

Statistical Considerations when Communicating Health Risks: Experiences from Canada, Chile, Ecuador and England Facing COVID-19

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ABSTRACT

Communicating statistics in health risk communication is a fundamental part of managing public health emergencies. Effective communication requires careful planning and the anticipation of possible information demands from the population. The information should be clear, relevant, easy to understand, timely, accurate and precise, allowing the public to make

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informed decisions about protective behaviours. COVID-19, being a new disease, with little known about its characteristics and effects, has challenged governments and healthcare systems in all countries. This article discusses the statistical issues involved, and the experiences of risk communication in four countries – Canada, Chile, Ecuador and England. These countries have communicated risks differently, partly because of their different healthcare systems, as well as socioeconomic, cultural and political realities. During a pandemic, health authorities and governments must step up to the challenge of communicating statistical information under pressure and with urgency, when little is known about the disease, the situation is dynamic and evolving, and the general public is gripped with fear and anxiety. This is in addition to the existing challenges relating to the generation of data of different quality by diverse sources, and a public with varying levels of statistical literacy. From a statistical perspective, communiqués about risks and numbers should convey the uncertainty there is about the information, the inherent variabilities in the system, the precision and accuracy of estimates and the assumptions behind projections. Complex technical concepts, such as ‘flattening the curve’, ‘range in risk estimates’ and ‘projected trends,’ should be explained.

Keywords: Risk Assessment; Health Indicators; Probability; Uncertainty; Statistical Literacy; Flattening the Curve; Lockdown; Coronavirus; SARS-CoV2; COVID-19; Pandemics; Vital Statistics

INTRODUCTION

On 11 March 2020 the World Health Organization (WHO) announced that COVID-19, the disease caused by the SARS-CoV2 virus, could be characterised as a pandemic (World Health Organization, 2020a). As of 16 November 2020, the coronavirus has infected over 54 million people and over 1.3 million people have died worldwide (World Health Organization, 2020b). The sudden emergence of the virus and its unique characteristics, including the fact that initially nothing was known about its infectivity, transmission mode, pathogenesis or virulence, made responses challenging. Each country’s response to the pandemic has been guided by its own public health experts, who have had to operate, make and recommend decisions, as well as communicate risks under extremely uncertain circumstances and strong sociopolitical and economic pressures.

Health risk communication is essential in public health emergencies. Its purpose is to exchange key information, advice and opinions between different parties, including experts, governments, the media, scientists, professional organisations and individual citizens who are at risk (World Health Organization, 2017). When it is well conducted, it enables better understanding and informs risk management decisions (Ahl et al., 1993). It gives people the opportunity to know the risks they face

and which decisions to make to protect themselves and their loved ones. Health risk communication is a big challenge, especially when it is essential for protecting public health.

Assessing the risk of a particular behaviour or situation and making decisions regarding risk are part of everyday life. However, most risks are not known. The probability of certain outcomes in a game of chance can be estimated ('educated guess') from theoretical assumptions or from repeatedly engaging in the game, that is, the 'frequentist' approach. Thus, the probability of rolling snake eyes with two six-sided standard fair dice is $1/36$. However, the probability (risk) of the occurrence of health outcomes, like getting a particular disease, be it cancer, diabetes or an infectious disease, is hardly known. These probabilities are estimated based on careful analyses in research studies and by using statistical models that account for some of the uncertainties. Nonetheless, even when a risk is 'known' or 'estimated with uncertainty', there are some challenges regarding informing the public of statistical aspects of a disease. These challenges are associated with different uncertainties of the biological and statistical processes, including ignorance of new phenomena. Another challenge is related to the poor performance of communicators when communicating risks and statistical aspects of a specific situation. Finally, the public might experience difficulty in understanding and processing statistical information due to low statistical literacy. For example, Naik and collaborators discuss the various challenges, including the general fear of numbers, lack of understanding of health statistics, lack of statistical literacy, unrepresentative information, poor quality and imprecise data, misrepresented information and a lack of consensus about the most appropriate methods for communicating health risks, that healthcare providers face in communicating statistical aspects of risk to patients (Naik et al., 2012).

During a public health emergency such as a pandemic, risk communication is even more challenging and relevant. Skovdal and collaborators explore the specific complexities involved in communicating risks surrounding COVID-19, stating that "individuals' understanding of their own risk of infection and death from COVID-19 is crucial for adopting new behaviours that are tailored for their own risk" (Skovdal et al., p. 284, 2020). Therefore, public health experts need to communicate effectively, clearly and accurately, bearing in mind the target audience and their perceptions, beliefs, concerns, knowledge and capacity to make informed decisions. It is essential that information be communicated using sound statistical and methodological considerations, such as the potential for bias from sampling, ascertainment and measurement, as well as uncertainties concerning inherent variability in humans' susceptibility and response to the disease and to interventions, and the uncertainties concerning the evolving dynamic nature of the pandemic. This 'uncertainty' is foundational in the field of statistics, which is also known as the science of uncertainty.

This manuscript analyses the early experiences from Canada, Chile, Ecuador and England with respect to the statistical components of risk communication during the COVID-19 pandemic. The purpose is not to judge the performance of the countries but to analyse how the statistical aspects of communication may enhance how risks are quantitatively presented to the public.

METHODS

DATA AND SOURCES

Two countries from the Global North (England and Canada) and two from the Global South (Chile and Ecuador) were analysed, given the availability and ease of access to data from those countries. For each country, we analysed general contextual information and risk communication strategies regarding COVID-19 from February 2020 up to August 2020.

Contextual data were extracted from official government websites. Similarly, we selected official COVID-19 and population statistics reported by public institutions in every country/region. For Chile, we obtained data from the Ministry of Science (Ministerio de Ciencia, Tecnología, Conocimiento, e Innovación, 2020) and the National Institute of Statistics (Instituto Nacional de Estadísticas, 2020). For Ecuador, we obtained data from the National Service of Risk and Emergencies Management (Servicio Nacional de Gestión de Riesgos y Emergencias del Ecuador, 2020b). For England, we obtained data from Public Health England (2020) and for Canada, we obtained data from public websites of the Provincial Government of Ontario (Statistics Canada, 2020) and the City of Hamilton (Hamilton, 2020). Information regarding the content of risk communication was also obtained from national official websites and reports.

Additionally, we studied information on community mobility as a proxy of the populations' general response to risk communication and restriction measures. The information on community mobility was obtained from Google's COVID-19 community mobility reports, which show cell phone movement in response to COVID-19 policies. These reports present percentage of change of daily visitor numbers to specific locations relative to a baseline day before the outbreak of the pandemic. More details are published elsewhere (Google, 2020). Particularly, we analysed mobility for retail and recreation, as well as residential mobility, from February 2020 onwards.

DATA ANALYSIS

We analysed and presented qualitative data from each country regarding statistical considerations when communicating risk. Complementary quantitative data were analysed, and different plots were obtained to show trends in new daily cases of COVID-19 per million inhabitants and percentage of change in mobility for retail and recreation and in residential mobility, along with a fitted LOESS curve with a span of 0.3. Also, different restriction measures were highlighted in each country. R software, version 3.6.2, was used to analyse data and the R package, ggplot2, was used to obtain plots.

RESULTS

HAMILTON, ONTARIO, CANADA

The first COVID-19 case in Hamilton was reported on 11 March 2020. Hamilton responded to the pandemic in conjunction with national and provincial health system partners and the Ministry of Health, adhering to directives and guidelines of the government. The province of Ontario (population 14.6 million) declared a state of emergency on 17 March and established a lockdown in terms of which only ‘essential services’, such as grocery stores, pharmacies, hospitals and ‘first responders’, could function. Ontario also developed an economic response of CAD\$17 billion to ensure the healthcare system, communities and the economy would weather the pandemic.

The Chief Public Health Officer of Canada and the Provincial Chief Medical Officer of Health have communicated daily through press conferences and other media. The province of Ontario has undertaken a ‘staged’ reopening as the pandemic evolves, and there has been a gradual increase in reopenings. The provincial website provides detailed information on which types of establishments and services can open at the different stages. The entire province entered Stage 1 of reopening on 19 May (refer to figure 1) and began allowing specific regions to enter Stage 2, starting on 12 June. The city of Hamilton was allowed to enter Stage 3 on 24 July, when nearly all businesses and public spaces were allowed to reopen gradually with public health and workplace safety restrictions in place. Some high-risk venues and activities will remain closed until they can safely resume operations. The staging decisions were based on the advice of the Chief Medical Officer of Health and other health experts.

Gathering limits, physical distancing and the use of protective masks guidelines form part of the communication.

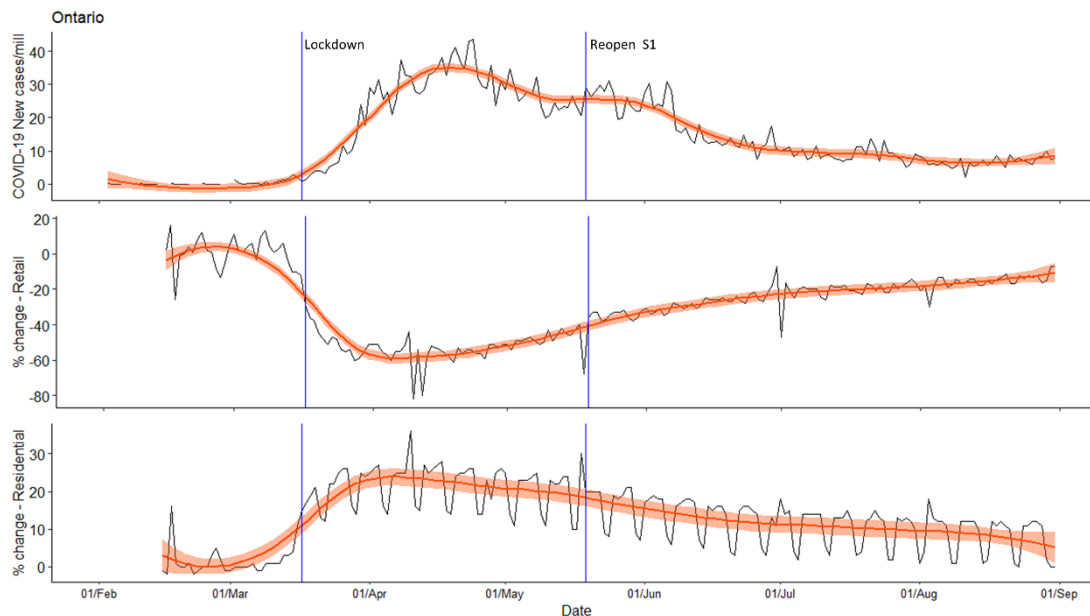


Figure 1: Time Series of New Cases per Million of Inhabitants and Percentage of Change from Baseline for Retail and Grocery Mobility and for Residential Mobility in the Province of Ontario.

Since early in the pandemic, the city of Hamilton has been communicating the evolving situation through a dedicated website and through the media. What the city communicates has evolved. Figure 2 illustrates some of the approaches followed. The city provides absolute numbers, as well as cumulative counts over time. It also provides a graph by census tracts of the proportion of positive cases per 100,000 inhabitants. In late summer 2020, it started to provide the number of ‘active cases’ and the age-group distribution of cases in the last 10 days.

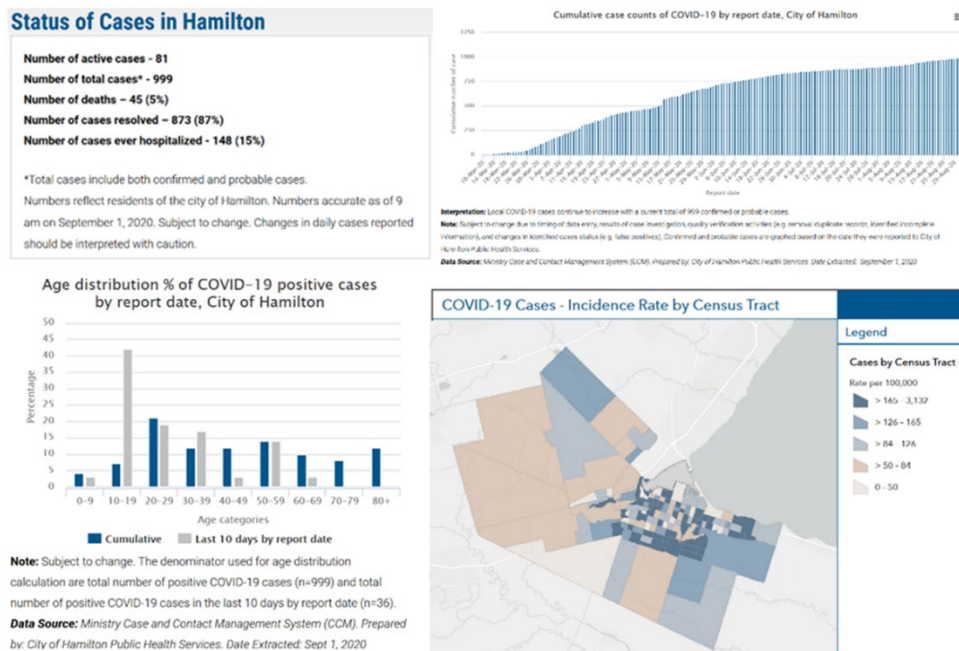


Figure 2: Screenshots of Hamilton's Webpage for Communicating COVID-19-related Information.

Note. From "Status of Cases in Hamilton" by The City of Hamilton, 2020 (<https://www.hamilton.ca/coronavirus/status-cases-in-hamilton>). Copyright 2020 by The City of Hamilton. Images of public service)

Communications mention some of the limitations of the data, but do not make any statements or judgements as to the severity of the risk – that is, they do not mention if the risk is low or high. The number of positive cases depends on the extent of testing and who is tested. Initially, when tests were limited, people with symptoms would have to obtain permission for a test from their primary healthcare provider first; now, anyone who feels they are at risk can be tested. The city does not provide the percent of daily tests that are positive, but it can be easily calculated. Figure 3 shows how, initially, the values were high and quite variable, but low in July–August 2020. If one smooths the trend using cubic splines and adds a band of uncertainty around the estimates, a slight increase at the end of August is visible.

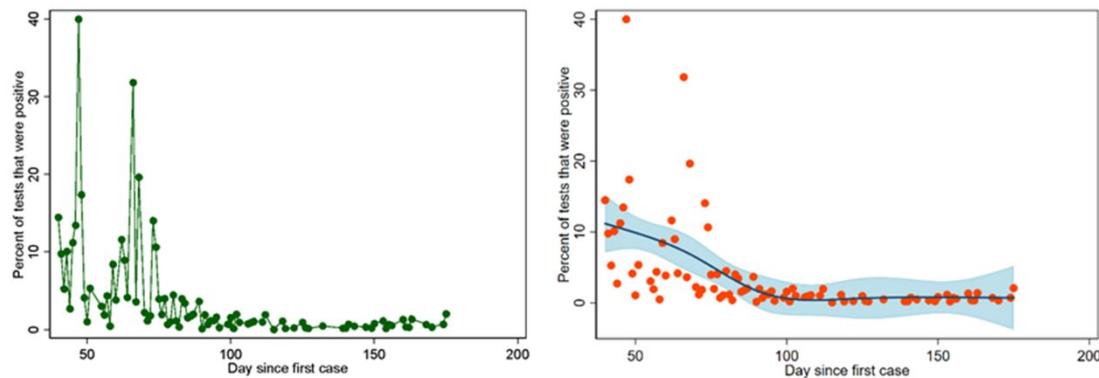


Figure 3: Percentage of Daily New Tests that Were Positive, Hamilton, Ontario. Connected Line Plot (Left) and Smoothed Restricted Cubic Spline (5-knots) with Confidence Band.

Note. Data abstracted from “Status of Cases in Hamilton” by Hamilton, 2020 (<https://www.hamilton.ca/coronavirus/status-cases-in-hamilton>). Note that only the data were taken from the public service communications from the City of Hamilton, but the statistical analyses and plots were generated by author SI Bangdiwala, using statistical software. There is no copyright for the graphs.

CHILE

Chile has been strongly affected by the COVID-19 pandemic, mainly due to the social inequity that exists in the country and the political instability that the country has been experiencing since the end of 2019 (Fraser, 2019). The response to the pandemic has mainly come from the health sector, with the late integration of other sectors. Unlike what is observed in other countries, partial or dynamic lockdowns have been established (Cuadrado et al., 2020) at the regional and even the district level. The metropolitan region has been the most affected; it concentrates roughly one-third of the country’s population (Departamento de Epidemiología, 2020b).

The first case of COVID-19 in Chile was officially reported on 3 March 2020 (Departamento de Epidemiología, 2020a). COVID-19 then spread rapidly throughout the country in the following weeks (Ministerio de Salud, 2020). On 15 March, the Chilean government ordered the mandatory closure of schools, followed by the announcement of voluntary university closures and reorganisation for remote instruction (Ministerio de Educación, 2020). On 18 March, the Chilean government declared a 90-day State of Emergency, enabling exceptional measures, which included limiting certain rights or constitutional guarantees and free transit. The government ordered the closure of all shopping centres, starting 19 March (Gobierno de Chile, 2020c). In the following weeks, the government implemented

several additional public health interventions, including a ban on mass gatherings and an overnight curfew starting on 22 March, among other things. These strategies were associated with important changes in the urban mobility of Chileans (refer to figure 4).

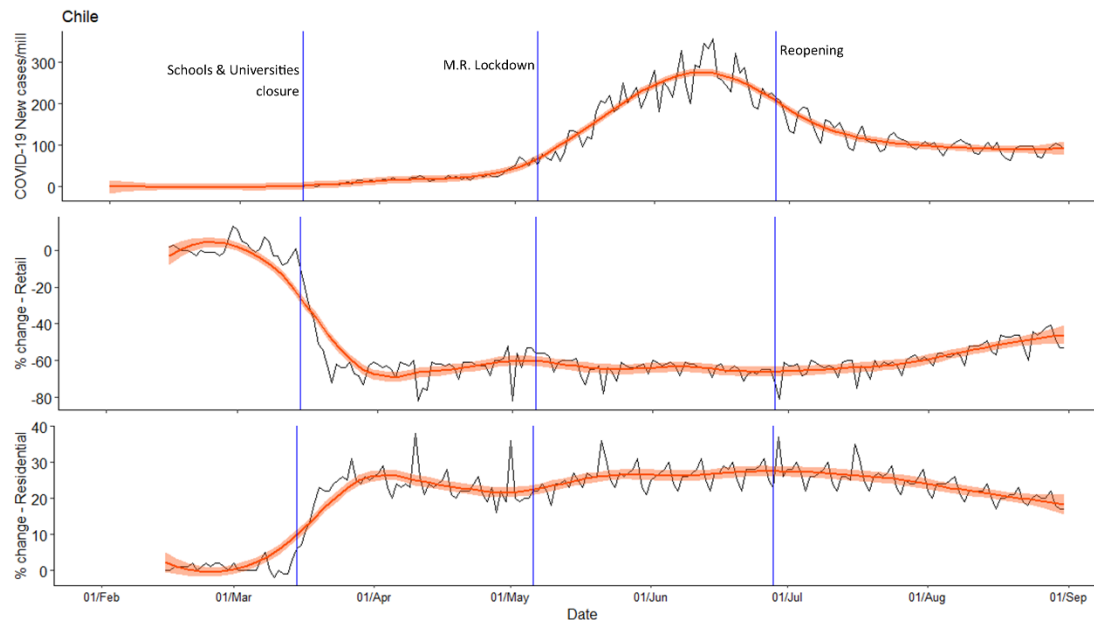


Figure 4: Time Series of New Cases per Million of Inhabitants and Percentage of Change from Baseline for Retail and Grocery Mobility and for Residential Mobility in Chile.

Small-area lockdowns were initially effective in maintaining reduced mobility but were not able to contain the need of people to leave their home to work, mainly in the most vulnerable sectors (Cuadrado et al., 2020). Currently, some small-area lockdowns have been lifted due to the implementation of a national "step-by-step" strategy that seeks to move towards the regularization of activities (Gobierno de Chile, 2020b). The indicators that are associated with these decisions (e.g., positivity rate and incidence rate) have not been clearly communicated from an epidemiological point of view.

Communication of the evolving pandemic has evolved. The first announcements were based on aggregate data that did not allow one to observe the reality of the pandemic at the district level. Owing to pressure from academics and scientific societies, the data provided improved substantially in quality and became based at the Chilean Ministry of Science. These advances in data transparency improved the communication of information to the population through various platforms (refer to figure 5).



Figure 5: Examples of Data Visualization from the Chilean Government's Webpages.

Note. From “Cifras Oficiales COVID-19” by Gobierno de Chile, 2020 (<https://www.gob.cl/coronavirus/cifrasoficiales/>). Copyright 2020 by Gobierno de Chile. Images of public service.

Despite the progress in the quality of the data, there have been complex situations in respect of the communication of risks. Among the most controversial of these situations was the announcement of the "new normal" and the possibility of returning to activities by the end of April, which was questioned due to the reduction in the public's perception of risk (MOVID-19, 2020).

ECUADOR

On 29 February 2020, Ecuador confirmed its first case of COVID-19 in a press conference. In the following days, the national government released bulletins on cumulative new cases through the media and social networks. On 12 March, the President of Ecuador held a press conference at which he declared a state of health emergency and activated the National Emergency Operations Committee (COE-N), which is made up of the President and his cabinet (El Comercio, 2020) and is responsible for managing the health crisis. On 17 March, a national lockdown began, reducing mobility throughout the country (refer to figure 6).

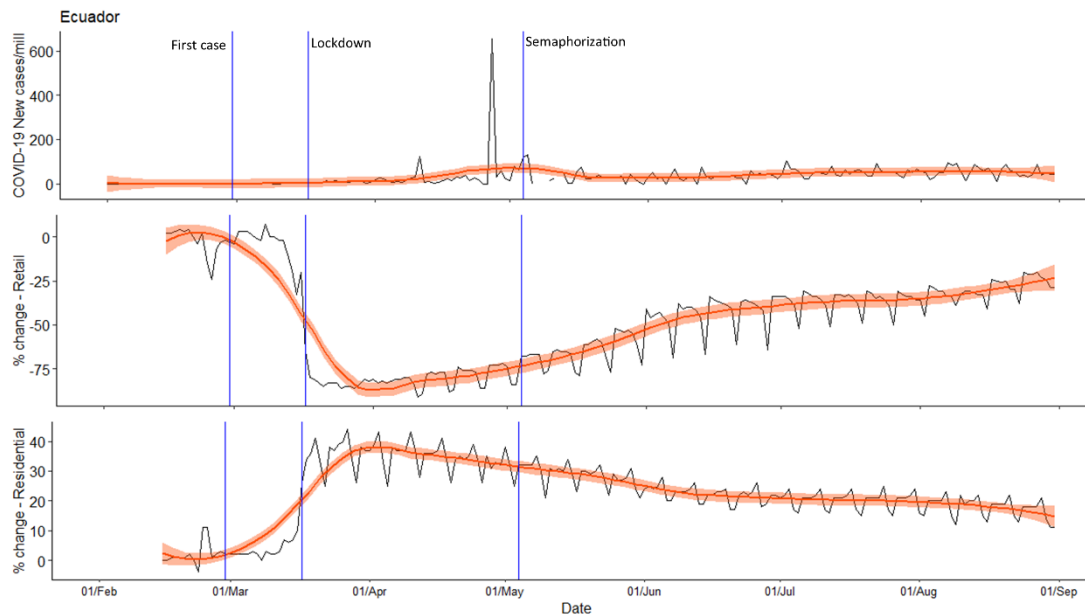


Figure 6: Time Series of New Cases per Million of Inhabitants and Percentage of Change from Baseline for Retail and Grocery Mobility and for Residential Mobility in Ecuador.

The COE-N reported the evolution of the pandemic in the country at least once a day through press conferences, reporting the number of cumulative confirmed cases. Infographics, along with details of cumulative confirmed cases, were released nationally and by province. The spokesperson of the COE-N changed several times. The infographics have undergone multiple changes, one of which was the addition of the cumulative cases by symptom, starting on 7 April. Since 3 June, the COE-N has communicated data only through infographics. On 2 July, the colour palette used for the map of the cumulative case distribution per province was changed. On 2 August, the COE-N started presenting percentage of cases by province rather than absolute counts (refer to figure 7).

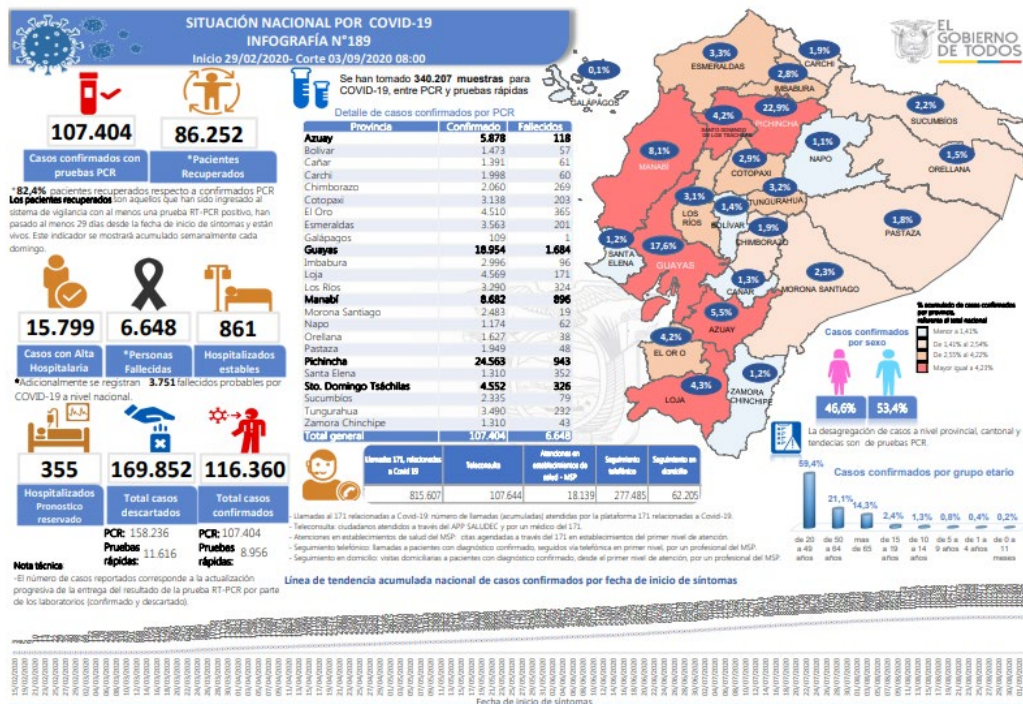


Figure 7: Infographics for Communicating Information in Ecuador.

Note. From " Informes de Situación e Infografías – COVID 19 – desde el 29 de Febrero del 2020" by Servicio Nacional de Gestión de Riesgos y Emergencias del Ecuador, 2020 (<https://www.gestionderiesgos.gob.ec/informes-de-situacion-covid-19-desde-el-13-de-marzo-del-2020/>). Copyright 2020 by Servicio Nacional de Gestión de Riesgos y Emergencias del Ecuador. Images of public service.

Reports cover national absolute cumulative numbers: the total number of samples taken, confirmed cases (by sex and age), deaths, probable deaths, recovered cases, hospital discharges, stable hospitalised people, hospitalised people with a reserved prognosis, calls to the phone number for COVID-19 cases, teleconsultation, care in facilities of the Ministry of Health, telephone monitoring and home follow-ups. Cases are disaggregated at the provincial and cantonal levels, and deaths only at the provincial level. So far, the COE-N has not reported the effective reproduction number, rates, the curve of active cases, new cases or new deaths.

There have been multiple inconsistencies in the data delivered, both in relation to the confirmed number of cases and the number of people who have died, especially during the last week of April and the first 12 days of May, when the Deputy Minister of Health reported that more than 2,000 cases had been deleted due to duplicated tests. On 24 April, 23,138 confirmed cases were reported, 10,938 cases more

than the previous day. However, on 27 April, it was reported that that figure was the sum of results of more than 8,000 rapid tests. Since that day, the total and separate results of polymerase chain reaction (PCR) tests and rapid tests have been reported. Since 18 May, rapid test results have no longer been reported (refer to figure 8).

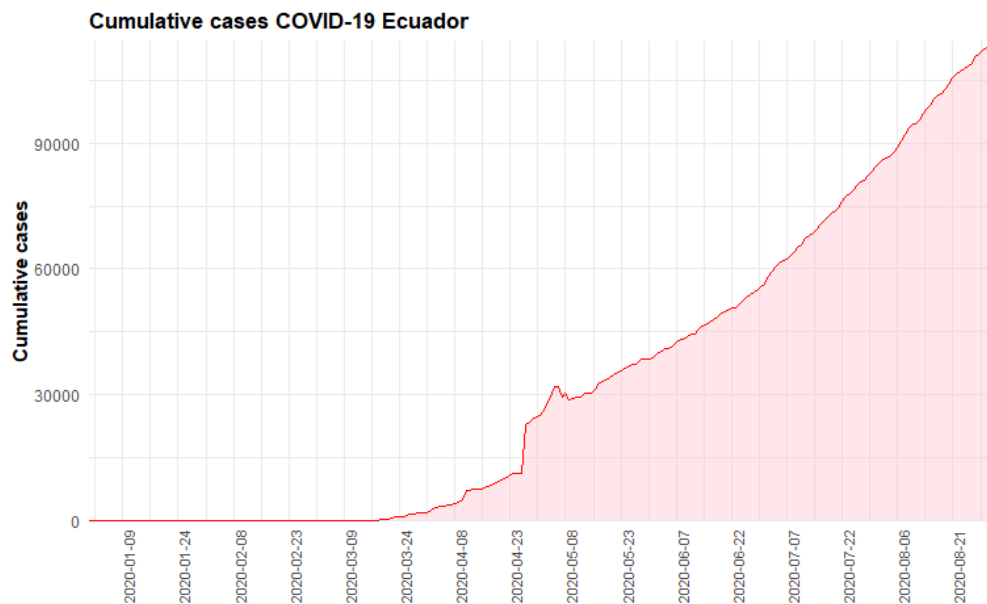


Figure 8: Cumulative Cases of COVID-19 in Ecuador.

Note. From “Informes de Situación e Infografías – COVID 19 – desde el 29 de Febrero del 2020” by Servicio Nacional de Gestión de Riesgos y Emergencias del Ecuador, 2020 (<https://www.gestionderiesgos.gob.ec/informes-de-situacion-covid-19-desde-el-13-de-marzo-del-2020/>). Copyright 2020 by Servicio Nacional de Gestión de Riesgos y Emergencias del Ecuador. Images of public service.

On 4 May, the COE-N implemented a ‘semaphORIZATION’ system (traffic light labelling) for communicating different restrictions by canton. Cantonal COEs, chaired by local governments, made the decision to change the level of restrictions on land mobility, economic activity and curfews using the system. The canton light changes are reported at press conferences and on radio, television and social networks. Meanwhile, cases have continued to increase across the country, especially after the easing of restrictions in provinces and cantons that did not have a high first wave. By the end of August 2020, of the 221 cantons, 2 were in red, 207 in yellow and 12 in green.

ENGLAND, UNITED KINGDOM

As soon as the WHO declared the SARS-CoV2 pandemic, the UK government made general recommendations to the public on how to lessen the risk of spreading the virus (Rusell, 2020). By that time, the first cases of COVID-19 had been confirmed, and the first reported deaths, involving elderly people and people with underlying health conditions, occurred in early March. Figure 9 shows daily new cases per million of inhabitants in England and the percentage of change from the baseline for mobility.

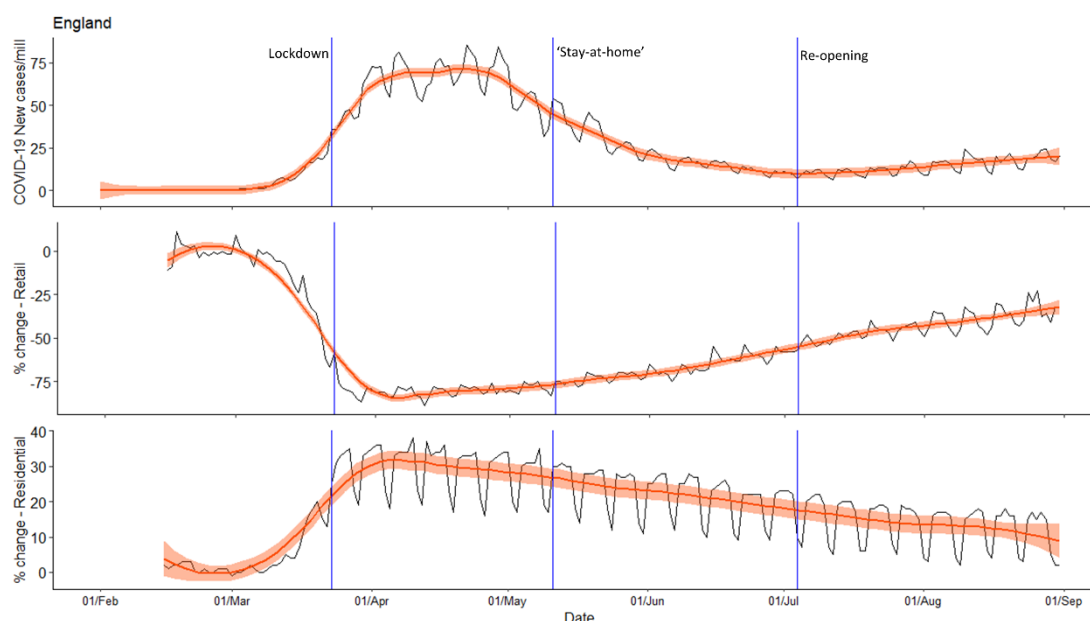


Figure: 9 Time Series of New Cases per Million of Inhabitants and Percentage of Change from Baseline for Retail and Grocery Mobility and for Residential Mobility in England.

The UK Coronavirus Action Plan was officially released on 3 March (Department of Health and Social Care, 2020). From 16 March, daily briefings have been transmitted on television, reporting epidemiological and statistical measurements and suggesting the avoidance of nonessential travel and contact with others (refer to figure 10). Following an increase in the number of cases, a general lockdown was imposed on 23 March, and the UK government launched the “stay-at-home” strategy in terms of which people were required to stay at home and avoid all nonessential travel, some businesses (e.g., pubs, cinemas, nonessential stores, gyms and hotels) were closed and gatherings of more than two people from different households were banned (Cabinet Office, 2020a).

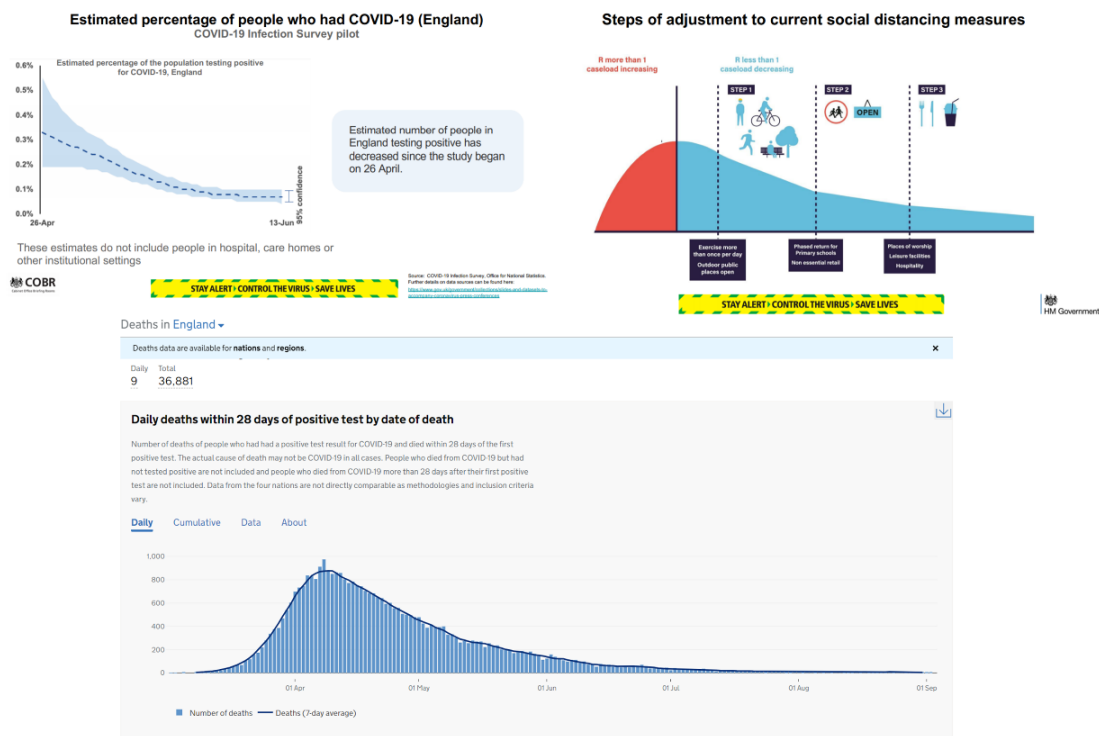


Figure 10: Images of the UK's Officially Released Information on COVID-19.

Note. From “Slides, Datasets and Transcripts to Accompany Coronavirus Press Conferences” by the Prime Minister’s Office, 2020, April 2 (<https://www.gov.uk/government/collections/slides-and-datasets-to-accompany-coronavirus-press-conferences>). Images of public service under Open Government Licence; “Coronavirus (COVID-19) in the UK: Deaths” by Public Health England, 2020 (<https://coronavirus.data.gov.uk/deaths>). Images of public service under Open Government Licence.

In late April, the Prime Minister announced that the UK had passed the peak of infections. On 11 May, a new plan, “Stay alert, control the virus, and save lives”, was set (Cabinet Office, 2020b), accompanied by an easing of lockdown measures, though some general restrictions were maintained. In the same month, a national COVID-19 alert system was introduced. The system was based on five levels that depended on the basic reproduction number (R_0). Some confusion emerged due to unclear methodology to calculate the R_0 and lack of precise definitions for actions in each level. Consequently, local governments used their own alert systems (Fearnley, 2020). Recently, a local three-level system for England was introduced to simplify directions regarding actions, depending on the level. Along with general advice from the government, a mobile application, run by the National Health System (NHS), was created and released to help contact tracing.

Even though daily briefings have stopped and briefings have been given on an ad hoc basis from June, all previous and current information related to COVID-19 has been published on the government's websites (Prime Minister's Office, 2020). These websites and other, independent websites such as that of the Office for National Statistics (ONS) have improved over time. Now, the general public has free access to spreadsheets containing daily information on cases, deaths and hospitalisations, among other variables.

DISCUSSION

The world is facing an unprecedented challenge with the SARS-CoV2 virus and the COVID-19 infection it causes. Every country has confronted the pandemic within their borders to the best of their abilities and resources, using a variety of approaches, including individual public health behavioural preventive measures, quarantines, lockdowns and other containment measures, preparedness measures for healthcare services, the adoption and adaptation of medical and pharmaceutical treatments and the rapid development of diagnostic tests and research into vaccines. Aside from the various actions taken, an important element is transmitting timely, clear, accurate and precise information about aspects ranging from the characteristics of the virus (virology, pathogenesis, health effects), the geographic spread of the virus and subgroups of the population most affected, to the risks and consequences that the virus poses.

At this point, several questions emerge. What is the purpose of communicating statistical aspects of the pandemic? What is the best strategy when communicating statistics in health risk communication? Do people understand statistics? Are definitions standardised and understood the same way by everyone? What information should be communicated? What visualisations are the most appropriate to display?

Despite different public health approaches to this pandemic, there are some similarities regarding the communication of statistical aspects in health risk communication. In general, at the beginning of the pandemic, statistical information was poorly communicated to the public and mainly consisted of cumulative numbers of persons infected and cumulative numbers of deaths. Information conveyed improved in the course of the pandemic in terms of clarity, transparency and accuracy. In our opinion, this evolution is highly relevant and worthy of analysis because it exposes the dynamic nature of a public health emergency and the capacity of experts, governments and citizens to adapt in a short period of time. It is also important to note that COVID-19 is not the first pandemic that humanity has faced,

nor will it be the last; therefore, we, as a society and global citizens, need to learn from this experience to be better prepared for the next pandemic and to improve public health.

UNDERSTANDING RISKS

The pandemic is a highly dynamic system, and the various risks associated with it are not only unknown, but are also different for different subgroups of the population and change as the pandemic evolves. Risks related to other health and non-health outcomes are also complex, and many are conditional risks. A conditional risk refers to the risk of a subsequent event, given that an event has occurred. For example, there is a risk of infection; then there is the conditional risk of severe symptoms, given that one is infected. Then there is the other conditional risk of hospitalization, given that one has severe symptoms. These stages of the disease meet the stages of disease progression described by the WHO (refer to table 1). There are other personal conditional risks, such as the risk of losing one's income or job, the risk of infecting others in one's household, the risk of emotional distress, the risk of permanent disability and the risk of death. There are also 'other' forms of risk, namely, the risk of social, economic and mental consequences of the responses to the pandemic, as well as the risk of delaying medical care for other diseases such as cancer (Maringe et al., 2020).

<i>State of patient</i>	<i>Description of state</i>	<i>Assigned score</i>
<i>Uninfected</i>	Uninfected; no viral RNA detected	0
<i>Ambulatory (mild disease)</i>	Asymptomatic; viral RNA detected	1
	Symptomatic; independent	2
	Symptomatic; assistance needed	3
<i>Hospitalized (moderate disease)</i>	Hospitalised; no oxygen therapy*	4
	Hospitalised; oxygen by mask or nasal prongs	5
<i>Hospitalized (severe disease)</i>	Hospitalised; oxygen by NIV or high flow	6
	Intubation and mechanical ventilation - (pO₂/FiO₂ ≥ 150 or SpO₂/FiO₂ ≥ 200)	7
	Mechanical ventilation - pO₂/FiO₂ <150, SpO₂/FiO₂ <200 or vasopressors	8
	Mechanical ventilation - pO₂/FiO₂ <150 and vasopressors, dialysis, or ECMO	9
<i>Dead</i>	Dead	10

Table 1: WHO Clinical Progression States.

Note. ECMO = extracorporeal membrane oxygenation, FiO₂ = fraction of inspired oxygen, NIV = noninvasive ventilation, pO₂ = partial pressure of oxygen, SpO₂ = oxygen saturation. *If hospitalised

for isolation only, record status as for ambulatory patient. Table created based on information presented by Marshall et al., (2020).

Aside from the risk of infection, other actual risks were never quantified but stated as low, medium or high overall and ‘higher’ in certain subgroups. Therefore, the public were forced to make their own interpretation of what these messages meant for them. People assess and interpret ‘risk’ on a personal level based on their beliefs and how information was presented; that is, they answer the question, “Do the risks mentioned apply to me? I have certain characteristics (sex, age group, ethnic group, socially disadvantaged, comorbidities, obesity) that place me at a higher risk, but how much higher? Does the higher risk matter?” The problem is that such information is unavailable, imprecise and even misrepresented, leading to confusion, anxiety and, possibly, poorly informed decisions.

Risks can be described using ‘qualitative labels’, such as low, medium or high, but these are subjective and vague. For example, the US Centers for Disease Control and Prevention (2020) state that “[a]dults of any age with certain underlying medical conditions are at increased risk for severe illness from the virus that causes COVID-19”. They refer to situations of ‘lowest risk’, ‘more risk’, ‘higher risk’ and ‘highest risk’, but do not provide quantifications. To quantify risk, an ‘estimate’, that is, an ‘educated guess’ is developed based on past experiences, observations, theories and statistical analyses. It is then reported as a probability, a number between 0 (certainty that an event does not occur) and 1 (certainty that an event does occur). Risk, otherwise known as probability, is thus simply a quantification of uncertainty.

In the case of a novel disease, there is no information on which to develop an educated guess, so initially the risks are simple ‘wild guesses’ that are improved upon as information is accumulated. However, once the risks have been quantified, as a probability between 0 and 1 or, more commonly, as a percent between 0 and 100, the number has to be interpreted when reported. For example, is 60% interpreted as high, or does it have to be at least, say, 85%, to be reported as high? Should one communicate the probability of having the event or the probability of **not** having the event? Is it preferable to say what factors, actions or behaviours increase or decrease the risk rather than just reporting the number? For example, if there are n numbers of active cases in a community of N persons, is the risk of infection n/N if you choose to mingle but lower if you restrict your movements and interactions? If one self-isolates, why is the risk of getting infected not 0? The psychology and sociology of how risks are perceived, given how they are communicated, are complex (Breakwell, 2007).

When communicating a risk, it is relevant to provide a clear definition of that risk. Even better, different levels of risk should have verbal and numerical definitions, accompanied by clear visualisations that are easy to understand by the target population (Spiegelhalter, 2017), considering the population's numeracy level.

UNCERTAINTIES AND STATISTICAL CONSIDERATIONS

The communication of quantitative risk information should adhere to foundational statistical considerations. All estimates are subject to uncertainties, from the 'known knowns' and the 'known unknowns' to the 'unknown unknowns' (Rumsfeld, 2002 in Spiegelhalter, 2017). Potential 'known unknowns' are quantified using confidence intervals. Rather than a single point estimate, the confidence interval is a range of values that is considered, with high confidence, to contain the true value in the population of the parameter being estimated. Presenting confidence intervals rather than simple point estimates conveys the uncertainty around the estimated risk. Confidence intervals account for uncertainties arising from sampling a subset of the population but do not account for potential biases relating to how the sample was obtained or how representative the sample may be of the population (selection bias), or ascertainment or measurement biases. Data obtained from interviews or surveys are subject to nonresponse bias or reporting bias. Data obtained from medical records or laboratories may be subject to measurement bias, incomplete information or imprecise instrumentation. Reporting the potential biases in estimated risks first requires that the biases themselves be estimated. The presentation of uncertainty about data has been highlighted as one of the most difficult elements of risk communication (Politi et al., 2007).

In order to inform statistical aspects of a pandemic clearly, uncertainties need to be acknowledged. It is easy to present the 'known knowns'; however, as we said earlier, facing a novel virus and disease involves many 'unknowns'. Public health experts, scientists and government officials need to be humble and recognise these many 'unknowns' but at the same time be aware and convey that, as the pandemic evolves, more information is collected and analysed, which is then used to make new decisions. Finally, these uncertainties should be conveyed along with point estimates narratively and graphically. Clear visualisations of these estimations, along with clear and precise conclusions, should be presented to the public in order to avoid misinterpretations.

STATISTICAL LITERACY OF THE PUBLIC AND PEOPLE'S PERSPECTIVES

Generally speaking, one could blame the public's low statistical literacy for their inability to understand information and numbers that are presented. This perspective is far from true. We know that the proportion of literate populations increases every year and it is now the highest that it has ever been (Roser & Ortiz-Ospina, 2018). However, it is very likely that statistical or data literacy could be lower, yet that is not the only reason for poor understanding. The public's response to risk and statistical information is also influenced and modelled by factors outside the field of 'numbers', such as the affect heuristic (Slovic & Peters, 2006), beliefs, cultural practices, social cohesion, trust and how information is displayed (coherence and transparency).

From our analyses, it is evident that authorities and health professionals typically report standard counts as indicators: cumulative total number of positive cases, cumulative total number ever hospitalised and cumulative total number of deaths attributed to COVID-19. Some standard epidemiological indicators, such as the number of days it takes to double the number of positive cases, or the R_0 , the expected number of cases directly generated by one case, assuming all individuals are susceptible, were not seen presented, probably because of their difficulty in interpretation. Since the number of positive cases depends on testing rates, an important indicator is the proportion of new daily positive cases among the number tested on a given day. Even this is subject to bias, given that those tested may be self-selected, or testing may have been restricted to symptomatic individuals. Ideally, it would be statistically better to have as an indicator the daily proportion of new positive cases in a daily random sample of individuals selected for testing.

Cumulative counts of positive cases, hospitalizations and deaths were provided daily. Cumulative counts are good at creating anxiety and fear and getting the population to comply with measures that are imposed. Information on what 'flattening' trends would be necessary to enter various stages of easing of mobility was not effectively communicated. Daily unsmoothed graphs were the norm, when smoothed graphs would have communicated trends. Additionally, methodology changes in counting or registering should be highlighted and adjusted for when analysing long-term trends.

Making informed decisions requires some degree of statistical literacy. Gigerenzer and colleagues describe the concept of collective statistical illiteracy – the public's general lack of basic competencies required to understand health statistics (Gigerenzer et al., 2007). Understanding variability and uncertainty is part of statistical literacy. Scientific uncertainty of the various risks (of infection, of

transmission, of severity of illness) and of the conditional risks of progression, must be properly communicated. Standard statistical concepts, such as information uncertainty (i.e., ‘we just don’t know’), statistical uncertainty around an estimate (confidence intervals) and the role of chance (i.e., not everyone facing the exact situation/conditions will get the same outcome), must be addressed. The smoothing of raw data makes it possible to study trends; confidence intervals around risk estimates and confidence bands around plots properly convey the uncertainty around the observations.

As the mobility and distancing restrictions changed due to perceived ‘changing risks’ or governments’ desire to reopen their economies, the public understand “it is OK”. They should be told that ‘the risk is still there – we believe it is lower, but you should still use caution; the risk is not 0’. Unfortunately, such statements are rare and the public see ‘the green light’ to go and behave as before.

During a public health emergency, it is imperative that the public be accurately informed of the risks they face so they can modify their behaviour and actions appropriately. Since the public have some difficulty in judging evidence and interpreting statistical data, risks, trends and the uncertainties around their estimates need to be communicated clearly and well (Von Roten, 2006). Skovdal et al. (2020) provide recommendations on how to communicate risks in the COVID-19 pandemic. Risks must be “considered in the broader context of a group of risks as great or greater than that from COVID-19.” [Skovdal et al (2020) p.283]. As the pandemic evolves, the changes in risk must be effectively communicated. Skovdal et al. (2020, p.283) state: “Self-perception of risk is not static but evolves constantly with the epidemic for the right reason (risk of infection is genuinely dynamic in the course of an epidemic) and the wrong reason (persons can acclimatize to a risk and risk compensation can set in). ... Adapting risk messaging to the epidemiology of COVID-19 will be critical to maintain positive behaviour change.” A good example of critical thinking and adaptation is the Office for National Statistics (ONS) in the United Kingdom, which has been adapting its communications based on the ease of understanding of different graphs that convey number of deaths or positive cases, for example, without compromising statistical rigour (Fry, 2020).

In the midst of a public health emergency, different disciplines and professionals, such as sociologists, psychologists, economists, epidemiologists and statisticians, should work together in order to provide a holistic perspective of the problem and potential holistic strategies. Nowadays, people are highly critical and want to be part of decision-making processes, especially when it comes to their own health and well-being. When people are considered and involved as key actors in a public health emergency,

it is possible to increase not trust, but trustworthiness, which is even more relevant when facing a pandemic.

PREVENTION IMPLICATIONS

Well-conducted health risk communication, which includes statistical considerations, contributes to preparedness for and the prevention or mitigation of disasters (e.g., high mortality rate) and empowers people to be key actors and make informed decisions. In this sense, one key aspect of communicating risks is to keep the public informed using the best evidence available at the time, in order to prepare effective responses to prevent damage.

During a public health emergency, communicating risks is challenging. The WHO and other authors provide clear recommendations on this point (Vaughan & Tinker, 2009; World Health Organization, 2017). We complement those recommendations with statistical considerations regarding the communication of risks (refer to table 2) since failure to communicate adequately may not only have implications for the management of the current public health emergency, but may also affect future situations if the public's trust in the information being provided is jeopardised.

Public health science has made great strides in establishing methodologies for estimating health risks, from developing research study designs that make it possible to reduce the uncertainty around estimates, to creating statistical analytical tools that make it possible to understand sources of variations and the significance of estimates better. However, proper methodology for communicating this information to a numerically fearful and statistically illiterate public remains challenging. The public are conditioned to 'brush aside' lifestyle recommendations regarding a healthier diet, adequate physical activity and the need to not engage in 'risky' behaviours, due in great part to mismanaged past communication of the risks and consequences involved. Such past communication primarily dealt with measures for reducing the risks of chronic diseases, such as diabetes, cardiovascular disease or cancer, and, possibly, the delayed cause and effect of their behaviour is difficult to grasp. During an infectious disease pandemic such as the current COVID-19 pandemic, we have the opportunity to communicate the risks and consequences of the public's behaviours in respect of an acute problem properly. It is imperative that we do not mismanage this communication, not only for the current pandemic, but for future ones we may face. Proper management of risk communication should involve the use of proper indicators (absolute numbers, relative numbers) when warranted; transparency about the uncertainties faced in

quantifying the risks (accurate and precise data, timely data, variability in the data, lack of adequate numbers); the provision of assessments about the uncertainties around the estimated risks; and the study of trends. Quantified risks should not simply be mentioned but explained and interpreted at both the individual and societal level. In addition, this information should be properly supported by clear and simple visual aids that convey one message at a time and should be available to the public at all times.

The communicators, whether public health officials or political figures, must themselves understand or be adequately advised on statistical literacy – they must understand variability in daily counts, smoothing techniques and the message transmitted by different types of charts and plots. The individuals who communicate the information must be trusted by the public by virtue of their educational credentials, their knowledge of science, their demeanour and their presentation style.

Those individuals and institutions who communicate risks must also realise that the public may hear the message correctly but may interpret the message depending on their understanding or expectations. Stating that the risk is lower so that the economy can move to the next stage of reopening has led to the public believing they have the ‘green light’ to engage in certain behaviours without risk. People in strict, long lockdowns may become desensitised to information and tired of hearing the same messages repeatedly. People become anxious to ‘resume their lives’ and may use any small ease in restrictions to take a big change in their risk engagement behaviour. Authorities must strive to communicate that ‘the risk remains but is lower; this is not a green light’.

General considerations

1. Establish a clear purpose for the health risk communication.
2. Develop a clear strategy to communicate statistics, including definitions, frequency of communication and media to be used.
3. Information should be communicated in a timely manner.
4. Tailor speech and visualisations to the target audience.
5. Involve different perspectives when planning and communicating. Include professionals from different fields and citizens/stakeholders.
6. Modify communication as necessary; be flexible and adaptable to different stakeholders and adjust communications as the situation evolves.

Statistical considerations

7. Present absolute numbers (e.g., # of positive cases) AND relative numbers (e.g., % of tests that were positive).
8. Consider defining categories of risk (e.g., high, medium, low) and groupings of allowed activities (e.g., high-risk activities).
9. Clearly convey if a risk is an absolute risk or a conditional risk.
10. Show how a particular risk was estimated and quantify and convey the uncertainty around the estimate (e.g., confidence intervals).
11. Use examples from everyday life to convey the message behind the numbers.
12. Mention potential biases in both the numerators and denominators (e.g., sample selection bias, positive case detection bias, nonresponse bias, measurement or ascertainment bias).
13. Recognise and convey 'unknown' uncertainties – accept our ignorance.
14. Present clear visuals (e.g., plots), accompanied by clear statements on their message.
15. Use and explain smooth trends when conveying time series.
16. When using regression models to project scenarios, point out the limitations of modelling.
(Remember: “All models are wrong, but some are useful.” (George Box, 1976))
17. Do not use data to manipulate opinion and behaviours, but to inform and build trustworthiness.

Table 2: Takeaways on Statistical Considerations when Communicating Health Risks

Finally, those individuals and institutions who communicate health risks must recognise that health risks are not isolated; there are economic, social, psychological and mental health consequences from modifying health risk behaviour, and the full package of risks and consequences must be communicated. The multiple governmental sectors must coordinate their assessments of risks and conditional risks and provide a unified, single presentation on a website in places with high internet coverage, via free messaging in places with high cell phone coverage and through other mass media avenues in places with poor information dissemination resources (Organizacion Panamericana de la Salud, 2011).

The current SARS-Cov2 pandemic has forced us to acknowledge that challenges in communicating risk in a public health emergency become more pronounced when the disease is totally new and everything about it is unknown. This increased level of uncertainty must be acknowledged by authorities transmitting information. If authorities do not do so and they appear to 'know it all', only to be shown to be wrong later, the public will mistrust future communications. We must inform the public how

newly acquired information changes the estimates of risks, making them more precise and accurate, lowering or raising them. Since this article was written, effective vaccines have come into the picture, and countries are slowly moving towards recovery. Now more than ever, proper risk communication is necessary to maintain and increase the trust of the public, to ensure a good level of vaccination coverage, and a prompt recovery from this global pandemic.

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