European Journal of Preventive Medicine
2016; 4(2): 28-31
Published online March 2, 2016 (http://www.sciencepublishinggroup.com/j/ejpm)
doi: 10.11648/j.ejpm.20160402.11
ISSN: 2330-8222 (Print); ISSN: 2330-8230 (Online)

Research/Technical Note

Changes in Rates of Measles Transmission and Force of Infection in Gweru City, Zimbabwe: A Retrospective Study

Tawanda Marufu[1], Willard Tinago[1], Seter Siziya[2]

[1]Department of Community Medicine, University of Zimbabwe College of Health Sciences, Harare, Zimbabwe
[2]Department of Clinical Sciences, Copperbelt University School of Medicine, Ndola, Zambia

Email address:
marufut@yahoo.com (T. Marufu), wtinago@gmail.com (W. Tinago), ssiziya@gmail.com (S. Siziya)

To cite this article:
Tawanda Marufu, Willard Tinago, Seter Siziya. Changes in Rates of Measles Transmission and Force of Infection in Gweru City, Zimbabwe: A Retrospective Study. *European Journal of Preventive Medicine.* Vol. 4, No. 2, 2016, pp. 28-31. doi: 10.11648/j.ejpm.20160402.11

Abstract: *Introduction* A study compared rates of measles transmission and force of infection in pre-vaccination era (1967), and at measles vaccine coverage rates of 50-80% (1978-84) and > 90% (1989). Using measles surveillance data cumulative proportions of measles cases by age were determined for the years 1967, 1978-89 (pooled) and 1989. From the cumulative curves estimates of the age dependent rate of infection with measles (force of infection) was determined for the years 1967, 1978-84 and 1989. *Results* In 1967 and 1978-84 some 75% of all measles cases occurred by age group 36-47 months while in 1989 this occurred by age group 72-83 months thus measles transmission was most rapid in 1967 and least rapid in 1989. Variation of force of infection between years 1967, 1978-84 and 1967 showed that force of infection was not significantly different between the years for age groups 24-35, 36-47 and 48-59 months. Meanwhile, the force of infection varied between the years in the rest of the age groups, with a significant reduction in force of infection over the years for age groups < 11, and 12-23 months; and significant increases in force of infection were observed in the age groups 60-71, 72-83, 84-95, 96-107 and 108-119 months. *Conclusion* Measles transmission rates in the community were highest in pre-vaccination era and least at vaccination coverage rates of > 90% most likely due to effect of herd immunity. From pre-vaccination era (1967) to vaccine coverage rates of > 90% (1989) there was a shift in force of infection from young age groups < 23 months to older age groups of 60-119 months most likely due to accumulation of susceptibles in these older age groups. Shift in force of infection to older age groups would have been responsible for the shift in age at infection to these older age groups.

Keywords: Measles, Transmission Rates, Force of Infection, Gweru City, Zimbabwe

1. Introduction

Measles is a major cause of morbidity and mortality in developing countries [1]. High measles vaccine coverage rates have reduced disease, disability and death attributed to measles [2]. Over and above the reduction in measles morbidity and mortality, in developing countries widespread measles vaccination has led to changes in measles epidemiology that have included changes in transmission patterns and force of infection [3]. A study was carried out in the city of Gweru in Zimbabwe to investigate changes in measles transmission rates and force of infection from the pre-vaccination era in 1967 to 1989 when measles vaccine coverage rates (for the vaccine applied at 9 months at age) were > 90%.

2. Materials and Methods

A retrospective observational study used data from measles vaccination records and measles disease surveillance data. Rates of measles transmission in the community and force of infection were determined for the years 1967 (pre-vaccination period), 1978-84 (when vaccine coverage rates were 50-80%) and 1989 (when vaccine coverage rates were > 90%).

3. Sources of Data

3.1. Vaccination Records

In Gweru, measles vaccinations were applied to children at static health facilities since 1971 and vaccination records

were available since then. Routine vaccinations were indicated on child health cards and vaccination records/statistics were compiled monthly.

3.2. Measles Disease Surveillance

The city of Gweru had an active measles surveillance system. On this system, cases were identified on the basis of a standard clinical case definition that was available to all staff at all the city's health centres and infectious disease hospital. There were personnel that were assigned to investigate unreported infectious diseases (including measles cases) within communities (active case search). Measles case surveillance/investigation forms indicated age at infection, vaccination status, sex, presenting features of disease, whether admitted into hospital or not, treatment regime instituted, occurrence of any other cases in relation to an identified case (which would also be investigated), and outcome of illness (alive of dead). Data on vaccination status of cases was only available from 1980 and not before. Complicated cases were managed at the city's single infectious disease hospital. Data on measles cases and deaths were entered on line lists that indicated the same variables as those on case investigation forms. Data from the measles surveillance system were compiled monthly.

3.3. Data Analysis

Cumulative proportions of measles cases by age were determined for the years 1967, 1978-89 (pooled) and 1989. Because the cumulative proportion curves were well age-stratified an estimate of the age-dependent rate of infection with measles (force of infection) was determined for the years 1967, 1978-84 (pooled) and 1989 from these curves using methodology described by Grenfell and Anderson [4].

3.4. Main Outcome Measures

(a) Measles vaccination coverage rates for the years 1967, 1978-84 and 1989
(b) Rates of measles transmission in the population in the 1967, 1978-84 and 1989
(c) Force of infection in the years 1967, 1978-84 and 1989

4. Results

4.1. Vaccine Coverage Rates

Vaccine coverage rates were 0% in pre-vaccination era in 1967 and > 92% in 1989. In1978-84 vaccine coverage rates were 50-80% (median: 72, $Q_1 = 63$, $Q_3 = 77$)

4.2. Cumulative Age Distribution of Measles Cases: Rates of Measles Transmission

Figure 1 shows three curves which are cumulative proportions of measles cases by age for the years 1967, 1978-84 (pooled) and 1989. In this study each of the cumulative curves or plots indicates proportion of population who have experienced infection by each age group and rate of rise of this proportion is a measure of the magnitude of transmission in the population or community i.e. the steeper the profile the more rapid the spread of infection in the population.

These curves therefore give an indication of the speed at which infection consumed susceptibles in various age groups.

In 1967 and 1978-84 some 75% of all reported measles cases occurred by age group 36-47 months while in 1989 this occurred by age group 72-83 months, meaning that rapidity of measles transmission was steepest in 1967 and least steep in 1989.

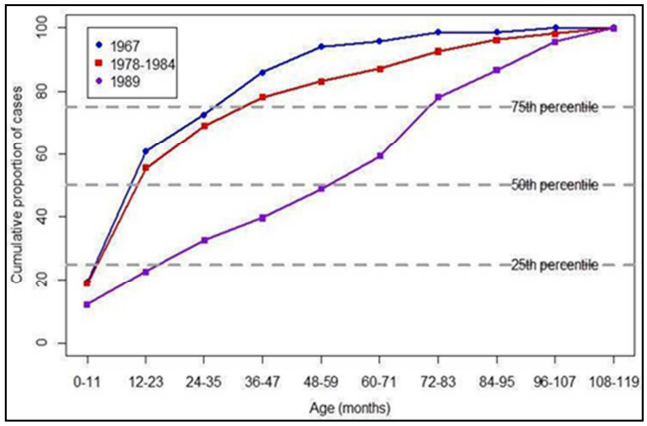

Figure 1. *Cumulative curves of reported measles cases for the years 1967, 1978-84 (pooled) and 1989.*

4.3. Force of Infection

Table 1 and figure 2 show age stratified rate of infection which is an indication of the likelihood of a susceptible being infected per unit time in each age group. Highest force of infection occurred in age group < 23 months in 1967. From age group 24-35 months susceptibility to infection by age declined up till age 60-71 months when force of infection petered off. In 1989 highest force of infection was in age group 60-83 months with a peak in age group 72-83 months.

In 1978-84 force of infection in age groups < 59 months was something of a mirror image of susceptibility experienced in 1967 but unlike in 1967 in age groups 60-119 months there was an increase in susceptibility to infection.

Table 1 shows variation in force of infection between the years 1967, 1978-84 and 1989. It also shows trends in force of infection between 1967 and 1989. Force of infection was not significantly different between the years for age groups 24-35, 36-47 and 48-59 months. Meanwhile, the force of infection varied between the years in the rest of the age groups, with a significant reduction in force of infection over the years for age groups < 11, and 12-23 months; and significant increases in force of infection were observed in the age groups 60-71, 72-83, 84-95, 96-107 and 108-119 months.

Table 1. *Variation in force of infection between the years 1967, 1978-84 (pooled) and 1989 and trends in force of infection in 1967-89.*

Age groups in months	Force of infection in years 1967, 1978-84 and 1989			Variation in force of infection between the years 1967, 1978-84 and 1989: $\chi 2$ (p-value)	Trends in force of infection between 1967 and 1989: χ^2 for trend (p-value)
	1967	78-84	1989		
< 11	0.19	0.18.	0.12	6.20 (0.045)	4.56 (0.033)
12-23	0.42	0.37	0.11	66.31 (< 0.001)	54.13 (< 0.001)
24-35	0.12	0.14	0.09	2.42 (0.298)	0.84 (0.360)
36-47	0.13	0.09	0.07	4.17 (0.124)	3.77 (0.052)
48-59	0.08	0.05	0.09	5.91 (0.052)	0.89 (0.346)
60-71	0.02	0.04	0.10	18.71 (< 0.001)	17.20 (< 0.001)
72-83	0.03	0.06	0.19	50.68 (< 0.001)	41.24 (< 0.001)
84-95	0.0	0.04	0.09	18.85 (< 0.001)	18.48 (< 0.001)
96-107	0.02	0.02	0.09	28.79 (< 0.001)	21.53 (< 0.001)
108-119	0.0	0.02	0.04	9.22 (0.010)	9.04 (0.003)

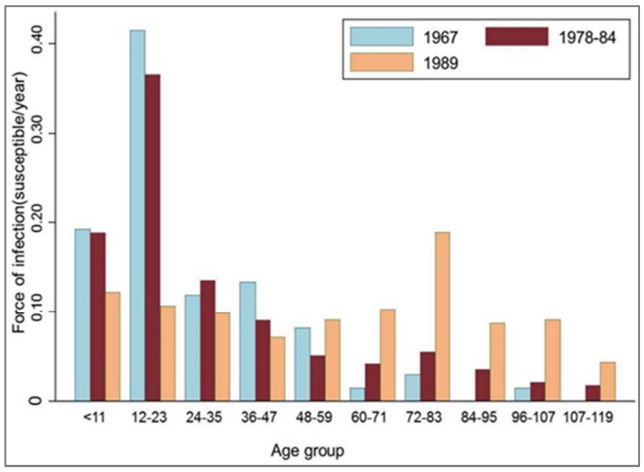

Figure 2. *Age stratified force of infection for the years 1967, 1978-84 (pooled) and 1989.*

5. Discussion

5.1. Rate of Transmission of Measles in the Population

This study found that rates of transmission of measles in the population were most rapid in the pre-vaccination era (and also at vaccine coverage rates of < 80%) particularly among the young aged < 48 months with a lot less transmission occurring among those > 48 months.

Studies from pre-vaccination era have shown that in densely populated communities in developing countries measles transmission was rapid and would consume mostly the underfives such that by the third birthday three quarters of a birth cohort would have been infected and very few underfives would escape measles in childhood [5]. This epidemiological picture is similar to what obtained in Gweru in the pre-vaccination era.

The current study found that rates of measles transmission in the population declined as vaccine coverage rates increased with lowest rates of transmission experienced at vaccine coverage rates of > 90%. At vaccine coverage rates of > 90% measles transmission in the Gweru would have been retarded by herd immunity [6-10] and this could have been particularly so after measles vaccine coverage threshold [6, 11-13] had been breached.

5.2. Force of Infection

This study found that force of infection was highest in children aged < 23 months (with a peak in 12-23 months) in pre-vaccination era and at vaccine coverage rates of < 80%. It was also found that in age group < 23 months force of infection significantly declined in 1967-89.

A high force of infection in children aged < 23 months found in the current study is in keeping with the observation that in developing countries in pre-vaccination era measles was predominantly a disease of the very young who would be susceptible to infection after loss of transplacentally acquired maternal antibodies [5]. Unlike findings of the current study, in developed countries such as USA and UK in the pre-vaccination era peak of force of infection was highest in children aged 5-9 years [5, 14].

Decline in force of infection in children aged < 23 months in 1967-89 observed in the current study would have been due to improved levels of immunity in this age group arising from continuous application of vaccine to successive 9 month old cohorts (from the time vaccination was commenced in 1971) and the high vaccine coverage rates of > 90% that had been attained among these cohorts by 1989.

The current study found that in 1989 highest force of infection was in children aged 60-119 months (with a peak in age group 72-83 months) and that the force of infection in this age group had significantly risen in 1967-89. A study that investigated susceptibility to measles infection in children aged 10-119 months in the city of Gweru in Zimbabwe in 1988 [15] had findings that were similar to those of the current study. That study [15] found that children in older age groups were more susceptible to infection than those in younger age groups and this was blamed on accumulation of vaccine failures (in these older age groups) arising from a vaccine of less than 100% efficacy. Shift of measles transmission from younger to older age groups that is associated with accumulation of vaccine failures among older age groups has occurred in some developing countries with high vaccine coverage rates of measles vaccine applied at 9 months of age [16-18]. A plausible explanation for the change in age at infection from younger to older age groups

would be that accumulation of vaccine failures led to an increase in force of infection. It is most likely that increase in force of infection in older age groups found in the current study in years 1978-84 and 1989 would have arisen from a similar experience.

6. Conclusion

Measles transmission rates in the community were highest in pre-vaccination era and least at vaccination coverage rates of > 90% most likely due to effect of herd immunity. From pre-vaccination era (1967) to vaccine coverage rates of > 90% (1989) there was a shift in force of infection from young age groups < 23 months to older age groups of 60-119 months most likely due to accumulation of susceptibles in these older age groups. Shift in force of infection to older age groups would have been responsible for the shift in age at infection to these older age groups.

Acknowledgements

We would especially like to thank city of Gweru Public Health Department staff who helped out with extraction of data from the surveillance records and carried out data entry.

References

[1] Moss WJ. Measles still has a devastating impact in unvaccinated populations. PLoS Med 2007; 4(1): e24.

[2] Andre FE, Booy R, Bock HL, Clemens J, Datta SK, John TJ, Lee W et al. Vaccination greatly reduces disease, disability, death and inequality worldwide. Bull WHO 2008; 86: 81-160.

[3] Goodson JL, Masresha BG, Wannemuehler K, Uzicanin A, Cochi S. Changing epidemiology of measles in Africa. J Infect Dis 2011; 204 Suppl 1: S205-14.

[4] Grenfell BT, Anderson RM. The estimation of age related rates of infection from case notifications and serological data. J Hyg Camb 1985; 95: 419-436 (methodology).

[5] Morley D. Severe Measles. In: Paediatric Priorities in the Developing World. Butterworts, 1979: 207-230.

[6] Willingham E, Helft L. What is Herd Immunity? www.pbs.org/wgbh/nova/body/herd-immunity.html [accessed 06 December 2015]

[7] Garnnet GP. Role of herd immunity in determining the effect of vaccines against sexually transmitted disease J Infect Dis, 2005; 191 (Suppl 1): S97-106.

[8] John TJ, Samuel R. Herd immunity and herd effect: new insights and definitions. E J Epidemiol, 2000; 16: 601-606.

[9] Anderson RM, May RM. Vaccination and herd immunity to infectious diseases. Nature, 1985; 318: 323-329.

[10] Anderson RM, May RM. Infectious diseases of humans: dynamics and control. Oxford: Oxford University Press; 1991.

[11] Fine P, Eames K, Heymann DL. "Herd Immunity": A rough guide. Clin Infect Dis, 2011; 52: 911-916.

[12] Fine PEM. Herd Immunity: History, Theory, Practice. Epidemiologic Reviews, 1993; 15: 265-302.

[13] Nokes DJ, Anderson RM. Measles, mumps and rubella vaccine: what coverage to block transmission? Lancet 1988; 2: 1374.

[14] Centers for Disease Control and Prevention. Measles In: Epidemiology and prevention of vaccine-preventable diseases, 13th Edition April 1995: 209-229.

[15] Marufu T, Murugasampillay S, Siziya S, Manyame B, Silape-Marufu Z, Xaba E et al. Is protection afforded vaccinees the same in children of all age groups? Cent Afr J Med 1995; 41: 144-7.

[16] Global Programme for Vaccines and Immunization. Immunization Policy. Expanded Programme on Immunization, WHO/EPI/GEN/92.3. WHO. Geneva: WHO; 1995.

[17] Coetzee N, Hussey GD, Visser G, Barron P, Keen A. The 1992 measles epidemic in Cape Town-a changing epidemiological pattern S Afr Med J 1994; 84(3): 145-9.

[18] Khuri-Bulos NA. Measles in Jordan: a prototype of the problems with measles in developing countries. Pediatr Infect Dis J 1995; 14(1): 22-6.