**Estimating the final number of cases and deaths in the UK**

Many methods of estimating the true number of cases have had to make assumptions: what follows is mostly based on simple arithmetic.

**Estimating Number of Cases**

On 2 April BBC News Scotland reported that of a total of NHS Scotland staff of 166,000, as of 1 April, 14% were recorded as off sick and 9,719 were recorded absent from work for corona virus related reasons, i.e. about 5.9%, say 6%.

An ONS infection study shows that COVID-19 patient-facing front line staff are 6 times more likely than everyone else to be infected; and a Cambridge University study says there are out of the 1.5 million NHS staff, one third (half a million) who are COVID-19patent facing. To estimate the infection rate (x) of the non-COVID-19-19-patient facing staff, we calculate as follows 1/3 * 6x + 2/3 * x =6% (the percentage off sick).

Some of them will be declared off sick because co-habitees are sick, etc., so the probability that the NHS worker has COVID-19 is less than 6%. To calculate this, we have to take into account household size. The distribution of household size in Scotland is approximately one third in each of single person households, two-person households and three-person plus households. In a study by Cambridge University Institute of Therapeutic Immunology and Infectious Disease (Rivett et al 2020) it is stated that half a million NHS UK staff are patient-facing (PF) hence making up 1/3 of the total NHS staff (1 1/2 million). In the ONS COVID-19 Infection Survey pilot 14 May it was estimated that 6 times as many PF healthcare workers or resident facing social care workers are infected than all other people. Given that the PF workers are six times more likely to be sick than other NHS staff a weighted average for all NHS staff is (1/3 x 6 +2/3 x 1) = 2 2/3. Therefore, those that are sick are 2 2/3 times more likely than other NHS staff (and housemates) to go off sick because they have CV. Clearly if the NHS worker is on his/her own they have CV, if they are in a two person household they have a probability of 2 2/3 divided by 3 2/3 = 8/11 of having CV and three person plus household they have a probability slightly less than 2 2/3 divided by 4 2/3 = 8/14. A weighted average of these three probabilities is (slightly less than) 0.73. Therefore, the equivalent percent of all other 18-64 year olds in the population - apart from the PF staff - that are actually sick = (0.73 x 6)/(2 2/3) = =1.65%.

Those NHS workers who have CV self-isolate for 7 days; those without CV but are returning to a household with a CV case self-isolate 14 days. Using a similar calculation as in previous paragraph, we estimate an average self-isolation time of 9 days. The daily rate of new symptomatic cases per day among these 'off-sick' health workers is therefore 1.65%/9=0.183% per day.

There is an average of five days between the symptoms appearing and hospitalisation, we must average the confirmed hospital cases for 6 April and the six days before; on that basis there are about an average of 320 new population cases of all-age per day in hospital in Scotland at beginning of April of which 50% are 18-64 = 160 (*publichealthmatters.blog*).

In Scotland the population is 5.4 million, and the proportion 18-64 is 60% so there are 3.12 million 18-64 year olds in Scotland (National Records of Scotland, 2018); the 18-64 hospitalised case rate is therefore 160/3.12 = 0.0051% per day.

In order to obtain an estimate of the factor by which actual symptomatic 18-64 year olds in

the population are related to 18-64 year old NHS workers, we divide 0.183/0.0051 = 35.9.

So the daily symptomatic case rate in the whole Scottish population is 35.9 times the symptomatic cases in hospitals per day. We assume this applies to the whole of the UK.

At the time of calculation (11th May), there were 220,000 confirmed cases including those hospital confirmed cases (i.e., excluding non-patients) in the UK, of which 60% are 18-64, so the cases in the whole 18-64 UK population would be 35.9*102,000 = 3.66 million.

Two million have been identified as extremely vulnerable and sent a letter asking them to self-isolate. There are near zero cases among the under 18s; 19% of the populations (c.12.8 million) are over 64 including 9.3 million over 70; those vulnerable (i.e. with an underlying health condition) and those over 70 have been asked to stay at home and to be particularly strict in following the general instructions (food shopping, medical visits, hand washing, outdoor exercise only with household members once a day). We have guesstimated that the additional cases among those over 64 would only be half the rate of 18-64 year olds because they are either self-isolating or following the Stay at Home strictly; given that 19% of the population are over 64 (i.e. 32% of 18-64 year olds), we add on half that 32%, i.e. 1/6th of 3.66 or 0.61 million cases, so a total 4.27 million cases[1], very similar to the figure estimated from the antibody test surveys.

**Estimating final total number of deaths (including care homes and in the community)**

We base an estimate on the fatality of NHS staff and the relation between mostly hospital confirmed cases and mostly hospital-based deaths in the UK.

[1] A Government Briefing about 8th May reported that 10% had antibodies in London and 4% elsewhere which is approximately 3.35 million. These would have been infected some weeks earlier, so we have guesstimated that their figure at the time of writing would be over 4 million.

According to PA Agency, by 9th May, 155 NHS staff of all stripes had died of CV19. https://uk.news.yahoo.com/nhs-care-workers-died-during-154932221.html. Given that the NHS employs c.1.5 million people in the UK, the NHS population fatality rate was therefore about 0.01% or 100 per million, at the time, compared at the time to an all-age whole population death rate of 470 per million, which we are assured is now a complete picture including deaths in care homes and in the community. If we then assume that the numbers will probably increase by a further 50%/100% by the end of this wave, then the total NHS fatality would be 0.015%/0.02%, or about 150/200 per million (making 225/300 dead in the NHS); and the population death rates about 700 per million (0.07%) and 935 per million (0.0935), or about 47,000/62,200 deaths.

Alternatively, as *More or Less* of 23rd April says that the death rate among all 18-64 year olds is similar to the NHS rate: those in the NHS are mostly in the working age bracket 18-64 year olds. According to *world-o-meter* that age group constitutes about 25% of all COVID-19deaths, so one should estimate total population death rate at about 0.06/ 0.08% (almost identical to the previous figure).