Communicating the Risk of Covid-19 through Personal Risk Ownership

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Abstract

Lessons learned from the early phase of the Covid-19 pandemic from other countries [1] has shown that there remain gaps in capacities, public understanding and issues in local data and communication strategies. As countries move away from national lockdowns towards managed local measures, there is an acknowledged need to sustain efforts in different components of the pandemic response, and to effectively communicate to the public about the importance of public health interventions. These interventions or 'harm-reduction strategies' like social distancing, wearing masks or improving personal fitness are realistic and sustainable, recognising the needs of individuals while maximizing the protection of others and preventing an overwhelmed health system [1].

This paper develops an effective communication framework that individual members of society can utilise in order to understand their personal and localised risk from Covid-19.

The Need for a Risk Communication Framework

Communication in response to a disease pandemic (such as publicising a vaccine or lack of one, or sanctioning or disapproving certain types of behaviour management) will provide statements from which a risk profile can be interpreted and which may communicate details of a disease risk even if this is not the intention of the communicator [2]. There are some distinctive elements in seeking to influence social behaviour in contexts where risk is a key focus of communication and where, for example, there may be increased anxiety or concern and also considerable uncertainty [3]. The way in which people make sense of risk takes account of many more factors than are contained within the likelihood and severity calculation used by industry experts to characterise risk. People may scrutinize communications and communicators for signals of trustworthiness and be influenced by the 'personality profile' of the hazard—is it familiar, dreaded, new and so on [4].

Within the UK, the national Government introduced the Covid-19 Alert and Tier Levels, and has discussed how these can be communicated and implemented to influence the public behaviours needed at each national risk level [5]. Some of the SAGE group topics discussed;

- A national Alert Level is important for public risk communication. Of equal importance is the information about the situation within a locality, i.e. how the risk applies locally and what actions are appropriate in a place, and when moving between places.
- Some public harm-reduction strategies (e.g. hand washing) will be required across all Alert Levels and these messages needs restating.
- For clarity of public communications, Alert Levels should be a simple step level system with no sub-division.
- People need clear messaging and behavioural advice. This can include how and when to make sensible judgements on protective behaviours as they move between places and risk situations.

Aristotle, the philosopher constructed the earliest mass communication model called "Aristotle's Model of Communication", proposed before 300 B.C. He specifically identified the importance of the target audience's role in the event chain of his communication model. Aristotle's model of communication is formed with 5 basic elements [6];

(i) Speaker, (ii) Speech, (iii) Occasion, (iv) Audience and (v) Effect.

Aristotle advises speakers to build their speech (communication) for different audiences at different occasions and for different effects. The communicator must prepare his communication and analysis of the audience's needs before he enters into the stage. The communication should influence the audience's mind and persuade their thoughts towards the communicated information. It is the analysis of the audience that is often missed out or mis-understood, requiring re-presentation and re-communication at some later, usually inconvenient, time [7].

The recent example of the communication difficulties associated with the UK Government's Direct Centre Performance Model for examination grading during Summer 2020 has shown that the obscurity in the decision algorithm, which was not published before use, caused significant confusion and loss of trust in the political regime [8]. It is judged that this will have also reduced public confidence in hidden '*rogue algorithms*' in deciding about and directing social behaviour.

A previous study on the relative persuasiveness of narrative versus non-narrative health messages in public health emergency communication [9] concluded that didactic, non-narrative messages may be more effective than narrative messages to influence knowledge and perceptions during public health emergencies.

Reiterating the SAGE discussion, risk communication with the public, students and workforce needs to be simple, open and clear [5], and I suggest that there needs to be some ownership by the public, such that possession leads to persuasion. It is judged that a risk communication method is developed that is simple, non-narrative with an element of ownership and influence by the individual audience member (the member of public).

The next section discusses how this may be completed and makes a proposal for a useable risk communication framework.

Risk as a Combination of Likelihood and Severity

The public does already have some experience with some risk communication frameworks. The Met Office's flood and weather warning impact matrix [10] is frequently shown on television and the internet – see figure 1. This combines the likelihood of a weather effect and the potential severity from it.

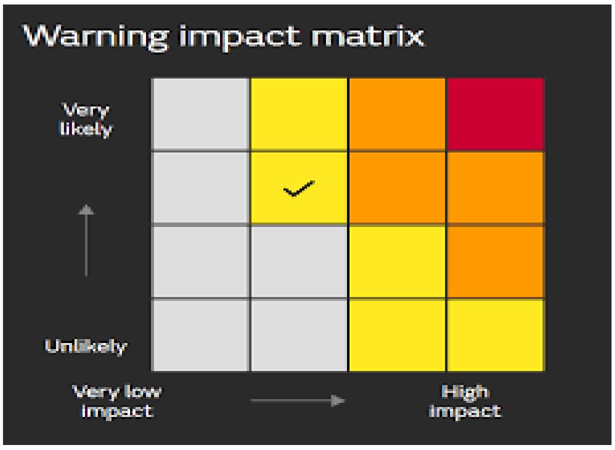

Figure 1 - Weather Warning Impact Matrix

“Yellow Warning: Yellow warnings can be issued for a range of weather situations. Many are issued when it is likely that the weather will cause some low level impacts, including some disruption to travel in a few places. Many people may be able to continue with their daily routine, but there will be some that will be directly impacted and so it is important to assess if you could be affected. Other yellow warnings are issued when the weather could bring much more severe impacts to the majority of people but the certainty of those impacts occurring is much lower. It is important to read the content of yellow warnings to determine which weather situation is being covered by the yellow warning.

Amber Warning: There is an increased likelihood of impacts from severe weather, which could potentially disrupt your plans. This means there is the possibility of travel delays, road and rail closures, power cuts and the potential risk to life and property. You should think about changing your plans and taking action to protect yourself and your property. You may want to consider the impact of the weather on your family and your community and whether there is anything you need to do ahead of the severe weather to minimise the impact.

Red Warning: Dangerous weather is expected and, if you haven’t already done so, you should take action now to keep yourself and others safe from the impact of the severe weather. It is very likely that there will be a risk to life, with substantial disruption to travel, energy supplies and possibly widespread damage to property and infrastructure. You should avoid travelling, where possible, and follow the advice of the emergency services and local authorities.” [11]

The identification of a weather impact warning position on the matrix is based on scientific interpretation of the likelihood influencing factors (e.g. size of weather phenomenon, geo-location etc.) and severity influencing factors (weather intensity, population density, duration of effect etc.).

Similar matrices that assess risk through a combination of likelihood and severity are used in major hazard industries, for example Liquid Natural Gas industry [12], US Department of Defence (figure 2) [13] and UK Defence Aviation (figure 3) [14].

		Severity			
		Minor	Major	Critical	Catastrophic
Likelihood	Frequent	M	H	VH	VH
	Occasional	L	M	H	VH
	Remote	L	L	M	H
	Improbable	L	L	L	M

Figure 3 - The Defence Aviation Hazard Risk Matrix

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

Figure 2 - US DoD Risk Matrix

Likelihood influencing factors for Covid-19

Regarding the likelihood factors for Covid-19, research has identified many models for epidemic spreading and contamination progression, in real life the contagion process depends on many factors such as contact, proximity [15] and the density of local infection cases [16]. The Reproduction number ‘R’ is defined as being based on the product of the risk of transmission per contact; the number of such contacts that an average person in the population would normally have per time unit (in the absence of any disease), the duration of infectivity of an infected person [17].

This research has also discussed the likelihood reduction factor when face masks are used during a pandemic situation [17]. Data from published clinical studies into other diseases similar to Covid-19 [18] [19] indicate that the infectivity of influenza A virus is very high, so that transmission of infection may only involve low doses of virus. At low doses, the relation between dose and the probability of infection is approximately linear, so that the reduction in infection risk is proportional to the reduction in exposure due to particle retention of the mask. An overview of published studies on face mask protection against influenza viruses and or other respiratory viruses has been made and this suggests that both certified and non-certified masks do have a significant influence on the reproduction number. The analysis shows that masks may have a median protection factor of between 2.4 and 6.5, or a mask efficiency of between 58% to 85% [17]. As it is an important factor, the mask effect should be used in our analysis of likelihood.

Further research has looked at the effects of ethnicity on the likelihood of developing Covid-19. Taking into account geography, socio-economic characteristics and health measures, including pre-existing conditions, males of Black African background retained a 2.5 times higher rate than those of White background, while for females a 2.1 times greater risk remained [20] [21]. So, our research will include a (rounded) factor of x2 on the likelihood score development.

Complex, algorithm-based models can determine absolute numbers for contagion and disease reproduction, but this is very technical and may be seen as too complicated by non-scientists – perhaps even as '*rogue algorithms*'. This may certainly be useful at the governmental level for holistic social decision making, but can result in significant confusion at the individual level [8].

Our research proposes that a likelihood scoring value for the general public may be more simply determined from the calculation shown in equation (1);

$$\text{Likelihood Score} = \frac{\text{Local Infection Rate (per 100,000) x Size of Contact Proximity Bubble (x 2 if BAME)}}{\text{Mask factor of 5 (if used)}} \quad \text{- (1)}$$

Where the local infection rate is identified from local health authority testing data; the size of the contact proximity bubble is identified from personal knowledge of the maximum number of persons that are allowed to be co-located during a typical day, e.g. at an office, or at school; and the mask factor is included if the individual person uses a mask during their social contact periods. It must be noted that the likelihood value is not an absolute likelihood, rather it is an indicative score that is easily determined, that is able to satisfy part of Aristotle's audience's needs [6].

As an example, my personal likelihood in Wiltshire on 16th September 2020, with me attending an office with a limit of 20 persons, and using a mask, would give me a likelihood score as follows;

Local infection rate = 15 cases per 100,000 [22]

Size of contact proximity bubble = 20

Likelihood Score = 15 x 6 / 5 = 60

Severity influencing factors for Covid-19

Regarding the severity factors of Covid-19, there is plenty of research into the factors that influence the severity of Covid-19 as a specific situation [23], one of the largest so far is the China Center for Disease Control and Prevention's report of 44 000 people with laboratory confirmed covid-19. Older age, cardiovascular disease, diabetes, chronic respiratory disease, hypertension, and cancer were all associated with an increased risk of death [24]. In other studies, obesity and smoking were associated with increased severity [25] [26].

Other research on 31,461 adults in the United States [21] has detailed the most common comorbidities (listed in accordance with the Charlson comorbidity index) as chronic pulmonary disease (17.5%, n = 5,513) and diabetes mellitus (15.0%, n = 4,710). Multivariate logistic regression analyses showed older age (odds ratio [OR] per year 1.06; 95% confidence interval [CI] 1.06–1.07; p < 0.001), male sex (OR 1.75; 95% CI 1.55–1.98; p < 0.001), being black or African American compared to white (OR 1.50; 95% CI 1.31–1.71; p < 0.001), myocardial infarction (OR 1.97; 95% CI 1.64–2.35; p < 0.001), congestive heart failure (OR 1.42; 95% CI 1.21–1.67; p < 0.001), dementia (OR 1.29; 95% CI 1.07–1.56; p = 0.008), chronic pulmonary disease (OR 1.24; 95% CI 1.08–1.43; p = 0.003), mild liver disease (OR 1.26; 95% CI 1.00–1.59; p = 0.046), moderate/ severe liver disease (OR 2.62; 95% CI 1.53–4.47; p < 0.001), renal disease (OR 2.13; 95% CI 1.84–2.46; p < 0.001), and metastatic solid tumour (OR 1.70; 95% CI 1.19–2.43; p = 0.004) were associated with higher odds of mortality with COVID-19 [21]. In the earlier China research, it was difficult to judge relative importance of factors as health records are often incomplete or inaccurate and chronic conditions are often underdiagnosed [23].

At the government level, when planning health responses, the quantitative details of the research may be used to determine a national or regional response. However, this research proposes that a severity quantification may be more easily determined at the personal level from a summation calculation of the higher factors that are readily quantified.

The particular factors that have been selected are Age; BMI (as a measure of obesity) [27]; a smoking factor, and a health condition factor. These are shown together in equation (2);

Severity Score = Age + BMI + Cigarettes + Health Factor -(2)

Where age is the individual’s actual age; BMI is the individual’s BMI value; a daily average of number of cigarettes smoked by the person; and the health condition factor is a numerical increase score of 50 based on the individual already having a pre-existing health condition similar to those listed in the research [24] [21]. The use of 50 has relevance in the later combining process of severity and likelihood as it would significantly affect the score and be enough to move the person’s score into the next higher severity class.

As an example, my personal severity score on 16th September 2020 would give a calculation as follows;

Age	=	51	
BMI	=	26	
Health condition	=	0	
Smoking	=	0	
Severity score	=	51 + 26 + 0 + 0	= 77

Combining Likelihood and Severity

As has already been developed, a risk measure may be derived from a combination of likelihood and severity [11] [12] [14]. In the case of Covid-19, a similar risk matrix may be developed setting together the likelihood and severity score calculations, populating them into pairs representing particular points in a risk domain. But even before a risk matrix can be populated, there is a need to set some more ground definitions and organisation in the way that a risk score is going to be judged [28]. The two axes of the Covid-19 risk matrix need to defined first.

The likelihood scale factor of local infection rate could range from 0 to something around the 500 per 100,000 people; the size of the proximity bubble could range from 0 to perhaps 300 in a large school or college year-group or open-plan office; and a doubling factor if the person is of BAME ethnicity. The likelihood score would therefore range from 0 to around 300,000 – determined from a product of 500 x 300 x 2. The lower the score indicates a lower likelihood of contraction– but it must be stressed this is a non-dimensional score, not a real probability measure. As this is a product calculation, a logarithmic scale would appear to be suitable here.

The severity scale factor of age could reasonably have a range of 0 to 110; the BMI number could have a range between around 20[1] to 40; the number of cigarettes could have a range of 0 to 50. This would give an interim summation range of 20 to 200. It is proposed that a severe medical condition would be a yes-no decision with a score of +50 for a yes decision. These factors together would give a severity score range of 20 to 250. As this is a summation calculation, a linear scale would appear to be suitable here.

It is also important to understand what the Covid-19 risk matrix would be used for. There needs to be some graduation in response to the varying levels of risk defined by the combinations of likelihood and severity [28]. There are five levels in the UK Covid-19 alert levels and there is some justification for following those. However, it is not completely transparent to the public how those levels have been determined and the situations that allow transfer between levels [5]. It is proposed that for out risk matrix, four classes of risk are used, and that these are given labels of LOW, MEDIUM, HIGH and VERY HIGH. Differing rigours of harm-reduction strategies can be employed for increasing risk from a basic approach of washing hands & social distance, up to full isolation and lockdown [29]. Personal strategies may also be recommended – e.g. actively reducing social bubble sizes, using masks more often, improving a BMI score or reducing smoking. More examples will be given in the later sections of this paper.

The likelihood and severity axes need to have some graduation in order to reflect the variety of possible risk class outcomes [28]. It is proposed that five categories are given for each axes. An unpopulated Covid-19 risk matrix can be laid out as shown in figure 4.

Increasing Severity

Over 200					
151 to 200					
101 to 150					
51 to 100					
Below 50					
	Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000

Increasing Likelihood

Figure 4 - Unpopulated Covid-19 risk matrix

The blank risk matrix can now be populated with the risk classes LOW to VERY HIGH. The combination of lowest severity and likelihood should be rated at the lowest risk class and the combination of highest severity and likelihood should be rated at the highest risk class [28] – see figure 5. The precise meaning of LOW or VERY HIGH is somewhat abstract and relative; LOW would usually mean that there is no need to take any severe reduction actions – just carry on hand washing and giving space. VERY HIGH would certainly indicate an urgent need to carry out some control strategies, including lockdowns [29]. It is not in the scope of this paper to mandate what must be done if an individual finds themselves in a particular risk position; individual and political tolerability and attitudes to risk will be different. Linkage to the UK national Alert Model [5] or some other 'traffic-light' system is possible, but has not been fully developed at this time.

[1] The BMI measure can obviously go below 20, but this paper does not advocate deliberately reducing BMI below 20, so a minimum score value of 20 is used even if a real BMI score is slightly below this value.

Increasing Severity

Over 200					
151 to 200					
101 to 150					
51 to 100					
Below 50					
	Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000

Increasing Likelihood

Figure 5 - Interim populated risk matrix

The rest of the populating of the risk matrix is undertaken on a trial and review basis. Interestingly, my personal risk position (**Me!!**) can be used to provide a fixed point on the matrix, along with a personal view that this risk position should probably be regarded as a MEDIUM risk. This point then helps define the others around to complete the risk matrix, see figure 6.

Increasing Severity

Over 200	**HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**
151 to 200	**MEDIUM**	**HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**
101 to 150	**MEDIUM**	**MEDIUM**	**HIGH**	**VERY HIGH**	**VERY HIGH**
51 to 100	**LOW**	**Me!!**	**MEDIUM**	**HIGH**	**VERY HIGH**
Below 50	**LOW**	**LOW**	**MEDIUM**	**HIGH**	**VERY HIGH**
	Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000

Increasing Likelihood

Figure 6 - Completed risk matrix

Presenting the Covid-19 risk matrix

Returning to the start of this paper, it is judged that a risk communication method is developed that is simple and non-narrative, with an element of ownership by the member of public. Therefore, as a final development on the matrix, the method of calculation for each of the scores is added to the axis's labels, see figure 7.

Severity score = Age + BMI + Cigarettes + Health Factor

Over 200	**HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**
151 to 200	**MEDIUM**	**HIGH**	**VERY HIGH**	**VERY HIGH**	**VERY HIGH**
101 to 150	**MEDIUM**	**MEDIUM**	**HIGH**	**VERY HIGH**	**VERY HIGH**
51 to 100	**LOW**	**Me!!**	**MEDIUM**	**HIGH**	**VERY HIGH**
Below 50	**LOW**	**LOW**	**MEDIUM**	**HIGH**	**VERY HIGH**
	Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000

Likelihood score = Local infection rate x Size of personal bubble (x 2 if BAME) ÷ Mask Factor

Figure 7 - Completed Covid-19 Risk Matrix

Usefulness of the Covid-19 risk matrix

The key to the usefulness of the Covid-19 matrix is the explicit appreciation that this is only a risk scoring model – it does not present real quantified probabilities, likelihoods or risks of death.

What the Covid-19 calculation matrix can do is to enable an individual audience member (member of public, student or worker) to take easy ownership of the calculation to see their own relative risk position. The earlier coined phrase 'possession leads to persuasion' is absolutely critical. The matrix can then be used as a key communication tool such that all stakeholders can understand individual risk in a social or workspace.

The way that the matrix scores have been developed does give the individual opportunity to carry out some self-help risk-reduction strategies in both the severity and likelihood domains – for example, reduction in bubble size and increasing mask use.

A series of exemplars can be demonstrated:

Example 1: Victoria is 15 years old in Bristol (infection rate of 11 on 16th Sept 2020 [22]), with a BMI of 21 and is due to go to school with a bubble size of a whole school year group of 220. Masks are not compulsory. She is not BAME, but does have reduced heart function from infant open heart surgery, and does not smoke!

Likelihood Score = 11 x 220 = 2420 (no mask factor and no BAME)

Severity Score = 15 + 21 + 50 = 65

Victoria's Risk Score position is as shown in figure 8 below;

Severity score = Age + BMI + Cigarettes + Health Factor	Over 200					
	151 to 200					
	101 to 150					
	51 to 100				**VICTORIA**	
	Below 50					
		Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000
		Likelihood score = Local infection rate x Size of personal bubble (x 2 if BAME) ÷ Mask Factor				

Figure 8 - Risk Score for Example 1 - Victoria

In this case, Victoria ends up in the 'HIGH' risk position. She could then decide how to positively reduce the risk that she is exposed to. As an individual, she can have no effect on her age, health condition, or the local infection rate. Her obesity measure is also already within an acceptable range, so should not be reduced. As such she cannot influence her severity score' she can take steps to reduce her likelihood score; she could opt to wear a mask, or she could reduce her bubble size so as to.

Using a mask would reduce the severity score from 2420 to 484, which moves Victoria one step to the left moving her into the HIGH risk class. A reduction in bubble size down to a school class size of 30, would also further reduce the likelihood score from 484 to 66. Employing both mitigations would reduce the severity score from 2420 to 66, which moves Victoria's personal risk score from HIGH to MEDIUM.

Example 2: Paul is aged 51 in Bradford (infection rate 88), with a BMI of 32, he smokes an average of 20 cigarettes per day and works in an office of 40 people. He doesn't like wearing a mask. He doesn't have any underlying medical conditions, but is of BAME ethnicity.

Likelihood Score = 88 x 40 x 2 = 7040 (no mask factor)

Severity Score = 51 + 32 + 20 = 104

Paul's Risk Score position is as shown in figure 9 below;

Severity score = Age + BMI + Cigarettes + Health Factor						
	Over 200					
	151 to 200					
	101 to 150				PAUL	
	51 to 100					
	Below 50					
		Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000
		Likelihood score = Local infection rate x Size of personal bubble (x 2 if BAME) ÷ Mask Factor				

Figure 9 – Risk Score for Example 2 = Paul

In this example, there are also harm reduction strategies available. Paul could start wearing a mask, he could reduce his bubble size at work, by for example, working from home (bubble size = 6); and he could improve his obesity score through the BMI measure (down to 30), and perhaps reduce smoking (down to 10). He can't change his age or ethnicity.

Likelihood Score = 88 x 6 x 2 / 5 = 211

Severity Score = 51 + 30 + 10 = 91

Paul's new risk matrix position is as shown in figure 10.

Severity score = Age + BMI + Cigarettes + Health Factor						
	Over 200					
	151 to 200					
	101 to 150				PAUL (old)	
	51 to 100			PAUL (new)		
	Below 50					
		Less than 10	10 to 100	100 to 1000	1000 to 10000	Over 10,000
		Likelihood score = Local infection rate x Size of personal bubble (x 2 if BAME) ÷ Mask Factor				

Figure 10 – Risk Score for Example 2 - New Paul

As already highlighted, it is not in the scope of this paper to mandate whether particular harm reduction strategies are adopted or not – for Paul, Victoria or anyone else. The concept of the paper is to allow the use of the matrix in order for any individual to understand and communicate their risk position and then, potentially for them to take some possession of managing their risk exposure.

Conclusion

Public understanding and communication strategies concerning Covid-19 risk and harm reduction strategies are identified as needing some level of improvement. People need clear messaging and behavioural advice and when considering decisions to be made, possession leads to persuasion. This paper produces a usable Covid-19 risk matrix that allows individual members of society to calculate their own relative personal risk position in social, educational and work locations, such that they are able to make rational decisions on harm reduction.

Further Work

The remaining work in this particular research is to back-validate the exact positions of risk classes in the Covid-19 risk matrix through analysis of real patient data. However, the availability of all the data types (e.g. time-stamped local infection rate, BMI, health conditions, personal bubble sizes, etc.) as personal demographics that are linked to clinical outcomes, is a difficult data set to develop in the immediate term.

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