

Modeling Secondary Vaccine Failure and Comparing Vaccination Strategies for Nosocomial Measles Infection

Junyoung Part ¹, Seok-Min Lee ² and Eunok Jung¹

1)Department of Mathematics, Konkuk University, Seoul, Korea

2)Department of Liberal Arts, Hongik University College of Engineering, Seoul, Korea

Corresponding Author: Eunok Jung, junge@konkuk.ac.kr

ABSTRACT

Globally, secondary vaccine failure (SVF) of measles following the second dose of the measles-mumps-rubella (MMR) vaccination has been increasingly reported. In the Republic of Korea, this phenomenon has been observed after the introduction of mandatory MMR2 vaccination, with notably low seroprevalence among individuals in their 20s. During the 2019 nosocomial measles outbreak, 76% of infected healthcare workers (HCWs) were seropositive yet contracted measles. However, the precise mechanism underlying SVF remains unclear. To capture this uncertainty, we categorized the population into three immunity states: protected, partially protected, and seronegative. Transitions between these states were modeled by using a Gamma distribution to represent time-dependent delayed waning of immunity. We developed a SEIR model incorporating these immunity states within a hospital setting and the reproductive number was then calculated to assess the risk of measles outbreaks under these conditions. We compared various hospital-based vaccination strategies: (1) vaccination of newly recruited HCWs, (2) serological screening followed by booster vaccination for seronegative individuals, and (3) mass vaccination of all HCWs. Among these, the first strategy was identified as the most effective. This study provides mathematical insights into SVF and is expected to support the vaccination strategies for measles control.

REFERENCES

1. SONG, Kyunghyun, et al. Control of a nosocomial measles outbreak among previously vaccinated adults in a population with high vaccine coverage: Korea, 2019. *European Journal of Clinical Microbiology & Infectious Diseases*, 2022, 1-12.
2. BESTER, Johan Christiaan. Measles and measles vaccination: a review. *JAMA pediatrics*, 2016, 170.12: 1209-1215.
3. LEBARON, Charles W., et al. Persistence of measles antibodies after 2 doses of measles vaccine in a post elimination environment. *Archives of pediatrics & adolescent medicine*, 2007, 161.3: 294-301.