Lotteries, Covid, and Communicating Risk

Wayne Oldford

May 1, 2022

Two sides of the same coin?

A few years ago, I was the "go to guy" at the University of Waterloo, asked to speak to local media, whenever a lottery jackpot got stupendously large (and the news cycle got exceedingly slow). My purpose was to relate to their audience **the size of the chance** of winning in a way that was quick yet comprehensible, which I did with some success on local radio and television stations.

Inevitably, though, the next day I would hear back of listener disappointment – that some of the fun of purchasing a ticket had been removed. **Joy came from anticipating winning the prize** and my exposition killed that for many, by them having gained an appreciation of the chance of actually winning.

I felt a little bit bad about this. I wanted people to understand the probabilities but I didn't want to be a kill joy.

To me, the pleasure just from anticipating the grand prize could very well be worth the ticket price, provided the price was right. Any person could, and should, **make that call for themselves** – my goal was simply that the person making the **choice be well informed**.

Over the past two years, we have been faced with something similar. This time the low probability is associated with **something we don't want** – **death from Covid-19** – hope replaced by fear, based on anxiety felt from imagining our, or a loved one's, possibility of death.

As with the lottery, people are willing to pay a price commensurate with the outcome. As hope, or fear, increases, people more willingly pay a higher price to gain, or avoid, the outcome.
Individuals vary, as will the prices they are willing to pay; in my view, in both cases, the choice should be left to the individual. Whatever the choice, **it should be an informed one**, one with a clear **appreciation of the chances** involved.

Just as the large lottery prize makes the chance of winning more likely in our imagination than it really is, the enormity of our possible death also makes its chance of occurrence loom very large in our mind.

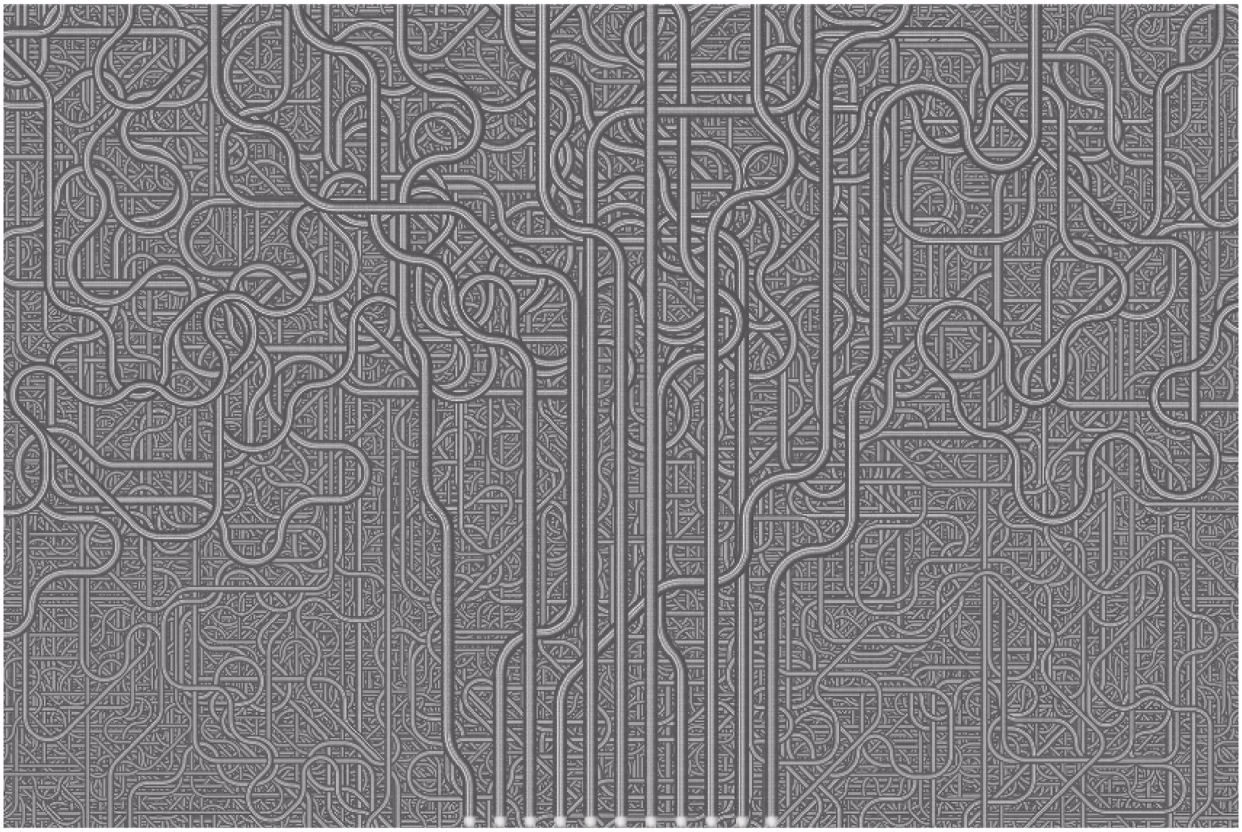
One in a million is hard to comprehend

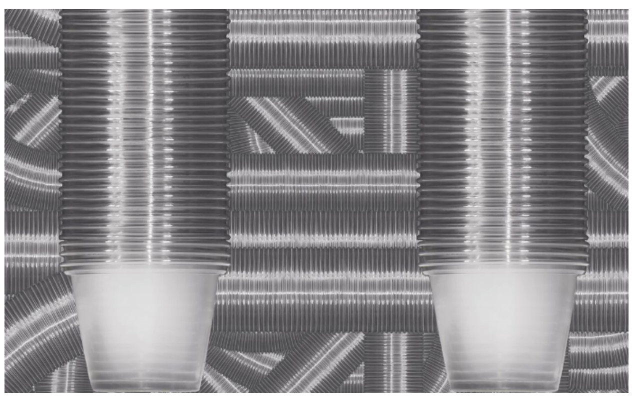
One problem is that we humans are not well equipped to comprehend very small numbers (or very big ones).

After all, what in our evolutionary history would have selected for this ability? One could imagine there to have been reproductive advantages to understanding a half of something, or a third, or a quarter, or even an eighth, but not likely much selection pressure, if any, to truly comprehend, say, one in a million.

It is difficult even to imagine the magnitude of, the totality that makes, one million of anything. It cannot even be reckoned directly, taking, as it would, at one per second, more than 11 days of non-stop counting.

The photographic art of Chris Jordan might give some idea. The image below is a screenshot from the interactive (zoomable) work called *Plastic Cups, 2008* from Chris Jordan's "Running the Numbers: An American Self-Portrait" website.





According to the artist, one million clear plastic cups (mostly seen only by their rims) are shown stacked together to create this picture of "pipes"; this is apparently the number of plastic cups that in 2008 were used on airline flights in the US every six hours.

To appreciate how many is a million, we need to comprehend **all** of the individual cups that went into this picture **at once**. This is difficult in the still picture above, but the detail shown helps a bit. A better appreciation is had by zooming and panning on the interactive one to explore the collection in its entirety.

To get a sense of **"one in a million"**, imagine that in this picture, **exactly one cup has your name written on its bottom** (which of course you do not know and cannot see) – it could be any cup in the picture. Then imagine selecting any single cup of your choice in the picture; the chance that it will have your name on its bottom is one in a million.

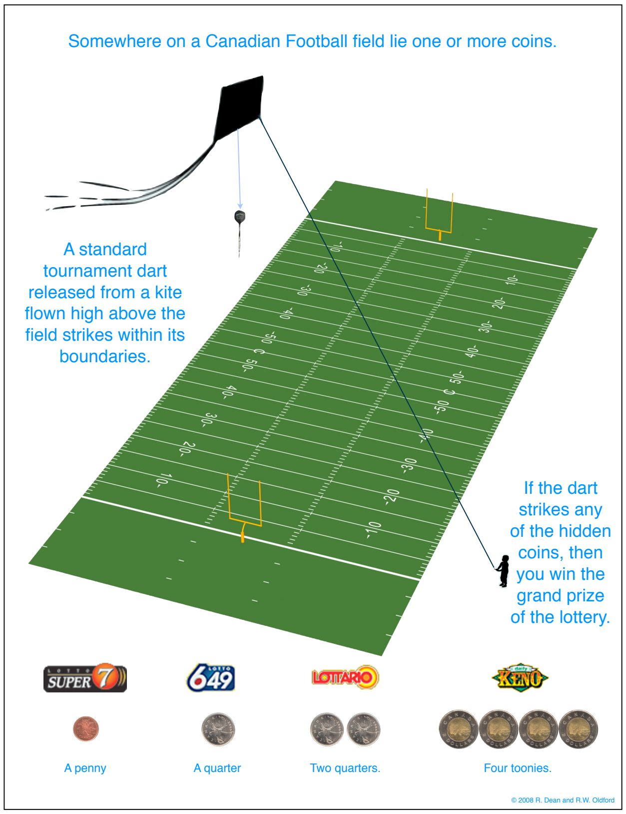
When numbers get too small, it becomes difficult to truly comprehend their differences. The smaller they get, the more alike they seem. At some point, exactly how small they are becomes lost on us; beyond some threshold they are all just, well, really really small. Again, the same may be said for extraordinarily large numbers.

Unfortunately, our modern society requires the informed citizen to understand both very very small fractions and very very large numbers. And this is not a problem for which we are naturally equipped.

Chance and probability

Back in 2008, Rachel Dean (then a graduate student) and I decided to create visual representations of the small probability of winning the grand prize in various Ontario lotteries. The challenge was twofold – to convey both just how tiny is the probability of winning **and** the nature of chance, or probability, itself.

For example, we presented the imaginary scenario shown in the figure below.



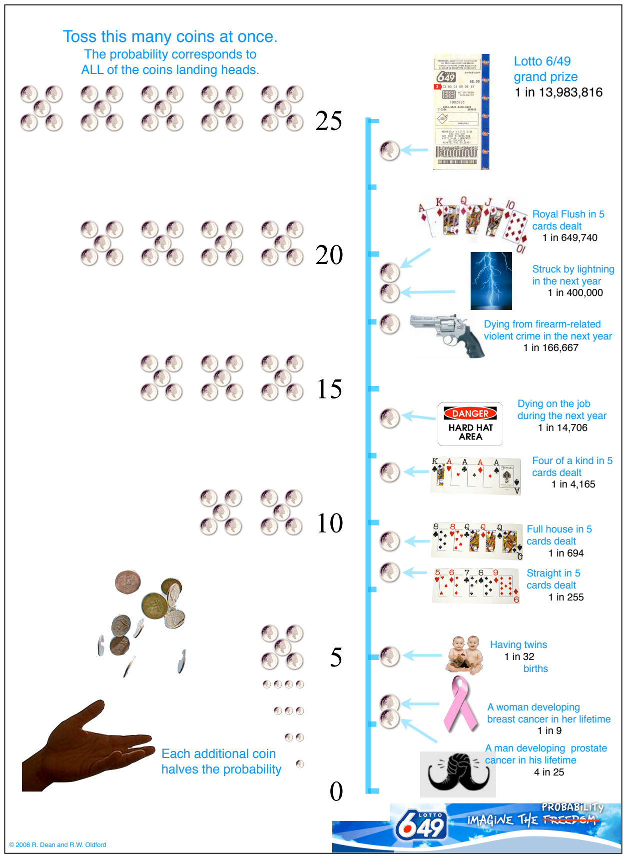
A Canadian football field is of a standard size (both longer and wider than an American one) which should be somewhat familiar to Canadians, as should the sizes of various Canadian coins. The ratio of the area of the coins to the football field is approximately the probability of winning. The random chance of hitting the spot where the coins lay hidden is conveyed by imagining dropping a dart onto the field from the air.

Winning the grand prize in *Lotto 6/49* has probability 1 in 13,983,816 (about 14 of Chris Jordan's "Plastic Cups" displays end to end). This chance of winning roughly corresponds to expecting to have a dart dropped from the air onto a Canadian football field and hitting a single Canadian quarter (about the same size as a US one) hidden somewhere on it.

For comparison, the coins (and their number) appear for the probabilities associated with winning the grand prize of other lotteries. Winning the grand prize for *Lottario* has about the same chance of hitting one of two quarters hidden somewhere on the field. **Relatively**, you were **twice as likely** to win the grand prize of *Lottario* as that of *Lotto 6/49*; however, in an **absolute** sense **you still had to hit one of the two quarters hidden on the field . . . with a dart!** *Keno* was by far the greatest – the equivalent of hitting any one of 4 two dollar coins (toonies); *Super 7* was the least – corresponding to striking a single penny (which no longer circulates but was slightly larger than a dime).

To better convey actual probabilities, consider a more familiar random device – **tossing a fair coin**. Tossing it once, the probability it lands heads is $\frac{1}{2}$. Tossing it twice, the probability that it lands heads both times is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$. A similar calculation holds for having any number of independent tosses **all land heads**; for example 10 tosses yields 10 heads with probability $\left(\frac{1}{2}\right)^{10}$.

The number of coin tosses each of which must produce "heads" can be used as a scale to compare probabilities. Below shows where various possible events occur on this scale (as determined from 2008 Canadian statistics).



The probability of winning *Lotto6/49* is about the same as 24 simultaneous fair coin tosses all landing heads. A chance of **one in a million** corresponds to about **20 out of 20 coin tosses all landing heads**. (Mathematically, the calculation of the number of heads for a probability p is $-\log_2(p)$ which is $19.93157 \approx 20$ when $p = 1/1,000,000$.)

Those more familiar with **rolling dice**, could do similar calculations to determine the corresponding number of times in a row a six must turn up – when rolling a fair six-sided die exactly that many times. For a six-sided fair die, **1 in a million** is about the same as rolling the die 8 times and getting a six every time.

(Aside: mathematically, the calculation for a 6-sided die is now $-\log_6(p)$ which is $7.710583 \approx 8$ for $p = 1/1,000,000$. The base of the logarithm is the number of sides of the die; so a 20 sided die would have to roll a 20 about 5 times ≈ 4.611731 as a rough guide. The actual value of $-\log_b(p)$ places the probability p precisely on a scale determined by rolling successive bs on a b-sided die.)

Other innovative ways to convey, and to compare, the chances of winning various lotteries can be found on the poster Rachel presented in 2008 (available here).

Micromorts

When our “prize” is death, and its probability is very small, a different scale was proposed in 1979 by R.A. Howard to convey the chance of dying. A **micromort** (MM) is a **one in a million probability of death**.

How is that helpful? Well, it turns out that (in many countries) the probability of dying on any given day from some accidental cause (that is not a disease, or a homicide, or self-harm, etc.) is about **one in a million**.

In Canada, using 2019 Statistics Canada data, there were 14,930 accidental deaths in a population of 37,589,262 residents over the calendar year 2019 having 365 days. That would give a chance of death for a resident in Canada on any particular day of

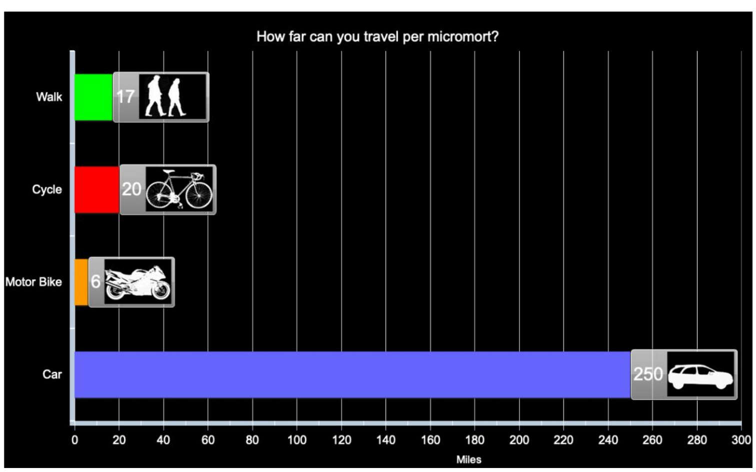
$$\frac{14,930}{37,601,230} \times \frac{1}{365} = 0.00000108784 \approx \frac{1}{1,000,000}$$

or about **1 micromort** (actually 1.09 MM). The chance of you dying on any given day from an accident, slipping and falling in the tub, being run over by a bus, etc. is about the same as picking the one cup with your name on the bottom in Chris Jordan’s *Plastic cups* or as tossing 20 fair coins in the air and all of them landing heads.

Of course, this is the chance for Joe, or Josephine, “average Canadian resident”. Individual results will vary, and if, for example, you are particularly reckless in your day to day living then your chance of dying from an accident might be higher. Indeed, based on the same Statistics Canada source, male residents have a daily risk of accidental death of 1.26 micromorts while females face only 0.91 micromorts of risk. Similarly, risks will be different for different age groups – more on this later.

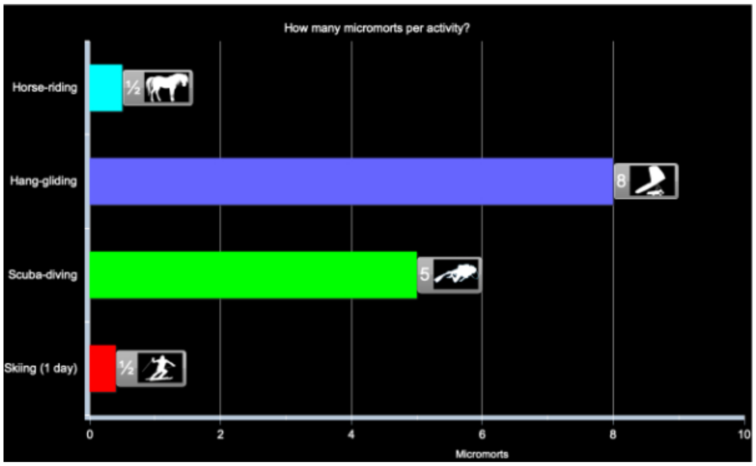
Understanding that a micromort is about the risk that you face dying from accident, on any day, provides a simple grounding to assess risks of all sorts of other activities. In their article “Understanding uncertainty: Small but lethal” David Spiegelhalter and Mike Pearson, using U.K. statistics at that time, used micromorts to compare a variety of activities.

For example, imagine a micromort as a unit of risk that could be spent. If you wanted to travel, but not incur any more risk than one might in a typical day, you could use data to give some idea of how far you might go depending on the mode of travel you chose. Putting the U.K. data together Spiegelhalter and Pearson produced the following chart.



For the equivalent daily danger of accidentally being killed in Canada, you could travel 250 miles (≈ 402 kilometres) by car, or, only 20 miles (≈ 32 kms) by bicycle.

Or, you might be trying to understand how dangerous some activities are, before you choose to engage in them. From Spiegelhalter and Pearson:

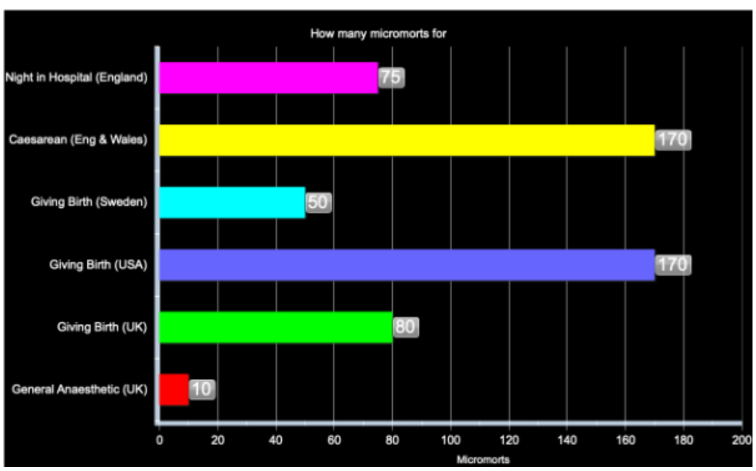


Of the four here, hang-gliding is 16 times more dangerous than is downhill skiing for a day (at least amongst those who participated in it to produce the data). This might seem alarming, but remember that this is comparing the **relative risks**.

Scuba-diving might be 10 times as dangerous as a day of skiing but it is equivalent to the danger you face in only 5 days of ordinary living – this is its **absolute risk** (your name on the bottom of 5 of Chris Jordan's plastic cups). Similarly, only 8 micromorts or days of accidental death danger living danger in Canada is the absolute risk of a hang-gliding activity.

Some people will consider these absolute risks to be a small and reasonable price to pay, just for the thrill and enjoyment of the activity. Others, of course, might not. The beauty of the micromort is that they now have a sense of just how dangerous the activity might be.

Similar comparisons could be made on the danger of different medical procedures. Spiegelhalter and Pearson offer the following chart:



According to this, giving birth in the U.S. is just as dangerous as having a Caesarean in England, but more than twice the danger of natural child birth there. These **relative risks** allow quick comparisons of the dangers faced by the women giving birth at these times in these countries. They do not, however, say **why** there is a difference. It could for example be the case that Caesareans are inherently more dangerous, or, it could be that none of these are elective in the U.K. and so the procedure is used only in already dangerous situations. The data here does not say either way.

The same is true for the **absolute risks**. A great many people undergoing general anesthetic, or spending a night in an English hospital, might already be in grave medical condition. Electing, as a healthy person, to stay overnight in the hospital, or to undergo general anesthetic for a dare, does not necessarily incur the same danger as 75 and 10 days of ordinary living.

Death from Covid-19

With this understanding of chance and the micromort as an interpretable measure of the danger of dying, we turn to looking at the danger faced by Canadians from Covid-19.

The Statistics Canada source gives data on the first year of Covid when fear was at its greatest and the lockdowns were first imposed. This is largely pre-vaccine data. This data would have been available on an ongoing basis throughout the year and for the whole of 2020 by early in 2021.

For 2020, the total number of accidental deaths was 15508 and the population had grown to 38037204. Being a leap year, daily risk will require dividing by 366 for 2020. Doing this calculation, the 2020 daily risk due to accident is still about 1 micromort (in spite of lock-downs) or, more precisely, 1.11395108587512 micromorts.

A similar calculation can now be made for the **daily deadly risk in 2020 due to Covid-19**. The number of Covid-19 deaths recorded in 2020 across the country was 16151. Dividing this by the 2020 population of 38037204 yields an **annual** risk of about 424.61 micromorts. Dividing now by 366 (as 2020 was a leap year) gives a **daily** risk of about 1.16 micromorts.

This is very **nearly identical to that due to accidental death** – both are effectively about **1 in a million**. Together, in 2020 in Canada, the daily risk of dying from an accident **or** from Covid-19 was "accidental death" + "covid death" $\approx 1.114 + 1.16 \approx 2.274$ micromorts.

That is, putting the two together, in 2020 Canada, Covid-19 changed the daily living deadly risk to everyone from about 1 to about 2 micromorts – your name is now on the bottom of **two** cups in Chris Jordan's *Plastic Cups*!

(Aside: A student of probability might note $Pr(A \text{ or } B) = Pr(A) + Pr(B) - Pr(A \text{ and } B)$. In the case of A = "accidental death" and B = "death from Covid-19", $Pr(A \text{ and } B)$ is either zero by definition or approximately zero in fact. Worst case, $Pr(A \text{ or } B) = Pr(A) + Pr(B)$ exaggerates the additional effect of Covid-19.)

One way to make this **scary** would be to report that the "average" Canadian's background **probability of death** on any given day **doubled in 2020** due to Covid-19! Yet another would be to report the increase in **relative risk** to Canadians in 2020 compared to 2019; this would be

$$\frac{\text{Absolute Risk in 2020} - \text{Absolute Risk in 2019}}{\text{Absolute Risk in 2019}}$$

or approximately (2.274 - 1.088) / 1.088 $\approx$ 1.09. Expressed as a percentage, this would be **a 109% increase in relative risk in 2020**!

Such reporting of **increases in relative risk is arguably misleading in this case**. Much **more meaningful is the absolute risk**, that is, the probability of death on any given day due to Covid-19 (alone) for the "average" Canadian in 2020. The **absolute risk** daily was about the same as tossing 20 coins in the air and having them all land heads.

(Mathematical aside: For those curious about the probability of **not** dying from Covid-19 over the entire (leap) year, it is simply the product of the probabilities of surviving every day. In 2020, $p = 1.16$ micromorts = 1.16/1,000,000 is the daily probability (or absolute daily risk) of dying from Covid-19, and so the probability of not dying that year would have been

$$(1-p) \times (1-p) \times \cdots \times (1-p) = (1-p)^{366}$$

which evaluates to 0.999575, or 99.9575% survival rate that year. As one might expect, this is nearly identical to the proportion of Canadians who **did not die of Covid-19** in 2020.)

"Average" Canadian?

Is anyone an "average Canadian"?

We are not all equally reckless or accident-prone, so our risks will not be the same. The above analysis is fairly low-resolution. A finer resolution analysis would take account of varying "risk factors", those that distinguish one person, or group of people, from another.

Sex

The same Statistics Canada data provides numbers for each sex. For example, the daily deadly risk due to accidents in 2019 and 2020 is 0.91 and 0.89 micromorts, respectively, for Canadian females and 1.26 and 1.34 micromorts, respectively, for Canadian males. Clearly, in Canada males face more deadly danger due to accidents than do females.

What about deadly daily risk from Covid-19 in 2020? For females it is 1.19 micromorts compared to 1.13 micromorts for males. Now females appear to have faced a greater danger than do males!

The difference between the two sexes is even greater when one compares the risk of death from covid compared to accidental death. For **females**, the daily probability of death due to Covid is 1.33 times larger than due to accident in 2020. For **males**, the daily probability of death due to Covid is only 0.84 times the size.

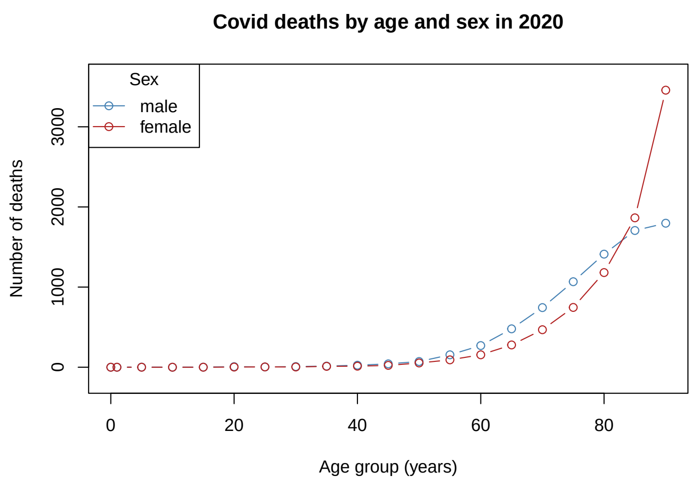
For **males**, the daily risk of death from Covid was **less** than the risk they faced from accidental death (in a time of lock-down), about 16% **less**. In contrast, the **females** faced a daily risk 33% **greater** of dying from Covid than from an accident.

Still, the **total absolute risk** of death faced daily from accident **or** Covid by each sex as only 2.09 micromorts for females and 2.46 micromorts for males.

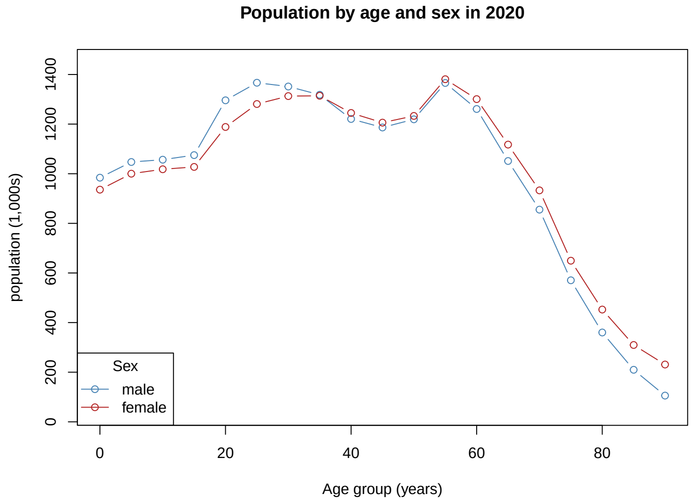
Sex and age

Since the earliest days of the pandemic, it has been known throughout the world that Covid has been deadlier among older than among younger people. Age has been one of the best predictors for Covid death (that and comorbidities).

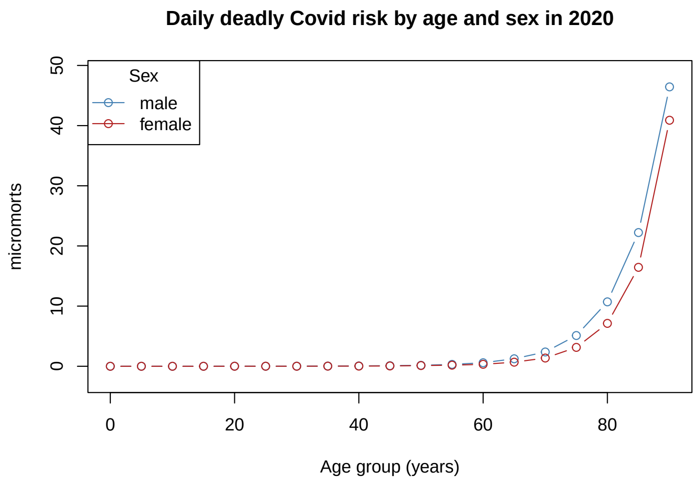
From the Statistics Canada data for 2020, we can plot the number of deaths for each age group for each sex.



One suspects that the reason there are more female deaths in old age than males, is simply that there are more females than males in old age. The populations are graphed below.



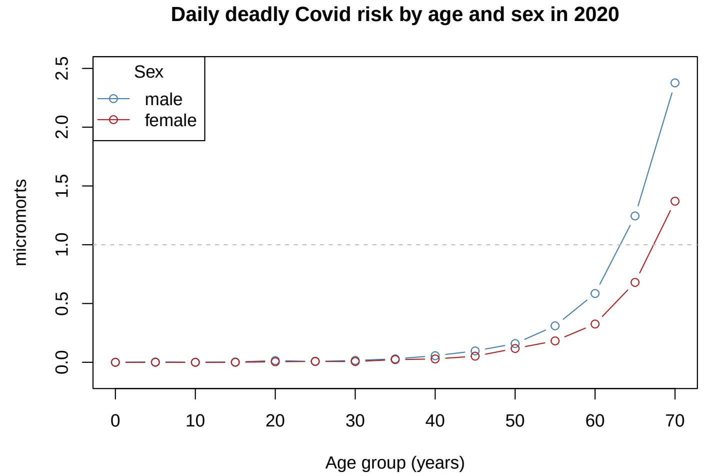
Putting these together, a daily deadly risk due to Covid-19 can be calculated in terms of micromorts (millionths of a chance of dying). As before, divide the number of deaths by the population, then divide again by 366 (leap year). Multiply by a million to get the number of micromorts.



After taking population into account, it is clear that

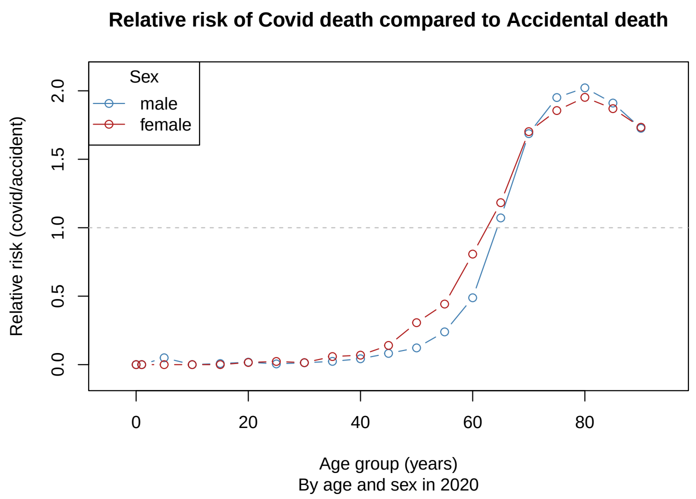
- males are uniformly at a greater risk than females
- the daily deadly risk of Covid is more than 40 micromorts for those 90 years old or more.
  - 20 micromorts is about the same probability as tossing 20 coins and having exactly 19 of them land heads
  - 40 micromorts (probability of 40 in a million) is about the same probability as tossing 20 coins and having exactly 19 of them being of one side (heads or tails) and 1 coin being the opposite.
- the risk seems very low for younger people

To check the latter point, we plot the values only for those 70 and under:



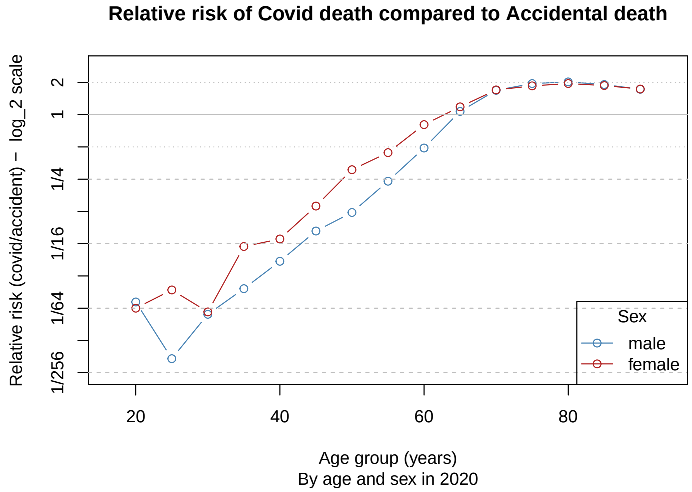
The deadly daily risk due to Covid in 2020 was **less than 1 micromort for any one under 60** and **nearly zero for anyone younger than 50**!

Comparing accidental death The relative risk of covid-19 death to accidental death can be determined by the ratio of their respective counts. The corresponding graph is below.



For both males and females, it is much more likely to die from an accident than from Covid-19 for anyone in their early 60s or younger. People in their late 60s run the same risk from Covid as from accidental death. For those 70 or older, dying from Covid was more likely than dying from an accident and this maxes out at about twice as likely in the late 70s and early 80s.

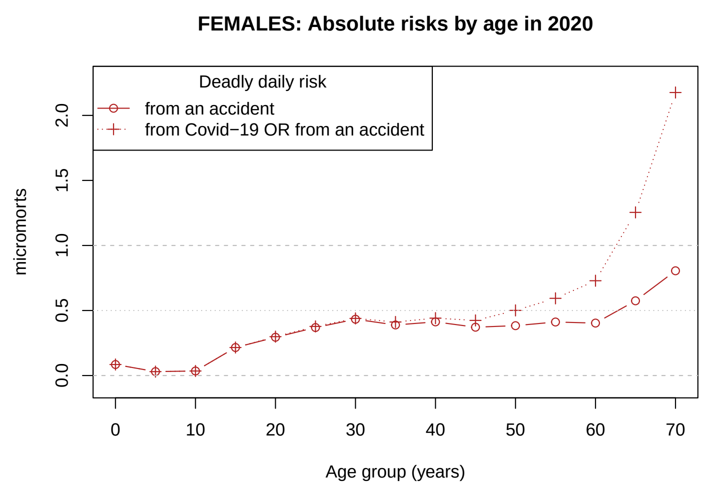
One problem with the above plot is that it exaggerates the effect on old people and minimizes the effect on younger people. For example, the a covid to accident ratio of 2 looks much farther from to equal effect line of one than does the ratio 1/2 – whose effect is just as large, but in the opposite direction. To have the visual effect match the actual effect, we can just stretch the vertical axes in places and relabel it with powers of 2, as below.



Now the farther a point is from the horizontal line at 1 (equal death rates), the greater is the effect. For example, an 80 year old man (or woman) was about twice as likely to die from Covid-19 as from an accident. In contrast, a 60 year old man was twice as likely to die from an accident from Covid. Both points are now the same distance from the equal chance ratio of 1.

In this plot, one can more easily see that the younger the age group the **many more times likely was death from an accident** than from Covid – e.g., a 40 year old woman was 16 times more likely to die from an accident than from Covid-19!
Almost all **age groups younger than 20 cannot even be displayed like this because they had zero Covid-19 deaths** but non-zero accidental deaths. Conservatively, **those under 40 had many more than 16 times the deaths from an accident than they had from Covid**.

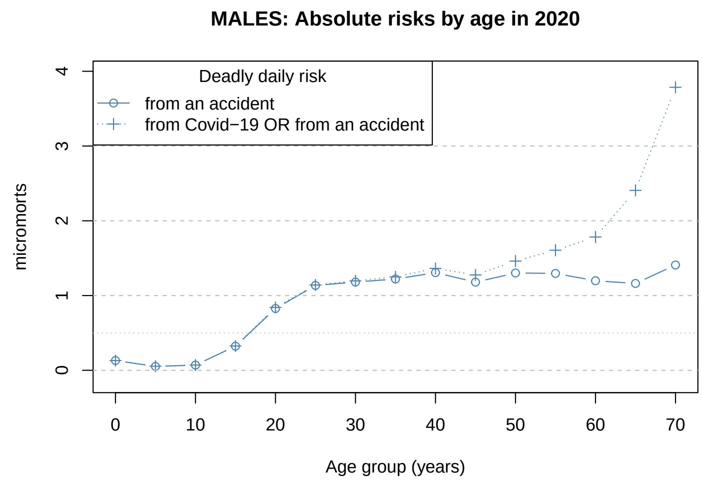
One can also compare the change in absolute risk by plotting the deadly daily risk for accidental risk and the increased risk because of Covid. Below just looks at those females aged 70 or less.



Females faced relatively low risks up to age 60.

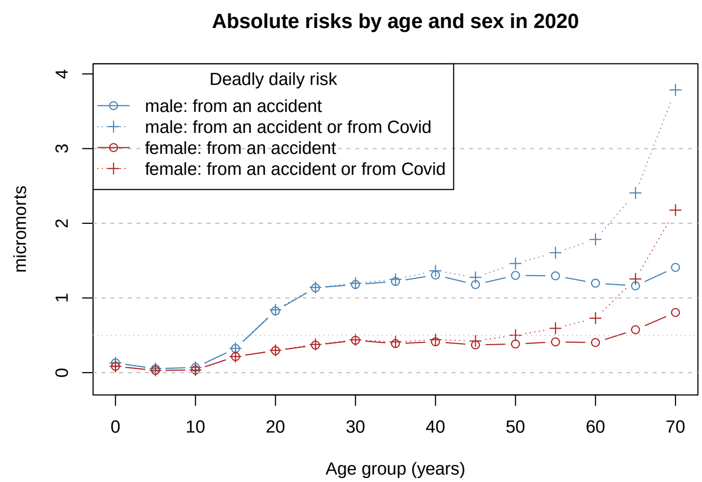
- Note that a micromort of 0.5 has approximately the same probability as tossing **21** coins and all of them landing heads.

In contrast, males aged 70 or less face greater daily risks.

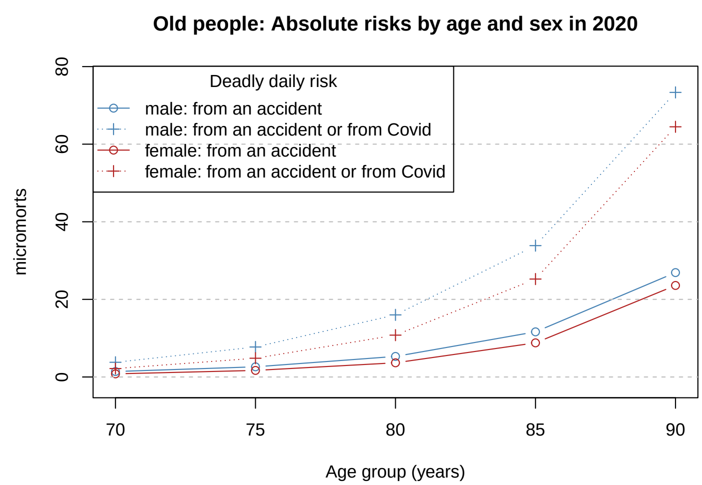


For either sex under 50, Covid-19 adds very little extra risk above accidental death.

Putting the previous two plots together:



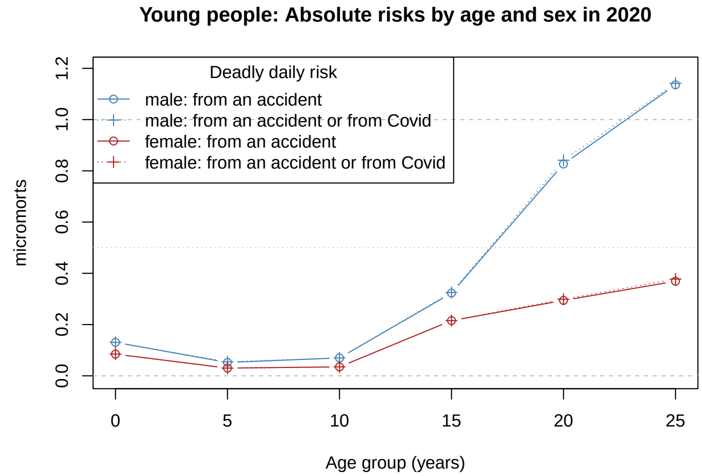
For those **70 or older**, the curves of absolute risks look like:



Clearly, **Covid-19 was a problem for the aged**. For people 90 or older, Covid has roughly tripled the daily risk of dying (compared to accidental death).

- 60-70 micromorts has about the same probability as tossing 14 coins in the air and all of them landing heads. Roughly, the probability of a 90 year old woman dying from an accidental death OR from Covid, according to the Statistics Canada 2020 data.

Finally, zooming in on those under 30



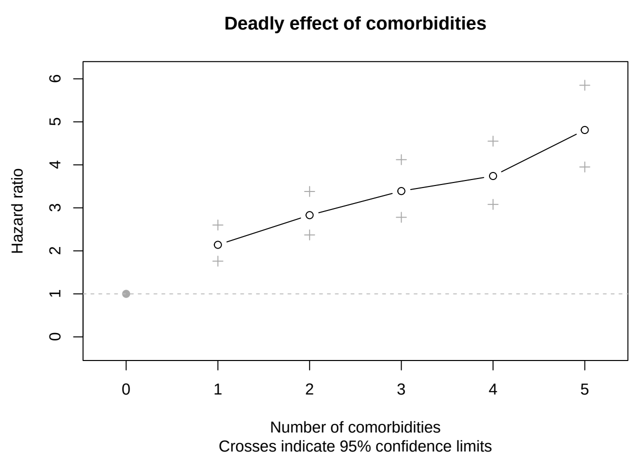
One wonders why people in this age group should be concerned at all.

Other factors

Again, there are many more differences between people and how they might be affected in any circumstance, including disease. In a relatively recent study (October 2021, Ontario study on comorbidities – 2020 data), the authors consider a vast host of individual factors that might possibly affect the outcome.

Theirs was a population based study based on *"all individuals with COVID-19 in Ontario, Canada diagnosed between January 15 and December 31, 2020"*. By linking different data sources, they were able to investigate the effect of sex, age, various comorbidities (e.g., diabetes, cardiovascular diseases, chronic obstructive pulmonary disease, severe mental illness, cancer, hypertension, organ transplant, and others). They were also able to determine the approximate income level (to which quintile of the population income range).

They found that, age and sex were the most important factors, followed by comorbidities. In fact, after taking the other factors into account, they isolated the effect of the **number of comorbidities** in their modelling. The **relative** effect of the number of pre-existing comorbidities on the mortality of the patient with covid, expressed as something called a **hazard ratio**. The effect is shown in the plot below:



Roughly, the hazard ratio is a multiplier. Whatever the probability of death from covid would be for a person having **no** comorbidities, you would multiply it by the appropriate hazard ratio for however many pre-existing comorbidities an infected person had. From the above plot, having one comorbidity would roughly double the chance of dying; 2 might triple it, and so on.

Of course, the caution of relative comparisons remains. These ratios are a good way to sort out the **relative** importance of the factors to the outcome, but do not tell you how likely death would occur. Again, doubling or trebling a very small probability of death may still result in a very small probability of death.

The authors found that the effect of comorbidities was most pronounced among younger people and had little effect on anyone over 80.

They conclude that

> *"solid organ transplant, dementia, chronic kidney disease, severe mental illness, CVD, hypertension, COPD, cancer, diabetes, rheumatoid arthritis, HIV, and asthma were associated with mortality or severity. Our study highlights that the number of comorbidities was a strong risk factor for deaths and severe outcomes among younger individuals with COVID-19."*

The evidence clearly suggests that **any covid prevention should prioritize by age, number of comorbidities, and sex**.

That was then ... this is now

A lot has changed since 2020 – new variants of the virus have emerged and vaccines have been made available (and often mandated).

New variants

The most recent "Omicron" variant has been observed to be more highly transmissible but far less deadly than the original variant (as would be predicted by evolutionary theory for any virus).

For example, a recent medrxiv preprint compared outcomes of people infected with "Omicron" to those of people infected with the "Delta" variant. The authors determined the hazard ratio of death due to Omicron to be about one-fifth that of Delta (HR = 0.21 with 95% c.i. of 0.10-0.42) and concluded that their

> *"findings demonstrate that the Omicron SARS-CoV-2 variant is associated with substantially [less] (sic) severity of illness in comparison to the Delta variant."*

As Omicron is currently the dominant variant, any **deadly daily risk now due to Covid-19 appears to be significantly lower than that of 2020**, possibly around 80% lower (i.e. multiply by 1/5). This was also reported in a January 12, 2022 tweet by Rochelle Walensky, Director of the CDC (though her even lower figure of 91% reduction in the risk of death comes from the first version of the paper which had reported 0.09 in place of 0.21).

Vaccines

During 2020, vaccines were developed at "warp speed", taking a matter of months rather than the average ten years. By November 2020, media reported Pfizer's vaccine was 95% effective.

(Aside: The Pfizer vaccine was made available in December under an "Emergency Use Authorization" which, under the PREP Act, also indemnified Pfizer against liability if something goes wrong. The same holds in other countries, including Canada.)

"95% effective" What that **"95% effective" actually means** and **what the public thinks it means** might be two very different things. The New England Journal of Medicine published study was a randomized trial with the following results:

- 18,198 received two doses of the Pfizer vaccine (BNT162b) and 8 people developed Covid-19 (i.e. symptoms and positive test);
- 18,325 received two doses of placebo and 162 of these developed Covid-19.

The **absolute risk** of **getting** Covid-19 (over the length of the study) was

- $AR_{vaccine} = 8/18198 = 0.0004396$, or about0.044% for those **vaccinated**, and was
- $AR_{placebo} = 162/18325 = 0.0088404$, or about 0.884% for those who were **unvaccinated**.

Both are very low probabilities, though the vaccinated probability is much smaller than the unvaccinated. To see how much smaller, we calculate the **relative risk**

$$RR = \frac{AR_{vaccine}}{AR_{placebo}}$$

to be 0.0497273, or about 1 in 20 – which means that, in the Pfizer study, **the absolute risk of getting Covid if vaccinated was about one twentieth that of the unvaccinated**.

(Note: With respect to the **deaths** observed during the study (6 out of 36,523; 2 in vaccine group, 4 in placebo), the authors reported

> *"No deaths were considered by the investigators to be related to the vaccine or placebo. No Covid-19–associated deaths were observed."*

The effectiveness of the Pfizer vaccine was based on whether, and by how much, it reduced the chance of **developing Covid-19**.)

There are a variety of ways to report the effectiveness of the vaccine. Authors of Smart Health Choices: Making Sense of Health Advice (from the The U.S. National Institute of Health's National Library of Medicine website) recommend:

> *"Absolute risk reduction (ARR) – also called risk difference (RD) –* ***is the most useful way of presenting research results to help your decision-making****." (emphasis added)*

For the Pfizer vaccine study, the absolute risk reduction

$$ARR = AR_{placebo} - AR_{vaccine}$$

was 0.0084008. That is, the Pfizer vaccination was estimated to have pushed down the probability of developing Covid-19 from 0.0088, or 88 in 10,000, down to 0.0004, or 4 in 10,000 – **a risk difference of 84 in 10,000**.

If you imagine Chris Jordan's million plastic cups, in the Pfizer study the unvaccinated had 8800 cups with their names on the bottom while those vaccinated had only 400 cups with their name on the bottom – **8400 fewer cups out of a million**.

Another way to imagine the effectiveness of the vaccine is to calculate the number of people that would need to be vaccinated to have one less person develop Covid. This is called the "number needed to treat" or NNT. The authors of Smart Health Choices: Making Sense of Health Advice offer this simple example of its meaning:

> *"For instance, supposing that a well-designed randomised controlled trial in children with a particular disease found that 20 per cent of the control group developed bad outcomes, compared with only 12 per cent of those receiving treatment. Should you agree to give this treatment to your child? . . .*
>
> *"In this example, the ARR is 8 per cent (20 per cent - 12 per cent = 8 per cent). This means that, if 100 children were treated, 8 would be prevented from developing bad outcomes. Another way of expressing this is the number needed to treat (NNT). If 8 children out of 100 benefit from treatment, the NNT for one child to benefit is about 13 (100 ÷ 8 = 12.5)."*

Based on the Pfizer randomized controlled trial, **the number needed to be vaccinated (treated) to prevent one person developing Covid-19** would be 1/ARR = 1/0.0084008 (= 100 ÷ 0.8400773, using percentages) or about 119 people.

So where does the 95% effectiveness come from? This is the **efficacy** of a treatment, a measure of how much a treatment lowers the risk of an outcome, as measured by the reduction in the relative risk, the RRR. From Smart Health Choices: Making Sense of Health Advice:

> *"For technical reasons, some other measures are often used. . . .*
>
> *"Relative risk reduction (RRR) tells you by how much the treatment reduced the risk of bad outcomes relative to the control group who did not have the treatment."*

For the children example from Smart Health Choices: Making Sense of Health Advice, the relative risk was RR = 12 / 20 = 0.6, so the relative risk reduction was RRR = (20 - 12)/20 = 1 - RR = 1 - 0.6 = 0.4 or 40%.

For the Pfizer study, then, the **relative risk reduction was 95 percent** (RRR = 1 - RR = 1 - 0.0497273 = 0.9503). This number is the one widely reported, though ARR or NNT might be better measures on which to base personal decisions about whether to be vaccinated.

The U.S. FDA required that the manufacturer of any Covid-19 vaccine demonstrate its efficacy (i.e., RRR) to be at least 50%. The efficacies of the various vaccines were widely reported with Pfizer's topping the list.

However, as early as April 2021, researchers pointed out in Lancet (Microbe) that the elephant (not) in the room was that *"[d]epending on how the effect size is expressed, a quite different picture might emerge."*. They write:

> *"Although the RRR considers only participants who could benefit from the vaccine, the absolute risk reduction (ARR), which is the difference between attack rates with and without a vaccine, considers the whole population. ARRs tend to be ignored because they give a much less impressive effect size than RRRs: 1 · 3% for the AstraZeneca–Oxford, 1 · 2% for the Moderna–NIH, 1 · 2% for the J&J, 0 · 93% for the Gamaleya, and 0 · 84% for the Pfizer–BioNTech vaccines."*

It is possible for two treatments with the same RRR to have quite different ARRs (and hence NNTs), depending on the background risk; $ARR = RRR \times AR_{background}$ where $AR_{background}$ denotes the "background" absolute risk being compared (i.e., this would be $AR_{placebo}$ in above definitions). The Lancet article gives an example of a medical study having an RRR of 94% (about the same as Pfizer's RRR) but with NNT of 217 (compared to Pfizer's 119).

Had ARR or NNT been used as a measure of effectiveness, the Pfizer vaccine would have performed worst of the five the Lancet article considered. As the authors argue, **both** RRR and ARR (or NNT) should be used to determine "vaccine efficacy".

Other considerations

At this time, **vaccine effectiveness appears to be waning** and the vaccinated have been observed to both get and to transmit covid.
Yet, medical officers and public health officials have been recommending third (given in Ontario since December 3, 2021) and even fourth boosters, in spite of recent studies like that in Israel which suggests that a 4th vaccine dose not very effective against Omicron. Some senior FDA Vaccine Officials resigned over the increasing "politicization" of the regulatory process.

Adverse events in reaction to mRna vaccinations further complicate decision making, especially for different sex and age groups. For example, a recent JAMA article studied the CDC's passive reporting VAERS concluded that

> *"the risk of myocarditis after receiving mRNA-based COVID-19 vaccines was increased across multiple age and sex strata and was highest after the second vaccination dose in adolescent males and young men. This risk should be considered in the context of the benefits of COVID-19 vaccination."*

Due to the nature of the VAERS data collection, any increases reported here are likely under counted – a relatively accessible discussion of the JAMA article (as well as the recent deadly case of Brandon Watt of Cobourg, Ontario) was given by Chris Martenson on YouTube

Table 1: Daily deadly risk due to accident in micromorts

Age	Male	Female	All
All ages	1.34	0.89	1.11
0 to 4 years	0.13	0.08	0.11
5 to 9 years	0.05	0.03	0.04
10 to 14 years	0.07	0.03	0.05
15 to 19 years	0.32	0.22	0.27
20 to 24 years	0.83	0.29	0.57
25 to 29 years	1.14	0.37	0.76
30 to 34 years	1.18	0.43	0.81
35 to 39 years	1.22	0.39	0.81
40 to 44 years	1.31	0.41	0.86
45 to 49 years	1.18	0.37	0.77
50 to 54 years	1.30	0.38	0.84
55 to 59 years	1.30	0.41	0.85
60 to 64 years	1.20	0.40	0.79
65 to 69 years	1.16	0.57	0.86
70 to 74 years	1.41	0.81	1.09
75 to 79 years	2.62	1.69	2.13
80 to 84 years	5.30	3.65	4.38
85 to 89 years	11.63	8.80	9.94
90 years and over	26.90	23.59	24.63

In the JAMA study, the Pfizer product was most associated with higher risk. Pfizer (page 6) early on recognized the need to address them:

> *"Pfizer has also taken a [sic] multiple actions to help alleviate the large increase of adverse event reports."*

Any further discussion of adverse events would require a much deeper dive, and, well designed (likely, new) studies with long follow-ups to get reliable data. At present, the current passive reporting systems can only reliably provide the signal that deeper and objective investigation is warranted, particularly if the public is expected to give **informed consent** for these medical interventions. Data that would allow reasonable estimates of the absolute risks of various adverse events (including death) would be especially valuable.

Similarly, honest and serious questions have been raised about why vaccines should be the "only way out of the pandemic"; these need to also be honestly and seriously addressed.

Deadly risk calibration

Governments have for some time been reporting the absolute number of incidents associated with Covid-19 (e.g. number of cases, number of deaths). Sometimes they report these as cumulative to date (arguably the least valuable way to report).

Lately, some governments have been reporting the number of daily incidents per 100,000 of that population (typically, as a several day average which reduces the variability). When the incident is "death", then multiplying the "per 100,000" value by 10 gives the daily figure expressed in micromorts.

For example, the Ontario government report for April 13, for persons aged 18 to 39, showed a "per 100,000" daily death rate of 0.04 for those "not fully vaccinated", 0.0 for those "fully vaccinated", and 0.01 for those with a third (or booster) shot. This corresponds to a daily risk of 0.4 micromorts, 0 micromorts, and 0.1 micromorts, respectively. The deadly daily risk due to accident for people in these age groups can be read from Table 1 and ranges from 0.27 to 0.86 micromorts.

For any deadly risk, Table 1 provides a valuable comparison to daily risk of deadly accident.

Table 2: Converting micromorts to coin tosses and dice rolls

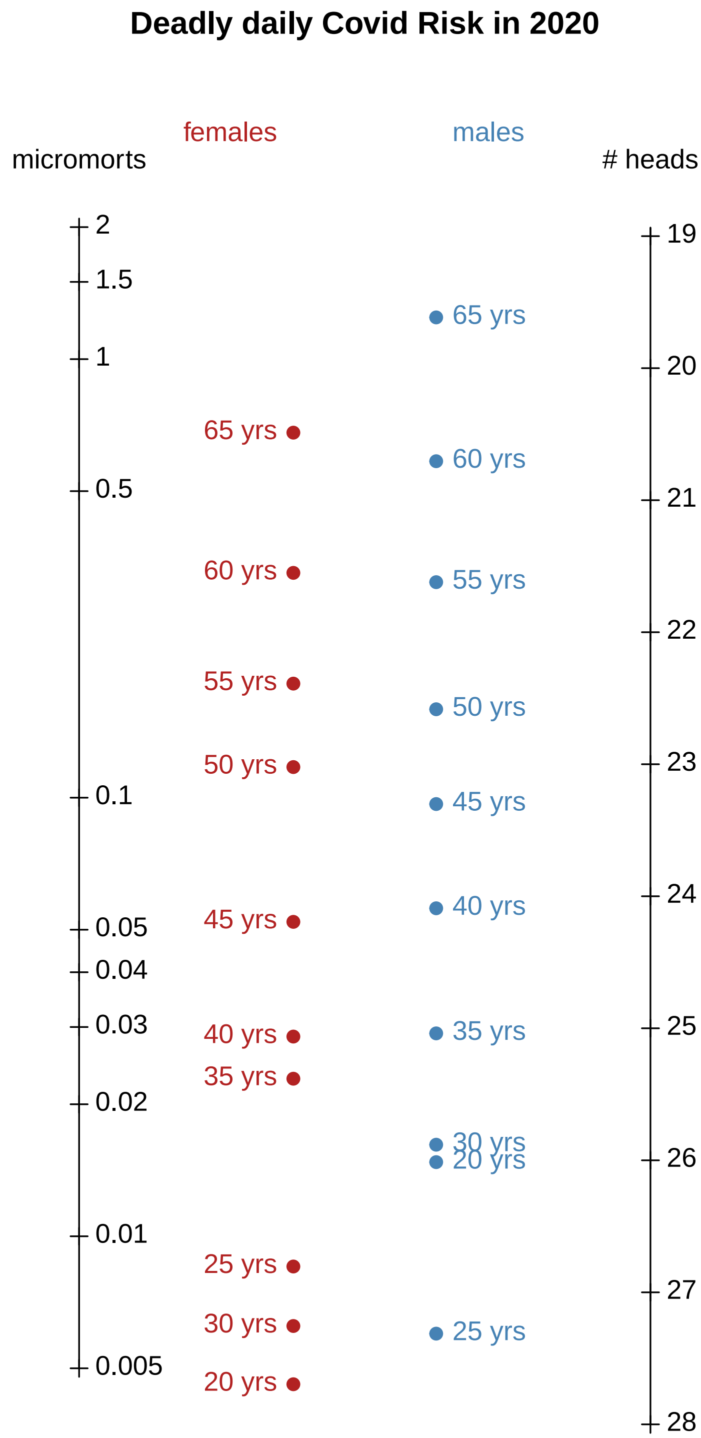
Micromorts	Heads	Sixes
0.01	26.58	10.28
0.02	25.58	9.89
0.03	24.99	9.67
0.04	24.58	9.51
0.05	24.25	9.38
0.06	23.99	9.28
0.07	23.77	9.19
0.08	23.58	9.12
0.09	23.41	9.05
0.10	23.25	9.00
0.20	22.25	8.61
0.30	21.67	8.38
0.40	21.25	8.22
0.50	20.93	8.10
1.00	19.93	7.71
1.50	19.35	7.48
2.00	18.93	7.32
3.00	18.35	7.10
4.00	17.93	6.94
5.00	17.61	6.81
10.00	16.61	6.43
20.00	15.61	6.04
30.00	15.02	5.81
60.00	14.02	5.43

Table 2 converts micromorts to equivalent number of heads that must be tossed in a row, or the equivalent number of sixes must be rolled in a row with a die.

In either case, the number is the equivalent number of tosses (determined in advance) which must land heads or as a six. So, a reading of 0.01 micromorts is about the same as 27 coins tossed in the air and **all** landing heads (actually a little over halfway between 26 and 27 coins), or, about the same as rolling a six-sided die 10 times and getting a six each time (actually a little lower probability than that but not as low as rolling 11 sixes in a row.)

Either table should be helpful in determining an understanding of published risks expressed as micromorts.

Finally, to return to the 2020 Canadian data, the following graphic



shows the deadly daily risk of Covid age groups from 20 to 65, separated by sex. The vertical position of any point can be checked against its micromort measurement on the left (displayed on a logarithmic scale) and against the number of coins that must be tossed in the air and all land heads on the right (linear scale).

For example, the deadly daily risk of dying of Covid-19 in Canada in 2020 for males in the 65 years old age group is more than 19 heads (and less than 20); for 20 year old males the deadly daily risk of death from Covid is about the same as the chance of throwing 26 coins in the air and all landing heads. A 40 year old woman's 2020 daily deadly risk due to Covid was less than the chance of tossing 25 coins in the air and having them all land heads – **less than the half the chance of winning the grand prize in Lotto 6/49**.

Denouement

There once was a time in Canada when lotteries were illegal. I can recall my parents and neighbours in the 1960s furtively buying "Irish Sweepstake" tickets in Ontario and worrying about how they might collect a prize should they ever win one. But, once lottery revenue can be cast as an opportunity to do good, governments change the law to allow them to run their own lotteries (often as monopolies).

What was once immoral, and even detrimental to some segments of society (e.g., in 2013, problem gamblers accounted for about 24.1% of the Ontario government-sponsored gambling revenue), becomes an opportunity for the **greater good** (e.g., funding the 1976 Montreal Olympics, funding recreation centres, arenas, theatres, art galleries, museums, or local non-profit groups, and to "Stand for Children").

Governments aggressively market their lotteries, spending 100s of millions of dollars annually. Mainstream media benefit from this government largesse (both in direct advertising and in attracting audiences) and return the favour with regular promotion of large jackpots, local winners, and the many ways to win.

With Covid, the pattern was repeated. Again probabilities are extremely small, and, again, government and media directed public attention toward extreme outcomes instead. Poorly defined definitions of Covid cases and Covid deaths led to inflated counts; continuous daily reporting of case counts and, especially early on, dramatic visualization, psychologically amplified the danger and generally stoked fear.

As with lotteries, traditional media had financial incentives to deliver government messaging, in Canada through direct subsidies, government advertising revenue (from early on), and through pharmaceutical advertising and sponsorship. Again, as with lotteries, media benefited from any audience traffic driven by an increased public interest in accessing Covid information.

Finally, as with the lotteries, Covid government policy was advocated as being for the greater good and based on mistaken assumptions about their potential consequences.

Two sides of the same coin, hope and fear. Both have been exploited by governments, the media, and other organized interests, but, of the two, **fear is by far the more dangerous**.

An understanding of the deadly (and other) risks surrounding Covid-19, one grounded in the reality of every day deadly risk, is each person's responsibility. Only by becoming informed, can any risk benefit analysis be done.

Hopefully, this essay helps reduce the **fear** generated from so many sources over the past two years by putting **risk** into the perspective of daily living.