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Estimated of COVID-19 Sampling Mean in Burkina Faso

Vini Yves Bernadin LOYARA[1], Remi Guillaume BAGRE [2], Frédric BERE[3]

[1] Université Joseph KI-ZERBO : Centre Universitaire Polytechnique de Kaya, BP 232 Kaya, Burkina Faso

[2] UFR-ST, Université Norbert ZONGO. BP 376 Koudougou, Burkina Faso

[3] Institut des Sciences, BP: 1757, Ouagadougou, Burkina Faso

Correspondence: Vini Yves Bernadin LOYARA, Centre Universitaire Polytechnique de Kaya, BP 232 Kaya Burkina, Burkina Faso. E-mail: loyarayves@outlook.com

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Abstract

Our objective in the development of this document, was to establish an estimate of the average of different variables in particular, the case of daily contamination of covid-19, the case of recovery and finally the case of lethality of COVID-19 in Burkina to give an idea of the real rate of contamination in Burkina Faso. To achieve this objective we used the tools of inferential statistics.

Keywords: mean, sampling, estimate, average, COVID-19, interval estimation, standard deviation

1. Introduction

The COVID-19 pendulum began in China in December 2019 and since humanity has been fighting against this disease. This emerging disease, little known around the world, has been declared a public health emergency of international concern (USPPI) by WHO. In light of the country's trade with China and the rest of the world, the spread of this pandemic was predictable. Burkina Faso registered its first case of COVID-19 on March 9, 2020. Since that day, it has been registering cases daily.

Coronaviruses, also called crown viruses,are transmitted from human to human by air, by coughing or sneezing and by close contact (touching or shaking hands). They can also be transmitted by contact with an object and / or a surface contaminated by the virus (door handle, stair railing, elevator buttons, etc.).

In view of the extent of COVID's disease, it is difficult for a scientist to sit around and do nothing.This in this dynamic that our small research team has decided to make our contribution. We offer through certain properties of mathematical statistics an estimate of the average of the following parameters: Number of daily contamination, number of healing and number of cotidient deaths

This modeling propose in our document is an empirical study. We have observed the evolution of the disease and the reaction of the population to the disease. For 63 days we collected data on the disease through local media. We believe that behind the figures announced lies the behavior of the people of Burkina. Working on 63 days of data is acceptable. We could have waited 90 days to observe again, but the urgency of the situation will not allow it.

The theory of sampling is the study of the links between the reference population called population and the samples from this population. For this to be possible, the sample must be constructed from more or less sophisticated techniques, the study of which constitutes the theory of surveys. In inferential statistics, there is also a common scheme involving probabilities or, a priori, unknown or poorly known and we seek, by means of observations of realizations of the random events governed by these distributions, to reduce to maximum effects of "lack of information" in making certain decisions.

First, we developed a point estimate of the different means. Then we modeled the confidence intervals of the mean with 0.05 of error of the different means. In the last part we modeled a confidence interval for the different variances. By proposing these estimates we hope to approach a certain optimized value for our different parameters (Contamination, Healing and death).

2. Method

The techniques we have used to estimate the different means (Contamination, Healing and death) come from methods of estimating inferential statistics.

2.1 Sample as Creation of a Random Tuple

If we consider the samples as the realization of a random variable with n dimensions $(X_1, X_2, ..., X_n)$, $(Y_1, Y_2, ..., Y_n)$ and $(Z_1, Z_2, ..., Z_n)$. These multidimensional variables is defined on the set of all possible samples of size n that can be extracted from the mother population (Burkina Faso). They then have all their own probability distributions, linked to that of X for X_i, Y for Z_i and Z for Z_i. All the quantities that can be calculated in the sub-population sample here become realizations of random variables, defined, like the tuple, on the set of all samples of size n that we can extract from the population.

$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, is the realization, in the sample considered, of empirical random mean variable defined by $\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$

$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$, is the realization, in the sample considered, of empirical random mean variable defined by $\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i$

$\bar{z} = \frac{1}{n}\sum_{i=1}^{n} z_i$, is the realization, in the sample considered,of empirical random mean variable defined by $\bar{Z} = \frac{1}{n}\sum_{i=1}^{n} Z_i$

$s^2_{n,x} = \frac{1}{n}\sum_{i=1}^{n} (x_i - \bar{x})^2$ is the realization, in the sample considered, of the random variable empirical variance defined by $S^2_{n,y} = \frac{1}{n}\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2$.

$s^2_{n,y} = \frac{1}{n}\sum_{i=1}^{n} (y_i - \bar{y})^2$ is the realization, in the sample considered, of the random variable empirical variance defined by $S^2_{n,y} = \frac{1}{n}\sum_{i=1}^{n}\left(Y_i - \bar{Y}\right)^2$.

$s^2_{n,z} = \frac{1}{n}\sum_{i=1}^{n} (z_i - \bar{z})^2$ is the realization, in the sample considered, of the random variable empirical variance defined by $S^2_{n,z} = \frac{1}{n}\sum_{i=1}^{n}\left(Z_i - \bar{Z}\right)^2$.

2.2 Estimated Average Contamination

X follows a normal law, σ_x is known. If $X \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$, so $\forall i \in \{1, ..., n\}$, $X_i \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$ and $\bar{X} \rightsquigarrow \mathcal{N}\left(\mu_x, \frac{\sigma_x}{\sqrt{n}}\right)$. Given a risk $\alpha = 0,05$, the centered-reduced normal distribution table gives a number $u_{\alpha/2} = 1,645$ such that :

$$\mathbb{P}\left[-u_{\alpha/2} \leq \frac{\bar{X} - \mu_x}{\frac{\sigma}{\sqrt{n}}} \leq u_{\alpha/2}\right] = 1 - \alpha$$

We then have

$$\mathbb{P}\left[-u_{\alpha/2}\frac{\sigma}{\sqrt{n}} \leq \bar{X} - \mu_x \leq u_{\alpha/2}\frac{\sigma}{\sqrt{n}}\right] = 1 - \alpha$$

Let

$$\mathbb{P}\left[\bar{X} - u_{\alpha/2}\frac{\sigma}{\sqrt{n}} \leq \mu_x \leq \bar{X} + u_{\alpha/2}\frac{\sigma}{\sqrt{n}}\right] = 1 - \alpha$$

We found two v.a:

$$T_1(X_1, X_2, ..., X_n) = \bar{X} - u_{\alpha/2}\frac{\sigma_x}{\sqrt{n}} \quad et \quad T_2(X_1, X_2, ..., X_n) = \bar{X} + u_{\alpha/2}\frac{\sigma_x}{\sqrt{n}}.$$

2.3 Confidence Interval Estimate of the Variance in the Number of Contamination Cases

μ_x is unknown. We take $S^2_{n-1,x}$ as an estimator of σ^2. Si $\bar{X} \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$ then

$$\frac{(n-1)S^2_{n-1,x}}{\sigma^2} = \frac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2}{\sigma^2} \rightsquigarrow \chi^2_{(62)}.$$

Given a risk $\alpha = 0,05$, the chi-square table at 63 degrees of freedom gives z_1 and z_2 such as :

$$\mathbb{P}\left[z_1 \leq \frac{(n-1)S^2_{n-1,x}}{\sigma^2} \leq z_2\right] = 1 - \alpha.$$

Since the interval $[z_1, z_2]$ is not unique, it depends on the risks α_1 and α_2 admitted outside the interval.

2.4 Estimated Average Contamination

X follows a normal law, σ_x is unknown. In this case, we consider the variable

$$T_x = \frac{\bar{X} - \mu_x}{\frac{S_{n-1,x}}{\sqrt{n}}}$$

with $s_{n-1,x} = \frac{63}{62} \times s_{n,x} = 9.95$.

which follows a Student law with 63 degrees of freedom. Given a risk $\alpha = 0.05$, Student's table at 63 degrees of freedom gives $t_{\alpha/2} = 1.669$ such as :

$$\mathbb{P}\left[-t_{\alpha/2} \leq \frac{\bar{X} - \mu}{\frac{S_{n-1}}{\sqrt{n}}} \leq t_{\alpha/2}\right] = 1 - \alpha$$

let

$$\mathbb{P}\left[\bar{X} - t_{\alpha/2}\frac{S_{n-1}}{\sqrt{n}} \leq \mu \leq \bar{X} + t_{\alpha/2}\frac{S_{n-1}}{\sqrt{n}}\right] = 0.95$$

3. Results

3.1 Classical Estimation (From a Sample of Size n)

Estimation of the different means : $\theta_x = \mathbb{E}[X] = \mu_x$, $\theta_y = \mathbb{E}[Y] = \mu_y$, $\theta_z = \mathbb{E}[Z] = \mu_z$, $n = 63$.

$\bar{x} = \frac{1}{n}\,\overset{[}{i}= 1]n\sum x_i$, mean of the values observed in the sample, is an estimate of μ_x. $\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$, "empirical mean" of random variable, is an estimator of μ_x. $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$, mean of the values observed in the sample, is an estimate of μ_y. $\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i$, "empirical mean" random variable, is an estimator of μ_y. $\bar{z} = \frac{1}{n}\sum_{i=1}^{n} z_i$, mean of the values observed in the sample, is an estimate of μ_z. $\bar{Z} = \frac{1}{n}\sum_{i=1}^{n} Z_i$, "empirical mean" of random variable, is an estimator of μ_z.

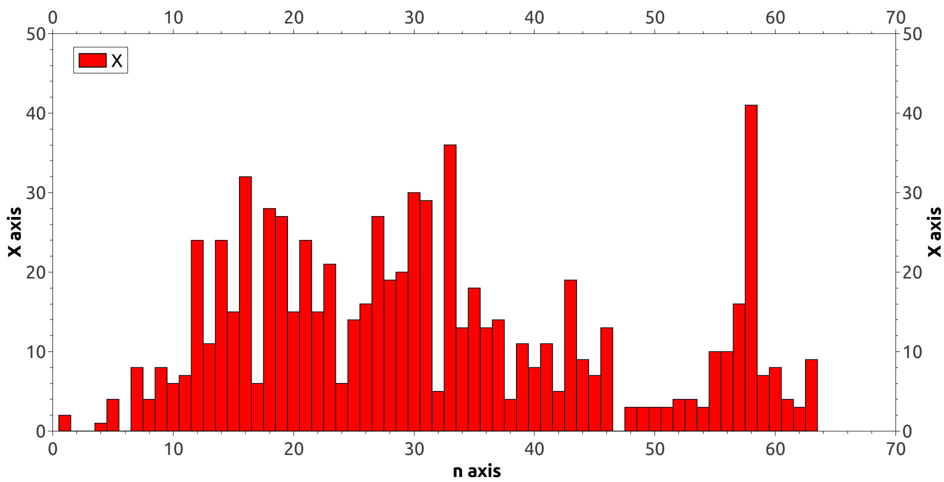

Figure 1. Histogram : Daily contamination cases in Burkina Faso

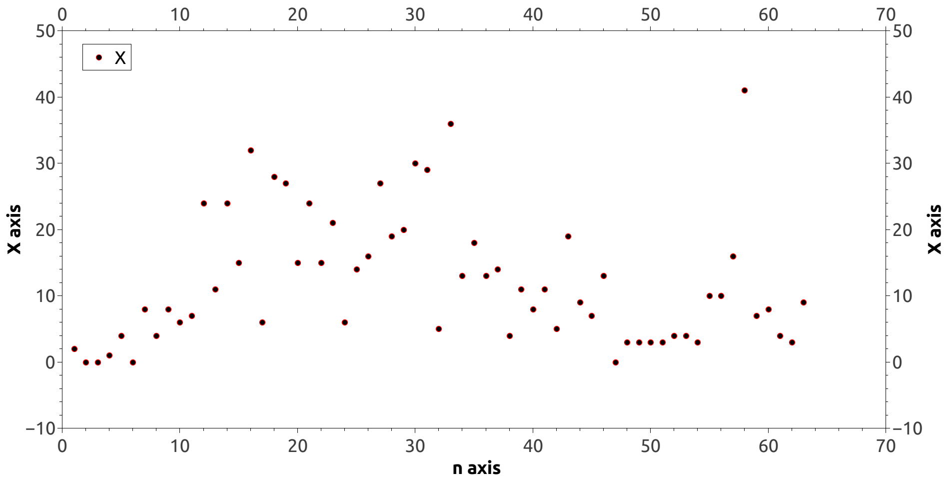

Figure 2. A cloud of dots : Daily contamination cases in Burkina Faso

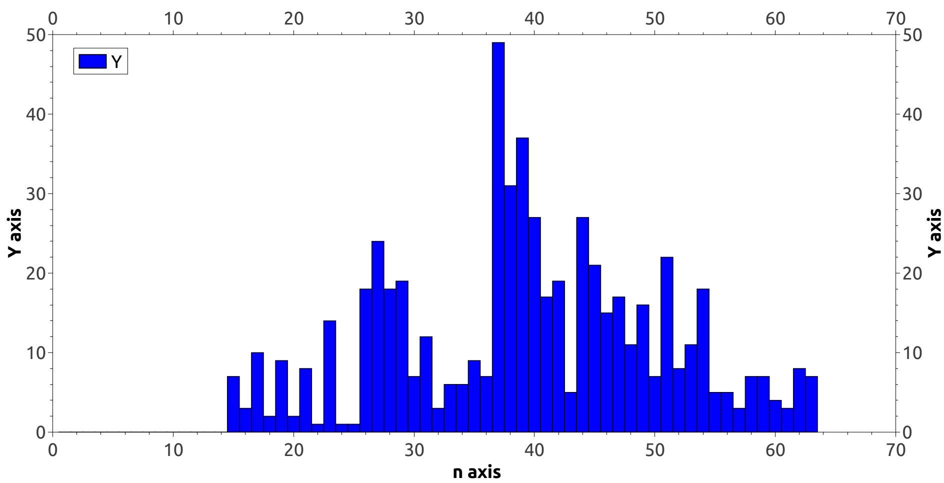

Figure 3. A cloud of dots : Daily contamination cases in Burkina

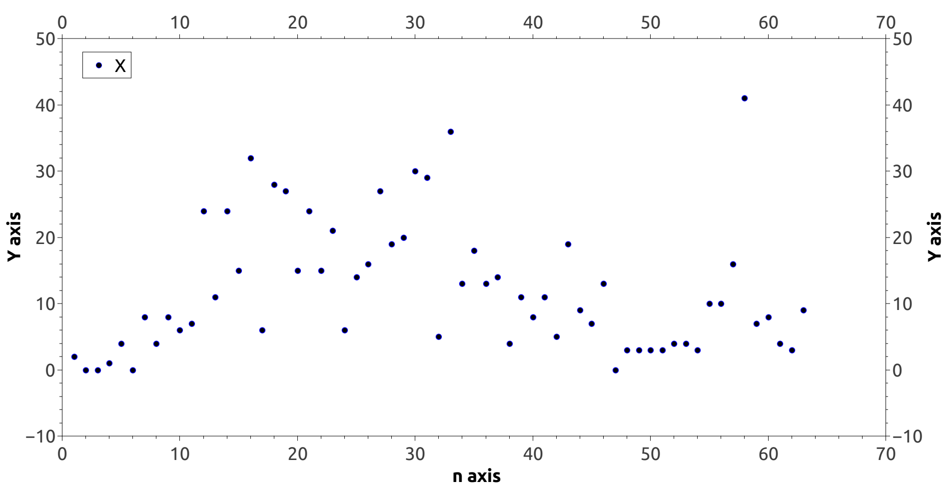

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Figure 4. A cloud of dots : Daily contamination cases in Burkina

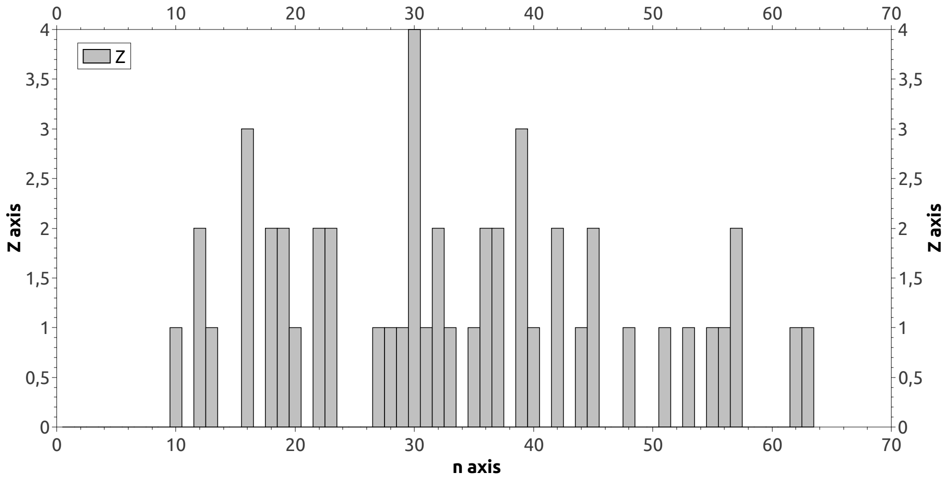

Figure 5. A cloud of dots : Daily contamination cases in Burkina

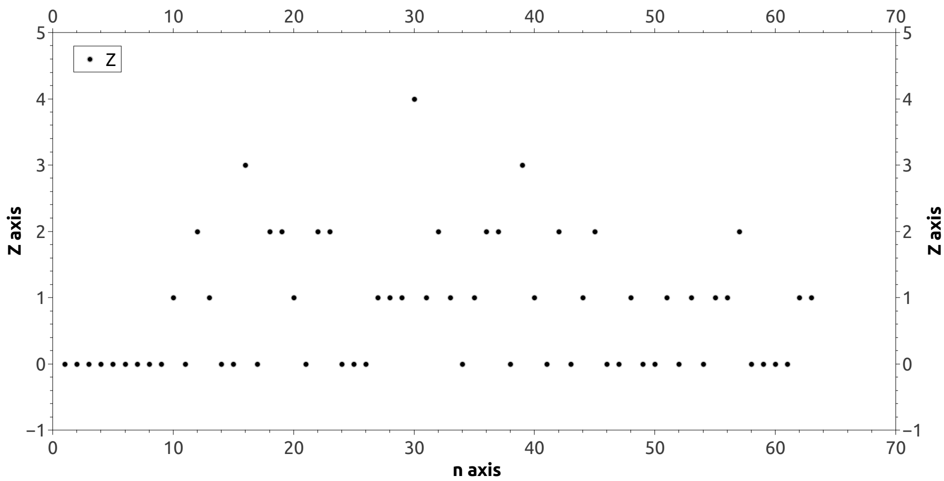

Figure 6. A cloud of dots : Daily contamination cases in Burkina

It comes that after observation and analysis of the different diagrams: The largest number (49 cases) of gestation was recorded on the 38th day out of the 63 test days with a median of 7. The peak (41 cases) of COVID-19 comtamination with burkina faso is reached on the 58th day out of the 63 days of testing with a median of 9. On the 30th day the Bukina recorded its largest case of death (4 deaths). We also have a median of 1 case of death over the 63 days of testing.

Table 1. Summary table of certain parameters on COVID-19 in Burkina

	X	Y	Z
$\mathbb{E}[\cdot]$	12.063,492,063,49	9.428,571,428,571	0.793,650,793,650,8
$V(\cdot)$	96.092,677,931,39	103.732,718,894	0.908,346,134,152,6
$\sigma(\cdot)$	9.802,687,281,118	10.184,926,062,28	0.953,071,945,947,7
$max(\cdot)$	41	49	04
$min(\cdot)$	0	0	0
$\sum$	760	594	50

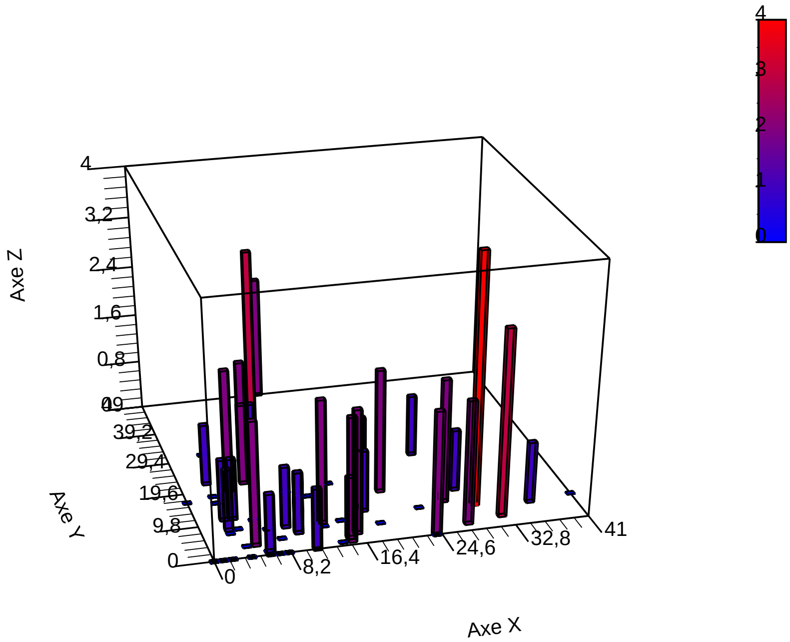

Figure 7. Number of deaths compared to the number of contamination and healing

The following table summarizes the point values of some characteristic parameters of the random values X, Y and Z

We observe in the following graph on the X axis we have the number of daily contamination of COVID-19, the Y axis represents the cases of recovery and finally the Z axis represents the daily lethality of COVID-19 in Burkina.

The properties of sampling an average gives:

$$\mathbb{E}\left[\bar{X}\right] = \mathbb{E}(X) = 12.06 = \mu_x$$

$$\mathbb{E}\left[\bar{Y}\right] = \mathbb{E}(Y) = 9.42 = \mu_y$$

$$\mathbb{E}\left[\bar{Z}\right] = \mathbb{E}(Z) = 0.79 = \mu_z$$

3.2 Confidence Interval Estimation

Let X, Y and are a random variable defined on the mother population, of mean μ_x, μ_y and μ_z, of variance σ_x^2, σ_y^2 and σ_z^2. We have 63 days of data, we assume that the different means are the means of another sampling to allow us to use the laws of inferential statistics. We also have different situations that presents itself to us. Either the laws of X, Y and Z are known or they are not. Which brings us to the following hypotheses.

3.2.1 Confidence Interval of an Average (so μ is Unknown)

Let $\bar{X}$ be the estimator of μ : $\mathbb{E}\left[\bar{X}\right] = \mathbb{E}[X] = \mu$ et $var\left(\bar{X}\right) = \frac{var(X)}{n} = \frac{\sigma^2}{n}$.

3.2.1 First Case: Estimated Average Contamination

3.2.1.1 Estimated Average Contamination

X follows a normal law, σ_x is known. If $X \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$, so $\forall i \in \{1, ..., n\}$, $X_i \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$ and $\bar{X} \rightsquigarrow \mathcal{N}\left(\mu_x, \frac{\sigma_x}{\sqrt{n}}\right)$. Given a risk $\alpha = 0.05$, the centered-reduced normal distribution table gives a number $u_{\alpha/2} = 1.645$ such that :

$$\mathbb{P}\left[-u_{\alpha/2} \leq \frac{\bar{X} - \mu_x}{\frac{\sigma}{\sqrt{n}}} \leq u_{\alpha/2}\right] = 1 - \alpha$$

We then have

$$\mathbb{P}\left[-u_{\alpha/2}\frac{\sigma}{\sqrt{n}} \leq \bar{X} - \mu_x \leq u_{\alpha/2}\frac{\sigma}{\sqrt{n}}\right] = 1 - \alpha$$

Let

$$\mathbb{P}\left[\bar{X} - u_{\alpha/2}\frac{\sigma}{\sqrt{n}} \leq \mu_x \leq \bar{X} + u_{\alpha/2}\frac{\sigma}{\sqrt{n}}\right] = 1 - \alpha$$

We found two v.a:

$$T_1(X_1, X_2, ..., X_n) = \bar{X} - u_{\alpha/2}\frac{\sigma_x}{\sqrt{n}} \quad et \quad T_2(X_1, X_2, ..., X_n) = \bar{X} + u_{\alpha/2}\frac{\sigma_x}{\sqrt{n}}$$

$$T_1(X_1, X_2, ..., X_n) = 10.02$$

$$T_2(X_1, X_2, ..., X_n) = 14.09$$

We can therefore say that in Burkina Faso, the average daily contamination is between 10.02 and 14.09 with an error rate of 5%. In short if we consider that σ_x is known and X follows a normal law; the number of contamination for the 63 days varies between 631.26 and 887.67. The total number of official contamination is from 760 the 63rd day. The 95% confidence interval is well verified.

In the same dynamic if we want to have an idea after 90 days how many cases we can have in the same conditions we will have an interval of [901.8;1,268.1]. The maximum number of cases that can be expected with this method is 1.269.

3.2.1.2 Average Healing Estimate

If $Y \rightsquigarrow \mathcal{N}\left(\mu_y, \sigma_y\right)$, so $\forall i \in \{1, ..., n\}$, $Y_i \rightsquigarrow \mathcal{N}\left(\mu_y, \sigma_y\right)$ and $\bar{Y} \rightsquigarrow \mathcal{N}\left(\mu_y, \frac{\sigma_y}{\sqrt{n}}\right)$. Given a risk $\alpha = 0.05$, the centered-reduced normal distribution table gives a number $u_{\alpha/2} = 1.645$ such that :

$$\mathbb{P}\left[-u_{\alpha/2} \leq \frac{\bar{Y} - \mu_y}{\frac{\sigma_y}{\sqrt{n}}} \leq u_{\alpha/2}\right] = 1 - \alpha$$

We found two v.a:

$$T_1(Y_1, Y_2, ..., Y_n) = \bar{Y} - u_{\alpha/2}\frac{\sigma_y}{\sqrt{n}} \quad et \quad T_2(Y_1, Y_2, ..., Y_n) = \bar{Y} + u_{\alpha/2}\frac{\sigma_y}{\sqrt{n}}$$

$$T_1(Y_1, Y_2, ..., Y_n) = 7.31$$

$$T_2(Y_1, Y_2, ..., Y_n) = 11.52$$

The average of daily healing is between 7.31 and 11.52 with a 95% confidence level.

3.2.1.3 Estimated Lethality Mean

If $Z \rightsquigarrow \mathcal{N}(\mu, \sigma)$, so $\forall i \in \{1, ..., n\}$, $Z_i \rightsquigarrow \mathcal{N}(\mu, \sigma)$ and $\bar{Z} \rightsquigarrow \mathcal{N}\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$. Given a risk $\alpha = 0.05$, the centered-reduced normal distribution table gives a number $u_{\alpha/2} = 1.645$ such that :

$$\mathbb{P}\left[-u_{\alpha/2} \leq \frac{\bar{Z}-\mu}{\frac{\sigma}{\sqrt{n}}} \leq u_{\alpha/2}\right] = 1-\alpha$$

We found two v.a:

$$T_1(Z_1, Z_2, ..., Z_n) = \bar{Z} - u_{\alpha/2}\frac{\sigma_z}{\sqrt{n}} \quad et \quad T_2(Z_1, Z_2, ..., Z_n) = \bar{Z} + u_{\alpha/2}\frac{\sigma_z}{\sqrt{n}}$$

$$T_1(Z_1, Z_2, ..., Z_n) = 0.59$$

$$T_2(Z_1, Z_2, ..., Z_n) = 0.98$$

The mortality rate fluctuates between 0 and 1 with an error of 5%.

3.2.2 Second Case

3.2.2.1 Estimated Average Contamination

X follows a normal law, σ_x is unknown. In this case, we consider the variable

$$T_x = \frac{\bar{X}-\mu_x}{\frac{S_{n-1,x}}{\sqrt{n}}}$$

with $s_{n-1,x} = \frac{63}{62} \times s_{n,x} = 9.95$.

which follows a Student law with 63 degrees of freedom. Given a risk $\alpha = 0,05$, Student's table at 63 degrees of freedom gives $t_{\alpha/2} = 1.669$ such as :

$$\mathbb{P}\left[-t_{\alpha/2} \leq \frac{\bar{X}-\mu}{\frac{S_{n-1}}{\sqrt{n}}} \leq t_{\alpha/2}\right] = 1-\alpha$$

let

$$\mathbb{P}\left[\bar{X} - t_{\alpha/2}\frac{S_{n-1}}{\sqrt{n}} \leq \mu \leq \bar{X} + t_{\alpha/2}\frac{S_{n-1}}{\sqrt{n}}\right] = 0.95$$

$$T_1(X_1, X_2, ..., X_n) = 9.96$$

$$T_2(X_1, X_2, ..., X_n) = 14.15$$

we have $(1-0.05)\times 100$ odds out of 100 that the interval $[9,96,\ 14,15]$ covers the average μ_x.

If we now consider that σ_x is unknown and that X always follows a normal distribution. We will have a number of cases at the end of 63 days between [627.48;891.45]. For an estimate of 90 days we will have a confidence interval of [896.4;1,264.5]. The maximum number after 3 months of hanging with these different considerations is 1,265.

3.2.2.2 Average Healing Estimate

Y follows a normal law, σ_x is unknown. In this case, we consider the variable

$$T_y = \frac{\bar{Y}-\mu_y}{\frac{S_{n-1,y}}{\sqrt{n}}}$$

with $s_{62,y} = \frac{63}{62} \times s_{63,y} = 10.34$.

which follows a Student law with 63 degrees of freedom. Given a risk $\alpha = 0.05$, Student's table at 44 degrees of freedom gives $t_{\alpha/2} = 1.669$ such as :

$$\mathbb{P}\left[-t_{\alpha/2} \leq \frac{\bar{Y}-\mu_y}{\frac{S_{n-1,y}}{\sqrt{n}}} \leq t_{\alpha/2}\right] = 1-\alpha$$

let

$$\mathbb{P}\left[\bar{Y} - t_{\alpha/2}\frac{S_{n-1,y}}{\sqrt{n}} \leq \mu \leq \bar{Y} + t_{\alpha/2}\frac{S_{n-1,y}}{\sqrt{n}}\right] = 0.95$$

$$T_1(Y_1, Y_2, ..., Y_n) = 7.24$$

$$T_2(Y_1, Y_2, ..., Y_n) = 11.59$$

we have $(1 - 0.05) \times 100$ odds out of 100 that the interval $[7.24,\ 11.59]$ covers the average μ_y.

3.2.2.3 Estimated Lethality Mean

Z follows a normal law, σ_z is unknown. In this case, we consider the variable

$$T_z = \frac{\bar{Z} - \mu_z}{\frac{S_{n-1,z}}{\sqrt{n}}}$$

with $s_{n-1,z} = \frac{63}{62} \times s_{n,z} = 0.96$.

which follows a Student law with 63 degrees of freedom. Given a risk $\alpha = 0.05$, Student's table at 44 degrees of freedom gives $t_{\alpha/2} = 1.669$ such as :

$$\mathbb{P}\left[-t_{\alpha/2} \leq \frac{\bar{z} - \mu_z}{\frac{S_{n-1,z}}{\sqrt{n}}} \leq t_{\alpha/2}\right] = 1 - \alpha$$

let

$$\mathbb{P}\left[\bar{Z} - t_{\alpha/2}\frac{S_{n-1,z}}{\sqrt{n}} \leq \mu \leq \bar{Z} + t_{\alpha/2}\frac{S_{n-1,z}}{\sqrt{n}}\right] = 0.95$$

$$T_1(Z_1, Z_2, ..., Z_n) = 0.59$$

$$T_2(Z_1, Z_2, ..., Z_n) = 1.22$$

we have $(1 - 0.05) \times 100$ odds out of 100 that the interval $[0.58,\ 0.99]$ covers the average μ_z.

3.2.3 Third Case

X follows an unknown law, n is large ($n = 63$).

The hypotheses of the central limit theorem are then satisfied and we deduce that $\bar{X} \rightsquigarrow \mathcal{N}\left(\mu_x, \frac{\sigma_x}{\sqrt{63}}\right)$.

- If σ is known, we are brought back to the first case.
- If σ is unknown, we should make the normality assumption for the law of X in order to be able to use the Student variable. However, as n is large, we would approach the student law by a reduced centered normal law and the results are identical to those of the first case (where we estimate σ by s_{n-1}). We will therefore content ourselves with estimating σ by s_{n-1} without the constraining assumption of normality for X.

3.3 Confidence Interval of a Variance

3.3.1 0.95 Confidence Interval Estimate of the Variance in the Number of Contamination Cases

μ_x is unknown. We take $S^2_{n-1,x}$ as an estimator of σ^2. Si $\bar{X} \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$ then

$$\frac{(n-1)\,S^2_{n-1,x}}{\sigma^2} = \frac{\sum\limits_{i=1}^{n}\left(X_i - \bar{X}\right)^2}{\sigma^2} \rightsquigarrow \chi^2_{(62)}.$$

Given a risk $\alpha = 0.05$, the chi-square table at 63 degree of freedom gives z_1 and z_2 such as :

$$\mathbb{P}\left[z_1 \leq \frac{(n-1)\,S^2_{n-1,x}}{\sigma^2} \leq z_2\right] = 1 - \alpha.$$

Since the interval $[z_1, z_2]$ is not unique, it depends on the risks α_1 and α_2 admitted outside the interval.

In fact z_1 is such that

$$\mathbb{P}\left(\frac{62 \times S^2_{62,x}}{\sigma^2} < z_1\right) = \alpha_1;$$

z_2 is such that

$$\mathbb{P}\left(\frac{62 \times S^2_{62,x}}{\sigma^2} > z_2\right) = \alpha_2$$

with $\alpha_1 + \alpha_2 = \alpha$.

for $n > 30$ the chi-2 law can be approximated by the normal law $\mathcal{N}\left(63,\ \sqrt{63}\right)$

$$\frac{z_2 - 63}{\sqrt{63}} = \frac{0.68 + 0.69}{2}$$

from where $z_2 = 68.43$.

by the same process we get

$$z_1 = 63 - 2.81 \times \sqrt{63}$$

from where $z_2 = 40.69$. If we take symmetrical risks $\alpha_1 = \alpha_2 = \frac{\alpha}{2}$, we have $(1 - 0.05) \times 100$ chance out of 100 that the confidence interval at risk that the confidence interval

$$\left[\frac{\sum\limits_{i=1}^{63}(x_i - \bar{x})^2}{z_2}, \frac{\sum\limits_{i=1}^{63}(x_i - \bar{x})^2}{z_1}\right] = \left[\frac{63 \times 96.09}{68.43}; \frac{63 \times 96.09}{40.69}\right] = [88.46; 148.77]$$

recovered variance σ_x^2. We take $S^2_{63,x} = \frac{1}{63}\sum\limits_{i=1}^{63}\left(X_i - \bar{X}\right)^2$ as an estimator of σ^2. Si $X \rightsquigarrow \mathcal{N}(\mu_x, \sigma_x)$, then

$$\frac{63 \times S^2_{63,x}}{\sigma_x^2} = \frac{\sum\limits_{i=1}^{63}(x_i - \bar{x})^2}{z_2} \rightsquigarrow \chi^2_{(62)}$$

because the X_i are independent and of the same law $\mathcal{N}(\mu_x, \sigma_x)$. Given a risk α, the chi-square table at n degrees of freedom gives 40.69 and 68.43 such as $\mathbb{P}\left[z_1 \leq \frac{63S^2_{63,x}}{\sigma_x^2} \leq z_2\right] = 0.95$ hence the risk confidence interval 0.05 for σ_x : $[9.38; 12.19]$.

3.3.2 0.95 Confidence Interval Estimate of Variance in Number of Healing Cases

μ_Y is unknown. We take $S^2_{n-1,y}$ as an estimator of σ^2. Si $\bar{Y} \rightsquigarrow \mathcal{N}\left(\mu_y, \sigma_y\right)$ then

$$\frac{(n-1)\,S^2_{n-1,y}}{\sigma_y^2} = \frac{\sum\limits_{i=1}^{n}\left(Y_i - \bar{Y}\right)^2}{\sigma_y^2} \rightsquigarrow \chi^2_{(62)}.$$

Given a risk $\alpha = 0.05$, the chi-square table at 63 degree of freedom gives z_1 and z_2 such as :

$$\mathbb{P}\left[z_1 \leq \frac{(n-1)\,S^2_{n-1,y}}{\sigma^2} \leq z_2\right] = 1 - \alpha.$$

Since the interval $[z_1, z_2]$ is not unique, it depends on the risks α_1 and α_2 admitted outside the interval.

In fact z_1 is such that

$$\mathbb{P}\left(\frac{62 \times S^2_{62,y}}{\sigma_y^2} < z_1\right) = \alpha_1;$$

z_2 is such that

$$\mathbb{P}\left(\frac{62 \times S^2_{62,y}}{\sigma_y^2} > z_2\right) = \alpha_2$$

with $\alpha_1 + \alpha_2 = \alpha$.

for $n > 30$ the chi-2 law can be approximated by the normal law $\mathcal{N}\left(63, \sqrt{63}\right)$

$$\frac{z_2 - 63}{\sqrt{63}} = \frac{0.68 + 0.69}{2}$$

from where $z_2 = 68.43$.

by the same process we get

$$z_1 = 63 - 2,81 \times \sqrt{63}$$

from where $z_2 = 40.69$. If we take symmetrical risks $\alpha_1 = \alpha_2 = \frac{\alpha}{2}$, we have $(1 - 0.05) \times 100$ chance out of 100 that the confidence interval at risk that the confidence interval

$$\left[\frac{\sum_{i=1}^{63}(y_i - \bar{y})^2}{z_2}, \frac{\sum_{i=1}^{63}(y_i - \bar{y})^2}{z_1}\right] = \left[\frac{63 \times 103.73}{68.43}; \frac{63 \times 103.73}{40.69}\right] = [95.49; 160.60]$$

recovered variance σ_y^2. We take $S_{63,y}^2 = \frac{1}{n}\sum_{i=1}^{63}\left(Y_i - \bar{Y}\right)^2$ as an estimator of σ^2. Si $Y \rightsquigarrow \mathcal{N}(\mu, \sigma)$, then

$$\frac{63 \times S_{63,y}^2}{\sigma_y^2} = \frac{\sum_{i=1}^{63}(y_i - \bar{y})^2}{z_2} \rightsquigarrow \chi^2_{(n-1)}$$

because the Y_i are independent and of the same law $\mathcal{N}\left(\mu_y, \sigma_y\right)$.

Given a risk α, the chi-square table at 63 degrees of freedom gives 40,69 and 68,43 such as $\mathbb{P}\left[z_1 \leq \frac{63S_{63}^2}{\sigma_y^2} \leq z_2\right] = 0.95$ hence the risk confidence interval 0.05 for $\sigma_y : [9.77; 12.67]$.

3.3.3 0.95 Confidence Interval Estimate of Variance in Number of Deaths

μ_Y is unknown. As resolved in cases of contamination or healing we get : If we take symmetrical risks $\alpha_1 = \alpha_2 = \frac{\alpha}{2}$, we have $(1 - 0.05) \times 100$ chance out of 100 that the confidence interval at risk that the confidence interval

$$\left[\frac{\sum_{i=1}^{63}(z_i - z)^2}{u_2}, \frac{\sum_{i=1}^{63}(z_i - \bar{z})^2}{u_1}\right] = \left[\frac{63 \times 0.90}{68.43}; \frac{63 \times 0.90}{40.69}\right] = [0.82; 1.39]$$

recovered variance σ_z^2. We take $S_{63,z}^2 = \frac{1}{63}\sum_{i=1}^{63}\left(Z_i - \bar{Z}\right)^2$ as an estimator of σ^2. Si $Z \rightsquigarrow \mathcal{N}(\mu_z, \sigma_z)$, then

$$\frac{63 \times S_{63,z}^2}{\sigma_z^2} = \frac{\sum_{i=1}^{63}(z_i - \bar{z})^2}{u_2} \rightsquigarrow \chi^2_{(62)}$$

because the X_i are independent and of the same law $\mathcal{N}(\mu, \sigma)$. Given a risk α, the chi-square table at 63 degrees of freedom gives 40.69 and 68.43 such as $\mathbb{P}\left[40.69 \leq \frac{63S_{63}^2}{\sigma_z^2} \leq 68.43\right] = 0.95$ hence the risk confidence interval 0.05 for σ_z : $[0.90; 1.17]$.

We observe in the following graph on the X axis we have the number of daily contamination of COVID-19, the Y axis represents the cases of recovery and finally the Z axis represents the daily lethality of COVID-19 in Burkina.

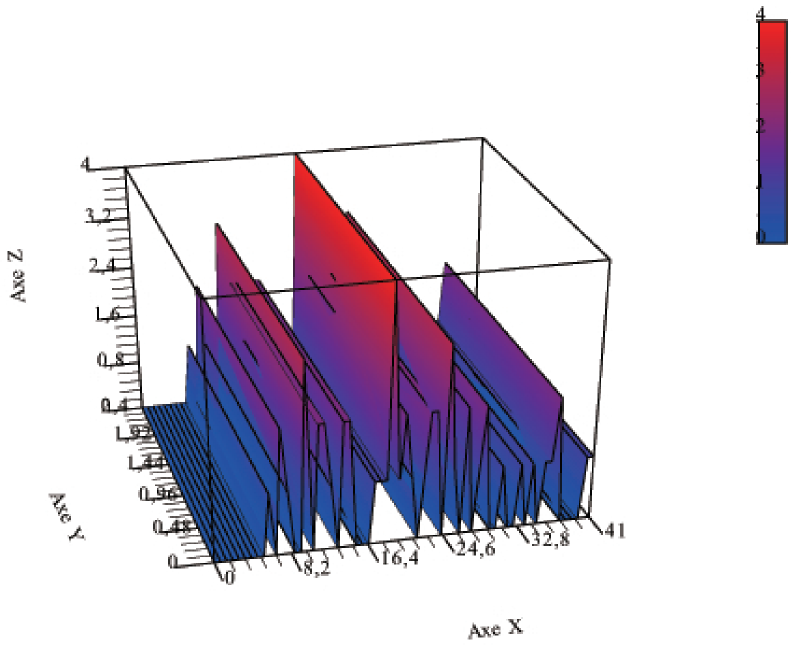

Figure 8. Number of deaths compared to the number of contamination and healing

Table 2. Data summary table 1

	$\mathbb{E}[\cdot]$	$V[\cdot]$	$\sigma(\cdot)$	I_1	I_2	I_σ
X	12.06	96.09	9.80	[10.02; 14.09]	[9.96; 14.15]	[9.38; 12.19]
Y	9.42	103.73	10.18	[7.31; 11.52]	[7.24; 11.59]	[9.77; 12.67]
Z	0.79	0.90	0.95	[0.59; 0.98]	[0.58; 0.99]	[0.90; 1.77]

Statistics and Data Analysis

In the following table we offer a summary of the different estimates that we were able to model.

- I_1 tolerance interval with 95% confidence starting from the fact that X follows a normal law and known sigma.
- I_2 tolerance interval with 95% confidence starting from the fact that X follows a normal law and unknown sigma.
- I_1^{63} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and known sigma after 63 days.
- I_1^{90} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and known sigma after 90 days.

Table 3. Data summary table 2

	I_1^{63}	I_2^{63}	I_1^{90}	I_2^{90}	I_1^{150}	I_2^{150}
X	[631.26; 887.67]	[627.48; 891.45]	[901.8; 1,268.1]	[896.4; 1,273.5]	[1,503; 2,113.5]	[1,494; 2,122.5]
Y	[460.53; 725.96]	[456.12; 730.17]	[657.9; 725.76]	[651.6; 1,043.1]	[1,096.5; 1,728]	[1,086; 1,738.5]
Z	[37.17; 91.14]	[36.54; 62.37]	[53, 1; 89, 1]	[52.2; 89.1]	[88.5; 147]	[87; 148.5]

- I_2^{63} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and unknown sigma after 63 days.
- I_2^{90} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and unknown sigma after 90 days.
- I_σ is the variance tolerance interval with a 95% confidence level.
- I_1^{150} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and known sigma after 150 days.
- I_2^{150} is the tolerance interval with 95% confidence starting from the fact that X follows a normal law and unknown sigma after 150 days.

3.4 Ancillary Analysis

The second case gives us a much wider interval. In this estimation context we think that it is the most suitable interval.

If we consider the information in table 1, the number of cases of contamination will be between [896; 1,274], the number of cases of recovery will be between [651;1,044], the number of deaths will be between [52;90] after three months .

The number of cases of contamination will be between [1,494, 2,123], the number of cases of recovery will be between [1,086;1,739], the number of deaths will be between [87;149] after three months . Report any other analyses performed, including subgroup analyses and adjusted analyses, indicating those that were prespecified and those that were exploratory (though not necessarily in the level of detail of primary analyses). Consider putting the detailed results of these analyses on the supplemental online archive. Discuss the implications, if any, of the ancillary analyses for statistical error rates.

4. Discussion

This study is based on a 5% error assumption. In clear terms, we have a 5% chance of being wrong. We also consider that the random variables follow a law. This forecasts is 2123 cases of contamination, 1739 cases of cure and 148 cases of death in 5 months if no palliative measure is taken. This study is an empirical modeling, these figures will remain true as long as the response to COVID-19 from the government and people of Burkina Faso does not evolve.

The maximum number of cures (1728) is lower than the number of new cases (2123). We believe that the Burkinabè State should optimize the system in place, so that the number of cures exceeds the number of new cases. It is in this sense that the disease can be overcome.

The rate of 90 dead over 3 months and 149 deaths after 5 months of covid-19 in Burkina. It is less than that of European countries. But it is not acceptable to let people die. The strategy implemented in Burkina needs to be improved. By popularizing the barrier gesture protocols. Undoubtebly taking a large-scale test. This will make it possible to detect and isolate vulnerable or affected people more quickly.

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Appendix A

The Heading to Appendix A

We have collected ourselves those data as when the epidemic evolves in our country through the press.

Table 4. Covid-19 data base

n	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
X_i	02	0	0	01	04	0	08	04	08	06	07	24	11	24	15	32	06	28	27	15	24
$\sum X_i$	02	2	2	03	07	07	15	19	27	33	40	64	75	99	114	146	152	180	207	222	246
Y_i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	07	03	00	02	09	2	08
$\sum Y_i$	0	0	0	0	0	0	0	0	0	0	00	00	00	00	07	10	10	12	21	23	31
Z_i	0	0	0	0	0	0	0	0	0	01	0	02	01	0	0	03	00	02	02	01	00
$\sum Z_i$	0	0	0	0	0	0	0	0	0	01	01	03	04	04	04	07	07	09	11	12	12

Table 5. Covid-19 data base

n	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
X_i	15	21	06	14	16	27	19	20	30	29	05	36	13	18	13	14	04	11	08	11	05
$\sum X_i$	261	282	288	302	318	345	364	384	414	443	448	484	497	515	528	542	546	557	565	576	581
Y_i	01	14	01	01	18	24	18	19	07	12	03	06	06	09	07	49	31	37	27	17	19
$\sum Y_i$	32	46	47	48	66	90	108	127	134	146	149	155	161	170	177	226	257	294	321	338	357
Z_i	02	02	00	00	00	1	1	01	04	01	02	01	00	01	02	02	00	03	01	00	02
$\sum Z_i$	14	16	16	16	16	17	18	19	23	24	26	27	27	28	30	32	32	35	36	36	38

Table 6. Covid-19 data base

n	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
X_i	19	09	07	13	00	03	03	03	03	04	04	03	10	10	16	41	07	08	04	03	09
$\sum X_i$	600	609	616	629	629	632	635	638	641	645	649	652	662	672	688	729	736	744	748	751	760
Y_i	05	27	21	15	17	11	16	07	22	08	11	18	05	05	03	07	07	04	03	08	07
$\sum Y_i$	362	389	410	425	442	452	469	476	498	506	517	535	540	545	548	555	562	566	569	577	584
Z_i	00	01	02	00	00	01	00	00	01	00	01	00	01	01	02	00	00	00	00	01	01
$\sum Z_i$	38	39	41	41	41	42	42	42	43	43	44	44	45	46	48	48	48	48	48	49	50

Appendix B

COVID-19 epidemiological situation in Burkina Faso - Situation N 66

Burkina Faso is a landlocked Sudano-Sahelian country located in the heart of West Africa. It is bordered to the north and west by Mali, to the east by Niger, to the south by Benin, Togo, Ghana and Cote d'Ivoire. It covers an area of 274,200 km2. Its climate alternates between two seasons: a dry season from October to April, during which the harmattan blows, and a rainy season from May to September.

According to data from the National Institute of Statistics and Demography (INSD), the population of Burkina Faso in 2020 is estimated at 21,478,529 inhabitants with a growth rate of 3.1% (RGPH 2006).

The epidemiological situation of March 27, 2020 is as follows: Twenty-seven (27) new confirmed cases of COVID-19 were reported on 03/27/2020, bringing the total to 207 confirmed cases.

The state of health alert as declared in Burkina Faso on March 26, 2020. Quarantine become compulsory for a period of two weeks starting on 27 March 2020 in all the cities affected by the COVID-19 epidemic in Burkina Faso. X represents the number of Infected cases, Y the number of cures and Z the number of deaths over a period from March 9 to April 15, 2020. We will also take n the number of days of contamination, in this case $n = 63$ days for our experience. The following image represents the contamination of covid-19 by city in Burkina Faso. We obtained this card on the website of the Ministry of Health of Burkina Faso (https://reliefweb.int/map/burkina-faso/situation-pid-miologique-du-covid-19-au-burkina-faso-situation-n-66). It was posted on May 4, 2020.

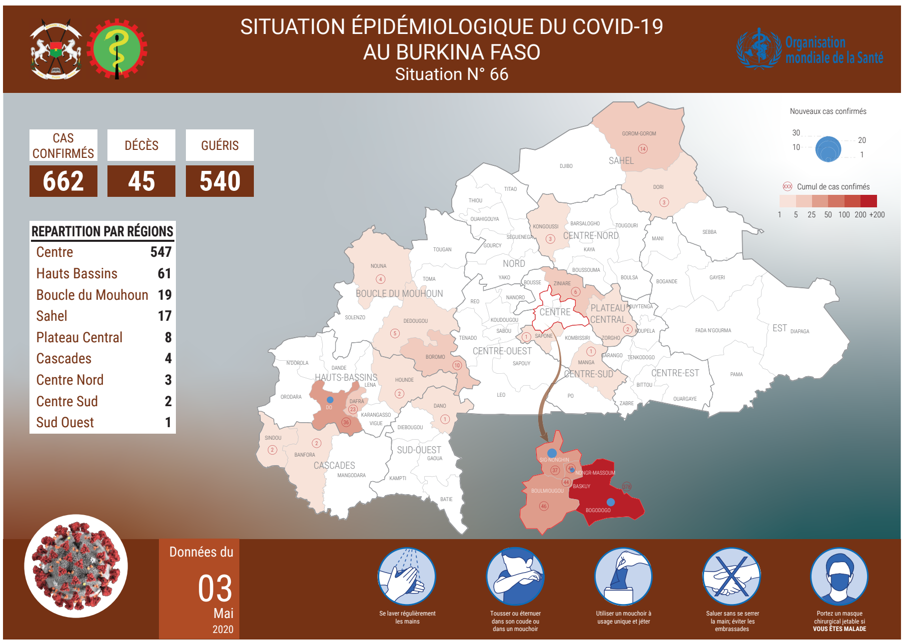

Figure 9. Histogram: Daily contamination cases in Burkina

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