of higher education, particularly in the fields of pharmacy and pharmaceutical sciences, in mitigating the detrimental effects of global warming. A personal perspective was summarized on the importance of climate change learned during my teaching career in pharmacy education. Specific subjects tailored to pharmacy education are introduced. Table 1 presents six examples of subjects for learning about global warming and its countermeasures in higher education within the realms of pharmacy and pharmaceutical sciences. These subjects, denoted as Subject #1, #2, #3, #4, #5, and #6, respectively, cater to diverse academic levels from freshman to senior students. Noteworthy is Subject #6, strategically

Table 1. Recommended topics for integrating global warming and mitigation strategies into higher education curricula for pharmacy and pharmaceutical sciences.

	Subject title	Primary contents of subject	Subject category
1	Fundamentals of Global Warming	Similar contents to the present text shown in **section 1** (Introduction). Introduction to the concept of global warming and its implications. Emphasis on fostering attitudes towards mitigation strategies. Importance of analyzing current global warming trends locally and globally.	Foundational literacy for all students in higher education
2	Societal impacts of climate change	Similar contents to the present text shown in **section 2** (Climate change and global warming). Examination of the broader social consequences of global warming. Incorporation of scientific investigations into climate change effects.	Essential for understanding societal impact (Desirable also for social science students)
3	Greenhouse gases (GHGs) regulation and carbon-neutral policies	(a) Chemistry of greenhouse gases (GHGs), and (b) Rationale and implications of carbon-neutral policies. (see **section 2.3** and **2.5**). Focused discussions on reducing GHG emissions.	Pertinent to natural science comprehension (Desirable also for natural science students)
4	Climate-associated health challenges	Investigation of health risks stemming from climate change, mirroring **section 3** (Impact of climate change on health outcomes and diseases in humans). Importance of devising strategies to address climate-induced health concerns.	Crucial for healthcare and life sciences (Desirable also for life and health science students)
5	Health management and hygiene in a warming world	Exploration of healthcare and hygiene strategies to mitigate global warming's impacts (see **section 3.4**). Individualized approaches to treat specific climate-related diseases.	A specialized study for health sciences (Desirable also for life and health science students)
6	Integrating emerging sciences and technologies against global warming	Application of emerging sciences (e.g., AI, IoT, data sciences) to combat global warming. Emphasis on active learning. Alignment with **section 4** (Global warming countermeasures and pharmacy education). Specific focus on pharmacy's role, drug development, and therapies. Exploration of low-CO_2 emission manufacturing and greener drug treatments and diagnostics.	Advanced level of subjects, preferably with lectures and discussion (Required subjects, particularly for pharmacy students)

Subjects #1 and #2 are suitable for freshman students, Subjects #3 and #4 are for sophomore students, Subject #5 for junior students, and Subject #6 for senior students in the fields of pharmacy and pharmaceutical sciences.

crafted for senior students, especially those specializing in pharmacy and pharmaceutical sciences. The prescribed teaching methodology, spanning all subjects, advocates for robust student engagement through a multifaceted approach encompassing investigative inquiry, dynamic presentations, and lively dialogues – both among students and in interactions between students and their esteemed lecturers. Each chapter within this paper is meticulously curated to serve as both a succinct summation and an integral element of the comprehensive content of the corresponding subject.

This paper was compiled during a time when the world was still heavily affected by the COVID-19 global pandemic and ongoing conflicts, including the war between Russia and Ukraine. These exceptional circumstances notably impeded the advancement of green energy reforms. Other causes of global warming have long been discussed by climate scientists, politicians, and the media, and measures to curb climate change and global warming have been considered, with some being put into practice. There will also be future impacts on fields of study represented by pharmacy and pharmaceutical sciences, and this study investigates some of these impacts. Recent work by Mathers et al. (2023) highlights the role of pharmacy education in addressing global warming, presenting various approaches to incorporate environmental sustainability into pharmacy curricula worldwide. Similarly, Self (2021) emphasized the urgency of including global warming awareness in education.

The integration of contemporary AI, IT, and digital tools is essential for pharmacy education to mitigate global warming. Furthermore, the significance of low CO_2 emission drug development and therapies for the future is underscored (see Subject #6 in Table 1). These endeavors will equip forthcoming generations to navigate climate fluctuations and contribute to establishing a sustainable and resilient world.

2. Climate change and global warming

2.1. Influence of global warming on human health

Climate change, global warming, and other natural and human-made stressors impact human well-being and the incidence of diseases in numerous ways. Climate change exacerbates several health risks and introduces new health threats. Public health, an essential subject in pharmacy and pharmaceutical sciences, is affected by disruptions in physical, biological, and ecological systems. The health impacts of these disruptions include increased respiratory and cardiovascular diseases, injuries, and premature deaths associated with extreme weather events, changes in the prevalence and geographical distribution of foodborne and waterborne illnesses, other infectious diseases, and threats to mental health (Haines et al., 2006).

2.2. Examining the reality of global warming

The reality of global climate change remains subject to

inquiry. Analyzing temperature data from the past 1,300 years in the northern hemisphere (Mann et al., 2008) reveals a warm period approximately 1,000 years ago during the medieval era, followed by a colder phase known as the Little Ice Age roughly 400 years ago. These historical fluctuations imply a recurrent pattern of Earth's temperatures rising and falling over the past millennium. However, more recent data spanning the last 130 years (Hansen et al., 2010) demonstrate that Earth's temperature has continued to rise, following a linear curve. This 130-year temperature increase is also considered a form of climate change, as seen in the warm periods and the Little Ice Age described earlier. The anthropogenic causes of this 130-year temperature rise will be discussed later.

The reversibility or irreversibility of current climate change and global warming has not been definitively established. The Intergovernmental Panel on Climate Change (IPCC) reported that the time remaining to avoid the worst-case scenario is limited, suggesting that Earth's temperature will continue to rise without sufficient efforts to counter current trends (Masson-Delmotte et al., 2021). Keeping the temperature increase below 1.5°C may reduce and possibly reverse projected damage. Different countries and regions exhibit varying vulnerabilities to climate change effects. For example, Tuvalu, situated in Oceania in the Pacific Ocean, is notably classified as "very vulnerable" due to rising sea levels. The 10 most adversely affected countries by global warming include Japan, the Philippines, Germany, Madagascar, India, Sri Lanka, Kenya, Rwanda, Canada, and Fiji. Among these, four are in Asia: Japan, the Philippines, India, and Sri Lanka (Germanwatch, 2020). Recent media reports highlight record-breaking instances of heatstroke-related hospitalizations and fatalities in Japan during the summer of 2023.

2.3. Causes of global warming

The term global warming refers to the gradual increase in ambient temperatures across Earth's atmosphere and oceans, with projections indicating further escalation in the future. The scientific community attributes the vast majority (90%) of global warming to increasing concentrations of greenhouse gases (GHGs) resulting from human activities, including deforestation and the use of fossil fuels such as oil, coal, and gas (Pichs-Madruga et al., 2014). This phenomenon accounts for a significant proportion of recurring worldwide events such as flooding, Arctic ice melting, and droughts.

As a consequence, global warming unfolds as a phenomenon wherein a substantial amount of GHGs is released into the atmosphere due to human activity, causing a sharp increase in Earth's average temperature. GHGs, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs), exist in trace amounts in the atmosphere. Each type of GHG has a different global warming potential (GWP), which is the heat absorbed by the gas relative to the heat absorbed by the same mass of CO_2. The GWP of a gas is expressed as a ratio against 1.0 for CO_2. For example, the GWP for methane in 2013 was 28 (Ponsioen, 2014).

HFCs constitute a subset of particularly potent gases, characterized by a GWP several orders of magnitude higher than CO_2, significantly amplifying their contribution to global warming. This emphasizes their considerable environmental hazard and influential role in the ongoing phenomenon.

2.4. Climate change hazards and associated health impacts

The collaborative efforts of the Ministry of the Environment, Japan, in conjunction with other key ministries, have delineated six primary climate change risks: (1) rising sea levels, (2) intensification of extreme meteorological events, (3) ecological repercussions, (4) propagation of infectious diseases, (5) proliferation of natural catastrophes, and (6) precipitating food shortages (Ministry of the Environment, Japan et al., 2018). An exploration of the illnesses stemming from these phenomena yields nuanced insights.

The increase in sea levels leads to reduced habitable and cultivable land areas while causing increased flood-related devastation. Acquiring potable water becomes challenging, impacting both communal and industrial sectors. The scarcity of safe water leads to a spectrum of health detriments, from mental disorders to malnutrition, cholera, and other ailments. The higher frequency of extreme weather events corresponds to an elevated incidence of heat-related illnesses, cardiovascular failures, and mortality rates. Ecosystem disruptions result in compromised crops, diminished marine yields, and an increased prevalence of infectious diseases. Moreover, frequent extreme weather events are linked to the emergence of mental health disturbances. Notable instances of recent infectious diseases include severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and COVID-19, highlighting the ramifications of global interconnectedness in disease transmission.

The interconnectedness of natural disasters and food crises with human health, as well as their impact on pharmacy and pharmaceutical sciences, is equally crucial. The World Health Organization (WHO) outlines the multifaceted effects of climate change on critical health determinants, encompassing clean air, potable water, adequate sustenance, and secure habitation (WHO, 2021). Projecting into the near future, the period from 2030 to 2050 anticipates an annual increase of approximately 250,000 deaths due to malnutrition, malaria, diarrhea, and heat-induced stress. Regions with fragile healthcare infrastructures, primarily in developing nations, will face acute resilience challenges unless supported by aid that enhances preparedness and responsiveness.

Mitigation strategies, including reducing GHG emissions through informed transportation, dietary, and energy choices, offer potential health benefits, particularly through improved

air quality. The imperatives of clean air, potable water, and sufficient nutrition resonate as themes within the domain of pharmacists, highlighting the multifaceted dimensions of their involvement.

2.5. Pathways towards addressing global warming

The United Nations adopted Sustainable Development Goals (SDGs) in 2015 as a universal call to eliminate poverty and protect the planet from degradation by 2030. Among the 17 goals listed, several closely relate to climate change and global warming. These goals include ending poverty (#1), ending hunger (#2), ensuring healthy lives (#3), ensuring water and sanitation availability (#6), promoting affordable energy (#7), fostering employment and decent work (#8), building infrastructure and fostering innovation (#9), promoting sustainable consumption and production (#12), taking action to combat climate change (#13), conserving marine resources (#14), and protecting ecosystems (#15). The healthcare industry is expected to expand significantly due to prevention, health management, life support services enhancement, and advancements in medical and long-term care technologies. An essential catchphrase of the SDGs is "No one will be left behind," emphasizing diversity and inclusion when promoting these goals.

The VUCA (Volatility, Uncertainty, Complexity, Ambiguity) era has arrived. Initially introduced by the U.S. Army War College, the concept of VUCA reflects the volatility and uncertainty of general conditions and situations. The term has gained traction in emerging ideas in strategic leadership across various organizations. The VUCA era is characterized by continuous unexpected events, often confounding assumptions about current and future events. In this era, both faculty members and students in pharmacy and pharmaceutical sciences need to comprehend technology, gather information, envision the irreplaceable aspects of humanity in the face of AI or robots, and strategize how to address climate change, global warming, and health issues. The connections between climate change, human health, and higher education in pharmacy and pharmaceutical sciences must be thoroughly examined. Notably, future pharmacists and pharmaceutical scientists must innovate medications and formulations characterized by low CO_2 emissions, as highlighted in the introductory context. This necessitates interdisciplinary engagement that intertwines scientific innovation with ecological considerations.

3. Impact of climate change on health outcomes and diseases in humans

Climate change has far-reaching implications for various health outcomes (Ebi et al., 2017). Table 2 highlights the most significant impacts of climate change on human health, encompassing rising temperatures, extreme weather events, sea-level rise, and increasing CO_2 levels. These effects collectively exert a substantial influence on human well-being.

3.1. Fatalities linked to global warming

Schwartz et al. (2015) demonstrated that global warming reduces mortality due to winter cold but amplifies mortality resulting from summer heat. This conclusion is drawn from an analysis of data collected from 209 cities in the United States. The researchers project that mortality rates during summer will continue to rise through 2030, 2050, and 2100. Elevated concentrations of GHGs will drive higher average and extreme temperatures, contributing to heightened incidents of heat-related illnesses and fatalities, as well as a potential decline in cold-related fatalities. These changes disproportionately impact vulnerable communities, including economically disadvantaged groups, children, and the elderly. Deviations from average summer and winter temperatures can lead to illnesses and an increased mortality rate by impairing the body's temperature regulation or inducing direct and indirect health complications. In this context, community pharmacists are encouraged to develop

Table 2. Effects of climate change on health and diseases in humans.

Climate change	Climate change impacts	Health impacts and diseases
1. Increasing CO_2 levels	Air pollution	Asthma, Cardiovascular disease
2. Rising temperatures	Change in vector ecology	Malaria, Dengue, Encephalitis, Hantavirus, Rift Valley fever, Lyme disease, Chikungunya, West Nile virus
3. More extreme weather events	Increasing allergens	Respiratory allergies, Asthma
4. Rising sea levels	Water quality impacts	Cholera, Cryptosporidiosis, Campylobacter, Leptospirosis, Harmful algal blooms
	Water and food supply impacts	Malnutrition, Diarrheal disease
	Environmental degradation	Forced civil conflict, Mental health impacts
	Extreme heat	Heat-related illnesses and fatalities, Cardiovascular failure
	Severe weather	Injuries, Fatalities, Mental health impacts

The four types of climate changes shown here cause the climate change impacts listed in the next column, which, in turn, result in the health impacts and diseases shown in the rightmost column.
This table referred to Fig. 8.1 in a book (Ebi et al., 2017).

guidelines for air conditioning use among elderly patients.

Loss of internal temperature control can trigger a cascade of illnesses, encompassing heat cramps, heat exhaustion, heat stroke, and hyperthermia during extreme heat episodes (Becker and Stewart, 2011). Extreme weather events with the greatest impact on mortality include heatwaves, tornadoes, hurricanes, and floods. Furthermore, extreme temperatures can exacerbate chronic conditions, such as cardiovascular, respiratory, cerebrovascular, and diabetes-related diseases. Prolonged exposure to high temperatures is linked to increased hospitalizations for cardiovascular, renal, and respiratory ailments. Certain regions in the United States have already borne the human and economic costs of extreme weather events. Health impacts may arise from injury or death caused by these events (Kintziger et al., 2017). Additionally, post-event cleanup and recovery activities may expose individuals to health-compromising situations. Community pharmacists play a crucial role in maintaining the health of the elderly and patients following such disasters. Extreme weather can lead to property damage, infrastructure loss, social and economic setbacks, environmental deterioration, and other adverse effects. Furthermore, concurrent or sequential occurrence of multiple events can give rise to unique health risks.

3.2. Allergies associated with global warming

Climate change has repercussions for both indoor and outdoor air quality. Warming contributes to elevated levels of outdoor air pollutants, such as tropospheric ozone and particulate matter. Concurrently, higher CO_2 levels promote the growth of plants releasing airborne allergens, with both pollutants and aeroallergens infiltrating homes, schools, and other enclosed spaces, thereby adversely affecting indoor air quality. School pharmacists and industrial pharmacists are expected to actively engage with these challenges. Poor air quality, whether indoors or outdoors, can adversely impact human respiratory and cardiovascular systems. Elevated pollen concentrations and prolonged pollen seasons amplify allergic sensitization and asthma episodes (D'Amato et al., 2020). Asthma stands as a prototypical allergy-linked disease. Additionally, global warming is anticipated to contribute to an increased prevalence of heart disease patients. Pharmacy education must comprehensively address the health implications of global warming.

3.3. Infectious diseases connected with global warming

(El-Sayed and Kamel, 2021)

Table 3 provides an overview of representative infectious diseases and the globally distributed causative vectors from the 13th century to the present. Instances of tuberculosis dissemination were linked to overcrowding during the Industrial Revolution. Bacterial agents underlie diseases such as cholera, typhus, and tuberculosis. Furthermore, periods of war have witnessed the emergence of severe infections. In contrast, influenza, a viral disease, often prevails during winter in Europe, the United States, and Japan. The Spanish flu virus, H1N1, spread through soldiers during World War I due to crowded conditions and increased global movement. Notably, the re-emergence of the H1N1 flu virus in 2009 indicates its persistence 100 years after the Spanish flu pandemic, suggesting resistance to inactivation. Acquired immunodeficiency syndrome (AIDS) was initially reported in 1981. Although advancements in antiviral drugs have markedly reduced mortality from AIDS-related illnesses, a definitive cure remains elusive. COVID-19, caused by a coronavirus similar to SARS and MERS, has underscored the potential emergence of new vector-borne diseases due to global warming and globalization. In pharmacy education, students must engage in discussions about strategies to address future pandemics following COVID-19.

The melting of the Arctic permafrost presents a critical concern. Thawing permafrost may release harmful bacteria

Table 3. Representative infectious diseases and causative vectors globally distributed from the 13th century to the present day.

Century	Infectious disease/Causative vector	Remark
13C	Leprosy/Leprosy fungus (bacteria)	Tropical endemic epidemic in Europe spread by the Crusades expedition
14–16C	Plague/Yersinia pestis (bacteria)	One-third of the global population died
16C	Syphilis/Spirochaetes (bacteria)	Antibiotics are used
16–17C	Smallpox/virus	Monkeypox: Brought to the Americas by Columbus and others
19C	Cholera/Vibrio cholerae (bacteria)	Spread to Europe by individuals returning from the British colonies in India
19C	Typhus/Salmonella typhoid (bacteria)	Widespread in the Crimean War and World War I
19–20C	Tuberculosis/Mycobacterium tuberculosis (bacteria)	Spread among the crowded workforce of the Industrial Revolution
20–21C	Influenza (virus)	Spanish flu (H1N1 virus): Spread by soldiers in World War I due to crowded conditions and global population movements
20–21C	AIDS/HIV (virus)	First reported in 1981: Active antivirus agents are used
21C	SARS/MERS/COVID-19 (virus)	Corona viruses

This table summarizes typical (textbook level) infectious diseases from the 13th century to the present.

and viruses into the atmosphere, potentially impacting human health. Numerous microorganisms have been identified in the permafrost of the European Alps, with many remaining unidentified (Frey et al., 2012). The effects of Arctic permafrost melt are challenging to predict, particularly in the context of new vectors and associated infectious diseases. Permafrost vectors constitute a research focus for pharmaceutical researchers.

3.4. ***Heat-related malnutrition and diarrhea*** (Hastings, 2020)

The impact of elevated CO_2 levels and climate change on malnutrition and diarrhea warrants further exploration, particularly within pharmacy schools. An adequate and safe food supply is integral to food security. Climate change disrupts global, regional, and local food security by affecting food availability, rendering food not only less accessible but also more challenging to utilize. Increased CO_2 levels and climate change can detrimentally affect food safety, nutrition, and distribution by influencing pollution, spoilage, and distribution disruptions. While elevated CO_2 levels foster carbohydrate production in certain plants, they can simultaneously reduce protein and essential mineral content in widely consumed crops like wheat, rice, and potatoes, potentially leading to inadequate essential mineral intake in humans.

Anticipating future global food demands, a five-fold increase in food resources would be necessary if global consumption mirrored that of the United States. The population surge in developing countries will necessitate augmented grain production. While it remains uncertain whether food resources will be depleted in the future, awareness of the need to adapt food types is crucial. Innovations such as artificial meat, cultured meat, entomophagy (insect consumption), and plant-based alternatives like burgers and sausages are likely to emerge in the near future.

Climate change is poised to impact freshwater and marine resources, potentially increasing exposure to waterborne contaminants causing illness. Waterborne diseases encompass pathogens like bacteria and viruses, as well as toxins produced by cyanobacteria and human-introduced chemicals. Public health and hygiene, significant components of pharmacy education, play pivotal roles in addressing these challenges.

3.5. ***Mental health issues associated with global warming*** (Gawrych, 2022)

Climate change significantly affects physical, mental, and community health. The impact of global climate change on mental health and well-being is an integral facet of its broader human health consequences. The mental health effects of climate change span from mild stress and distress symptoms to clinical disorders like depression, post-traumatic stress, and suicide. Furthermore, climate change influences various aspects of daily life, perceptions, and experiences for individuals and communities striving to comprehend and respond to its implications. The interactive and cumulative nature of climate change's impact on mental health and well-being is paramount to understanding the overall ramifications of climate change on human health.

4. Global warming countermeasures and pharmacy education

4.1. Integrating global warming into the pharmacy education curriculum

Despite the ongoing increase in global warming, we find ourselves in an era where the potential for a 100-year lifespan has become a reality. With individuals now living to the age of 100 and beyond, pharmacy students must redefine their understanding of human lifestyles, placing heightened emphasis on the implications of climate change for human health. A comprehensive examination of health sciences across various life stages is imperative. Pharmacists are poised to contribute significantly to public health, mental health care, and elderly care within communities, coupled with pharmaceutical interventions for patients. Consequently, educators and professors within pharmacy schools must adapt their pedagogical approaches to address these evolving dynamics within higher education in the field of pharmaceutical sciences. In light of these shifts, pharmacists and pharmacy students must prioritize diagnoses and preventive medicine, as well as explore the escalating significance of preventive practices, self-medication, and alternative therapies. Table 1 underscores six pertinent subjects that necessitate inclusion within the pharmacy education curriculum.

While a definitive solution to global warming remains elusive, the knowledge and awareness cultivated among future generations regarding its current status and challenges are poised to pave the way for its resolution. Table 1 elucidates the typical curriculum spanning freshman to senior years in pharmacy schools. Pharmacy students are urged to delve deeper into this curriculum, particularly leveraging the insights from Subjects #5 and #6 in the table.

4.2. Harnessing new technologies in pharmacy education to address global warming

Japan has introduced the concept of "Society 5.0" as a blueprint for the future. This model envisions a highly interconnected blend of virtual cyberspace and physical reality, aiming to drive economic progress while addressing key societal issues. The evolution of Society 5.0 follows the progression of hunting, agricultural, industrial, and information societies, denoted as Societies 1.0, 2.0, 3.0, and 4.0, respectively. Society 5.0 seeks to achieve the following objectives: (1) resolve current challenges through Internet of Things (IoT) connectivity, knowledge sharing, and novel

value creation; (2) leverage AI to provide essential information and technologies, including robots and self-driving vehicles, to combat challenges such as a declining birthrate, aging population, rural depopulation, and wealth disparities; and (3) drive social innovation to overcome stagnation, foster intergenerational respect, and enable each individual to contribute actively to society. The concept of Society 5.0 holds the potential to mitigate climate change-related issues.

As pharmacists and pharmaceutical scientists, we must not overlook this global imperative. Global warming instigates shifts in the landscape of diseases afflicting humanity. New diseases are poised to emerge alongside those that have previously escaped attention or concern. Our foremost endeavor must be directed at reversing the adverse effects of global warming. Simultaneously, we must deliberate the role that higher education and pharmacy education should play in this context. A heightened emphasis on life and health sciences education within pharmacy schools is crucial to addressing the new diseases borne out of global warming. However, a comprehensive understanding of IT, AI, DX, and Society 5.0 is also indispensable in pharmacy education, empowering pharmacists and pharmaceutical scientists to effectively navigate the challenges posed by these emerging diseases.

The realm of medical and care technology, including pharmaceutical sciences, harbors the potential to save both the world and humanity. Exemplars include the da Vinci Surgical System and Elon Musk's Neuralink. Furthermore, advancements in progressive life sciences like regenerative medicine, genome editing, gene recombination technologies, and innovative pharmaceutical modalities are imperative. This century has witnessed remarkable strides in IT. Contemporary AI systems, with reliable input data, yield superior outputs even without explicit knowledge of the underlying algorithms. Data science facilitates the identification of regions and seasons disproportionately affected by warming trends. The continued utilization of cutting-edge IT and AI technologies is poised to significantly contribute to strategies mitigating global warming.

This study scrutinized the prevailing global social landscape, the catalysts and consequences of climate change and global warming, and the resultant impact on human health and diseases. Figure 1 encapsulates the transformation of social conditions, human activities, climate change, global warming, new diseases, human health, and the primary concerns in higher education, spanning from the 18th century to the present day. The focus of higher education has continually evolved, a trajectory mirrored in pharmacy and pharmaceutical sciences due to their intrinsic ties to science and technology. Competency-based education has risen to prominence. In the face of technological progress, a profound understanding of IT, AI, and DX has never been more vital. As previously discussed, advancements in life and health sciences, including genome science and regenerative medicine, are advancing rapidly, with certain innovations already integrated into practice. Pharmacy students must contemplate how pharmacists and pharmaceutical scientists

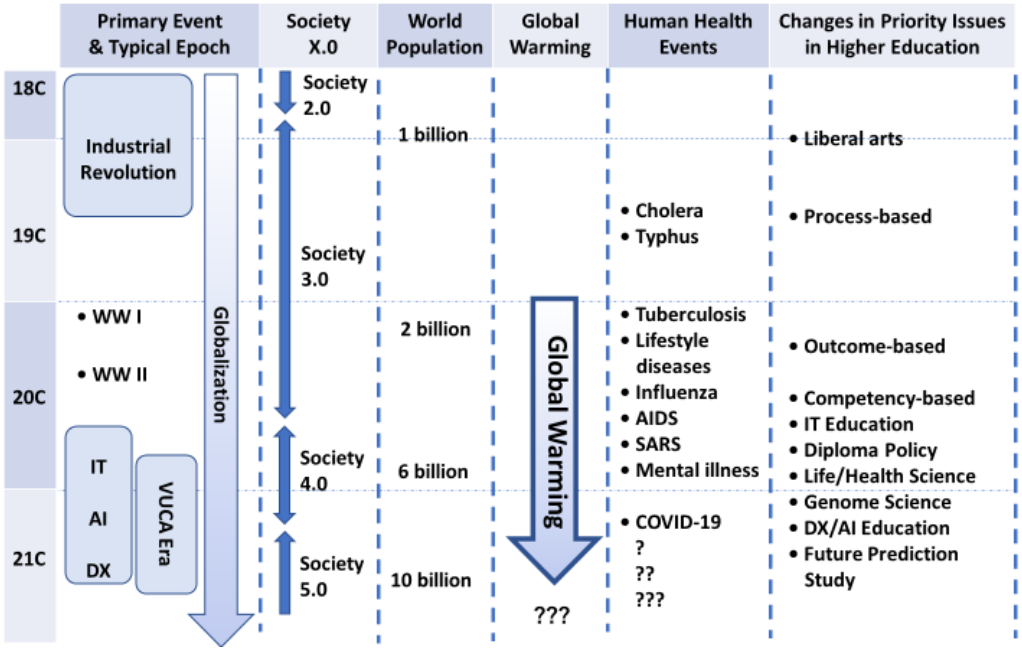

Figure 1. Changes in priority issues in higher education. This figure summarizes the primary events and typical epochs, including the transition from Society 2.0 to 5.0, worldwide population growth, global warming, human health incidents, and changes in priority issues in higher education, from the mid-18th century to the near future of the mid-21st century. This was drawn to help understand the importance of higher education in mitigating the detrimental effects of global warming on human health by the author.

can harness these new technologies and knowledge to tackle global warming's challenges.

The development of "thinking skills" or "cognitive processes," encompassing problem identification and analytical ability, has become pivotal in accurately evaluating current global circumstances, elucidating objectives and challenges, designing optimal solutions, and generating novel values in higher education within the realms of pharmacy and pharmaceutical sciences. The time is ripe to revolutionize pharmacy education, thereby expanding the scope of responsibilities for pharmacists and pharmaceutical scientists.

5. Conclusion

Higher education within the realms of pharmacy and pharmaceutical sciences holds the pivotal role of devising optimal procedures and methodologies for the treatment, prevention, and symptom alleviation of diseases that will potentially afflict humanity in the future. As elucidated in Section 4, pharmacists actively contribute to public health, mental care, and elderly support within communities, accompanied by tailored pharmaceutical interventions for patients. Additionally, pharmacy education must extend its focus to encompass innovative methodologies for devising novel disease treatments. This approach fosters the development of students' cognitive processes, enabling them to think critically, particularly concerning the prevention and containment of infectious diseases on both individual and societal scales. Amidst a backdrop of advancing science and technology, pharmacy education emerges as an essential component alongside medical disciplines, humanities, and social sciences.

The relentless progression of global warming cannot be curtailed solely through the knowledge housed within the pharmaceutical domain. Consequently, fostering collaboration and cooperation among higher education institutions specializing in pharmacy and pharmaceutical sciences across Asia, and extending this collaborative effort globally, becomes imperative to formulate strategies combating climate change, global warming, and the concomitant health challenges. The author envisions that graduates, equipped with substantial experience gained from pharmacy schools, will play a pivotal role in addressing global warming. This role would encompass the innovation of pharmaceutical formulations and medical techniques that uphold environmental sustainability while eliminating carbon emissions. While traditional pharmacy education places emphasis on patients, diseases, drug treatments, and related domains, its evolution is indispensable—specializing further while expanding the scope to encompass contributions to pre-disease conditions and holistic well-being. It's important to acknowledge that fostering a culture of creative human resources necessitates flexibility, avoiding rigidly defined core curricula. In several countries, including Japan, an excess supply of pharmacists exceeds demand. Overcoming this challenge entails adopting a more encompassing perspective on pharmacy education, thus transcending the prevailing trends.

Conflict of Interest

The author reports no conflicts of interest associated with this work. This research was conducted in the absence of any commercial or financial relationships.

Acknowledgments

This manuscript is based on a talk given at the Asia Summer Program 2022 organized by Josai International University (JIU), to which the author belongs.

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