LOPA Versus Covid - Return to Sustainable Living

Presentation for the paper by;

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Layers of Protection Analysis (LOPA)

Origin of LOPA: This is an engineering design method to ensure safety of electromechanical equipment which are used in ‘high - risk’ industrial applications and the design guide is based on below references;

- IEC 61508 - “Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems (E/E/PE, or E/E/PES)”. First Edition 1998

- IEC 61511 - "Functional safety - Safety instrumented systems for the process industry sector“. First Edition 2000.

- AIChE – “Layer of Protection Analysis: Simplified Process Risk Assessment”, 2001.

IEC stands for ‘International Electrotechnical Commission’, it was formed in UK 1906. It is now an international organisation with headquarters in Switzerland.

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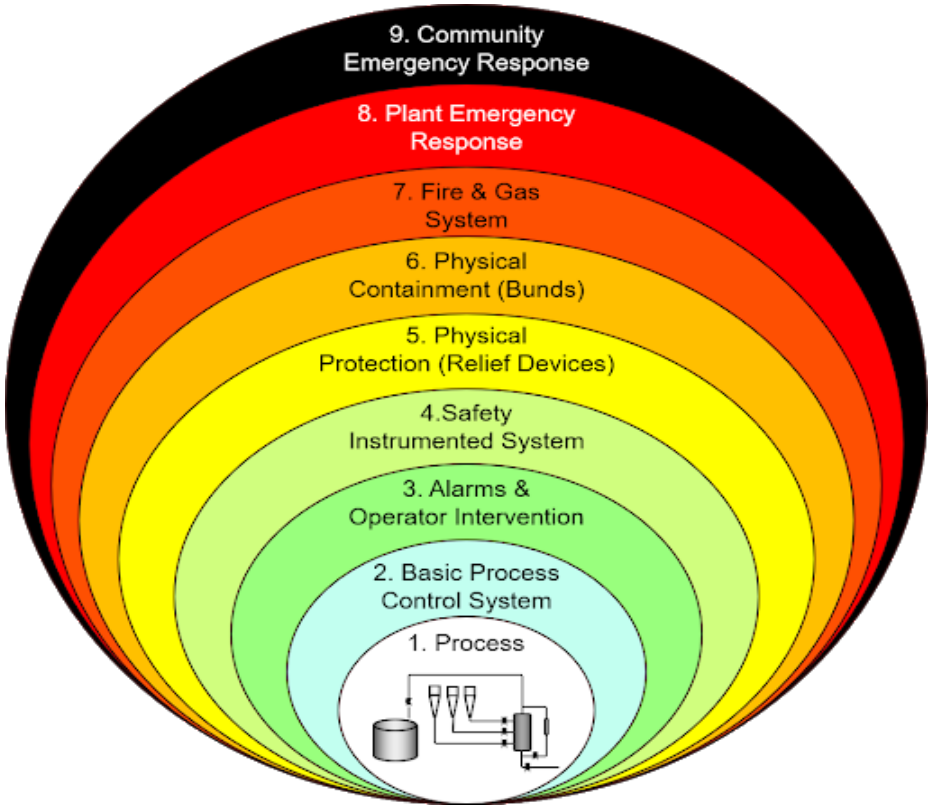
The Layers of Protection Analysis (LOPA) is widely used as a successful and simplified risk assessment tool in chemical process industries to design the plant protection and safety systems. This method considers an initiating event, namely a process mishap leading to catastrophic failures, then examines the requirements of independent protection devices to mitigate the risk.



Each zone is called an Independent Protection Layer (IPL) and the initiating event can be any cause of plant instability leading to human safety compromise, environmental damage, asset loss and/or reputational damage.

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Chemical Process LOPA Example

3	4	5				6		7			8	10	11
		Active IPLs				Passive IPLs		Conditional Modifiers					
Initiating Cause	Initiation Likelihood (events per year)	General Process Design (Probability)	Process Control System (Probability)	Alarms, Etc. (Probability)	Pressure Relief (Probability)	Mitigations such as; Dike/Bund - Underground Drainage System - Open Vent (Probability)	Mitigations such as; Fireproofing - Blast Wall - Flame / detonation arrestors (Probability)	Additional Mitigation such as; Restricted Access - Shift manning patterns (Probability)	Probability of Time Spend at Risk Event	Probability of Ignition	Intermediate Event Likelihood (events per year)	Probability of Failure on Demand	Acceptable Risk for a Fatality (events per year)
Manual Valve Left Open	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment		In SIL 2 range	
	0.05	1.00	0.15	0.05	0.20	1.00	0.80	1.00	0.17	0.40	4.00E-06		
Control Valve failure	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment			
	0.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.17	1.00	1.67E-02		
Pump Trip	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment			
	0.02	1.00	0.15	1.00	0.30	1.00	0.80	1.00	0.17	1.00	1.20E-04		
Procedure not Followed	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment	Comment			
	0.00	1.00	0.15	0.05	0.40	1.00	1.00	1.00	0.17	1.00	5.00E-07		
											1.68E-02	5.96E-03	1.00E-04

LOPA method defines Safety Integrity Level (SIL) of the system design target, as such it specifies the reliability of the protection system in relation to the perceived risk category.

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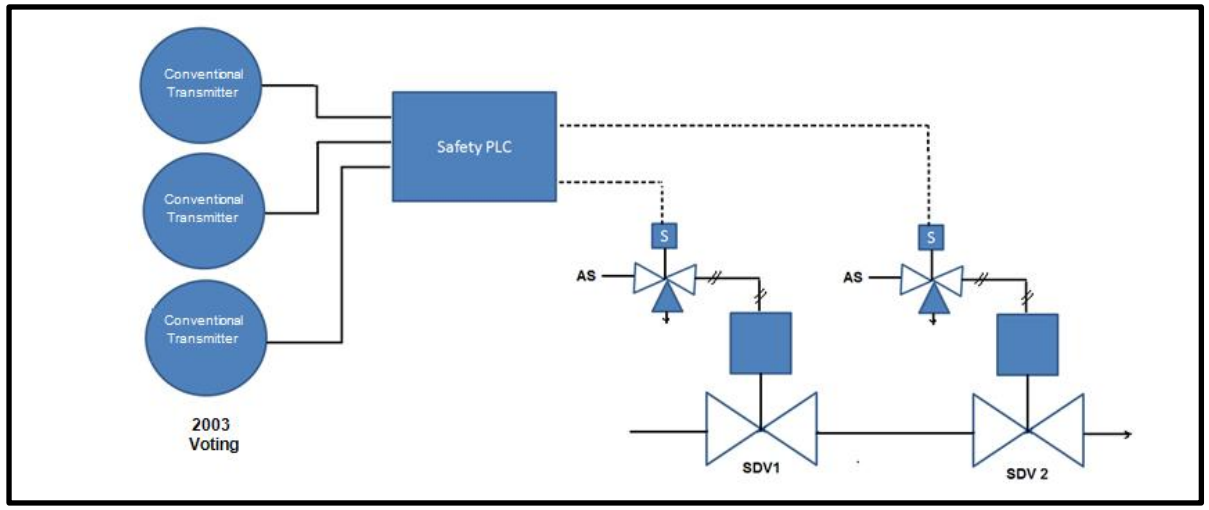
What LOPA Means in Practice for Chemical Process Design?

SIL	Prob. Of Failure on Demand (PFD_{avg})	Safety Availability % ($(1 - PFD_{avg})*100$)
4	$\geq 10^{-5}$ to $< 10^{-4}$ (≥1 in 100,000 to < 1 in 10,000)	99.999 to 99.99
3	$\geq 10^{-4}$ to $< 10^{-3}$ (≥1 in 10,000 to < 1 in 1,000)	99.99 to 99.9
2	$\geq 10^{-3}$ to $< 10^{-2}$ (≥1 in 1,000 to < 1 in 100)	99.9 to 99.0
1	$\geq 10^{-2}$ to $< 10^{-1}$ (≥1 in 100 to < 1 in 10)	99.0 to 90.0

Safety Integrity Level (SIL) Probability of Failure on Demand Specification Table.



Emergency Shutdown System Design with SIL 2 Specification where this configuration of shutdown system hardware has is a probability of failure on demand between 10^{-3} and 10^{-2}.

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LOPA Adaptation to Virus Spread, Infection and Fatality

- The Challenge is how to apply this simplified risk assessment and engineering design tool to the risk of a virus pandemic.
- From a chemical engineering point of view, transmission of the SARS-COV-2 virus is a process, and the disease Covid-19 can be managed like any other process hazard.
- Thus a similar methodology is applied to Covid transmission and the pertinent safeguarding measures.
- Accordingly human to human virus transmission is taken as an initiating event and then defining independent protection layers such as social distancing, ventilation, hand hygiene, face mask and vaccine to mitigate the fatalities.

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Use of LOPA to Produce ‘Covid Fatality Metrics’

The object is to develop a ‘measurement tools’ to be used for minimising the chance of Covid infections. This tool is defined as Covid Fatality Metrics. This tool determines the premises’ status with regard to the compliance of Covid prevention safeguards. The safeguards are the ‘Social Distancing, Face Mask, Hand hygiene, Ventilation & Vaccination’. These measures along with vaccination and the closed space ventilation are the independent protection layers (IPLs). Example: Consider the case of shoppers to a Shopping Centre in the Midlands;

- LOPA Modelling to protect people from Covid Infection is conducted based on human behaviour compliance surveys by organisation responsible entities:

- Use cases of weekly observations of the shoppers. The weekly survey is conducted to determine the ‘Social Distancing, Face Mask & Hand hygiene’ compliance.
- spread.

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This example uses Case 1 (Week: 17-June-2021) and Case 2 (Week: 01-July-2021) surveys;

- After observational survey in Case 1, organisation responsible body publish the survey results for ‘Covid Fatality Metrics’ to assess the risk of possible infection and fatalities. Then instructions are made to improve the Covid prevention safe guards.

- In Case 2, the following week, another set of observational survey is conducted to develop the ‘Covid Fatality Metrics’, with the purpose of lowering the risk of infection and fatalities. The results as bar charts are management tools to control the virus spread.

The Methodology

- The LOPA method uses observational survey to calculate probability of failure for compliance to Covid prevention protection measures, namely Social Distancing, Face Mask and Hand Hygiene.
- The results are tabulated in a ‘Survey Matrix’.
- The survey measures the probability of a target population non-compliance, i.e. Probability of Failure on Demand (PFD).
- Calculate virus transmission rate from human to human.
- The other protection measures are ‘Ventilation and Vaccine efficacy’ which also require pertinent failure probabilities.
- Use public domain websites to calculate Covid death probability based of age, gender, ethnicity and health status.
- Use LOPA ‘solution engine’ to calculate the Covid death annual rate, and the Covid Fatality Metrics*.
- Final Result is ‘Covid Fatality Metrics’ which is the virus spread prevention management tool.

*Covid Fatality Metric is the ratio of Covid death annual rate to common flu annual death rate, the latter is used for comparison and benchmarking purposes.

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The Benefit of LOPA Methodology

The advantage of the LOPA method is that the main outcome which is a calculated **Covid Fatality Metrics** value. The magnitude of this calculated value determines how much improvement in the transmission rate variables and the safeguarding health protocols should be made in order to bring down the annual death rate in parity with the common flu. This Metrics can be used by stakeholders to manage and control the spread of infection.

To survey for 'Rules' compliance with 800 shoppers sampling (observe people for 180 minutes a working day and record how many people observe social distancing within this survey period).

Survey (observation) to be conducted by HSE Department

Week 1 (17.06.21) Social Distancing Survey

Day 1, 1st survey: 270 people out of 800 do not observe 2 metres rule;	0.3375
Day 2, 2nd survey: 700 people out of 800 do not observe 2 metres rule;	0.875
Day 3, 3rd survey: 330 people out of 800 do not observe 2 metres rule;	0.4125

Geometric Mean = 0.4957 probability of failure for social distancing

Week 2 (01-07-21) Social Distancing Survey

Day 1, 1st survey: 220 people out of 800 do not observe 2 metres rule;	0.275
Day 2, 2nd survey: 450 people out of 800 do not observe 2 metres rule;	0.5625
Day 3, 3rd survey: 80 people out of 800 do not observe 2 metres rule;	0.1

Geometric Mean = 0.2492 probability of failure for social distancing

To survey for 'Rules' compliance with 800 shoppers sampling (observe people for 180 minutes a working day and record how many people wash their hands within this survey period). Survey (observation) to be conducted by HSE / HR

Survey (observation) to be conducted by HSE Department

Week 1 (17.06.21) Hand Hygiene Survey

Day 1, 1st survey: 600 people out of 800 do not wash their hands;	0.75
Day 2, 2nd survey: 450 people out of 800 do not wash their hands;	0.5625
Day 3, 3st survey: 230 people out of 800 do not wash their hands;	0.2875

Geometric Mean = 0.4950 probability of failure for hand hygiene

Week 2 (01-07-21) Hand Hygiene Survey

Day 1, 1st survey: 110 people out of 800 do not wash their hands;	0.1375
Day 2, 2nd survey: 300 people out of 800 do not wash their hands;	0.375
Day 3, 3st survey: 180 people out of 800 do not wash their hands;	0.225

Geometric Mean = 0.2264 probability of failure for hand hygiene

To survey for 'Rules' compliance with 800 shoppers sampling (observe people for 180 minutes a working day and record how many people observe wearing face mask within this survey period).

Survey (observation) to be conducted by HSE Department

Week 1 (17.06.21) Face Mask Survey

Day 1, 1st survey: 290 people out of 800 do not wear or not fully face mask;	0.3625
Day 2, 2nd survey: 550 people out of 800 do not wear or not fully face mask;	0.6875
Day 3, 3rd survey: 360 people out of 800 do not wear or not fully face mask;	0.45

Geometric Mean = 0.4822 percentage people that do not wear or not fully face mask

Then, PFD of wearing mask protection is 0.1759 e.g. for type B mask

Week 2 (01-07-21) Face Mask Survey

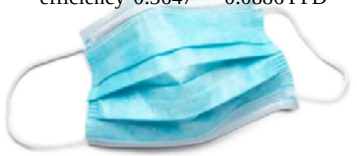
Day 1, 1st survey: 150 people out of 800 do not wear or not fully face mask;	0.1875
Day 2, 2nd survey: 350 people out of 800 do not wear or not fully face mask;	0.4375
Day 3, 3rd survey: 140 people out of 800 do not wear or not fully face mask;	0.175

Geometric Mean = 0.2430 percentage people that do not wear or not fully face mask

Then, PFD of wearing mask protection is 0.0886 e.g. for type B mask

PM2.5 Surgical Masks

Geometric Mean '0.2430' x mask filtering efficiency '0.3647' = 0.0886 PFD



The PM2.5 surgical masks were originally designed for those living in areas with high air pollution levels.

- PM2.5 masks provide good filtration (62%-65%), though not as much as N95 masks.

TYPE B MASK;Probability = 62% to 65% Protection;

pfds = 0.38 to 0.35; Geometric Mean = 0.3647

Observational Surveys

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Modelling of Vaccination and Ventilation Probability of Failure

- Vaccination Probability of Failure on Demand estimation, is used as an independent protection layer:
  - It is expected that Covid virus will circulate amongst the human population permanently and periodic vaccinations to be required continuously - similar to yearly flu jabs.
  - Accordingly, the probability of failure on demand of the vaccination independent protection layer ‘IPL’, is taken as 70% which is higher than flu vaccination of 50% to 60% but less than the vaccines manufacturers’ claims of over 90% efficacy as its effectiveness declines in short times.

- For quantification of the probability of failure on demand of buildings’ ventilation independent protection layer, the following rules are applied:

Rule 1	With or without recirculation, ACH > 12 with HEPA Filter or Equivalent PFD = 0.1
Rule 2	No recirculation, ACH > 6 with filter less efficiency than HEPA or Equivalent PFD = 0.5
Rule 3	No re circulation, ACH< 6 with filter less efficiency than HEPA or Equivalent PFD = 1.0
Notes;	
ACH = Air Changes per Hour	
HEPA = High-Efficiency Particulate Air	
IPL = Independent Protection Layer	
PFD = Probability of Failure on Demand	

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Calculation of Transmission Rate

COVID-19 is atypical of process hazards as it is all pervasive, often carried by asymptomatic individuals, without any obvious sign of infection. However, it is possible to evaluate the frequency of an “initiating event” defined as an “effective” contact with an infected person or the transmission rate, based on the following inputs:

- Local rolling infection rates, for example published in the UK as the Covid-19 virus interactive map for England. https://coronavirus.data.gov.uk/details/interactive-map
- Hours spent in the risk area with potential of person-to-person infection
- Number of human contact events per year with potential virus transmission
- Adjust for asymptomatic cases.
- These factors are used to evaluate the number of effective infections per year, i.e., the transmission rate, which is the initiating event in the LOPA calculation.

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Calculation of Transmission Rate

- There are hundreds of people from different locations visit the Shopping Centre. Each post code has its own infection rate.
- The statistical regression analysis is used to help look at the mean infection rates of COVID-19.
- The Covid infection is unpredictable and could be arbitrary. The statistical modelling algorithm uses an ‘arbitrary random population sampling’ approach which is meant to randomize the virus person to person transmission in the community.
- The input local infection rates data was randomly selected and fed into a regression analysis model.
- The infection is random, which means it is impossible to predict future human infections based on past or present ones.
- The modelling therefore requires probabilistic assessment to account for the randomness.
- The maths is designed to simulate the real-life virus transmission randomness and develop predictive tools on virus behaviour in each population sample.

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Random Shoppers Population Sampling per Post Code

Data for a Shopping Mall in the Midlands week ending 17th June			
Random Population Sample	**Infection/Case Rate Per 100,000 People**	**Area**	**Randomly Selected Postcode Area**
134	301.2	Oldham	OL1 3DH
96	147.2	Glossop	SK13 7QU
52	60	Warrington	WA5 1TH
78	109.3	Barnsley	S70 6BG
46	42.5	Huddersfield	HD1 4SJ
13	89.4	Knutsford	WA16 9EA
159	245.2	Bolton	BL1 2DP
289	325	Chorley	PR7 1JA
335	544.6	Preston	BB2 6NZ
147	147.2	Handforth	SK9 3QB
55	59.1	Buxton	SK17 6PX
21	47.5	Sheffield	S10 5RQ
101	238.4	Northwich	CW8 1EQ
268	348.2	Blackburn	BB2 1QT
211	273.8	Liverpool	L7 1AG
340	897.3	Manchester	M4 5LA
180	241.3	Macclesfield	SK11 7BB
300	545.9	Burnley	BB11 3LP
226	350.9	Chester	CH1 3HE
131	211.8	Ashton-under-Lyne	OL6 7PQ
59	37.2	Wakefield	WF2 9QS
74	82.8	Keighley	BD21 2QW
91	192	St Helens	WA10 1JA
88	100.1	Rochdale	OL11 1JN
112	206.2	Halifax	HX3 6AD
64	158.9	Leeds	LS12 1YL
73	198.6	Bradford	BD7 3AG
105	207.6	Stockport	SK1 4NW
117	367.4	Wigan	WN1 1HA
41	75.6	Runcorn	WA7 1BQ

Data for a Shopping Mall in the Midlands week ending 1st July			
Random Population Sample	**Infection/Case Rate Per 100,000 People**	**Area**	**Randomly Selected Postcode Area**
134	403.1	Stockport	SK1 4NW
96	392	Liverpool	L7 1AG
52	145.6	Bradford	BD7 3AG
78	206.2	Halifax	HX3 6AD
46	142.6	Sheffield	S10 5RQ
13	127.4	Huddersfield	HD1 4SJ
159	430.5	Rochdale	OL11 1JN
289	486.3	Burnley	BB11 3LP
335	838.2	Oldham	OL1 3DH
147	438.9	St Helens	WA10 1JA
55	203.8	Chester	CH1 3HE
21	191.9	Warrington	WA5 1TH
101	368.6	Runcorn	WA7 1BQ
268	468.5	Barnsley	S70 6BG
211	467.1	Chorley	PR7 1JA
340	1101.3	Manchester	M4 5LA
180	442	Ashton-under-Lyne	OL6 7PQ
300	527.9	Blackburn	BB2 1QT
226	496.6	Buxton	SK17 6PX
131	387.2	Knutsford	WA16 9EA
59	211.2	Preston	BB2 6NZ
74	220.6	Bolton	BL1 2DP
91	316.7	Wigan	WN1 1HA
88	294.4	Handforth	SK9 3QB
112	347.6	Wakefield	WF2 9QS
64	217.2	Macclesfield	SK11 7BB
73	279.5	Keighley	BD21 2QW
105	343.5	Glossop	SK13 7QU
117	374.6	Leeds	LS12 1YL
41	221.4	Northwich	CW8 1EQ

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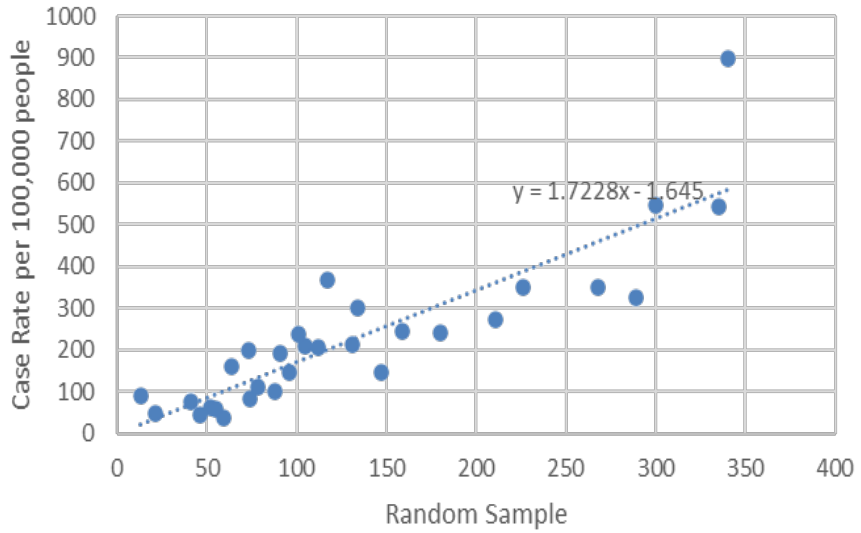
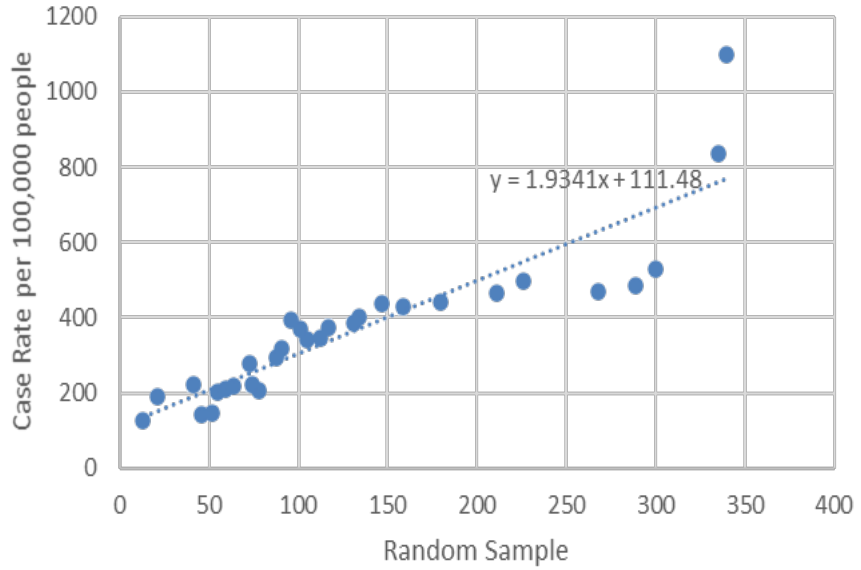
Regression Analysis



Graph to show the rate of Covid-19 cases in shopping mall visitors' addresses (17th June 2021). The regression line was equal to: $y = 1.7228x - 1.645$ and the geometric mean of the random population sample was calculated to be 102.86. Therefore, substituting these values gave a geometrically adjusted mean infection rate (y) of 175.57.



Graph to show the rate of Covid-19 cases in shopping mall visitors' (1st July 2021). The regression line was equal to: $y = 1.9341x + 111.4$, the geometric mean of the random population sample would be the same as that calculated from the previous set of data (due to the random population samples not changing), the geometrically adjusted mean infection rate for this case equalled (y) 310.43.

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Calculation of infection transmission rate per year for shoppers (infection transmission rate is the LOPA initiating event rate per year)

Infection in Closed Space	Case 1
UTLA selected Location	Shopping Mall Midlands
Date	17-Jun-21
Rolling Infection rate pr 100,000	175.57
Rolling Infection rate as decimal (per individual)	0.0017557
Hours spent per day in Risk Areas	5
Total number of hours per year spent in risk areas	400
Total number of human transmission per day	40
Estimate for the asymptomatic proportion of SARS-CoV-2 infections is 28%, thus increase by 28%	1.28
Infection Transmission Rate per Year	35.96

Calculation for Infection Transmission Rate – 17 June 2021

Infection in Closed Space	Case 2
UTLA selected Location	Shopping Mall Midlands
Date	1-Jul-21
Rolling Infection rate pr 100,000	310.43
Rolling Infection rate as decimal (per individual)	0.0031043
Hours spent per day in Risk Areas	5
Total number of hours per year spent in risk areas	400
Total number of human transmission per day	40
Estimate for the asymptomatic proportion of SARS-CoV-2 infections is 28%, thus increase by 28%	1.28
Infection Transmission Rate per Year	63.58

Calculation for Infection Transmission Rate – 01 July 2021

= User Input
= Calculation Output
= Input from other sources (Relevant websites)
= Change Variable

UTLA in UK is Upper Tier Local Authority (UTLA), rolling rates reported from: https://coronavirus.data.gov.uk/details/interactive-map

It is possible to include Covid Testing (LFT & PCR) in Transmission Rate calculation, however in a communal place wit high population density, it is not possible to know the number of people who have done their regular testing.

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Calculation of Death Probability from ALAMA data

Case 1	Age actual, Category	Flu death risk for All ages (many younger people work in process plants)	Sex	Ethnicity	BMI	Heath Status	Covid age	Lower Fatality Limit	Upper Fatality Limit	Geometric Mean of Fatality for 1 person
A	62	1.87E-04	Male	Asian	40+	Good	77	13	52	2.60E-02
B	40	1.87E-04	Male	White	30-34.9	Good	45	0.5	1.9	9.75E-04
C	40	1.87E-04	Female	White	30-34.9	Good	40	0.3	1.2	6.00E-04
D	40	1.87E-04	Male	White	40+	Asthma, Type 2 diabetes	85+	30	119	5.97E-02

https://alama.org.uk/covid-19-medical-risk-assessment/

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Covid Fatality Metrics Calculation, 70% Vaccination Efficacy and No Vaccination – 17 June 2021 (Case 1)

Case 1	Infection transmission Rate per Year	Transmission pathway	Independent Protection Layers (IPL)					Infection rate per year	Death Probability for 1 infected person	Risk of Death per Year	Flu Annual Death Rate	Covid Fatality Metric
			Social Distancing	Building Ventilation	Face Mask	Hand Hygiene	Vaccine					
A	35.96	Direct	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
		Total						1.28E+00	2.60E-02	3.32E-02	1.00E-04	331.88
B	35.96	Direct	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
		Total						1.28E+00	9.75E-04	1.24E-03	1.00E-04	12.44
C	35.96	Direct	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
		Total						1.28E+00	6.00E-04	7.66E-04	1.00E-04	7.66
D	35.96	Direct	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	0.30	6.38E-01				
		Total						1.28E+00	5.97E-02	7.63E-02	1.00E-04	762.68

Case 1	Infection transmission Rate per Year	Transmission pathway	Independent Protection Layers (IPL)					Infection rate per year	Death Probability for 1 infected person	Risk of Death per Year	Flu Annual Death Rate	Covid Fatality Metric
			Social Distancing	Building Ventilation	Face Mask	Hand Hygiene	Vaccine					
A	35.96	Direct	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
		Total						4.25E+00	2.60E-02	1.11E-01	1.00E-04	1106.27
B	35.96	Direct	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
		Total						4.25E+00	9.75E-04	4.15E-03	1.00E-04	41.47
C	35.96	Direct	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
		Total						4.25E+00	6.00E-04	2.55E-03	1.00E-04	25.53
D	35.96	Direct	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
	35.96	Indirect	0.4957	0.50	0.4822	0.4950	1.00	2.13E+00				
		Total						4.25E+00	5.97E-02	2.54E-01	1.00E-04	2542.27

Covid Fatality Metric is defined as the ratio of the Covid risk of death per year to the flu annual death rate. If the ratio drops towards 1, it means it is an improvement as the Covid death rate nears the common flu death rate.

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Covid Fatality Metrics Calculation, 70% Vaccination Efficacy and No Vaccination – 01 July 2021 (Case 2)

Case 2	Infection transmission Rate per Year	Transmission pathway	Independent Protection Layers (IPL)					Infection rate per year	Death Probability for 1 infected person	Risk of Death per Year	Flu Annual Death Rate	Covid Fatality Metric
			Social Distancing	Building Ventilation	Face Mask	Hand Hygiene	Vaccine					
A	63.58	Direct	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
		Total						2.61E-01	2.60E-02	6.80E-03	1.00E-04	67.98
B	63.58	Direct	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
		Total						2.61E-01	9.75E-04	2.55E-04	1.00E-04	2.55
C	63.58	Direct	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
		Total						2.61E-01	6.00E-04	1.57E-04	1.00E-04	1.57
D	63.58	Direct	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	0.30	1.31E-01				
		Total						2.61E-01	5.97E-02	1.56E-02	1.00E-04	156.22

Case 2	Infection transmission Rate per Year	Transmission pathway	Independent Protection Layers (IPL)					Infection rate per year	Death Probability for 1 infected person	Risk of Death per Year	Flu Annual Death Rate	Covid Fatality Metric
			Social Distancing	Building Ventilation	Face Mask	Hand Hygiene	Vaccine					
A	63.58	Direct	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
		Total						8.72E-01	2.60E-02	2.27E-02	1.00E-04	226.60
B	63.58	Direct	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
		Total						8.72E-01	9.75E-04	8.49E-04	1.00E-04	8.49
C	63.58	Direct	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
		Total						8.72E-01	6.00E-04	5.23E-04	1.00E-04	5.23
D	63.58	Direct	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
	63.58	Indirect	0.2492	0.50	0.2430	0.2264	1.00	4.36E-01				
		Total						8.72E-01	5.97E-02	5.21E-02	1.00E-04	520.74

Covid Fatality Metric is defined as the ratio of the Covid risk of death per year to the flu annual death rate. If the ratio drops towards 1, it means it is an improvement as the Covid death rate nears the common flu death rate.

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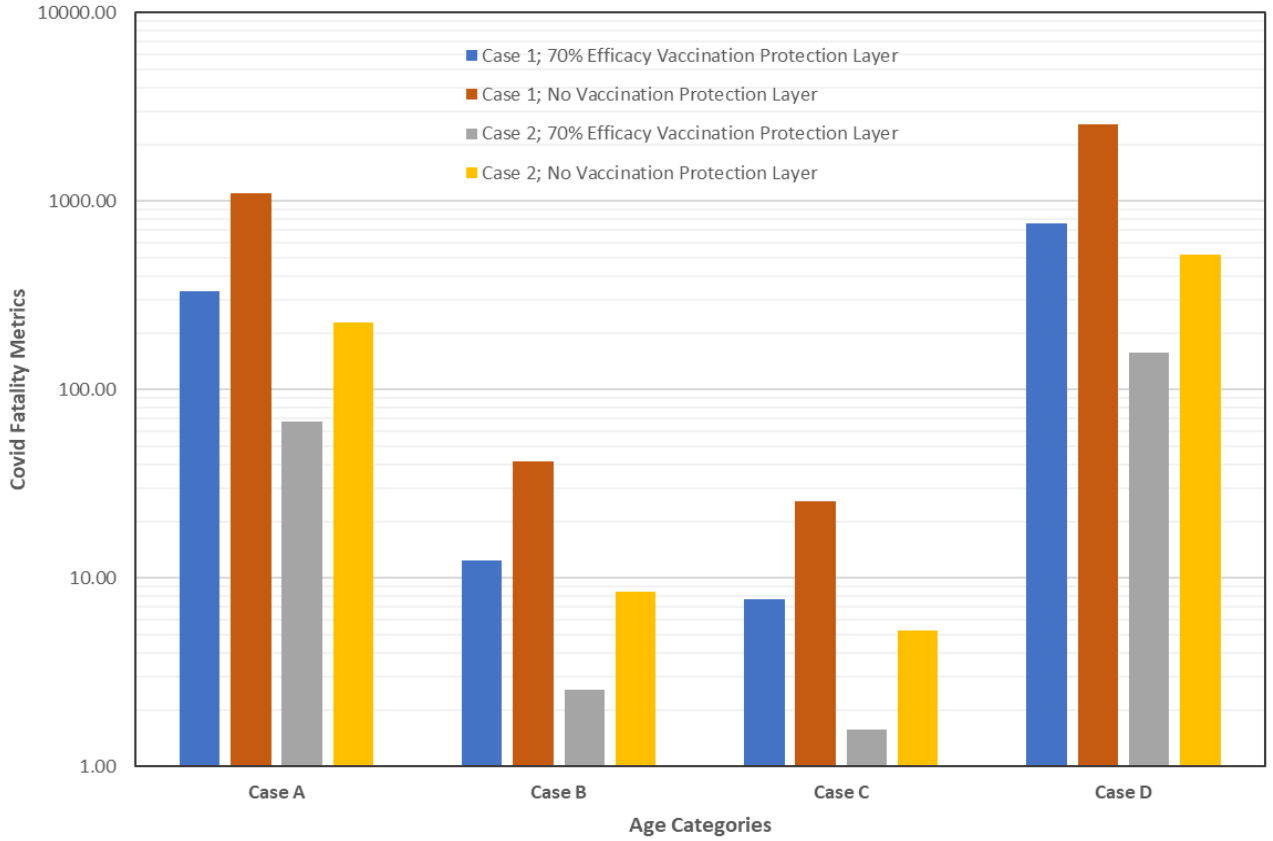
Results: Covid Fatality Metrics



Covid Fatality Metrics for Cases 1 & 2, showing lower expected fatality in Case 2 and lower fatalities at 70% efficacy vaccination.

Category	Age	Sex	Ethnicity	BMI	Heath Status
A	62	Male	Asian	40+	Good
B	40	Male	White	30-34.9	Good
C	40	Female	White	30-34.9	Good
D	40	Male	White	40+	Asthma, Type 2 diabetes

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Main Conclusion

It is now accepted that COVID-19 Virus has become an omnipresent entity within human population. It has been suggested that there need to be a debate about what is an "acceptable" level of Covid, "Covid is here to stay - we need to discuss what we are willing to live with". The proposed LOPA Versus Covid model can provide an analytical quantitative method to identify ‘what is the acceptable rate’ in relation to the calculated transmission rates and the health protocols effectiveness.

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Recommendations

- This study proposes to use a designated area in heavily populated locations such as shopping centres and transport hubs, equipped with CCTV and digital image processing to survey the public compliance.
- For populated hubs it is practical to use observational surveys and include Covid testing in Transmission Rate calculations.
- The statistical modelling, random number population sampling and LOPA calculation in this study were performed manually by the authors. It is recommended to develop a ‘Covid LOPA software’ tool for automation.
- It is recommended that other process safety risk assessment tools may also be applied to Covid-19 infection spread. Structured process safety reviews such as Hazard Identifications (HAZIDs), with relevant modifications may be applied to identify the Covid infection risks.

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- Societal risk (FN-curve) can set out to provide a single measure of the chance of virus outbreak that could harm a number of people in a pandemic. FN-curves may be used for presenting information about societal risks and to depict at least three different types of information:
  - Historical record of local rolling infection rates and outbreaks in the community;
  - Results of a Probabilistic Safety Assessment; and
  - Criteria for judging the tolerability of risk.

- It is realised that efficient ventilation in closed spaces is the key to safeguarding against the virus spread in confined areas. The ventilation system can be treated as a safety critical element with the rigorous safeguarding performance standards as applied to process engineering critical equipment.

Thank You

- For listening
- Questions and further explanations

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