National Science and Technology Forum
S.E.T. for socio-economic growth

Message from the NSTF Executive Director

Communicating and modelling the spread of the Wuhan virus

In our global village, we know instantly when there is a contagious plague 12 000 km away, on the other side of the planet, and so it was and is with the Novel Coronavirus (2019-nCoV). We are able to follow it blow by blow across the planet from wherever we are. The origin of the virus is 'just around the corner' so-to-speak, and can be reached within a mere 24 hours. The natural response is fear and panic. People then get confused about the facts or accept wild rumours on social media as true. 'Cures' get 'invented' by very innovative people without the scientific understanding (or sense of responsibility), and others present a ready market for these 'cures'. The World Health Organization (WHO) calls the overload of information about the virus an *infodemic*. There is so much information that people do not know what to believe, and cannot hear the most important messages among the various noisy bits of info clamouring for attention.

Science communication

Communication during epidemics is of utmost importance. Although all the communication does not have to be done by scientists, it is very important that scientists have an input into the messages that are disseminated widely. The context of the spread of nCoV is a good example where science communication can make all the difference.

The key challenges of science communication are (in my opinion):

- Explaining complex scientific knowledge in understandable terms
- Communicating about uncertainty and risk in a manner that does not cause misunderstanding
- Debunking preconceptions and commonly held misconceptions

It is crucial to communicate in the time of virulent viruses

Already, myths, rumours and misinformation are doing the rounds in South Africa, according to Africa Check (radio talk on 3 February, SAFM). One of these is that if you drink bleach, you will not get the virus. Another is that a vaccine has been developed in Nigeria. How do we counter the spread of 'fake news' among the broader public? Radio talks are obviously a very good way to do so. But social media are notorious for spreading misinformation like wildfire. Prof George Claassen (Distinguished Professor in Science Communication and Media Ethics: Stellenbosch University) says scientists must participate on social media to respond to misleading posts and provide scientific information to counter the non-scientific. (He presented his advice at the NSTF discussion forum, 'Implications of the US President's actions and policies for science and scientists').

The WHO posted on its website (2 February): "Due to the high demand for timely and trustworthy information about 2019-nCoV, WHO technical risk communication and social media teams have been working closely to track and respond to myths and rumours." The WHO also publishes daily Situation Reports to update people across the world about the spread of the virus.

The WHO has guidelines for managing the public's reactions to an emerging epidemic, called *Risk communication and community engagement (RCCE)* readiness and response. These guidelines are meant for governments to prepare communication strategies for their countries for a possible outbreak of the disease, and then roll out a public communication plan very quickly when the epidemic appears and spreads. It advises to continue regular communication with the population, to counter fear, give instructions and provide information.

"One of the major lessons learned during public health events of the 21st Century – including outbreaks of severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), influenza A (H1N1) and Ebola – is that RCCE is integral to the success of responses to health emergencies." (WHO)

"Challenges such as communicating uncertainty and risk while addressing public concern can lead to a range of outcomes, including a loss of trust and reputation, economic impacts, and – in the worst case – a loss of lives." (WHO)

Among the many points on the WHO's checklist for RCCE, are the following:

- RCCE is essential for surveillance, case reporting, contact tracing, caring for the sick, delivering clinical care and gathering local support for any logistic and operational needs for the response.
- Effective RCCE can minimize social disruption. Therefore, in addition to protecting health, it can protect jobs, tourism and the economy.

Basic information and resources are readily available on the WHO website.

The Situation Report on 4 February said that there has been communication with representatives of over 50 multinationals where the WHO provided an update of the 2019-nCoV situation. WHO also gave advice about "improving communications with employees; the role of businesses in public health crises; and managing uncertainty through accessing accurate information".

Some questions for South Africa

It is wonderful that the WHO provides us with reliable information that can be accessed by anyone with internet access. However -

- **How do we get people to consult the WHO website for information** BEFORE reading and sharing social media postings? Just because the search engine and Twitter are on the same smartphone, does not mean people will go to the search engine first. It is an issue of raising awareness and this should be done in South Africa by South Africans.
- **How do we get the correct and crucial information to people without access to the internet?** We need multiple ways of communicating to increase the likelihood of the correct messages getting through.
- **How do we prevent situations like with the Ebola plague in West Africa?** Local people became totally distrustful of the doctors and foreigners who were trying to help, preferring instead to maintain their traditional ways of mourning and honouring the dead. A lack of trust can have dire consequences. If Johannesburg had to be placed under quarantine, e.g., how would people react? Our government's credibility with its people is tenuous at the best of times. Would people obey its inconvenient instructions?
- **How should traditional healers be involved?** Ideally, they should play a key role in identifying cases of flu symptoms and referring the patients for testing for the virus. Is it possible to enlist their help and empower them to do part of the testing? Traditional healers need to know enough to protect themselves from infection from their clients, but would they be willing to wear surgical masks and sterilise their hands?
- **The WHO posters seem clear and informative, but they must be translated into South Africa's languages.** Is the Department of Health, or provincial authorities doing so? Who will explain to people what the posters are saying, when many people are still illiterate and the school children learn to read too late?
- **People in all government structures will have to understand the situation and the importance of communicating accurately** and in a manner that does not cause panic, as the WHO document says: "in a rapid, transparent and accessible manner". This requires preparation. "Agree on procedures to ensure the timely release of information, such as

clearance procedures for messages and information products: keep clearance chains short." Spokespeople will have to be trained at all levels.

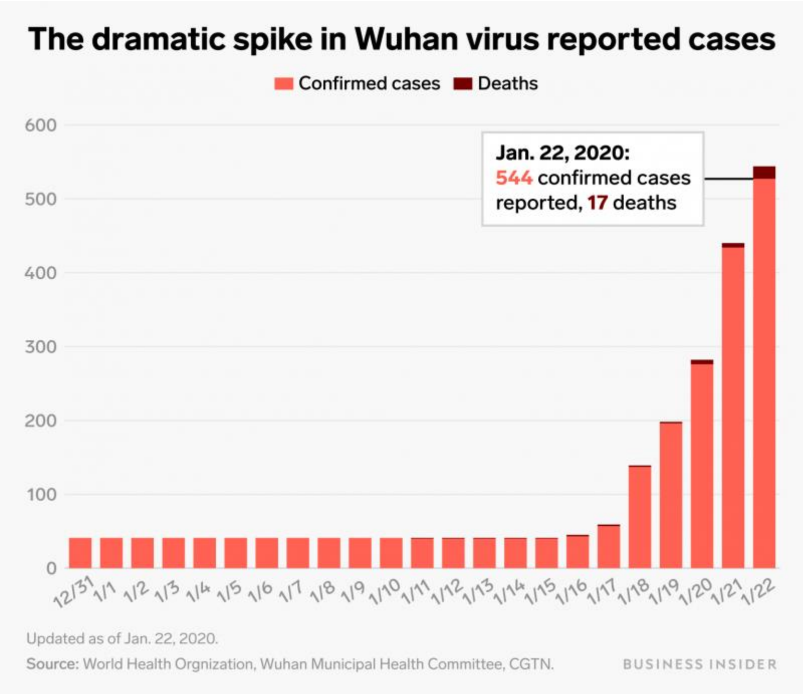
- **Will all health workers be thoroughly briefed or trained?** As the WHO says, "it is critical that health professionals are aware of public concerns and trained to provide public health advice to people". For doctors and other well-trained professionals this should not be a problem, but the 'front of house' staff, nurses and assistants at hospitals and clinics also have to be aware of the importance of accurate and sympathetic communication. Especially because the symptoms of a coronavirus infection are the same as those of the common cold. Are the various Provincial Departments of Health ready to train clinic staff?

Communication with numbers and graphs

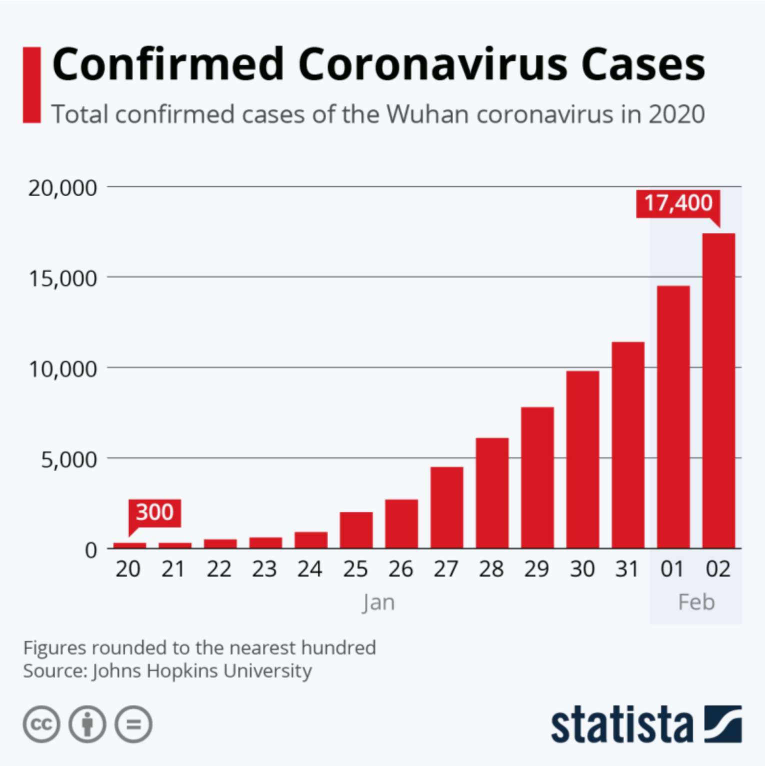
The wonderful thing about graphs and other forms of descriptive statistics is that they give a visual form to the numbers, revealing quantities in relation to one another. It is an ideal form of communication about an epidemic, provided that it is clear and accurate. Graphs and infographics on the 2019-nCoV have been proliferating on the internet, not always with a source or even an author mentioned.

Here are a few examples of graphs that seem of reliable origin:

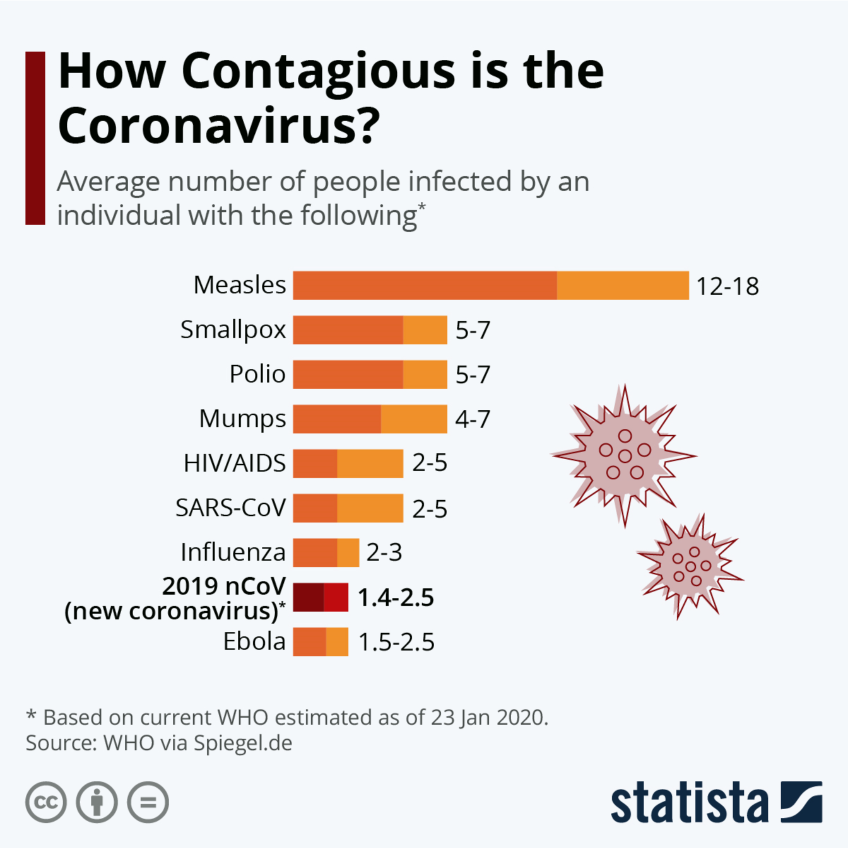
WHO Wuhan Municipal Health Committee (Business Insider, Germany)



[John Hopkins University](#):



[WHO via Der Spiegel](#):



The last graph above is interesting in that it shows just how contagious the top four diseases are that are currently included in vaccination programmes. This graph should convince parents to have their children vaccinated!

Science communication and school education

For the somewhat better-informed public that rely on various media including online news, it might sometimes be a challenge to understand the technicalities of what is happening, beyond knowing what to do in case of emergency. An article in The Atlantic reflects on the commonly used 'indicator' of the risk of coronavirus infection: R_0, which has been referred to in the American media. This is a variable commonly used to indicate how transferable an infectious disease is. R_0 is "the average number of people that a single infectious person will infect over the course of their infection." If $R_0 > 1$, then each person on average infects more than one other person. Then the disease will spread exponentially. The bigger the value of R_0, the faster the disease is supposed to spread. If $R_0 < 1$, then each person infects less than one person on average, so the disease will die out. And if $R_0 = 1$, then the disease will move throughout the population in a linear way.

The important detail to note, is that R_0 is an average. If R_0 is 3, it does not mean literally that each infected person will infect exactly three other people. There could be only one infected person that infects many others, while the other infected people only infect one or fewer others. The Wuhan virus has proved to spread relatively slowly. The cases outside of China have not (yet) generally infected others. Thus, even if its R_0 value causes concern at e.g. $R_0 = 3$, one should look at the bigger picture to understand that if one infected person arrives on South African soil, he/she might not infect anyone else.

Communicating about such 'indicators' or statistics is a bigger challenge than communicating to the public to reassure them or give instructions. The scientific way is to handle degrees of certainty, estimates, and a range of possible outcomes to understand a situation. The public has difficulty believing scientists if they do not pronounce certainties. In fact, mathematical modelling is poorly understood by the public in most countries, so that only communicating about an isolated variable can be completely misleading.

Mathematical modelling

Mathematical modelling is ubiquitous but often invisible. E.g., all graphs are mathematical models. Their usefulness lies in schematising real situations so that real solutions to problems can be found mathematically.

I had the privilege recently of listening to international and local experts on mathematical modelling in school education at a closed workshop held at Stellenbosch University. Mathematical modelling is key to making mathematics as a school subject meaningful, promoting understanding of mathematical concepts, and for developing the skills of applying maths to analyse the world around us. Thus modelling an epidemic can teach children about the epidemic itself, as well as certain forms of graph which describe trends. This is content with high relevance and the maths is included in the school curriculum. There is a convincing argument to be made that mathematical modelling should be a compulsory part of the school curriculum.

Modelling of infectious diseases

Wikipedia explains that mathematical modelling of the spread of disease dates back to 1766. Daniel Bernoulli was a physician who created a mathematical model to argue for inoculation (vaccination) against smallpox. He demonstrated with this model that universal inoculation against smallpox would increase life expectancy (at the time) from 26 years 7 months to 29 years 9 months.

"Models are only as good as the assumptions on which they are based". Assumptions always have to be made when models are used, as modelling is a simplification (a schematisation) of a real and complex situation.

When modelling the spread of an infectious disease, it is useful and common practice to assume:

- "Rectangular and stationary age distribution, i.e. everybody in the population lives to age *L* and then dies, and for each age (up to *L*) there is the same number of people in the population."
- "Homogeneous mixing of the population, i.e. individuals of the population under scrutiny assort and make contact at random and do not mix mostly in a smaller subgroup." Although this is an unrealistic (or unjustified) assumption, "homogeneous mixing is a standard assumption to make the mathematics tractable [possible]".

The spread of the coronavirus may be modelled in the following way. The whole population is assigned to compartments representing stages of the epidemic: the *susceptible* population, the *infected* population (that can infect the susceptible population), and the *'removed'* population ('removed' as in no longer infected - those that have died, or recovered). These compartments or variables are then related to each other by a mathematical formula. Another important variable is *time*. In this manner an epidemic is regarded as the movement of population numbers from being susceptible to being infected and then to being cured or having succumbed to death, over a period of time.

The model is called the 'SIR' model because of the variables it uses: S(t) being the susceptible part of the population at a particular time, I(t) being the infected part of the population at that time, and R(t) being the recovered or removed part of the population at that time. During an epidemic, there is a movement from S(t) to I(t) and then to R(t).

The total population is represented by the variable N and is a combination of the three compartments: **N = S(t) + I(t) + R(t).**

W. O. Kermack and A. G. McKendrick created this 'SIR' model in 1927. Because time is included as a variable, differential equations can be used. Kermack and McKendrick formulated such equations which allow one to understand and estimate these changes over time. "These processes which occur simultaneously are referred to as the Law of Mass Action, a widely accepted idea that the rate of contact between two groups in a population is proportional to the size of each of the groups concerned." There are many variations on the SIR model that take more variables and circumstances into account.

The mathematical models speak eloquently, and without words, and are universally understood by mathematicians. They have proved very useful in understanding epidemics and making predictions about their outcomes. The problem comes when explaining to the general public 'how we know' what will happen and what won't. Mathematics remains mysterious to most people. It would be very helpful if more children in South Africa learned mathematics!

Conclusion

We as humans have created the conditions for new viruses to be transmitted from animals to humans, and to spread fast among people in high density conditions in cities. Epidemics are an inevitable consequence of progress and we can expect an increase in the occurrence of epidemics in future. Being prepared is critical. Part of all countries' readiness is *risk communication and community engagement* (RCCE) as advised by the WHO.

Communication is key. Reliable information is of the utmost importance in managing an epidemic. The WHO website is a reliable and central source. People at all levels and in most positions must be trained and kept informed. We all should try to counter misinformation, especially as scientists.

South Africa's preparations should take into account the circumstances of our population – low density rural areas, high density urban areas, levels of education and literacy, and the vehicles available to spread reliable information to the whole population.

Communication includes visual forms of communication and models. These make numbers and trends more obvious. Statistics, indicators and mathematical models tend to be harder to understand by the general public than words and pictures. Yet, these are useful for descriptions, analysis and predictions by scientists to analyse and discuss a complicated or complex situation. Care should be taken when communicating numbers, variables and trends to the public as they could lead to misunderstandings. However, studying these tools at school level should prepare learners better to have a grasp on the concepts and applications.

The opinions expressed above are those of the Executive Director, Jansie Niehaus, and do not necessarily reflect the views of the Executive Committee or members of the NSTF.