WEEKLY EPIDEMIOLOGICAL REPORT

A publication of the Epidemiology Unit
Ministry of Health

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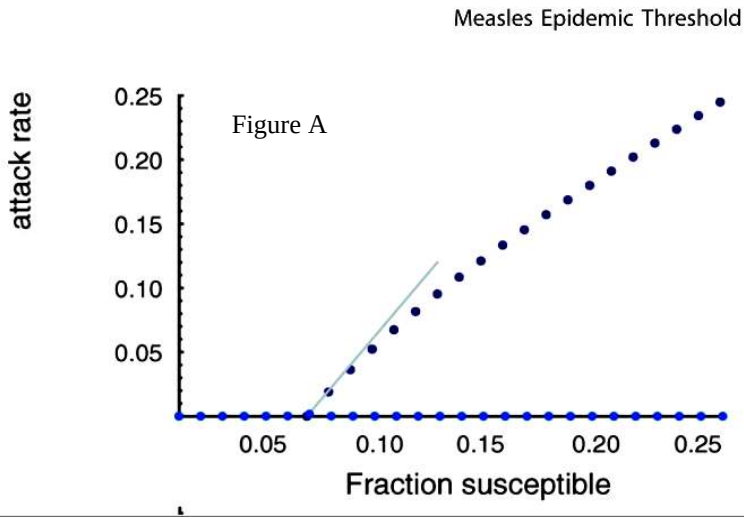
Measles Epidemic Threshold

Background

Measles is one of the most contagious diseases of humans and an important cause of childhood deaths. The global effort to reduce measles mortality aims to achieve a routine measles vaccination coverage of at least 90% in every district throughout the world. So far, this effort has resulted in a dramatic decline in deaths from measles. High vaccination coverages have changed the epidemic pattern from a roughly biennial cycle to an irregular sequence of outbreaks. A proper understanding of the size and timing of these outbreaks is a prerequisite for adequate monitoring of vaccination programmes and essential for assessing the risk of future measles outbreaks.

The size of an outbreak depends on both the fraction of susceptible individuals in the population and on chance events in the transmission process. The fraction of susceptible individuals determines the expected size of an outbreak. Existence of a critical threshold level was predicted as early as 1927 for the fraction of susceptible individuals, below which introduction of infection can only lead to minor outbreaks. This so-called threshold theorem underlies the concept of herd immunity and it explains why it is possible to eradicate an infectious agent even without achieving complete vaccine coverage. Variability in the size of outbreaks arises due to chance events in the transmission process. This variability becomes very large when the fraction of susceptible individuals is close to the epidemic threshold level. When the fraction of susceptible individuals exceeds the threshold level, chance events determine whether a minor or a major outbreak will occur. The probability that the outbreak will be a major one increases with the fraction of susceptible individuals in excess of the threshold. It was shown in 1927 that when the proportion of susceptible individuals is only slightly above the threshold level, almost two infections occur per susceptible individual in excess of the threshold level during a major outbreak; this so-called second threshold theorem has been useful in calculating expected outbreak sizes.

Figure A



Thus, the epidemic threshold for fraction of susceptible individuals marks a bifurcation in expected attack rates from only minor to both minor and major

Contents **Page**

outbreaks, where the attack rate during major outbreaks is almost twice the excess fraction of susceptible individuals (Figure A).

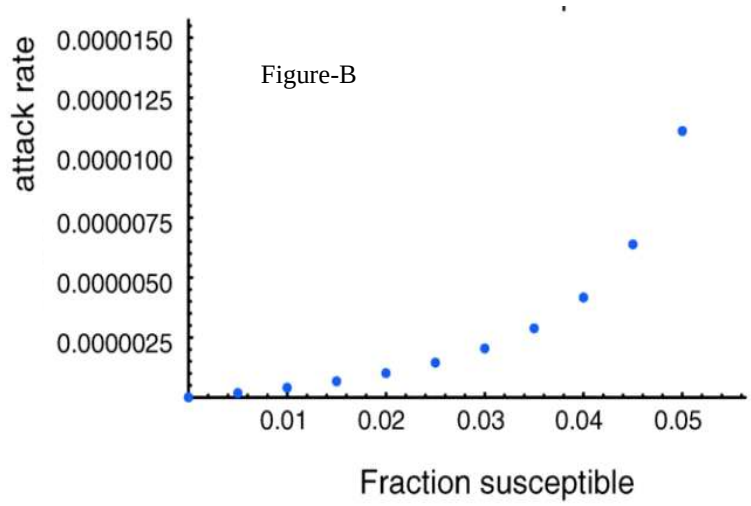


Figure-B

Most observational studies on outbreak sizes in highly vaccinated populations have relied on two assumptions: first, the fraction of susceptible individuals is uniform throughout the population, and, second, the fraction of susceptible individuals remains below the epidemic threshold. If these assumptions are met, the population is protected by solid herd immunity and no major outbreaks can occur. A simple one-to-one relationship exists between the observed attack rate and the fraction of susceptible individuals in the population (Figure B).

This one-to-one relationship makes it possible to derive several epidemic variables of interest from observed outbreak sizes. For example, countries and regions with elimination strategies for measles have been advised to monitor the average outbreak size as an indicator of ''elimination status'': smaller outbreaks are indicative of fewer susceptible individuals in a homogeneous population that is protected by solid herd immunity.

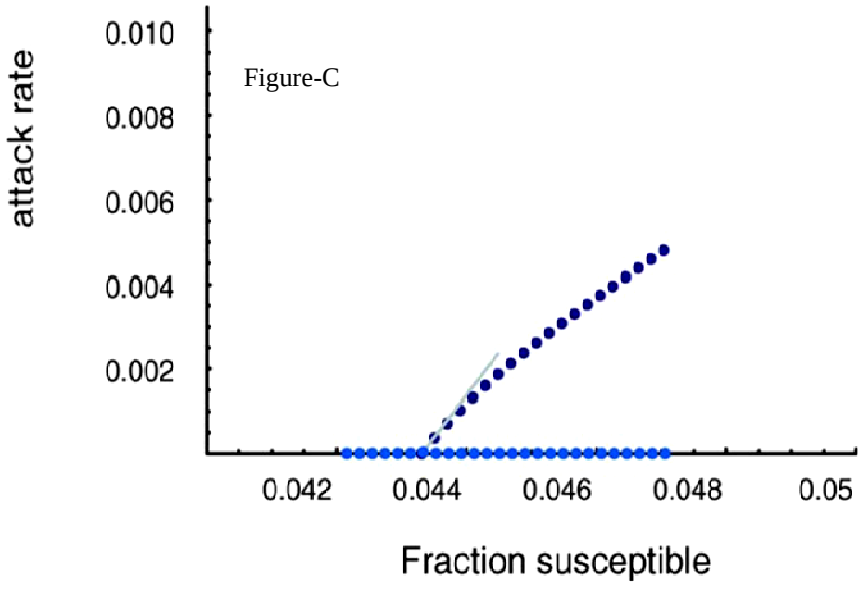


Figure-C

Many countries and regions have a heterogeneous distribution of the fraction of susceptible individuals. This heterogeneity can be due to communities that refrain from vaccination or due to different vaccination programmes (for example, failure to implement additional vaccinations). The threshold concept, although often illustrated for an idealized homogeneous population, also applies with a few minor modifications to a heterogeneous population. In a simple heterogeneous population, consisting of a community with many susceptible individuals embedded in a population with few susceptible individuals, one still recognises an epidemic threshold for the average fraction of susceptible individuals in the entire population. And when a major outbreak hits the community with many susceptible individuals, approximately two cases occur per susceptible individual in excess of this population average threshold (Figure C). As a consequence, there is no longer a simple one-to-one relationship between the observed attack rate and the fraction of susceptible individuals in the population.

There are no direct observations that show the precise nature of the relation between the fraction of susceptible individuals and attack rate during the irregular measles outbreaks that are characteristic for highly vaccinated populations. However, such observations could shed light on how one should interpret observed attack rates and how to assess the risk of future measles outbreaks once endemic transmission has been interrupted. To overcome this deficiency, the relation between the fraction of susceptible individuals and the attack rate for measles outbreaks over a 28-y period in the Dutch population has been analyzed. The analysis revealed a bifurcating relation with a clear threshold level for the fraction of susceptible individuals near 0.043 . Below the threshold level only minor outbreaks occurred. The attack rates during minor outbreaks tended to increase when the fraction of susceptible individuals was closer to the threshold level. Above this threshold level both minor and major outbreaks occurred.

Source-A Measles Epidemic Threshold in a Highly Vaccinated Population,

available from *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1255760/*

Compiled by Dr. Madhava Gunasekera of the Epidemiology Unit

Table 1: Vaccine-preventable Diseases & AFP

22nd – 29th March 2013 (13th Week)

Disease	No. of Cases by Province									Number of cases during current week in 2013	Number of cases during same week in 2012	Total number of cases to date in 2013	Total number of cases to date in 2012	Difference between the number of cases to date in 2013 & 2012
	W	C	S	N	E	NW	NC	U	Sab					
Acute Flaccid Paralysis	00	00	00	00	00	01	00	00	00	01	01	15	23	- 34.8 %
Diphtheria	00	00	00	00	00	00	00	00	00	-	-	-	-	-
Measles	08	05	01	01	00	03	00	00	01	19	01	144	17	+ 747.0 %
Tetanus	00	00	00	00	00	00	00	00	00	00	00	06	02	+ 200.0 %
Whooping Cough	00	00	00	00	00	00	00	00	00	00	00	18	24	- 25.0 %
Tuberculosis	40	00	18	21	16	01	00	00	00	96	139	2220	2257	+ 01.6 %

Table 2: Newly Introduced Notifiable Disease

22nd – 29th March 2013 (13th Week)

Disease	No. of Cases by Province									Number of cases during current week in 2013	Number of cases during same week in 2012	Total number of cases to date in 2013	Total number of cases to date in 2012	Difference between the number of cases to date in 2013 & 2012
	W	C	S	N	E	NW	NC	U	Sab					
Chickenpox	07	05	12	06	07	08	03	02	12	62	98	1119	1475	- 24.1 %
Meningitis	02 KL=2	01 ML=1	02 GL=1 HB=1	04 VU=1 JF=2 MU=1	00	01 KG=1	04 AP=3 PO=1	02 MO=1 BD=1	01 RP=1	17	07	250	183	+ 36.6 %
Mumps	00	03	02	08	02	06	02	00	06	29	96	414	1304	- 68.2 %
Leishmaniasis	00	00	05 MT=1	00	00	00	09 AP=8 PO=1	06 RP=6	00	20	04	315	195	+ 61.5 %

Key to Table 1 & 2

Provinces: **W**: Western, **C**: Central, **S**: Southern, **N**: North, **E**: East, **NC**: North Central, **NW**: North Western, **U**: Uva, **Sab**: Sabaragamuwa.

DPDHS Divisions: **CB**: Colombo, **GM**: Gampaha, **KL**: Kalutara, **KD**: Kandy, **ML**: Matale, **NE**: Nuwara Eliya, **GL**: Galle, **HB**: Hambantota, **MT**: Matara, **JF**: Jaffna, **KN**: Killinochchi, **MN**: Mannar, **VA**: Vavuniya, **MU**: Mullaitivu, **BT**: Batticaloa, **AM**: Ampara, **TR**: Trincomalee, **KM**: Kalmunai, **KR**: Kurunegala, **PU**: Puttalam, **AP**: Anuradhapura, **PO**: Polonnaruwa, **BD**: Badulla, **MO**: Moneragala, **RP**: Ratnapura, **KG**: Kegalle.

Data Sources:

Weekly Return of Communicable Diseases: Diphtheria, Measles, Tetanus, Whooping Cough, Chickenpox, Meningitis, Mumps.

Special Surveillance: Acute Flaccid Paralysis.

Leishmaniasis is notifiable only after the General Circular No: 02/102/2008 issued on 23 September 2008. .

Dengue Prevention and Control Health Messages

Check the roof gutters regularly for water collection where dengue mosquitoes could breed.

Table 4: Selected notifiable diseases reported by Medical Officers of Health

22nd – 29th March 2013 (13th Week)

DPDHS Division	Dengue Fever / DHF*		Dysentery		Encephalitis		Enteric Fever		Food Poisoning		Leptospirosis		Typhus Fever		Viral Hepatitis		Human Rabies		Returns Received
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	%
Colombo	77	2160	1	38	1	9	0	37	0	9	3	68	0	2	0	26	0	0	**77**
Gampaha	48	1020	4	29	0	7	0	13	5	6	9	91	0	6	4	72	0	0	**87**
Kalutara	19	456	2	42	0	8	0	24	0	7	9	134	0	1	0	5	0	0	**46**
Kandy	5	522	0	23	0	4	0	6	0	1	1	22	4	37	0	40	0	0	**74**
Matale	8	129	0	30	0	0	0	1	0	0	2	15	0	1	2	13	0	0	**69**
NuwaraEliya	5	70	1	22	0	2	0	2	0	2	0	8	2	22	0	1	0	0	**62**
Galle	8	193	1	26	0	7	0	1	0	4	8	52	0	15	0	4	0	0	**84**
Hambantota	2	105	1	16	0	2	0	5	0	9	5	94	0	25	2	52	0	0	**75**
Matara	11	181	1	18	0	7	0	4	0	4	5	64	1	27	2	73	0	1	**100**
Jaffna	20	251	1	53	0	3	15	144	0	5	0	0	20	209	0	6	0	0	**92**
Kilinochchi	3	17	0	10	0	0	1	5	0	1	0	4	0	8	0	0	0	0	**50**
Mannar	0	40	0	14	0	1	1	39	0	11	0	5	0	7	0	0	0	0	**60**
Vavuniya	2	30	2	19	1	9	0	4	0	4	3	20	0	1	0	0	0	0	**100**
Mullaitivu	3	32	0	2	0	1	0	3	1	1	2	9	0	2	0	0	0	0	**60**
Batticaloa	10	208	4	38	0	2	0	0	0	2	0	6	0	2	0	4	0	0	**57**
Ampara	6	47	0	33	0	0	0	1	0	0	0	5	0	0	0	1	0	0	**29**
Trincomalee	13	92	1	18	0	1	0	0	0	0	3	42	0	3	0	2	0	1	**75**
Kurunegala	27	1441	4	62	0	14	0	17	0	3	10	99	1	12	1	18	0	1	**81**
Puttalam	4	400	1	19	0	3	0	5	0	1	2	9	0	7	0	1	0	0	**67**
Anuradhapu	7	218	1	22	0	10	0	1	0	1	16	118	1	8	0	8	0	0	**53**
Polonnaruw	2	117	0	32	0	0	0	5	0	0	6	75	0	1	0	14	0	0	**57**
Badulla	2	130	1	36	0	0	0	4	1	1	0	11	3	19	0	12	0	0	**76**
Monaragala	2	77	1	28	0	3	0	6	0	17	2	59	0	18	3	26	0	0	**55**
Ratnapura	34	470	7	123	1	69	1	12	0	12	18	114	1	15	4	89	0	1	**83**
Kegalle	4	313	1	16	0	10	0	5	0	3	1	32	1	25	3	75	0	0	**73**
Kalmune	9	362	0	23	0	1	0	0	0	11	0	4	1	2	0	4	0	0	**46**
SRI LANKA	**331**	**9081**	**35**	**795**	**03**	**173**	**18**	**344**	**07**	**115**	**105**	**1160**	**35**	**475**	**21**	**546**	**00**	**04**	**71**

Source: Weekly Returns of Communicable Diseases WRCD).
***Dengue Fever / DHF** refers to Dengue Fever / Dengue Haemorrhagic Fever.
****Timely** refers to returns received on or before 29th March, 2013 Total number of reporting units 336. Number of reporting units data provided for the current week: 238
A = Cases reported during the current week. **B** = Cumulative cases for the year.

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Comments and contributions for publication in the WER Sri Lanka are welcome. However, the editor reserves the right to accept or reject items for publication. All correspondence should be mailed to The Editor, WER Sri Lanka, Epidemiological Unit, P.O. Box 1567, Colombo or sent by E-mail to **chepid@sltnet.lk.**

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