BIRMINGHAM
FOOD COUNCIL

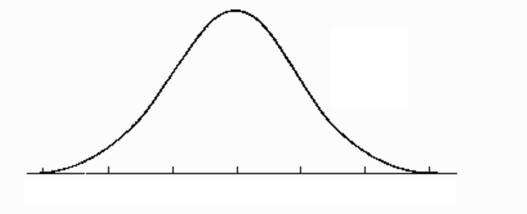
HOW EPIDEMICS HAPPEN

Epidemics: Agents, hosts, vectors/fomites & rates of infection

Epidemiology is the study of infections and disease in populations.

All epidemics at the population level have this same bell-curve pattern.

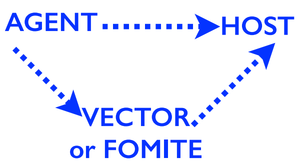
What we don't know is the scaling.



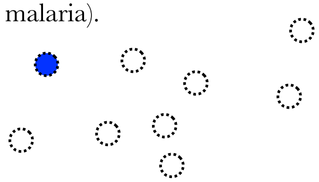
SCENARIO 1
An epidemic doesn't happen

In this scenario, an **agent** (e.g. measles, Covid-19) infects a **host** (e.g. you or me) who then recovers or dies.

If R is the rate of infection, and R=<1 (i.e. less than one), there is no chance of an epidemic.



An **agent** can infect a **host** directly, *or* indirectly through an inanimate **fomite** (e.g. virus-laden droplets on surfaces, as with a cold, measles or Covid-19) or an animate **vector** (e.g. *Anopheles* mosquito as with malaria).

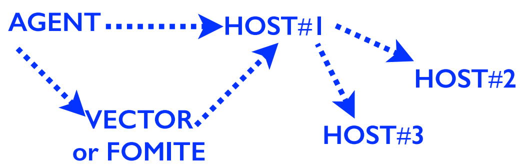


If R = <1 (less than one)
no other host is infected
before the host either recovers or dies.

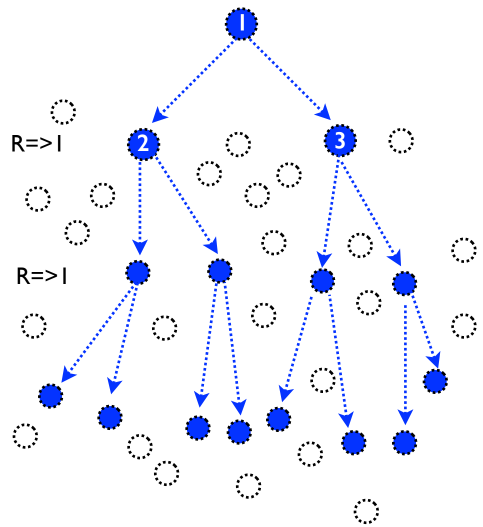
SCENARIO 2
An epidemic happens

In this scenario, an **agent** (e.g. measles, Covid-19) infects *and* before recovery or death, infects one or more other hosts.

If R is R=>1 (i.e. more than one), there's a chance of an epidemic.



Host carriers can be *true* (i.e. infected, but not diseased), *incubatory* or convalescent.



The four factors for disease epidemics: i.e. when R=>1

The factors for Scenario 2 are fourfold and a change in any one of them changes the outcome:

1: Probability of transmission: dependent upon **infectivity** (how quickly it goes from host to host), **virulence** (the severity of the agent's effects on the host) and **pathogenicity** (the ability of the agent to cause damage to the host). Virulence & pathogenicity are sometimes used interchangeably.

2: Duration of infectivity: e.g. For measles, it's 4 days before the symptoms begin and about four days after the rash first appears. It's less than 7 days for Covid-19.

3: Contact rates: Who comes into contact with the agent.

4: Susceptibility: Determinants can be changed through the *physical environment* (e.g temperature, nutrients, toxins), *interventions* (e.g. vaccines, animal dips, movement controls, quarantines) or other *biological* conditions (e.g immuno-suppression, or being in utero).

Susceptibility is the fuel upon which epidemics run. But it gets even more complicated than this.

A host's susceptibility depends on all the factors above *and* upon whether the agent is, itself, changing. If it stays the same, the epidemic follows what's known as **the SIR-model**; if the agent changes, it follows **the SIS-model.**

We don't know for certain if Covid-19 follows the SIR or the SIS model, nor if recovered hosts are immune and, if they are, whether partially or wholly, nor for how long.

The SIR-model
e.g. measles, mumps, rubella

S	I	R
Susceptible	Infective	Removal

Removal is through death or natural immunity or cross-immunity effects or vaccination.

The SIS-model
e.g. influenza, HIV

S	I	S
Susceptible	Infective	Susceptible

Hosts become re-susceptible after recovery from a first infection because of antigenetic change in the agent, either *drift* (to which the host has partial immunity), or *shift* (so the host has no immunity).

In both SIR and SIS models, new susceptibles arrive through births, loss of immunity or immigration.