Interim report 2
Measles risk assessment, modelling and benefit–cost analysis

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1 Introduction

The well-known equation for the final size of an epidemic in a homogeneously mixing susceptible population is [13]

$$\log(1-\mathcal{P}) + \mathcal{R}_0\mathcal{P} = 0$$

where $\mathcal{R}_0$ is the basic reproduction number and $\mathcal{P}$ is the proportion of the population infected over the course of the outbreak. If a proportion x_0 of the population is susceptible following vaccination, then the reproduction number under vaccination is $\mathcal{R}_V = x_0\mathcal{R}_0$, and the final size equation becomes

$$\log\left(1-\frac{\mathcal{P}}{x_0}\right) + \mathcal{R}_0\mathcal{P} = 0$$

Hence the relationship between the proportion initially susceptible and the proportion infected in an epidemic is

$$x_0 = \frac{\mathcal{P}}{1-e^{-\mathcal{R}_0\mathcal{P}}}$$

In order to prevent future epidemics, it is necessary that $\mathcal{R}_V < 1$. Hence, the proportion of the population that must be vaccinated to prevent future outbreaks is $x_0 - 1/\mathcal{R}_0$.

These formulae were applied at a District Health Board (DHB) level, assuming no mixing between DHBs.

DHB	Size	Naïve	Attack	Vacc
Auckland	436350	52010	31159	17920
Bay of Plenty	206000	20679	8437	4585
Canterbury	482180	51357	24695	13687
Capital and Coast	283700	32625	18403	10461
Counties Manukau	469300	55544	32903	18880
Hawke's Bay	151700	15602	6846	3751
Hutt Valley	138380	15198	7836	4388
Lakes	98196	10558	5192	2886
MidCentral	162560	17328	8348	4628
Nelson Marlborough	137000	13059	4411	2356
Northland	151690	14921	5688	3071
South Canterbury	55620	5238	1678	893
Southern	297420	31607	15115	8371
Tairawhiti	43650	4769	2431	1359
Taranaki	109750	11473	5262	2899
Waikato	359310	39402	20248	11331
Wairarapa	41112	3932	1346	720
Waitemata	525550	58350	30774	17291
West Coast	32151	3197	1265	685
Whanganui	60120	6075	2530	1378
TOTAL	4241739	462924	234567	131539

Table 1: Size: DHB Population, Statistics NZ 2013; Naïve: DHB naïve population ($x_0 \times$ Size); Attack: Number infected in DHB in an outbreak of measles ($\mathcal{P}$); Vacc: Number to be vaccinated in DHB to reduce $\mathcal{R}_V$ below one ($(x_0 - 1/\mathcal{R}_0) \times$ Size).

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