Age-Structured SEIR Model with vaccination for modeling the Spread of measles in Africa

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Measles is a highly contagious viral infection that transmits from person to person through respiratory droplets produced when an infected person coughs or sneezes. According to the United States Center for Disease Control and Prevention (CDC), measles is caused by a single-stranded, enveloped RNA virus with 1 serotype, which is classified as a member of the genus Morbillivirus in the Paramyxoviridae family. Measles is one of the few infectious diseases that have been consistently around for over a millennium. According to the World Health Organization (WHO), before the introduction of vaccines in 1963, measles epidemic was quite frequent that used to occur in two-three years interval and caused up to 2.6 million deaths every year, see [1]. The virus is so contagious that CDC estimated (before the introduction of vaccines) almost everyone got infected by the age of 15, see [2]. Measles is not clinically treatable, but preventable; once infected one has to wait the virus to finish its course, see [3]. The best protection is to get vaccinated, which usually is administered in two doses; the first from 12-15 months of age and the second from 4-6 years of age. According to [4] about 45% of Africa is fully vaccinated while 76% of Americas, 91% of Europe and Western pacific, 78% of Eastern Mediterranean and 85% of South East Asia are vaccinated. As a result measles epidemic is still common in Africa and contributes most of the global recorded cases and deaths, see [5, 6]. In this work, we will design an age-structured SEIR model that considers the time gap between the two doses. We will propose a Semi-linear Cauchy problem in an appropriate Banach space and will study the existence and uniqueness of a solution. We will also analyse the stability the solution based on the basic reproduction number, run numerical experiments and fit the model to a data from appropriate sources. Based on analytical and numerical results, besides the efforts to improve vaccine coverage in Africa, we will discuss what additional measures to be taken to reduce the impact and control or eliminate the spread.

References

[1] WHO,https://www.who.int/news-room/fact-sheets/detail/measles

[2] CDC, https://www.cdc.gov/measles/cases-outbreaks.html

[3] Cleveland Clinic. https://my.clevelandclinic.org/health/diseases/8584-measles

[4] WHO,https://www.who.int/data/gho/data/indicators/indicator-details/GHO/measles-containing-vaccine-second-dose-(mcv2)-immunization-coverage-by-the-nationally-recommended-age-(-)

[5] WHO, https://www.who.int/data/gho/data/indicators/indicator-details/GHO/measles---number-of-reported-cases

[6] Patel, M.K., 2020. *Progress toward regional measles elimination—worldwide, 2000–2019.* MMWR. Morbidity and Mortality Weekly Report, 69.