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Effectiveness of Vaccines and Barriers Against Effective Cold Chain Systems

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Abstract

Vaccination is often considered a cost-effective strategy for the prevention and control of most infectious diseases or vaccine-preventable diseases. Poverty, ignorance, cultural belief and practices, locality of residence, level of awareness on vaccine safety and lack of access to health care facilities are among the obstacles to vaccination leading to low vaccine coverage. Low vaccine coverage among young children across remote and rural areas, slums and riverine areas is not a reflection of the health and social-related Sustainable Development Goals. Poor handling of vaccines has been identified as one of the reasons for the reduction in vaccine effectiveness at the time of administration. Cold chain is the system of transporting, storing and distributing vaccines in a viable state at the recommended temperature from the point of manufacture to the point of use. Some factors contributing to the weakness of the cold chain are delays during transportation, quality of refrigerators, method of storage, period of storage at the health facility, improper use of refrigerators, equipment breakage, lack of trained personnel capable of managing the cold chain, unreliable power sources and limited resources (material, financial, and human).

Keywords: Cold chain, Effectiveness of vaccines, Barriers.

Introduction

The discovery, development and availability of vaccines is a recognized health intervention and accomplishment of public health[1] towards the prevention and reduction of morbidity and mortality associated with some bacteria, parasitic and viral diseases. Vaccine administration has been considered a cost-effective strategy[2-4] for the prevention and control of most infectious diseases or vaccine-preventable diseases and it enhances population growth. The cold chain is the method of transporting and storing vaccines at the recommended temperature[3,4] and starts from the time the vaccine is manufactured, stored, and distributed and ends when the vaccine is administered to a person. It consists of a series of storage, transport and supply links,[5] all designed to keep vaccines within recommended temperature range until it reaches the users, and a system of different elements, i.e.

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human, material and financial resources, and certain norms and standards that ensure the high quality of vaccines.

Effectiveness of vaccines

The outbreak of some widespread and deadly infectious diseases led the scientific world1 to search for appropriate solutions, which lead to the discovery of vaccines and it has become one of the major revolutions[2] in the history of human health care.

A vaccine[1,2] is a substance that is introduced into the body to prevent infection or to control disease due to a certain pathogenic organism, such as a virus, bacteria or parasite. It is a biological product that can be used to safely induce an immune response that confers protection against infection and/or vaccine preventable disease[1,3,6] such as Measles, Pertussis, Tetanus, Hepatitis B, Tuberculosis, Poliomyelitis, Mumps, Rubella, Cholera, Haemophilus influenzae type b, Diphtheria, Rotavirus, Human papillomavirus, Japanese encephalitis, Yellow fever etc.

Vaccines may be live attenuated or inactivated vaccine.[1] Live attenuated vaccines contain attenuated replicating strains of the relevant pathogenic organism and are capable of replicating within the body and stimulating an immune response. They provide long-lasting immunity, one dose usually suffices, and are contraindicated in immunocompromised states. Inactivated vaccines contain only components of a pathogen or killed whole organism, they do not multiply in the body and need to be given in multiple primary and booster doses.[1] In addition to the traditional live attenuated vaccines and inactivated vaccines, there are also nucleic acid-based RNA, DNA vaccines etc.

Bacterial infection

Live Attenuated Vaccines: Bacillus Calmette- Guerin (BCG), Typhoid vaccine

Inactivated Vaccines: Cholera, Pertussis, Tetanus, Diphtheria, Meningococcal, Pneumococcal vaccines

Viral infection

Live Attenuated Vaccines: Polio (Sabin), Measles, Mumps, Rubella, Yellow fever, Rotavirus.

Inactivated Vaccines: Polio (Salk), Rabies, Hepatitis B, Influenza, Hepatitis A, Human papillomavirus.

Vaccines are very sensitive biological products or substances. Some vaccines are sensitive to cold, some are sensitive to heat and others are sensitive to light.[3-5] They are highly temperature -sensitive substances[3,7] that have a shelf life that loses viability over time. This loss of viability is irreversible and accelerated if proper storage and adequate temperature conditions are not maintained.[3,5] Excess cold or excessive heat exposure can totally or irreversibly damage the quality of vaccines and increase the risk of side effects.[3,7] Vaccines naturally biodegrade over time and this process may be accelerated if they are stored outside the recommended temperature range.[3] Vaccine quality depends on correct storage temperatures, monitoring of the storage temperature of the vaccine is very important and care must be taken to see that the vaccine does not lose their effectiveness, before the date of expiration.[3]

Poor handling of vaccines has been identified as one of the reasons for the reduction in vaccine effectiveness at the time of administration.[3,8] The effectiveness of a vaccine in preventing disease depends largely on the quality of the immunizing agent. Failure to adhere strictly to recommended specifications for vaccine handling and storage can render vaccines ineffective. Improper handling and storage, appropriate storage conditions (temperature range) deficiencies at all levels

such as inadequate infrastructure, power shortages and poor maintenance are associated with vaccine wastage.[8] Periodic assessment of vaccine handling, distribution and storage practices is instrumental in correcting wrong vaccine management practices like the absence of appropriate cold chain equipment to store and transport vaccines, equipment failure, absence of systems to monitor the temperature of heat-sensitive vaccines and insufficient cold chain capacity.[3]

Poor handling of vaccines and the exposure of vaccines to improper conditions through nonadherence to recommended specifications for vaccine handling and storage can result in the reduction of vaccine effectiveness. With the availability and effectiveness of many vaccines, the benefits to a country or society depend on vaccines acceptance by the populace, adequate cold chain infrastructure, knowledge, training, supervision of staff, procurement of the right vaccines, in the right quantity, in the right condition, delivered to the right place, at the right time and for the right cost.[4] The benefits of vaccination or vaccines to a country or society also depend on effective and well-organized transportation systems, logistics management of the vaccine cold chain system, compliance to the standards, strong partnerships and effective community[1] participation, and a functional and sustainable health care system which include adequate funding, dynamic and a motivated health workforce.

Barriers against effective cold chain systems

The cold chain is the method of transporting and storing vaccines at the recommended temperature range which ranges from +2°C to +8°C for refrigerator vaccines and -15°C to -25°C for freezer vaccines.[5] Cold chain system start from the time the vaccine is manufactured, stored, and distributed and ends when the vaccine is administered to a person. The cold chain system is considered to be at high risk, particularly in tropical countries[4] where a power supply is unreliable and facilities for its maintenance are not well developed.[9] Developing countries in Africa with tropical climates and the absence of stable electricity continue to handle the challenges of maintaining the strict temperature range of the vaccine cold chain system.[4] From storage facilities in some African countries, some health workers under tropical climates carry vaccines in cold boxes and vaccine carriers,[3] traveling by motorcycle, bicycle, boat, canoe or on foot to deliver vaccines down to the health facility in the village level and even in the most remote of villages.

Cold chain management[10] vulnerability is often observed during the transportation and storage of vaccines. Storage and transport equipment such as cold rooms, Vaccine Vial Monitor, refrigerators, freezers, cold boxes and vaccine carriers in some resource-poor countries do not meet or comply with performance standards[11] by the World Health Organization (WHO). Active and effective vaccines can be sustained by harnessing the essential elements in the cold chain namely the vaccines, manpower, equipment and transportation.[7] Logistics management involves the efficient coordination and control of the flow of all operations that include products selection, forecasting demand, ordering and procuring, warehousing and storing, managing inventory, managing commodity-related data and transport of commodities from one level to the next until they reach the recipient or user.

Conclusion

Effective management of the cold chain system at all levels is one of the crucial factors for maintaining vaccine potency. Improving availability and access to quality vaccines; irrespective of slum areas, riverine areas, and remote and rural areas can reflect the benefits of the health and social-related Sustainable Development Goals among children, adolescents and the populace.

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Conflict of interest
There are no conflict of interest among the authors.

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