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Applications of Medical Drones in Public Health: An Overview

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Abstract

Use of drones like technology is dated back to the 200 BC, when a bird-shaped artifact named The Egyptian Saqqara bird was developed, which had the wingspan of 180 mm and a length of 150mm. As the time goes by, that old era idea is progressively developed into currently present highlyefficient drone technology which is serving various functions.Its application is rangedfrom various military purposes to the many crucial civilian applications such as weather monitoring and aerial medical supply.In underdeveloped and developing countries, the availability of roads is crucial for medical supplies such as medicines and vaccines. Air transportation, such as helicopter is much costly and not affordable. The success story of drones around environmental sciences and ecology make us realize that they can be employed in the field of public health as a consumable medical carrier. A significant strength of drones' utility is its ability to reduce the travel time behind diagnosis and treatment. Drones considered to be a cost-efficient substitute for road transport in hard to reach areas. They can also be used for the transportation of blood from the blood bank to the site of its need, and specimens from the areas with difficult accessibility to laboratories in nearby cities. Medical drones can transport essential drugs such as anti-venom and post-exposure vaccines for dog bite and snake bites and avoid causalities.Various disaster management and relief operations can be assisted by drones to rescue the victims and the delivery of essential consumables.Similarly, biomedical drones reduce the time for organ transportation from the site of its harvest to the location of transplantation.Drones equipped with AED can provide visual feedback and help a bystander in cardiopulmonary resuscitation of the cardiac arrest patient.The role of drones in pandemic like COVID-19 is being evaluated, and studies are going on to provide maximum facilities with minimum time and chances of spreading infection. However, the usage of drones needs skilled staff and proper infrastructure. People who are residing in the areas of previous military drone attacks having a fear of drones and suffering from various mental disorders. Medical drones may be mistakenly considered as military drones, hence can be attacked by armed forces. Moreover, being an emerging technology, various laws and regulations are being evolved and are still in developmental phase.

Keywords: Medical Drones; Unmanned Vehicle; Public Health; Drones

Introduction

Unmannedaerial vehicles are the small aircraft that are operated and fly by remote devices. The term drone is alternatively used for the unmanned aerial vehicle. This term could have various origins. It may be evolved as a term descriptive of "dry and dull" reconnaissance work done in its early history [1].IIt has also been drawn to "Fairey Queen," a target drone whose success lead to the formation of Queen Bee drones. This might be leading to the use of "drone" as

the queen bee's counterpart. In 1936 Delmer Fahrney, a Lieutenant Commander in US Navy, used the term drone in his report. He was head of a project working of unmanned aircraft to be controlled by the radio system [2]. As its origin shows, drones have been connected with armed services in the popular imagination, and encompass negative meanings because of their utility to kill remotely [3]. Although their connection with negative meanings is progressively changing because now, an increase in their civilian use is evident.

Previously there are known as "pilotless aircraft" [1]. In 1944, this term was used by the Chicago convention of international civil aviation in article 8 [3]. In the decades of the 1960s, a new termed emerged, i.e., Remotely Piloted Vehicles (RPV) [1], which was replaced in the 1980s by another term Unmanned Aerial Vehicles (UAV) [2]. There were many other terms that were used extensively, such as "autonomous drones," "unmanned drones," "remotely piloted aviation systems" (RPAS), "unmanned aircraft" (UA), and "unmanned aircraft systems" (UAS) [2].

Most of the time, when we talk about drones, it comes a sketch of Warfield, death, destruction. It is mainly due to the reason that drones are traditionally used by the forces to destroy focused targets. These are known as military drones. Besides this damaging objective, various other potential uses do exist of drones. Currently, there is an increase in the use of drones for commercial andcivilian purposes to deliver the commodities in the areas with difficult or no access. They are helpful in quick access to images and real-time videos. Computer or smartphone operated drones equipped with video cameras are being used for the safety management in the construction industry, in landscape ecology as in the research of malaria linked with rubber plantations, to monitor wildlife, vehicle-pedestrian accidents and behavior of pedestrians, occupational hygiene, greenhouse gases, and for air sampling [4].

History

Uses of drones involve an ancient history. To kill the enemies, a warlord had been used explosives loaded kites in china.An ancient Greek philosopher, Archytas, designed and developed steam-operated "pigeon," which was able to fly for 200 meters and then run out of the stream. A vertical flight device named "Chinese Top" was invented in 400 BC by China, which was built on a stick having feathers on its end. A spin force by hands was required to generate lift prior to its release in the air to fly [3].

In the period around 200 BC, a bird-shaped artifact named The Egyptian Saqqara bird was developed, which had the wingspan of 180 mm and a length of 150mm. It might have possessed the ability to fly because its wings were much alike of modern era aircraft, which shows that the ancient Egyptians have a basic understanding of aerodynamic processes [3].

An aerial balloon was designed by French armed personnel in 1818 that would use a time delimited phenomenon to fly over the enemies aiming to launch rockets from the top. Two hundred pilotless balloons were launched by the Austrians to bomb the Venice during their siege of the city. Even though wind over Austria caused a hurdle in the complete success of this mission [3], and after five weeks, Venice surrendered before them. In the decade of 1870s, the siege of Paris was assisted by such balloons.

A timing device guided hot air balloon carrying explosives named "Perley Aerial Bomber" was invented by Charles Perley, a New York-based inventor during the time of the American Civil War in 1863 [5]. However, it proved to be highly dangerous due to its extreme inaccuracy [5].

A camera mounted kite used by Douglas Archibald, a British meteorologist, to capture the aerial photographs. Afterward, in 1898, the US has used a camera mounted kites for the monitoring of the American-Spanish War. Moreover, in addition to military use, rubber band powered devices and unpowered gliders were succeeded by manned flights. For example, in 1804, Cayley Model Glider, and in 1796, Cayley Model Helicopter was developed by Sir George Cayley. And in 1871, Alphonse Penaud designed Penaud Planophore [6].

The Hargrave box kite was invented in 1893 by an Australian, Lawrence Hargrave. By connecting a few box kites together, he became able to fly the kites at the height of 4.9 meters. There are many ancient instances of drones precursors such as a steam-powered glider flight by John String fellow in 1848 and in 1907 an unmanned but powered kite by Samuel Franklin Cody [7].

Turning Points

An early key turning point in the history of aviation was the invention of the aircraft. It was used by the armed forces in World War-I and then used globally for commercial purposes. Now it is serving as a vital component of global air transport. The second most important turning point in this sector was the convention in International Civil Aviation in 1944, which is also known as the Chicago Convention. A permanent aviation regulatory body, i.e., ICAO and the principle guidelines were established by this Chicago Convention.

The third major turning point in the field of aviation was the entry of drones. The development of drones is comparable to that of the car. Drones represent a third turning point.

The evolution of drones can be compared to that of the car, at the beginning referred to as the "horseless carriages" or "locomobiles" [8]. The emergence of cars symbolized a groundbreaking technology. They provoked different legal matters, and they influenced the world's geography all around them; a network of roads was constructed throughout the world to accommodate and facilitate these cars. The modern industry emerged around cars [8]. Similarly, the drone has the same developmental phases in the twenty-first century.

Nowadays, drones are serving various purposes. Portable drones for delivery purpose are no more a dream now. An origami-inspired delivery drone has been developed by a team from Switzerland, which has the ability to fly over 2 km carrying a load up to 500 grams. Moreover, it can also be folded into a flat pack. In China, Flamethrowers carrying drones are used to clean the powerlines, which is a very dangerous occupation for human beings [9]. Safety assessment of an Infrastructure, assessment of the damage occurred, the rescue and search missions, and insurance investigation in the aftereffects of the hurricanes such as Harvey in the US are assisted by the drones [9].

The upper-mentioned examples illustrate there exists a huge diversity in the functions of the drone, hence encompass a broad scope in the future. Despite the variety of innovative applications for unmanned aerial vehicles, the further development of drone technologies from around the world is facing challenges associated with substantial ethical and legal issues and regulatory systems. Safety, security, and privacy are the key issues in the integration of drones in the civil airspace.

Drone in Civilian Use

Various unmanned and radio-controlled model air craft's are coming under the term civilian drones. The only difference which may be existed between the terms is that unmanned aircraft are linked with commercial use, and model aircraft are connected with recreation and leisure. Hydrogen-filled model aircraft are seemed to be the initial example of radio-controlled model aircraft [10]. A converted Nortrhop P-61 Black Widow Warplane is another example that was flown in 1946 by the Weather Bureau to collect the meteorological data during the thunderstorms [3].

In the decade of the 1990s. A rise in the civilian use of drones was observed when, according to DeGarmo, "scientific endeavors, such as persistent environmental monitoring, were seen as [an] ideal function for UAVs." For example, NASA has developed Pathfinder aircraft and solar-powered Helios in the decade fo 1990s, and the Aerovironment Corporation illustrated research modernization. Aersonde Laima was produced by an Australian company, AAI, in 1998, which spanned the Atlantic Ocean freely by using utilizing just 1.5 gallons of gasoline. By the decade of the 1990s, Japan attained full-scale production and operation of the drones for the spraying of pesticides and the fertilizers. The utilization of drones besides military purposes continues to increase beyond the 1990s. In 2007, an Aerosonde drone drove into a hurricane at 300 feet altitude, and 80 mph winds, which was so dangerous for the manned airplane. Hobbyists and model aircraft have played their crucial parts in the civilian use of drones [11]. Drones were categorized into macro and micro drones by the Perritt. According to him a drone powered by "4-8 electrically driven rotors" and having the weight less than 55 pounds are micro drones whereas drones "powered by internal combustion engines driving conventional fan jets or propellers" and having the weight more than 55 pounds are considered as macro drones [11]. He suggested that microdrones are progressed from the efficiently downsizing of the electrical propulsion, flight, and imaging systems, which enable them to fly down low, in close quarters, and in situations where manned aircraft would simply be to large to go [11]. This kind of micro aircraft has emerged to the commercial used from the model aircraft hobbyist community [11]. Macro drones, which are now being used for civilian purposes too, were originally developed for the combat purpose and, hence, find their origin in the military [11]. The recent advancements in technology made the use of drones for various civilian as well as recreational purposes.

The progress in the smartphone technology permitted the drones to learn their orientation movement direction. For the drones, smartphones are being acted as their remote controls. Rising demand by the consumer also played a role in the development of it. An article published in a newspaper linked increased popularity of modern era drones to the reason that they permit capturing the spectacular aerial photographs of the users and their homes. In the most popular drones, one category is the Quadcopters. They are much popular due to their decreased complexity and cheaper cost. Theilmann hints the recent boom in users of the drones to the Las Vegas Consumer Electronics show 2010, which presented the French-based Parrot AR 1.0; it might be managed by an iPhone application as well as 'allowed users to take low-quality photos and videos' [12].

In 2013, China-based DJI introduced what many others think to be the predecessor of the modern era drone technology, which enables live streaming by using a smartphone application and a high-quality GoPro Camera mounted on the drone [12]. In comparison with the consumer drones, the commercial drones are still required to gain a large scale utility (basically due to state laws and regulations), companies openly anticipate the business purpose drone

use. "primeAir" was a project unveiled by the Amazon in 2013 which is involved with drone assisted delivery of the orders. Afterward, Google has revealed its home delivery drone in 2014. A hexacopter was used by the BCC to perform their very first drone-assisted reporting back in 2013. About 1.1 million commercial and 2 million consumer drones were sold in 2016, reported by the Economist [13]. Similar to the smartphone industry, "fastest innovation is taking place in the consumer market and then being adopted by companies" [13].

The Emergence of Drones in Public Health

Previous literature [14] suggests that even with increasing adoption and maturation of drone technology in various fields, their development within the biomedical area is still slower as compared to other civil uses. This is because, most of the time, there is urgency is associated with the clinical circumstance, where location, time, and the date are the factors that don't permit control [14]. Rules and regulations are also imposing many restrictions on the field of healthcare. The potential areas for the application of drones in public health are filming accidents and medical services being provided, assessment of the patients in disasters, secure and search missions, and where drones can assist in remote telemedicine and patient care at home [15].

Medical goods that can be carried and delivered through the drones can be non-biological and biological material. These include laboratory samples, blood and transplantation material, sterile goods, medicine, and other pharmaceuticals, and various medical devices. An example of the drone assisted medical goods is the supply of blood and related products to the far rural areas by using drones. Since 2011, the on-demand blood supply to the various regional health centers is being performed by a company Zipline working with the Rwanda government. In Tanzania and |Rwanda, the Provision of medicine and vaccine to various clinics is being carried by many drones on a daily basis [15].

Most projects on the application of drones in the healthcare sector are mainly for the remote villages in underdeveloped and developing countries. Recently several projects have been launched in the urban areas too. In the Netherlands, a drone ambulance (which is not commercialized yet) has been developed, which is equipped with essential life-supporting supplies and a heart defibrillator. This drone will act as a medical device having a video supported channel which will enable two-way communication to assist an emergency situation by the delivery of instructions from emergency specialist to the first operator. The principle goal to develop such a device to provide quick medical aid to the patients suffering from cardiac arrest or other severe conditions so as to boost the survival rates [15].

Various projects associated with the delivery of medical goods by drones are going on in different countries such as Denmark, Norway, the United Kingdom, and Switzerland. Today, drones are acting as a mode of transportation in Switzerland, and many other countries have their projects in the research phase. In Oct 2017, first swiss drone delivery was carried out. Since then, more than 3000 lab samples carrying flights having been completed successfully between the Zurich and Lugano [15]. The transportation of pathological samples associated with kidney transplantation between St Thomas' and Guy's hospital is being investigated to draw the feasibility of future drone use. Last Of All, in Oslo, the medical supplies that in the first place are scheduled to be transferred between the hospitals are the biopsies, tissue samples, blood bank-related products, and blood samples. At some point in the future, the aim is for the transportation of both heavy and lightweight medical supplies with the help of various types of drones where smaller drones would be used for short distances and large efficient drones will be employed to the long distances with consolidated goods [15].

Lab samples are among common medical goods that are and are planned to be delivered by the medical drones in many projects. One of the benefits of the drone-assisted lab samples is that it will save the time of transportation that is very important for the laboratory procedures as well as for the physicians to carry out or plan a treatment therapy [16].

In underdeveloped countries and regions, having forests, deserts, or mountains arehaving challenging routes, or it takes a long distance to reach the destination. Delivery of medical supplies like drugs and vaccines in greatly influence if there is no access to the road or difficult accessibility. Many medical supplies are susceptible to different factors, such as temperature and an unstable environment. Hence delayed delivery along with other issues such as faulty supplies carrying vehicles can influence the quality of the drugs and vaccines. In such areas, air transport by helicopters is the only available option to deliver the supply. But there is a great cost linked with this mode of transportation, which is not affordable to the health system and patients. The success story of the drones in the field of environmental science and ecology encourages its use in the public health sector for the delivery of drugs and other medical aids.Research by the school of medicine at John-Hopkins University revealed that laboratory specimens transportation by drones doesn't influence the accuracy of routine coagulation, hematology, and biochemistry test results.For the first time in the United States,the government permitted the delivery of medical consumables via drones that were carried out in July 2015. This was another encouraging about the usage of drones in

the delivery of medical supplies to the remote areas with difficult accessibility. "The use of drones to deliver lifesaving medical products can overcome the lack of infrastructure. We need to let our imaginations soar when looking for ways to get quality medical products to those in greatest need." This was the message by former director-general of the World Health Organization, Dr. Margaret Chan [17].

Strengths of Biomedical Drones

One of the essential benefits of the biomedical drone is its ability to reduce the travel time for the diagnosis and treatment. A drone can reach the patients in a radius of 4.6 mile^2 within a minute, which is ten times faster if compare with traditional emergency services. In terms of economy, they are cost-efficient alternatives, especially in the areas with difficult terrains. A simulation model has illustrated that drones could enhance the availability of vaccines with the associated reduction in the costs [18]. Drones provide more accurate data because of their flight near to the earth's surface, and ultimately, they decrease the limitations linked with satellite images, for example, cloud contamination [19]. Drones can be used in difficult areas such as snow-covered grounds, canyons, or mountains, and can assist the rescue squads in searching and documenting operations [20].

Drawbacks associated with biomedical drones

Certain limitations do exist for using drones in the area of public health, such as

Infrastructure and human resources

A skilled workforce and constant supervision from the ground is needed to operate a drone. Structure related issues such as the unavailability of runway can be a potential issue in this regard. However, it can be compensated by employing the drone having the ability of vertical landing and takeoff. Furthermore, the utility of medical drones can be a reason forthe downsizing of the employee in the industry related to medical supply. However, it will produce opportunities as well by creating space for drone operators [21].

Technical constraints:

In contrast with commercial helicopters and planes, drones are not able to transport the supplies over a long distance or carry heavy payloads. The approximate load-carrying capacity of a drone is ranged between two to four kilograms [22]. The smarter a drone, its cost, and weight will be increased. Likewise, the efficiency and safety of the drones are not well established yet. Biological items are far more sensitive and fragile and require proper care and package to avoid tampering during transit.

Moreover, the transportation of vaccines and drugs by drones require coolers and ice packs to be pre-installed in the drones to ensure the cold chain. Another technical issue linked with medical drones is its battery life, which can be managed by providing solar energy like Aquila by Facebook [23]. Furthermore, return to the safe point can be ensured by the programming of the drone in case if there is any communication problem or their battery is low. Drones' tolerance to the harsh environment, such as turbulence and wind, is also unclear and not established yet. Electromagnetic waves interruption also disturb the normal drone's operation from the ground [24].

Regulations and legal concerns:

Drone being a newly emerging technology has created many important regulatory challenges. Different regulatory regimes are still evolving for the drones at the domestic and international level. A considerable barrier in employing the medical drone is the legal clearance from the state aviation department. For instance, in many countries, like in India, commercial purpose drones are not allowed to fly. In the united stated, license to operate to the unmanned aerial vehicle is awarded under Federal Aviation Administration rules. And this permission is subjected to the weight, i.e., less than 25 kilograms, territory, i.e., it will fly within a visual line of sight, and its altitude and speed, i.e., maximum height can be 400 feet above the ground. The maximum permitted speed is 100 miles per hour [25].

Various regulation approaches are being used to fly drone by different countries. Austria is using Experimental beyond visual line of sight (BVLOS). According to this approach exceptions to the constant visual line of sight requirement are possible with certain restrictions and pilotratings [26].

Drone being a species of aircraft comes under many articles of the Chicago convention. For example, in article 36, in allowing contracting states to "prohibit or regulate the use of photographic apparatus in aircraft over its territory" [27] may be applicable to the drones. Similarly, article 33, 32, 29, 31, 15, and 3 may also be applied to drones [27].

In 2011, ICAO released Circular 328-AN/190, stating its understanding of integrating drones into the international regulatory regime [28]. In 2015, this organization also issued a 'Manual on Remotely Piloted Aircraft Systems' to better guide on the operational and technical problems for commercial drones [29]. ICAO is also developing Standards and Recommended Practices (SARPs) particularly for the drones.

Future Uses

There are various potential uses of biomedical drones in the field of public health, and its applications are expanding. Some of the opportunities can be;

Transportation of biological consumables, medicines, and blood

In developing and underdeveloped countries, safe blood is deficient in areas with difficult accessibility. Blood can be transported from the blood banks to remoted healthcare facilities by using the drones in specific emergencies such as during parturition or other surgeries. This will save costs by avoiding the need to set up a blood bank in remote areas. These drones can also be used in massive causalities situations such as in natural disasters and other tragic incidents [30]. The Government of Rwanda is using drones to transport blood to the clinic situated in hard to reach locations in the cost of motorbike deliver and comparably in less time.

In villages and remoteareas, delayed diagnosis of the disease is a common issue due to the unavailability of the laboratory facilities. This issue can be avoided by using drones for the transportation of diagnostic aids and samples. Health care personnel can be trained for the collection and transportationof the samples to the nearby laboratory with the help of drones.Furthermore, the results and associated medicines can be sent back if the results are positive. Previously drones have been used to collect blood samples from the areas with no laboratory facilities in Madagascar [21]. Similarly, in Malawi, HIV testingof infants have been assisted by the drones to transfer dried blood samples. In Papua New guinea, sputum samples have also been transported from rural areas to Kerema city by using drones [21].

Drones can also be used for the delivery of essential medicines such as anti-venom and other post-exposure vaccines for the dog and snake bites to prevent the causalities which are much common in rural areas [31]. Drones can be employed for the transportation of the medicines and samples from one building to another or one floor to another flood within thesame building to decrease the human resources. In homes, drones can be helpful for the old age persons to bring essentials required by them.

In underdeveloped and developing countries, there is a shortage of contraception in hard to reach areas, and as an outcome, family planning is a significant issue in these areas. People inhabiting such areas are already suffering from the lack of necessary facilities, and the unavailability of contraception further increases population, which pose amore significant impact on the life quality of the local people. Contraceptive medicines and related material can be supplied by the drones to these hard to reach areas where local health care staff can collect and distribute among beneficiaries.UNFPA (United Nations Fund for Population Activities),along with the Government of Netherlands has successfully launched and conducted a project in Ghana where they distribute the condoms in hard to reach rural areas.

Disaster relief and medical emergencies

In disaster management operations, drones can be used to rescue the victims from the disaster areas such as collapsed buildings or in seas where fishers lost. Drones can further used for the transportation of medicine, water, and food in any disaster situation and to the patients who are on offshore ships. A drone can havethe potential to be used as an ambulance during emergencies.Drones can supply devices like AED(Automated External Defibrillator) to the cardiac arrest patient in the area withno hospital facility within a short time,which can enhance the chances of survival [32]. Drones equipped with AED can provide visual feedback and help a bystanderin cardiopulmonary resuscitation of the cardiac arrest patient. Drones delivering real-time videos are efficient and time-saving in locating drowning persons and the provision of flotation devices in comparison to surf-lifeguards [33].

Organ transplantation

One of the main hurdles in the organ transplantation sector is the transportation of donated organs from the harvesting facility to the transplantation hospital with the least possible time. Traditionally, in many countries, the traffic police department forms a green passageway for the vehicle carrying donated organs by blocking the other everyday traffic. Donated organs can be delivered within the possible shortest time by using the drones, avoiding densely populated roads. Drones assisted kidney transportation did not show any significant damage by the extrinsic forces [34].

Surveillance in hard areas

Many surveys can be conductedunder challenging areas within a short time by using the drones, which may becomeotherwise inaccessible by ground. Back in March 2011, radioactive material was spread in the environment of Fukushima, Japan, due to tsunami and earthquakes. Drones equipped with a gamma spectrometer were used to illustrate nuclear contamination and to create resolution maps of contamination [35].

Role in pandemic/epidemic like COVID-19

Recent work has analyzed the COVID-19 pandemic, drone-based systems, and proposed mechanisms for managing pandemic circumstances in various scenarios by using real-time and simulation-based studies. This study recommended architectureapplies wearable devices to track the observations in body area networks in a pull-push data fetching mechanism. This mechanism is revealed to be helpful in highly congested and remote pandemic regions where COVID-19 spread chances are high or where internet connectivity is a significantproblem. It gathers, stores, and analyzes a considerableamount of data within a given time frame and assists in taking suitable measures as and when needed [36].

It is observed that a real-time drone-based healthcare system for COVID-19 operation can cover a vast area for thermal image collection, patient identification, sanitization within a short time, i.e., 2 kilometers in about ten minutes by. Furthermore, collision-resistant strategies are also found working effectively for outdoor and indoor healthcare operations [36].

Associated Risks/Threats

Public safety

In case of a crash, a drone can be fall in the residential areas and damage the public property and injure residents. Previously various military drones have been crashed and produced a significant loss. A collision of a commercial drone by accident had caused a skull fracture in a boy having the age of 13 years. A misadventure occurred with a recreational drone, which caused a traumatic ocular injury with entire thickness corneal laceration to a nine-year-old boy [37]. There is a fear of military drones in the residents of specific areas. An example of such fear existed in the residents of Waziristan, where drone attacks were carried out to destroy terrorist's site [38]. These military drone attacks have raised mental health issues such as depression and anxiety in Pakistan [39]. The utility of civilian drones by the terrorists and extremists can cause considerable damage by their attacks. As a security measure, a drone can be tracked by attaching a transducer to a drone.

Drone safety

Medical drones can be mistakenly considered as a military drone by the surveillance forces. Other possibilities, such as package loss, can also be occurred due to any fault or issue. A drone can be hijacked by the hacker using GPS jammers, and they can loot the payload or drone. So there is a necessity for the development of software, which makes drones resistant to hack.

Air Traffic Congestion

There can be a significant interference by the biomedical drones to the air traffic and may pose confusion to the commercial airplanes. Previously, In California, United States, drones have delayed aerial firefighter jets deployed to fight fire in California [21].

Future Prospective of Medical Drones

Above reviewed literature illustrated that drones encompass great prospects in the area of public health. They can be employed to deliver specimens, blood, and biological consumables like vaccines and drugs to the hard to reach remote places within minimum possible time. They can be used to save lives and disaster management and relief. However, some threats and weaknesses are associated with the application of drones, which can be addressed by the advancements in research and technology. Drone delivery ports and systems can be developed near health care centers. Public privacy and safety analysis should be carried out prior to the scaling up of medical drones in the field of public health. Further studies are encouraged and required on the drones' safety, involving crashes of drones along with the reason for the crash. upgradation in health education is also needed to ease the apprehension and fear in people's mind about the drones.

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