International Journal of Infectious Diseases 57 (2017) 92–97

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Increasing mumps incidence rates among children and adolescents in the Republic of Korea: age–period–cohort analysis

Young-June Choe[a,b], Young Hwa Lee[a,b], Sung-Il Cho[a,b,*]

[a] Medical Research Center, Seoul National University College of Medicine, 599 Gwanak-ro, Gwanak-gu, Seoul 151-742, Republic of Korea
[b] Department of Epidemiology, Seoul National University School of Public Health, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 21 October 2016
Received in revised form 12 February 2017
Accepted 13 February 2017
Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:
Mumps
Vaccine
Strain
Rubini

SUMMARY

Background: To characterize the temporal dynamics of mumps epidemiology according to the different vaccine strains used, sex-specific trends were decomposed in an age–period–cohort (APC) analysis for mumps cases reported in South Korea.
Methods: National surveillance data were used to describe the epidemiology of mumps cases from 2001 to 2015. An APC model was used to break down the reported mumps cases into the effects of age, period, and birth cohort.
Results: From 2001 to 2015, the incidence started to increase from fewer than 10 cases to more than 100 cases per 100 000. The incidence rate was highest among males aged 15–17 years during 2013–2015, reaching 508.7 per 100 000 persons. There was an increased incidence during the late teenage years in the 1998–2000 cohort. An age shift towards the earlier teenage years was observed across the 2001–2003 and 2004–2006 cohorts. The risk of mumps increased according to the birth cohort; the net drift from 2001 to 2015 was 27.67 (95% confidence interval 27.5.47–29.90) for males and 27.25 (95% confidence interval 24.91–29.65) for females.
Conclusions: The increase in mumps seen in Korea may have been affected by the birth cohort exposed to the Rubini strain; however other factors may have contributed to the increase in non-exposed cohorts.

Introduction

Mumps is an acute communicable disease characterized by swelling of the parotid glands. The incidence of reported mumps has increased in many countries since the turn of the century. In the USA, more cases of mumps were reported in 2006 than in any year since 1955.[1] An increase has also occurred in France, with more cases reported in 2013 than in the prior two decades.[2] A variety of explanations have been proposed for this resurgence of mumps, including inadequate vaccine coverage, a mismatch between the genotype of the wild-type and the vaccine virus strains, circulation of other pathogens that can cause parotitis, and the use of ineffective vaccine strain(s).[3]

The Urabe AM9, Jeryl-Lynn, and Rubini mumps vaccine strains have been used widely. The Urabe AM9 and Jeryl-Lynn strains have shown an efficacy of 75.8% (95% confidence interval (CI) 35.6–90.9) and 64.7% (95% CI 10.6–86.0), respectively.[4] However, the Rubini strain has been shown to be ineffective, with efficacy rates ranging from −55.3% (95% CI −121.8 to −8.8) to 12.4% (95% CI −102.0% to 62.1%).[4] In 2000 the World Health Organization (WHO) recommended against using the Rubini strain in public vaccination programs.[5]

In Korea, a recent increase in mumps was noted among 10–19-year-old adolescents.[5] The Rubini strain vaccine was used from 1997 to 2000 in Korea. Hence it was hypothesized that the increase in mumps incidence in Korea could be attributed to the accumulation of susceptible adolescents vaccinated with the Rubini strain.

To understand the effect of the Korean birth cohort immunized with vaccines containing the Rubini strain on the recent increase in mumps in Korea, an age–period–cohort (APC) analysis of sex-specific mumps incidence in Korea from 2001 to 2015 was performed.

* Corresponding author. Tel.: +82-2-880-2717; fax: +82-2-743-8240.
E-mail address: persontime@hotmail.com (S.-I. Cho).

http://dx.doi.org/10.1016/j.ijid.2017.02.011

Materials and methods

Data source

An APC analysis breaks down the time trend in disease incidence into the effect of age, calendar period, and birth cohort. Data on age-specific and sex-specific mumps cases from 2001 to 2015 were obtained from the National Notifiable Disease Surveillance System.[6] Mumps has been a notifiable disease in Korea since 1955. Information on age and sex have been included since 2001. No additional policy was implemented to improve the reporting of cases during the period of observation. All physicians are obliged to report laboratory-confirmed or clinically suspected mumps cases. The clinical case definition for the diagnosis of mumps is based on the WHO case definition, which is a case with acute onset of unilateral or bilateral tender, self-limiting swelling of the parotid or other salivary gland and without any other apparent cause.[7] All clinical and laboratory confirmed cases were included in the analysis.

One dose of measles, mumps, and rubella (MMR) vaccine was introduced into the National Immunization Program in 1985, and a second dose has been given since 1995. The vaccination coverage rate of the first dose of MMR remained relatively constant at 95–99% during the surveillance years.[8,9] The Rubini strain was used in the National Immunization Program from 1997 to 2000, and was given to birth cohorts in the years 1992–1994 as their second dose, in the years 1995–1997 as their first and/or second dose, and in the years 1998–2000 as their first dose. Between 1997 and 2000, the proportion of Rubini strain among all vaccine strains was around 50% (unpublished data, Korea Centers for Disease Control; see **Supplementary Material**). In Korea, the major vaccine strain used in the 1990s was the Urabe AM9 strain and beginning in 2000 was the Jeryl-Lynn strain.

Statistical analyses

The annual age-standardized incidence per 100 000 population per year was calculated using population data from the Korea Statistical Information Service and the WHO standard population as the reference. Age-specific incidence according to sex was calculated for periods and birth cohorts in 3-year blocks to determine the difference in incidence between the aforementioned cohorts affected by the Rubini strain.

The Poisson APC model was used to estimate the age, period, and cohort effects on the secular trend of mumps from 2001 to 2015. The log age-specific rate $\lambda(a,p)$ at age a in period p for those born in cohort $c = p-a$, is as follows: $\log[\lambda(a,p)] = f(a) + g(p) + h(c)$. The age–period model was fit, choosing the year 2001 as the reference period. The log of the fitted values from this model was used as an offset variable in a model of the cohort effect. The cohort effect was used as the residual log rate ratios by cohort.

The APC modeling was performed and the data analyzed using R 3.0.2 statistical software, the Epi 1.1.49 package, and a Web tool developed by the National Cancer Institute.[10] The Web tool generates the smoothing longitudinal curve from observed cohort-specific age-specific rates. The local drifts are derived from log-linear regression. The relative rates are calculated in a given period or birth cohort versus a reference period or cohort.

This study was approved by the Institutional Review Board of Seoul National University (IRB No. SNU 16-01-050).

Results

The secular trend in mumps incidence is shown in Figure 1. Between 2001 and 2005, the annual number of mumps cases reported was around 10 cases per 100 000. From 2006 to 2010, the incidence increased from 13 cases to 40 cases per 100 000. From 2011 to 2015, reported mumps incidence increased dramatically to more than 100 cases per 100 000. On average, the annual percentage changes were 26.8%, 26.8%, and 26.7% for total, male, and female incidences per 100 000, respectively, which were all significant increases from 2001 to 2015 (all $p < 0.001$). The incidence for males was significantly higher than that for females ($p < 0.001$, Wilcoxon signed rank test). The mumps incidence rate was highest in males during all periods.

Incidence rates by sex, age group, and calendar period are shown in Table 1. The incidence rate was highest among males aged 15–17 years during the period 2013–2015, being 508.7 per 100 000 persons. The age-specific mumps incidence rates for males and females across time periods are shown in Figure 2. From 2001 to 2003, the age-specific rate was relatively constant across all ages. From 2007 to 2009, the age-specific incidence rate increased steadily in males aged 3–5 years, with a surge in cases noted at 15–17 years of age. Both males and females showed increased incidence rates from 2013 to 2015, with two peaks at preschool age (3–8 years) and adolescent age (15–17 years).

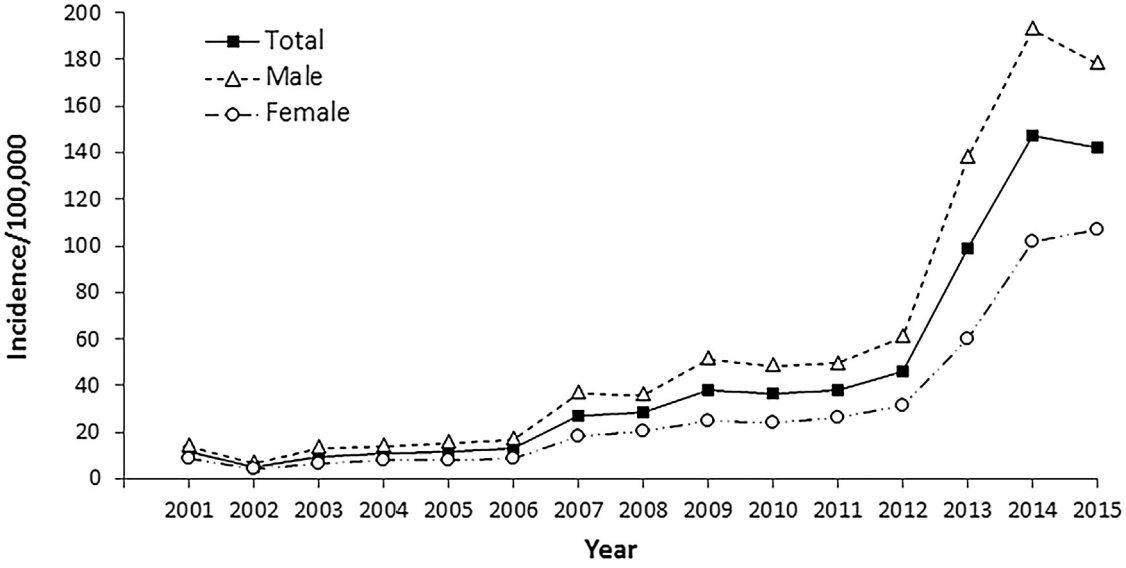

Figure 1. Age-standardized mumps incidence rates by sex, Republic of Korea, 2001–2015.