

		DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL	AVG/MTH
BASE DATA												
CANADIAN POPULATION		38,125,449										
FULLY VACCINATED (FV)		-	173,779	573,661	716,100	1,123,678	3,050,396	13,646,757	22,627,721	24,888,997		
PARTIALLY		82,512	727,623	1,281,130	5,072,294	11,655,857	19,960,756	11,888,385	4,196,923	2,666,476		
NOT VACCINATED		38,042,937	37,224,047	36,270,658	32,337,055	25,345,914	15,114,297	12,590,307	11,300,805	10,569,976		
CASES		199,695	193,255	85,487	114,717	236,045	160,823	32,973	15,413	64,978	1,103,386	
HOSPITALIZATIONS		8,226	11,255	5,976	4,702	8,934	7,759	3,292	1,411	1,881	53,435	
DEATHS		3,592	4,295	1,977	965	1,260	1,328	748	302	321	14,788	
CANADIANS FULLY VACCINATED (FV)		-	173,779	573,661	716,100	1,123,678	3,050,396	13,646,757	22,627,721	24,888,997		7,625,090
Proportion fully vaccinated		0%	0.5%	1.5%	1.9%	2.9%	8.0%	35.8%	59.4%	65.3%		-
Confirmed cases	Nbr		23	77	96	151	410	1,832	3,038	3,342	8,970	1,121
	%											0.015%
Hospitalizations	Nbr		1	4	6	9	24	106	176	194	521	65
	%											0.001%
Deaths	Nbr		1	2	2	4	10	43	72	79	211	26
	%											0.0003%
	Per million		3									
CANADIANS PARTIALLY / NOT VACCINATED		38,125,449	37,951,670	37,551,788	37,409,349	37,001,771	35,075,053	24,478,692	15,497,728	13,236,452		30,500,359
Proportion not fully vaccinated		100%	99.5%	98.5%	98.1%	97.1%	92.0%	64.2%	40.6%	34.7%		-
Confirmed cases	Nbr	199,695	193,232	85,410	114,621	235,894	160,413	31,141	12,375	61,636	1,094,416	121,602
	%	0.5%	0.5%	0.2%	0.3%	0.6%	0.5%	0.1%	0.1%	0.5%		0.4%
Hospitalizations	Nbr	8,226	11,253	5,972	4,697	8,925	7,735	3,185	1,234	1,687	52,914	5879
	%	0.022%	0.030%	0.016%	0.013%	0.024%	0.022%	0.013%	0.008%	0.013%		0.019%
Deaths	Nbr	3,592	4,294	1,975	963	1,256	1,318	705	230	242	14,577	1620
	%	0.009%	0.011%	0.005%	0.003%	0.003%	0.004%	0.003%	0.001%	0.002%		0.0053%
	per 100K	9	11	5	3	3	4	3	1	2		5.3
	One per	10,614	8,837	19,012	38,857	29,450	26,605	34,731	67,274	54,649		18,832

SOURCE / METHODOLOGY

Aggregated YTD & monthly case count and death statistics provided by PHAC. YTD Hospitalizations count (N=53,435) allocated by month based on relative hosp. days. The prevalence of FV vs NFV is calculated on the basis of "person month". FV represents 20% of Dec-Aug "person months". The avg monthly FVs is weighted accordingly. Attribution of cases by vaccination status is based on a data sample comprising 75% of YTD cases (Dec-Aug). See allocation methodology below.

KEY TAKEAWAYS PART 1: REVISITING OUTHIINK MODELLING PREDICTIONS - APRIL 2020

AGE DISTRIBUTION OF CONFIRMED CASES SINCE MARCH 2020 IN LINE WITH MODEL PROJECTIONS

Age	Total	Case %	Pop %
0-20	287,200	18%	22%
21-59	935,635	58%	54%
60-69	244,114	15%	12%
70-79	61,226	4%	8%
80+	71,804	4%	4%
Total	1,599,979	100%	100%

As predicted, cases **highly correlated** with population distribution. The risk of infection is not significantly skewed by age.

TOTAL DEATHS AND RELATIVE RISK OF DEATH BY AGE GROUP ALSO CLOSELY ALIGNED WITH MODEL PREDICTIONS

AGE DISTRIBUTION	DEATH DISTRIBUTION		DEATH TOLL		IFR			
	OUTHINK	ACTUALS	OUTHINK	ACTUALS	WHO	OUTHINK	ACTUALS	
	Projections *		Projections		Projections	Projections @10%	@ 10% infection rate	Based on Reported Case
LESS THAN 20	0%	0%	81	16	-	0.01%	0.002%	
20-59	13%	6%	3,460	1,589	-	0.2%	0.1%	
60-70	10%	10%	2,604	2,606	-	0.56%	0.6%	
70-80	32%	20%	8,589	5,435	-	3.0%	2%	
80 +	45%	64%	12,037	17,109	-	7.4%	11%	
	100%	100%	26,771	26,755	3.6%	0.71%	0.71%	1.8%
60+	87%	94%						

* Outhiink and WHO predictions as of April 2020. Outhiink projected distribution based on 10% Infection Rate. Actuals as of August 8 2021

Actual death toll and relative IFR risk by age group aligned with predictions.

Assuming population infection levels is 4 times higher than reported cases, the IFR would be, as projected, approximately .7%

KEY TAKEAWAYS PART 2: FULLY VACCINATED VS NON FULLY VACCINATED RISK PROFILES BASED ON DEC-AUG 2021 DATA

RISK OF CONTRACTING COVID

	As reported*	Likely	Per million (as reported)
Not fully Vaccinated	.4% per mth	0.1%	4,000
Fully Vaccinated	.015% per mth	0.004%	150

Unvaccinated people **are 30 times more likely** to contract COVID

* "As reported" reflects reported infection cases. "Likely" assumes 25% of actual infection cases are identified / reported.
Allocation of cases between FV & NFV based on the methodology presented below in section 1.2
Incidences per million are rounded for clarity.

RISK OF HOSPITALIZATION

	As reported	Per million
Not Fully Vaccinated	.019% per mth	190
Fully Vaccinated	.001% per mth	10

Unvaccinated people **are 19 times more likely** to be hospitalized

Note: Risk of hospitalization & death expressed as % of FV & NFV populations, not cases.

RISK OF DEATH

	As reported	Per million	
Not Fully Vaccinated	.002% to .005% per mth	20-50	1 per 20k - 50K
Fully Vaccinated	.0003% per mth	3	1 per 300K

Unvaccinated people are **6 to 16 times more likely** to die from contracting COVID

Note: "Not Fully Vaccinated" death risk: YTD average 1 per 20K per month, last two months trending at 1 per 50K

Improved recent trends likely due to higher population immunization levels. Propagation of new variants of concern could alter these trends.

CONCLUSION

Unvaccinated Canadians are at a **much higher risk** of contracting COVID, being hospitalized, or dying.

... in spite of the fact that as a group, the unvaccinated cluster is **much younger** than the vaccinated population

THEORETICAL... WHAT IF THE CURRENT VACCINATION LEVEL REMAINS UNCHANGED OVER THE NEXT 12 MONTHS?

Let's assume 10.6M Canadians refuse vaccination and infection run rate remains constant over the next 12 months*

Unvaccinated Canadians: 10.6M as of Sept 2022	Over the next 12 months:	% of Population	% of occurrences
If New cases remains constant at .4% per month...	506,880 new cases	28%	91%
If Hospitalization rates remain constant at .019% per month...	24,077 new hospitalizations		90%
If Death rates remain constant at .005% per month...	6,716 new deaths		69%

* Current count of unvaccinated Canadians includes children not yet eligible for vaccination. Further analysis should lower the base for this theoretical case.

SOURCES & METHODOLOGY

1) Data Breakdown by Vaccination Status

1.1 Decision to group "unvaccinated", "partially vaccinated" and "unprotected" for comparison with fully vaccinated (protected) Canadians.

Segregating the non-fully vaccinated segments does not seem to provide any useful insights.

Ratios at this level presented as a % of cases seem counterintuitive, and may be driven by other factors such as age. For example, fully vaccinated, but not yet protected individuals, have a death rate of 1.9% compared to unvaccinated @ 1.1%.

Dec-August 2021 Sampled Data					
	Cases	Hospitalization	Death	Hosp Ratio	Death Ratio
Unvaccinated	562,343	28,575	5,974	5%	1.1%
Cases not yet protected	33,178	2,459	639	7%	1.9%
Partially vaccinated	31,543	2,392	570	8%	1.8%
Subtotal	627,064	33,426	7,183	5%	1.1%

Source: <https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html>

What is more telling is to compare the cases, hospitalizations and death incidences of fully vaccinated Canadians (FV) vs everyone else.

As stated, the sampled data covered more than 75% of cases since Dec 2020. The actual coverage may be somewhat lower but it remains a very large subset which should provide assurance of directional correctness.

That did we learn? Fully vaccinated Canadians (FV) account for less than 1% of total cases. During the Dec - Aug 2021 period, FV relative weight expressed as "person month" was 20%.

So in conclusion, approximately 20% of the population accounts for 1% (+/- 1/2%) of all cases, hospitalizations and deaths.

Person Mth Equivalent	National Sample (N = 75% of Dec-Aug cases)						
	Cases	Hosp	death	Cases %	Hosp %	Death %	
Fully Vaccinated (FV)	20%	5,139	329	104	0.8%	1.0%	1.4%
NFV	80%	627,024	33,426	7,183	99.2%	99.0%	98.6%
Total		632,163	33,755	7,287	100%	100%	100%

Person Months Calculation	PERSON MONTHS										Person Month %
	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL	
CANADIANS FULLY VACCINATED (FV)		173,779	573,661	716,100	1,123,678	3,050,396	13,646,757	22,627,721	24,888,997	66,801,089	20%
CANADIANS PARTIALLY / NOT VACCINATED	38,125,449	37,951,670	37,551,788	37,409,349	37,001,771	35,075,053	24,478,692	15,497,728	13,236,452	276,327,952	80%
										343,129,041	100%

1.2 Attribution of monthly results by vaccination status

Available data by vaccination status is based on a large sample (75%) of actual cases since December 2020.

Two options were considered to reconcile actuals with sampled data.

Option 1: Scale the sample data by 33% to estimate total case count, hospitalizations, and deaths by vaccination status. This option would not reconcile with monthly published reports.

Option 2: Leverage sample data by using the relative FV vs Non FV incidences to allocate published monthly statistics by vaccination status.

We favored option 2. Here's why:

Relying solely on "scale up" sampled data would not reconcile with official reports and introduce risk of improper interpretation.

As stated previously the relative FV incidences as % of total incidences seems to provide the clearest insight from this data.

For example, 14,788 deaths occurred since the vaccination effort began. We know from the sample data that 1.4% of total deaths were individuals fully vaccinated and protected. As per the proposed methodology,

1.4% of the 14,788 deaths would be attributed to fully vaccinated individuals in line with the sample results. Allocation by month is weighted by vaccination ramp up but monthly aggregations reconcile with published reports.

The same logic is applied to allocate cases, hospitalization and death occurrences by vaccination status (ie FV count as % of total sample).

DEC- AUG 2021	Actual Data	FV %	FV Allocation
CASES	1,103,386	0.8%	8,970
HOSPITALIZATIONS	53,435	1.0%	521
DEATHS	14,788	1.4%	211

1.3. DETERMINING THE RISK OF CONTRACTING COVID (CASE RISK)

As per above, fully vaccinated individuals represent 20% of total in terms of "person months" and .8% of all cases.

Overlaying the percentage of cases pertaining to fully vaccinated vs others, we can calculate the relative case risk by vaccination status:

	Person Mth equiv.	%	Case Sample Allocated	Case %	Actual Cases Allocated	Relative risk
Fully Vaccinated	66,801,089	20%	5,139	0.8%	8,970	0.01%
Others	276,327,952	80%	627,024	99.2%	1,094,416	0.4% 31 times higher
			632,163	100%	1,103,386	

Applying to actual data (Dec -Aug) and calculating monthly infection risk (case incidence)

	Pers/Mth	Avg Canadians per month	Avg Cases /month	Case Risk /month	Case Risk Dec-Aug
Fully Vaccinated	20%	7,625,090	1,121	0.015%	0.01%
Others	80%	30,500,359	121,602	0.4%	4%
Canadian Population	100%	38,125,449	122,723		

Summary

FV represented 20% of "person months" and .8% of cases.

NFV represented 80% of "person months" and 99.2% of cases.

The relative risk of contracting Covid is 31 times higher for non FV individuals

1.4 SUMMARY: RELATIVE RISK FV VS NFV

	Infection risk/mth	Hospitalization risk/mth	Death risk/mth	Incidence per million per month		
				Infections	Hospitalizations	Deaths
Fully Vaccinated (FV)	0.01%	0.001%	0.0003%	147	9	3
Others (NFV)	0.40%	0.02%	0.0053%	3987	193	53
RATIO NFV / FV (rounded)				30	20	15

2) MONTHLY CASE COUNTS

Total cases

Pre Dec 2020	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	DEC - AUG
378,000	203,395	197,577	87,531	115,613	237,309	162,157	33,702	15,541	57,411	
Cumulative	581,395	778,972	866,503	982,116	1,219,425	1,381,582	1,415,284	1,430,825	1,488,236	1,110,236

<https://www.worldometers.info/coronavirus/country/Canada/>

3) TOTAL AND MONTHLY HOSPITALIZATION COUNT

Total hospitalizations since March 2020: 77,167 - source PHAC

Monthly hospitalization figures based on relative monthly hospitalization days. Source <https://ourworldindata.org/covid-hospitalizations>

4) CASES, HOSPITALIZATION AND DEATH RISK PROFILES BY VACCINATION STATUS

see note 1.2. Source <https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html>

5) CASE DISTRIBUTION BY AGE GROUP

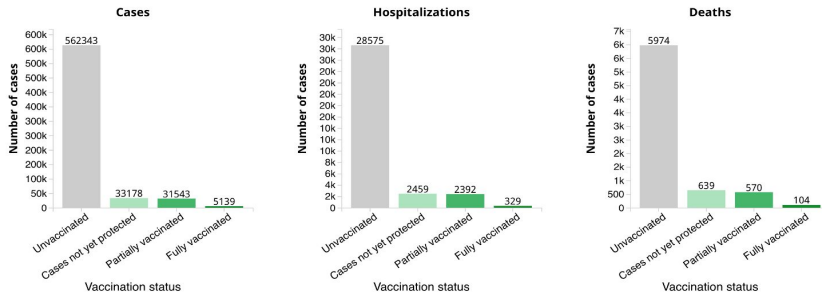
<https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html>

POTENTIAL SOURCE OF DATA DISCREPANCIES / FURTHER ANALYSIS REQUIRED

6) Death Count Inconsistencies December to August 2021

14,788 of the 26,918 deaths have been officially reported since vaccination began (December to August 2021). For the same timeframe, Canada Infobase reports 9,716 deaths (7,287 based on a 75% case sample), a gap of 35%.

Figure 5. Number of confirmed COVID-19 cases reported to PHAC by vaccination status as of August 07, 2021



<https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html>

7) Relative Risk of complications: Vaccinated (full) vs not fully vaccinated Canadians

As per the above analysis, vaccination seems to provide 6 to 19 times lower risk of severe complications and death for the fully vaccinated population as a whole. Death avoidance from vaccination is primarily driven by infection risk reduction (case avoidance) which is not reflected in the risk assessment below (table 3). While fully vaccinated individuals represented on average 20% of the total population on the basis of "person months", they incurred less than 1% of cases since Dec 2020.

	person/mth	% of cases	% of hosp.	% of death
Fully Vaccinated	20%	0.81%	0.97%	1.43%
Others	80%	99.19%	99.03%	98.57%

To help Canadians fully appreciate the advantage of vaccination, properly assessing and communicating the infection protection provided by vaccination is paramount.

Table 3. Risk of severe outcomes among fully vaccinated cases compared to unvaccinated cases as of August 07, 2021

Severe Outcome	Adjusted* Odds Ratio (95% CI)
Hospitalizations	0.28 (0.25 - 0.32)
Deaths	0.50 (0.41 - 0.63)

*Adjusted for 10-year age groups and month of episode date
 Source: Detailed case information received by PHAC from provinces and territories
 Note: Due to the nature of the dataset (i.e. confirmed cases of COVID-19 in Canada), the odds of severe outcomes among cases following vaccination only considers vaccinated individuals that contracted COVID-19. It does not reflect the protection conferred by the vaccines to prevent COVID-19 infection.

MODEL IMPROVEMENT

8) The following data breakdown would be highly beneficial

By Month, Vaccination Status and Age Group: Population count, Confirmed cases, Hospitalization and Death. This information is likely available but has not been released.

9) Furthermore, this analysis is based on YTD actual data (baseline). Future projections should integrate known changes in risk dynamics, namely:

- 1) Adjusting the average risk of severe complications (H&D) based on Dec-Aug data to reflect changing demographics amongst unvaccinated Canadians. The average age of unvaccinated Canadians is trending down since Dec. 2020.
- 2) Upward pressure in propagation velocity and illness severity from change in variant profiles.
- 3) Relative downward pressure on propagation velocity due to population increased immunization levels.