Example of a DOE Application to Coronavarius Data Analysis

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Introduction

This **example illustrates** how **Design of Experiments/DOE** can be used in the analysis and research of Covid-19 Data, to identify and assess the effects of significant factors in Virus Containment. **The Data has been made-up; our objective is to illustrate the Power of DOE in Covid-19 problems.**

This type of analysis can be implemented at County or Regional levels, with periodically collected data, to verify that containment measures in use are working correctly and, if so, to quantify their results.

DOEs may be implemented using a pre-established statistical design (e.g. full, fractional factorials, etc.) Some professional statistical guidance is necessary. DOEs can also be implemented in a similar manner as EVOP (Evolutionary Operations), taking advantage of the sequential implementation of the several containment measures. Results should be interpreted with care, using professional statistical help.

In the present example the DOE results have been analyzed using an Excel Spread Sheet, thus avoiding the use of expensive statistical software. A tutorial example on the use and the calculations of Fractional Factorial DOE analysis matrices using Excel Spread Sheets (as we will do below) can be found in article: https://web.cortland.edu/matresearch/FFDOEOverview2007.pdf

The DOE Example

Assume we collect weekly infection rate data from several counties or regions that implement different forms of *containment measures*. The three measures (here-on *Factors*) we consider are:

(A) Recommended Social Distancing, when persons are in congested places, with two options (levels): in Operation (denoted as -1) and None (denoted +1);

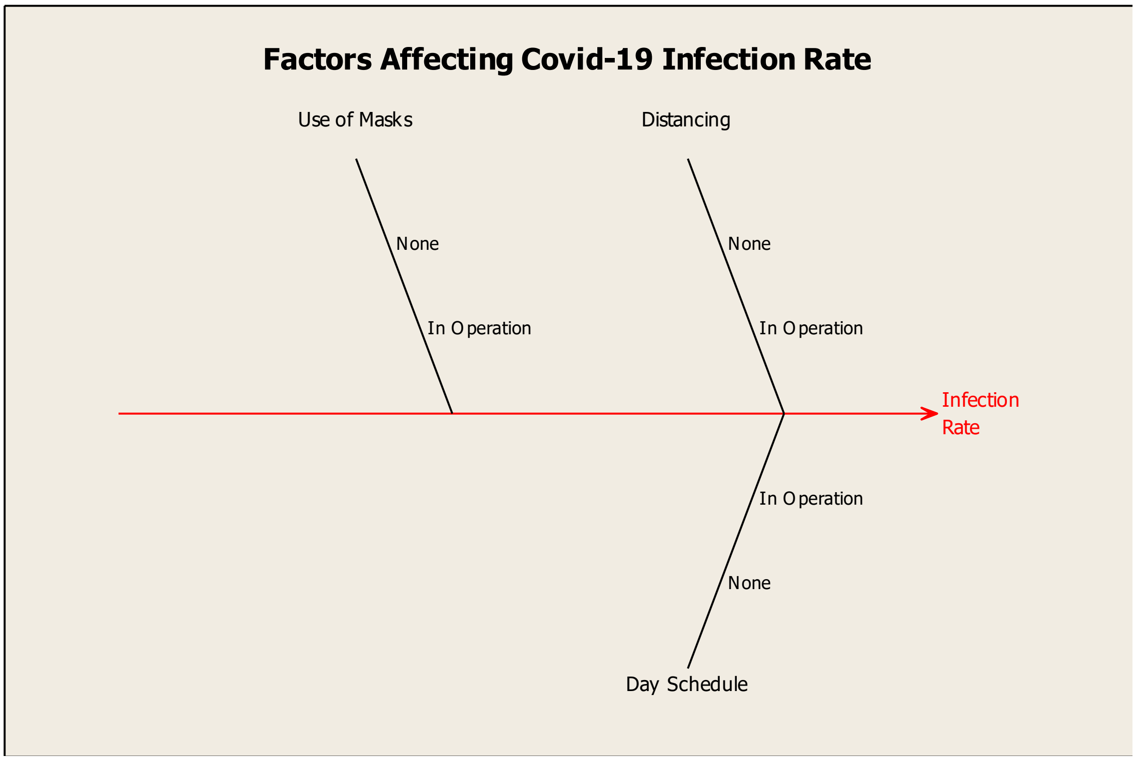
(B), Recommended Use of Face Masks, when persons are in congested areas, with two options (levels): in Operation (denoted as -1) and None (denoted +1);

(C), Recommended Use of Birthday Schedule (e.g. those born on odd years should go out on M/W/F, and those born on even years, should go on T/Th/S), with two levels: in Operation (-1) and None (+1);

We take three *replications* (measurements) of three weekly Infection Rates in regions where these three above-defined factors (A, B, C) have been used in specific combinations (e.g. -1, -1, -1) in different time periods (weeks). For example, in the matrix below, *Run 1* (-1, -1, -1) means that the data comes from a county/region where that week, Social Distancing, Use of Masks and Day Schedule were all in Operation.

Let the *Response* of interest be the *Effect on* the *Infection Rate, of Factors Social Distancing, Face Masks and Day Schedule*. We will *compute this Effect* by comparing the measured rate with *a **standard/desired rate (say** **5%) below which Community Spread can be effectively contained.*** *Responses* are computed, for example: if *actual infection* rate was *7%*, the *value recorded* in our analysis would be *7 - 5 = 2%*

Below, we show the *Ishikawa Chart* (Cause and Effect) for the stated problem:



This graph expresses *how the three factors*, at their two stated levels, can *affect infection rate*.

Design of Experiments Results

We show below the DOE Analysis Table. There are *eight runs* (eight possible combinations of the three Factors A, B, C, at their -1 and +1 levels). Each run is a line, where under the respective columns A, B, C are recorded the levels at which these had occurred when the data was collected. There are *three replications* (measurements) denoted Y1, Y2, Y3 corresponding to the three weeks in which said *factors* were operating at said *levels*. Replications are then averaged and their variance is calculated.

The *Effects,* for the different column values (*Factors*), are obtained by algebraically adding the eight row Averages, according to the +/- signs below each respective Effect column.

For example, for Factor A (Social Distancing), we would add: -1.5 + 1.7 … - 4.1 + 4.9 = 0.23. This value is the increment over desired 5%, Its *95% Confidence Interval* (-.3, 0.76) defines the region where such +/- increment lies, 95% of the times (remember, the *data is only a sample*).

Table of DOE Analysis Results:

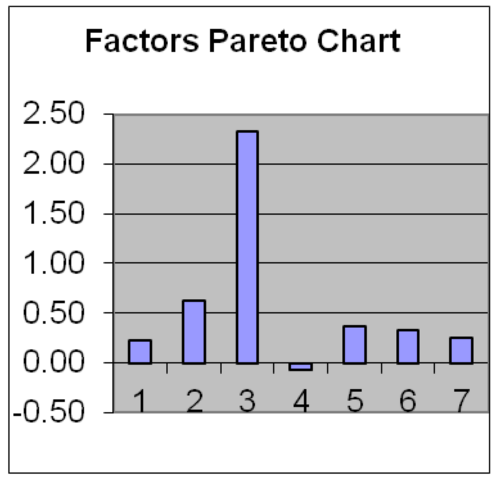
			Design of Experiments				Covid-19					IV/2020	
		Factorial Experiments 2^3 (Three Replics/Treatment)							Run Results				
Run	A	B	C	AB	AC	BC	ABC	Y1	Y2	Y3	Avg.	Var.
1	-1	-1	-1	1	1	1	-1	1.50	1.42	1.72	1.547	0.024
2	1	-1	-1	-1	-1	1	1	1.56	1.73	1.87	1.719	0.024
3	-1	1	-1	-1	1	-1	1	1.71	2.75	2.02	2.161	0.286
4	1	1	-1	1	-1	-1	-1	1.98	1.64	1.50	1.704	0.062
5	-1	-1	1	1	-1	-1	1	2.52	4.12	3.61	3.417	0.673
6	1	-1	1	-1	1	-1	-1	4.08	3.86	3.57	3.835	0.064
7	-1	1	1	-1	-1	1	-1	4.19	3.49	4.90	4.193	0.492
8	1	1	1	1	1	1	1	5.71	5.02	4.19	4.976	0.577
TotSum								23.24	24.04	23.38	23.55	2.20
SumY+	12.23	13.03	16.42	11.64	12.52	12.44	12.27					
SumY-	11.32	10.52	7.13	11.91	11.03	11.12	11.28					
AvgY+	3.06	3.26	4.11	2.91	3.13	3.11	3.07					
AvgY-	2.83	2.63	1.78	2.98	2.76	2.78	2.82					
Effect	**0.23**	**0.63**	**2.32**	**-0.07**	**0.37**	**0.33**	**0.25**					

Factors Analyzed:

Factor A:	Social Distance
Factor B:	Use Face Mask
Factor C:	Day Scheduling
Response:	**InfectionRate**

Factors	**SocialDistance**	**Use Face Masks**	**DayScheduling**
Low Level	Implemented	Implemented	Implemented
HighLevel	None	None	None

Var. of Model	0.28	**StdDv**	0.52
Var. of Effect	0.05	**StdDv**	0.21
Student T (0.025;DF) =		2.473	
C.I. Half Width =		**0.530**	



Significant Factors & 95% CI Limits:

Factor	**A**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**
Signific.	**No**	**Yes**	**Yes**	**No**	**No**	**No**	**No**
LwrLimit	-0.30	0.10	1.79	-0.60	-0.16	-0.20	-0.28
UprLimit	0.76	1.16	2.85	0.46	0.90	0.86	0.78

Data Analysis Interpretation:

Two of the three Main Effects are statistically significant (i.e. they increase the infection rate over 5%). *Effect A, Social Distancing, is not statistically significant*: its Effect is 0.23; its 95% Confidence Interval (CI) is -0.3 to 0.76, and covers zero. **Social Distancing helps maintain infection rate at the desired level of 5%.** *Effect B, Use of Face Masks, is mildly significant*. Its 95% CI shows its use may allow an infection rate increase 0.1 to 1.16% over the desired 5%. *Effect C, Day Scheduling is statistically significant*. Its 95% CI shows Social Distancing allows an infection rate increase 1.79 to 2.85% over 5%. Thus: *Social Distancing is the most helpful tool to help keep infection rates at the desired 5% levels*. *Taking more replications will help* determine if *Wearing Masks* may be Not Significant; currently it is *barely/mildly significant*.

THE ABOVE RESULTS ARE JUST FOR ILLUSTRATION, AND DO NOT REPRESENT REAL DATA ANALYSES.