Multi-criteria multi-decision maker approach for determining the best care center of severe cases of covid-19 in the city of Ouagadougou/Burkina Faso: The case of three decision makers.

Zoïnabo SAVADOGO *
Frédéric NIKIEMA†
Blaise SOME ‡

October 21, 2020

*Université Joseph KI-ZERBO, UFR-SEA/LANIBIO, Burkina Faso. E-mail : serezenab@yahoo.fr

†Université Joseph KI-ZERBO,UFR-SEA/LANIBIO Burkina Faso. E-mail: fredericnikiema0@gmail.com

‡Université Joseph KI-ZERBO, UFR-SEA/LANIBIO, Burkina Faso. E-mail :blaisesome@gmail.com

Abstract

The world has been rocked by the covid 19 pandemic from March until today. Each country is trying somehow to find a solution. In the literature on decision support, it seems that a decision made by a single individual reflects little reality, hence the importance of group decision support.

There are methods of solving group decision problems, but using some of them leads to a lot of calculations and others give controversial results. It is in this context that we extended the AHP method to group decision-making to determine the best health center for the management of severe cases of covid-19 in the city of Ouagadougou/ burkina faso.

key words : covid 19– group decision– extension of AHP to group decision.

2010 Mathematics Subject Classification: 90Bxx, 97M40, 80M50

1 Introduction

Appeared since March in China, the covid-19 has resulted in significant damage all over the world. Indeed, many countries around the world have recorded a significant number of deaths related to the covid-19. The economic sector has not been spared. Some countries are trying to develop a vaccine to relieve their populations for a while. We believe that this is a problem that deserves to be addressed by a group and not by each country individually.

Thus, in this work, we limit ourselves to a particular group in the city of Ouagadougou/Burkina Faso for the management of severe cases of covid-19.

Note also that decision support is important in decision-making by any company. Thus, according to Pierre Fixmex, Christian Brassac [7], from all areas of daily life to the labour world, a great number of decisions are made, individually or collectively. Having long been deald with, the decision taken by a single individual seems to give way to the group decision. According to Bouzarour-Amokrane, Yasmine and Tchangani, Ayeley and Perès, François [4], we mean by group decision here, selection by a large set.

Indeed, some thinks that a decision made by a single individual reflects little reality, so according to [11], many times, decisions are not an individual issue, however, they are questions of a group of people. Most of the time, without group decision support, we encounter situations where there are several people who are involved in the decision making and sometimes with multiple and often contradictory criteria where people have divergent or even conflicting points of view. The decision support in this case is to provide solutions that tend towards the general interest, to a consensus. According to Mario Fedriand Gabiella Pasi [6], The notion of consensus plays a key role in the modeling of group decisions. According to F. J. Cabrerizol, S. Alonso2, I. J Perez1, and E. Herrera-Viedma [5], in group decision-making problems, a natural issue in the process of consensus is the way to measure the proximity of the views of experts in order to achieve the level of consensus. In this work we have made an extension of the AHP method to group decision making to find a method which gives satisfactory results. After a summary, an introduction, a literature review, hypotheses and objectives, the presentation of our methodology, the limits, a conclusion and finally a bibliography will follow.

2 State of the art

2.1 Applying the arithmetic mean to the group decision: the MACASP method

This step comes from [14].

Consider n values x_i, then the arithmetic mean of these n values is given by:

$$\overline{x} = \frac{\sum_{i=1}^{i=n} x_i}{n} \tag{1}$$

We assume $M \geq N$. Note G_i the additive value aggregation function for the decision maker d_k. It is assumed that the set of actions chosen by all the decision-makers according to each G_i is $\{a_1, a_2, ..., a_k\}; k \leq N$. We will consider the following arithmetic mean:

$$U_j(a_i) = \sum_{i=1}^{N} G_j(a_i)/N; i = 1, ..., N; j = 1, ..., m; \tag{2}$$

$$G_k(a_i) = \sum_{j=1}^{j=m} w_j^k g_j^k(a_i). \tag{3}$$

The collective aggregation function based on the arithmetic mean called MACASP (Modèle d'Agrégation Collective à l'Aide de la Somme Pondérée), denoted U is defined by:

$$U(a_i) = \sum_{k=1}^{k=N} G_k(a_i)/N. \tag{4}$$

and

$$U(a_i) = \sum_{k=1}^{k=N} \sum_{j=1}^{j=m} w_j^k g_j^k(a_i)/N. \tag{5}$$

$$U(a_i) = \sum_{j=1}^{j=m} \sum_{k=1}^{k=N} w_j^k g_j^k(a_i)/N \tag{6}$$

2.2 Presentation of the harmonic mean applied to the group decision: the Lon-Zo method

This step comes from [14].
In this whole part w_j^k represents the weight assigned to the criterion j by the decision maker k.

Consider the harmonic mean $\overline{x}_h$ of n values x_i next:

$$\overline{x}_h = \frac{n}{\displaystyle\sum_{i=1}^{n} \frac{1}{x_i}} \tag{7}$$

Let's note:

a) N the number of decision makers and D the set; $D = \{d_1, d_2, ..., d_N\}$;

b) m the number of criteria whose set of indices is $\{1, 2, ..., m\}$;

c) M the number of shares and their set $A = \{a_1, a_2, ...a_M\}$.

Note G_k function aggregation additive value for the decision maker d_k. Suppose that the set of actions chosen by all the decision makers according to each G_k is $\{a_1, a_2, ..., a_k\}, k \leq N$
The collective aggregation function based on the harmonic mean, called the Lon-Zo method (Longin-Zoïnabo) is defined as follows:

$$U(a_i) = \frac{N}{\displaystyle\sum_{k=1}^{N} \frac{1}{G_k(a_i)}}. \tag{8}$$

with

$$G_k(a_i) = \sum_{j=1}^{j=m} w_j^k g_j^k(a_i); i = 1, ..., M; j = 1, ..., m. \quad (9)$$

2.3 Presentation of the method Electre I applied to the Group Decision

For this section, if necessary, the reader may refer to [1].

3 Assumptions/Objectives

The objective of this study is to extend the classic AHP method to group decision-making to determine the best center for the management of severe cases of the covid-19 in the city of Ouagadougou/burkina Faso, because we believe that a decision made by a group seems to be better than one made by one person. We will call this method, Collective Aggregation Method based on the AHP method (MAC-AHP).

4 Research Design/Methodology

4.1 Definition: The AHP method

This definition comes from [3].
The "Analytic Hierarchy Process" method, known as AHP, is a multi-criteria analytical decision support approach developed by Saaty [11] which allows to decompose a complex problem in its components, then to present them under the form of a [2] hierarchy. The decision maker must then perform binary comparisons between the different elements of the hierarchy using a nominal scale. The results are then transposed into comparison matrices. From these matrices, one extracts vectors of relative priorities under the form of proportion scale. This then makes it possible to calculate the relative weight of the criteria and thus establish the priority of actions or solutions analyzed. Although it is based on a very complex hierarchical structure, the method remains easy enough to implement.

The AHP method has the advantage of being relatively simple to use, flexible and adaptable in order to better understand the real world in which decisions are characterized by a multi-criteria and multi-decision maker [9].

4.2 Formulation of the problem

Consider the decision support problem involving multiple criteria and multiple decision makers below. Such a problem occurs when you have the following five sets:

- ▷ $D = \{d_1, d_2, ...d_N\}$ with $N \geq 2$: set of all s decision makers;
- ▷ $A = \{a_1, a_2, ...a_M\}$with $M \geq 2$: denotes a collection of M alternatives or actions;
- ▷ $C = \{g_1, g_2, ...g_m\}$with $m \geq 2$: designating the m criteria selected;
- ▷ $X = \{g_{ij}^k, i = 1, ..., M, j = 1, ..., m, k = 1, ..., N\}$ designating the performance of the alternative i on the criterion j for the k^{me}decision maker. *Hypotheses related to the problem posed*:
  - ○ No decision maker is a dictator;
  - ○ The ideal solution is not feasible;
  - ○ decision-makers are equally important;
  - ○ decision makers prefer the same; alternatives and the same criteria.

4.3 Presentation of the method-based collective aggregation method AHP (MAC-AHP).

The collective aggregation method based on the AHP approach, known as MAC-AHP, proposed to solve, in general, the problem of multi-criteria selection in a certain environment and, in particular, the problem of selecting the best outlet center in serious cases of covid-19, is based on the five steps described below:

Step 1 : Determination of criteria weight

This step consists, first, in calculating the overall weight (w_j) of each criterion(c_j where $j = 1, ..., m$) based on the equation (10). This makes it possible to establish the matrix of the overall weights of the criteria (W) expressed as follows:

$$W = \begin{pmatrix} w_1 & w_2 & \cdots & w_m \end{pmatrix}.$$

$$w_j = med\{w_j^k\}_{k=1,...,N} \tag{10}$$

and $i = 1, ..., M$ where med is the median function and $(w_j^k, j = 1, ..., m$ et $k = 1, ..., N)$ the weight of the criterion c_j affected by the decision maker d_k.
and, then, to calculate the normalized overall weight $(\widehat{w}_j)$ of each criterion (c_j où $j = 1, ..., m$) based on the equation (11) . This makes it possible to establish the matrix of the standardized global weights of the criteria $(\widehat{W})$ expressed as follows:

$$\widehat{W} = \begin{pmatrix} \widehat{w}_1 & \widehat{w}_2 & \cdots & \widehat{w}_m \end{pmatrix}.$$

$$\widehat{w}_j = \frac{w_j}{\sum_{j=1}^{m} w_j} \tag{11}$$

where w_j is the overall weight of the criterion (c_j where $j = 1, ..., m$).

2nd step :Determination of the evaluation of alternatives

This step determines the overall assessment (g_{ij}) of each alternative (a_i where $i = 1, ..., M$) according to the criterion $(c_{j,j=1,\dots,m}$)based on the equation (12). This makes it possible to establish the decision matrix (D) expressed as follows:

$$D = \begin{pmatrix} g_{11} & g_{12} & \cdots & g_{1m} \\ g_{21} & g_{22} & \cdots & g_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ g_{M1} & g_{M2} & \cdots & g_{Mm} \end{pmatrix}.$$

$$g_{ij} = N\sqrt{\prod_{k=1}^{N} g_{ij}^k}. \tag{12}$$

where $(g_{ij}^k, i = 1, ..., M \ ; \ j = 1, ..., m \ ; \ k = 1, ..., N)$ is the evaluation of the action (a_i ,$i = 1, ..., M$) by the decision maker $d_k$according to the criterion($c_j, j = 1, ..., m$) .

Step 3 : Determination of judgment matrices by binary comparison of alternatives according to a given criterion and consistency check. This step is broken down into several sub-steps described below:

Step 3.1 : consider a criterion c_j and calculate the ratio (m_j) the absolute value of the difference between the maximum and minimum evaluations according to this criterion $(c_{j,j=1,\dots,m}$) based on the equation (13).

$$m_j = \frac{max\{g_{ij}\} - min\{g_{ij}\}}{n} \tag{13}$$

where (g_{ij} , $i = 1, ..., M$,$j = 1, ..., m$) is the overall evaluation of the action a_i according to the criterion c_j et n the number of shares.

Step 3.2 : calculate judgment by binary comparison of actions $a_i, i = 1, ..., M$ and $(a_l, l = 1, ..., M)$ (J_{il}^j) according to the criterion c_j using the equations (14)(15). This makes it possible to establish the judgment matrix by binary comparison of the actions according to the criterion c_j expressed as follows:

$$J = \begin{pmatrix} J_{11}^j & J_{12}^j & \cdots & J_{1M}^j \\ J_{21}^j & J_{22}^j & \cdots & J_{2M}^j \\ \vdots & \vdots & \ddots & \vdots \\ J_{M1}^j & J_{M2}^k & \cdots & J_{MM}^j \end{pmatrix}.$$

If the criterion c_j is to be maximized then:

$$J_{il}^j = \begin{cases} arr\left(\dfrac{\mid g_{ij} - g_{lj} \mid}{m_j} + 1\right) & if \quad g_{ij} > g_{lj} \\ \dfrac{1}{arr\left(\dfrac{\mid g_{ij} - g_{lj} \mid}{m_j} + 1\right)} & else \end{cases} \tag{14}$$

If the criterion c_j is to be minimized then:

$$J_{il}^j = \begin{cases} arr\left(\dfrac{\mid g_{ij} - g_{lj} \mid}{m_j} + 1\right) & if \quad g_{ij} < g_{lj} \\ \dfrac{1}{arr\left(\dfrac{\mid g_{ij} - g_{lj} \mid}{m_j} + 1\right)} & else \end{cases} \tag{15}$$

where

- "**arr**" designates a strictly positive integer function which, with a given real, associates the integer which is immediately superior to it
- (g_{ij},$i = 1, ..., M$, $j = 1, ..., m$) and (g_{lj} , $l = 1, ..., M$, $j = 1, ..., m$) are the global evaluations according to the criterion c_j respectively of the actions (a_i, $i = 1, ..., M$) and (a_l , $l = 1, ..., M$).

Step 3.3 : calculate the sum of judgments by binary comparison of actions

(s_i , $i = 1, ..., M$) of each column i of the judgment matrix by binary comparison using the equation (16). This allows to obtain the matrix (S) defined by:

$$S = \begin{pmatrix} s_1 & s_2 & \cdots & s_M \end{pmatrix}.$$

$$s_i = \sum_{l=1}^{M} J_{il} \tag{16}$$

where (J_{li} , $l = 1, ..., M$, $i = 1, ..., M$) is the judgment by binary comparison of the action (a_l , $l = 1, ..., M$) compared to the action (a_i, $i = 1, ..., M$).

Step 3.4 : normalize judgment by binary comparison of actions, (b_{li}) based on the equation (17). This makes it possible to obtain the normalized judgment matrix (B) expressed as follows:

$$B = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1M} \\ b_{21} & b_{22} & \cdots & b_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ b_{M1} & b_{M2} & \cdots & b_{MM} \end{pmatrix}.$$

$$b_{li} = \frac{J_{li}}{s_i} \tag{17}$$

where

- (g_{li} , $l = 1, ..., M$, $i = 1, ..., M$)is the judgment of the action a_l , $l = 1, ..., M$) compared to the action a_i , $i = 1, ..., M$);
- the sum of the judgments of the column i.

Step 3.5 : calculate the arithmetic mean of the normalized judgments of the row l of the matrix (B), (μ_l, $l = 1, ..., M$) based on the equation (18). This makes it possible to establish the priority matrix, (I_j)) expressed as follows:

$$I_j = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_M \end{pmatrix}.$$

$$\mu_l = \frac{\sum_{i=1}^{M} b_{li}}{M} \tag{18}$$

where

- $(b_{li}\ ,\ l = 1, ..., M\ ,\ i = 1, ..., M)$ is the standard judgment of the action $(a_l\ ,\ l = 1, ..., M)$ compared to the action $(a_l\ ,\ l = 1, ..., M)$;
- M being the number of shares.

Step 3.6 : this step consists in determining first, the eigenvalue $(\lambda_i\ ,\ i = 1, ..., M\ )$ using the equation (19). This allows to determine the matrix (λ) expressed as follows:

$$\lambda = \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \vdots \\ \lambda_M \end{pmatrix}.$$

$$P.I_j = \lambda.I_j \tag{19}$$

then, the eigenvalue λ_{max} based on the equation (20).

$$\lambda_{max} = \frac{\sum_{i=1}^{M} \lambda_i}{M} \tag{20}$$

Etape 3.7 : calculate the consistency index (CI) based on the equation (21).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{21}$$

where n is the size of the matrix and λ_{max} the maximum eigenvalue.

Step 3.8 : determine the randomized index RI, function of the size n of the matrix. This is given by the table below:

Table 1: Weight synthesis matrix

size of the matrix	3	4	5	6	7	8	9	10
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Etape 3.9 : calculate the consistency ratio CR based on the equation (22). This makes it possible to test the consistency of judgments by binary comparison of actions.

$$CR = \frac{CI}{RI} \tag{22}$$

According to the work of Yurdakul et al .(2004) [13], the value of CR must be less than 0.1 to conclude that the judgments are consistent. On the other hand, if the value of CR is greater than 0.1, the coefficients of the matrix are incoherent and one cannot refer to them for the continuation of the analysis Wong et al.(2007)[12].

Step 4 :Determination of the priority matrix according to all the criteria
This step makes it possible to build the priority matrix according to all the criteria, M from the individual priority matrices (M_j with $j = 1, ..., m$), expressed as follows:

$$M = \begin{pmatrix} M_1 & M_2 & \cdots & M_m \end{pmatrix}.$$

Step 5 : Determination of the final score of each alternative and recommendation.
This step determines the score (α_i avec $i = 1, ..., M$) based on the equation (23). This makes it possible to establish the score matrix of the actions (α) and expressed as follows:

$$\alpha = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_M \end{pmatrix}.$$

$$M.{}^t\widehat{W} = \alpha \tag{23}$$

where M is the priority matrix relative to all the criteria and ${}^t\widehat{W}$ the transpose of the normalized global weight matrix.

Recommendation

By using the usual order on the reals applied to the coefficients of the matrix *alpha*, we define a complete preorder structure on the set of actions A. This makes it possible to establish the classification of all the actions with the possibility of a tie and consequently to obtain the best action in a consensual manner.

5 Data/Model Analysis

In this part, we should formally collect the judgments of the National Assembly, the Order of Doctors, the Covid-19 management unit. But due to health situation, we were not able to make the trip to meet them. In addition, to achieve it, we needed a little more time. This is why we took this example in the thesis for obtaining a doctorate from the University of Law and Sciences of Aix-Marseille, presented by Rasmi Ginting [8]. We reformulated it to adapt it to the context of the covid-19.

5.1 Position of the problem

The problem is to find a better center for the management of severe cases of the covid-19 in Bukina Faso. For this, three decision-making committees (a covid-19 management unit, the Order of Doctors,

the National Assembly) had the difficult task of evaluating four hospitals in the city of Ouagadougou/Burkina Faso (Yalgado hospital: Yalg hos, Bogodogo district hospital: Dist.Bog hosp, Tingandogo hospital: Ting hosp, peace clinic: clin.pe) on the basis of criteria (Equipment in respirators: Equi.Resp, Equipment in beds: Equi.Lit, Qualification of personnel: Qual.Pers, Quality of reception: Qual.Accu, Accessibility: Access).

The data is provided by three (3) decision makers (or assigned to the criteria) in the form of scores between 0 and 10. The range of the rating scales may differ from one decision maker to another, and each criterion is subject to 'a weighting coefficient expressing the importance of the criterion. The result obtained is a classification of hospitals containing alternatives (products) which must respect the following principle: "the hospital which is classified first must be accepted by the majority of decision-makers, and must not be rejected, even by one decision maker ".

Each decision-making committee builds its assessment matrix. Suppose the different profiles are these:

Table 2: Assessment matrix and weight of the management unit

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
weight	6	3	2	4	3
yalg hos	6	5	2	4	5
dist.Bog hosp	5	6	3	3	4
Ting hosp	7	5	4	6	3
clin.pe	6	4	5	3	6

Table 3: Matrix of assessments and weight of the medical order

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
weight	7	5	3	3	4
Yalg hosp	7	6	2	3	3
dist.Bog hosp	6	5	2	5	3
Ting hosp	5	7	3	6	4
clin.pe	5	4	4	4	3

Table 4: Matrix of evaluations and weight of the national assembly

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
weight	6	4	2	3	3
Yalg hosp	6	5	2	4	4
dist.Bog hosp	7	6	3	5	3
Ting hosp	6	5	4	3	5
clin.pe	5	4	3	6	4

5.2 Resolution of problem

a) Search for the weight synthesis matrix and the normalized weight matrix.

Table 5: Weight synthesis matrix

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
weight	6	4	2	3	3

Table 6: Standardized weight matrix

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
standardized weight	0.33	0.22	0.11	0.16	0.16

b) Search for the evaluation summary matrix

Table 7: Assessment synthesis matrix

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
Yalg hosp.	6.31	5.31	2	3.63	3.91
dist.Bog hosp	5.94	5.64	2.62	4.21	3.30
Ting hosp.	5.94	5.59	3.63	4.76	3.91
clin.pe	5.31	4.00	3.91	4.16	4.16

c) Determination of judgment matrices by binary comparison of alternatives and their consistency.

- Matrix of judgments based on the respirator equipment criterion and its consistency

Table 8: Matrix of judgments

Equi.Resp	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	3	3	5
dist.Bog hosp	$\frac{1}{3}$	1	1	4
Ting hosp	$\frac{1}{3}$	1	1	4
clin.pe	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{4}$	1

Table 9: Matrix of judgments and sum by column

Equi.Resp	Yalg hos	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	3	3	5
dist.Bog hosp	$\frac{1}{3}$	1	1	4
Ting hosp	$\frac{1}{3}$	1	1	4
clin.pe	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{4}$	1
Sum	1.86	5.25	5.25	14

Table 10: Standardized judgment matrix

Equi.Resp	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg. hosp	0.54	0.57	0.57	0.36
dist.Bog hosp	0.18	0.19	0.19	0.29
Ting hosp	0.18	0.19	0.19	0.29
clin.pe	0.11	0.05	0.05	0.07

Table 11: Priority vector

Equi.Resp	priorité
Yalg hosp	0.52
dist.Bog hosp	0.21
Ting hosp	0.21
clin.pe	0.07

$\lambda_1 = 4.09$, $\lambda_2 = 4.14$, $\lambda_3 = 4.14$, $\lambda_4 = 3.98$
$\lambda_{max} = 4.08$
$CI = 0.02$
$RI = 0.90$
$CR = 0.02 < 0.1$
We can conclude with certainty that the judgments expressed on the criterion Equipment in respirators are reliable and are not random.

- Matrix of judgments based on the bed equipment criterion and its consistency.

Table 12: Matrix of judgments

Equi.Lit	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{2}$	$\frac{1}{2}$	5
dist.Bog hosp	2	1	2	5
Ting hosp	2	$\frac{1}{2}$	1	5
clin.pe	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	1

Table 13: Matrix of judgments and sum by column

Equi.Lit	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{2}$	$\frac{1}{2}$	5
dist.Bog hosp	2	1	2	5
Ting hosp	2	$\frac{1}{2}$	1	5
clin.pe	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	1
Sum	5.20	2.20	3.70	16

Table 14: Standardized judgment matrix

Equi.Lit	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	0.19	0.23	0.13	0.31
dist.Bog hosp	0.38	0.45	0.54	0.31
Ting hosp	0.38	0.23	0.27	0.31
clin.pe	0.04	0.09	0.05	0.06

Table 15: Priority vector

Equi.Lit	priorité
Yalg hosp	0.21
dist.Bog hosp	0.42
Ting hosp	0.29
clin.pe	0.06

$\lambda_1 = 4.06$, $\lambda_2 = 4.15$, $\lambda_3 = 4.16$, $\lambda_4 = 4.10$
$\lambda_{max} = 4.12$
$CI = 0.04$
$RI = 0.90$
$CR = 0.04 < 0.1$
We can conclude with certainty that the judgments expressed on the bed equipment criterion are reliable and are not random.

- Judgment matrix based on the personnel quality criterion and its consistency.

Table 16: Matrix of judgments

Qual.Pers	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{6}$
dist.Bog hosp	3	1	$\frac{1}{4}$	$\frac{1}{4}$
Ting hosp	5	4	1	$\frac{1}{2}$
clin.pe	6	4	2	1

Table 17: Matrix of judgments and sum by column

Qual.Pers	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{6}$
dist.Bog hosp	3	1	$\frac{1}{4}$	$\frac{1}{4}$
Ting hosp	5	4	1	$\frac{1}{2}$
clin.pe	6	4	2	1
Sum	15	9.33	3.45	1.61

Table 18: Standardized judgment matrix

Qual.Pers	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	0.06	0.03	0.05	0.09
dist.Bog hosp	0.20	0.10	0.07	0.15
Ting hosp	0.33	0.42	0.28	0.31
clin.pe	0.40	0.42	0.57	0.62

Table 19: Priority vector

Qual.Pers	priorité
Yalg hosp	0.06
dist.Bog hosp	0.13
Ting hosp	0.33
clin.pe	0.50

$\lambda_1 = 4.06$, $\lambda_2 = 3.99$, $\lambda_3 = 4.25$, $\lambda_4 = 4.13$
$\lambda_{max} = 4.10$
$CI = 0.03$
$RI = 0.90$
$CR = 0.04 < 0.1$
We can conclude with certainty that the judgments expressed on the personnel quality criterion are reliable and are not random.

- Matrix of judgments based on the quality criterion of the reception and its consistency.

Table 20: Matrix of judgments

Qual.Accu	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$
dist.Bog hosp	2	1	$\frac{1}{2}$	2
Ting hosp	3	2	1	2
clin.pe	2	$\frac{1}{2}$	$\frac{1}{2}$	1

Table 21: Matrix of judgments and sum by column

Qual.Accu	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$
dist.Bog hosp	2	1	$\frac{1}{2}$	2
Ting hosp	3	2	1	2
clin.pe	2	$\frac{1}{2}$	$\frac{1}{2}$	1
Sum	8	4	2.33	5.5

Table 22: Standardized judgment matrix

Qual.Accu	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	0.12	0.12	0.14	0.09
dist.Bog hosp	0.25	0.25	0.21	0.36
Ting hosp	0.37	0.50	0.42	0.36
clin.pe	0.25	0.12	0.21	0.18

Table 23: Priority vector

Qual.Accu	priorité
Yalg hosp	0.12
dist.Bog hosp	0.26
Ting hosp	0.41
clin.pe	0.19

$\lambda_1 = 4.05$, $\lambda_2 = 4.08$, $\lambda_3 = 4.06$, $\lambda_4 = 4.06$
$\lambda_{max} = 4.06$
$CI = 0.02$
$RI = 0.90$
$CR = 0.02 < 0.1$
We can conclude with certainty that the judgments expressed on the reception quality criterion are reliable and are not random.

- Matrix of judgments based on the accessibility criterion and its consistency.

Table 24: Matrix of judgments

Acces	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	2	$\frac{1}{2}$	$\frac{1}{2}$
dist.Bog hosp	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{3}$
Ting hosp	2	2	1	$\frac{1}{2}$
clin.pe	2	3	2	1

Table 25: Matrix of judgments and sum by column

Acces	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	1	2	$\frac{1}{2}$	$\frac{1}{2}$
dist.Bog hosp	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{3}$
Ting hosp	2	2	1	$\frac{1}{2}$
clin.pe	2	3	2	1
Sum	5.5	8	4	2.33

Table 26: Standardized judgment matrix

Acces	Yalg hosp	dist.Bog hosp	Ting hosp	clin.pe
Yalg hosp	0.18	0.25	0.12	0.21
dist.Bog hosp	0.09	0.12	0.12	0.14
Ting hosp	0.36	0.25	0.25	0.21
clin.pe	0.36	0.37	0.50	0.42

Table 27: Priority vector

Acces	priorité
Yalg hosp	0.19
dist.Bog hosp	0.12
Ting hosp	0.26
clin.pe	0.41

$\lambda_1 = 4.04$, $\lambda_2 = 4.06$, $\lambda_3 = 4.10$, $\lambda_4 = 4.06$
$\lambda_{max} = 4.06$
$CI = 0.02$
$RI = 0.90$
$CR = 0.02 < 0.1$
We can conclude with certainty that the judgments expressed on the accessibility criterion are reliable and are not random.

d) Construction of the priority matrix according to all the criteria

Table 28: Priority matrix according to all the criteria

Criterion	Equi.Resp	Equi.Lit	Qual.Pers	Qual.Accu	Acces
Yalg hosp	0.52	0.21	0.06	0.12	0.19
dist.Bog hosp	0.21	0.42	0.13	0.26	0.12
Ting hosp	0.21	0.29	0.33	0.41	0.26
clin.pe	0.07	0.06	0.50	0.19	0.41

e) Determination of the matrix of the overall scores of the centers and recommendation.

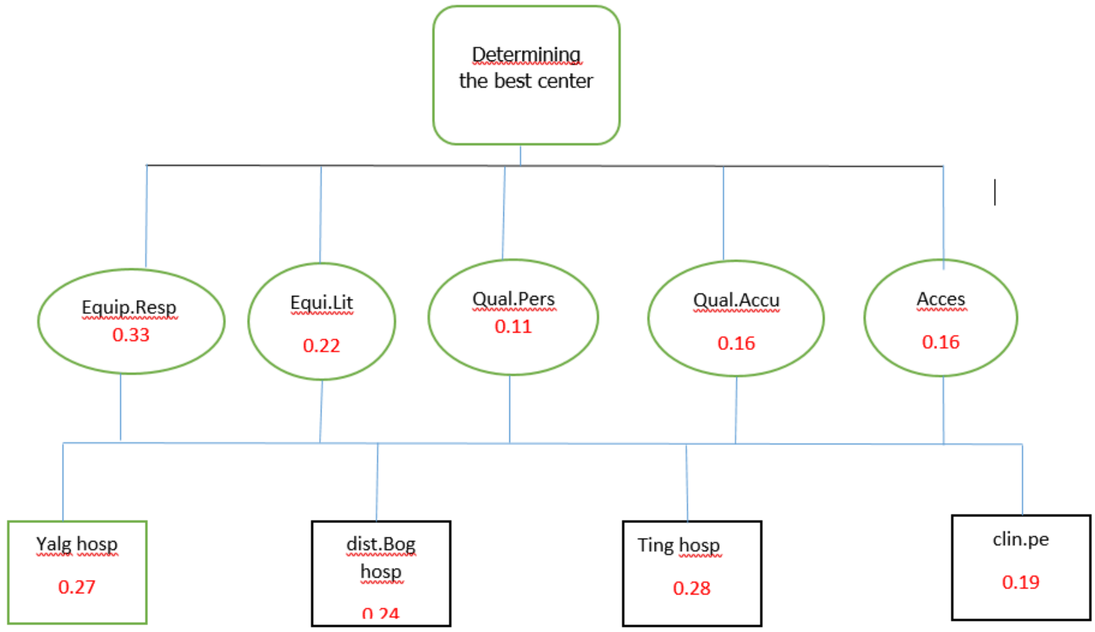
Table 29: Score matrix

Hospital	global Score
Yalg hosp	0.27
dist.Bog hosp	0.24
Ting hosp	0.28
clin.pe	0.19

Recommendation:

According to our resolution method, for severe cases of fhe covid-19 in the city of Ouagadougou/Burkina Faso, the Tingandogo hospital seems better for consistent care. In terms of ranking (from best to worst) of the centers, for better management of covid-19 cases, we have: Tingandogo hospital, Yalgado hospital, Bogodogo district hospital, peace Clinic.

Figure 1: Illustration of hierarchical structure of problem with priorities



6 Limits

It should be noted that we were not able to carry out studies in the field to collect judgments from the various actors given the lack of time.

We only used an example in another article to be able to make a digital application. we would be very happy to carry out this study by obtaining the sincere judgments of all the partners if we had had more time. As perspectives, we would like to send a student to the field of construction for the application of the AHP method within the framework of several decision makers for the award of contracts.

7 Conclusion

At first glance, we note that the extension of the ElectreI method to group decision-making is already long. As for the MACASP and Lon-Zo methods, it seems to us that they use the arithmetic mean a lot which is a lot criticized in the literature for compensating weak criteria with stronger ones.

By using the AHP method, we found the same results as MACASP, Lon-Zo and ElectreI and, that with a certainty that the matrices considered are coherent. Doesn't it seem like there aren't some totally better methods than others? It seems that the aim is to provide a method giving satisfactory results. We hope that countries around the world will unite to find solutions to this covid-19 pandemic together.

References

[1] Adel Hatami-Marbini. Madjid Tavana. (2010), *An extension of the ELECTREI method for group decision-making under a fuzzy environment*, Omega 39(2011)373 à 386, Elsevier.

[2] Al-Harbi, K. M. A.(2001), *Application of the AHP in the project management*, International Journal of Project Management 19 19-27.

[3] Ben Makram Jeddou, Wahiba Kalboussi.(2015), *Application de la méthode AHP pour le choix multicritère des fournisseurs.*, Revue Marocaine de Recherche en Management et Marketing, n0 12.

[4] Bouzarour-Amokrane, Yasmina. and Tchangani, Ayeley. and Pérès, François. (2015), *A bipolar consensus approach for group decision making problems*, Expert Systems with Applications, vol. 42 n0 3. p 1759-1772.

[5] F.J. Cabrerizo, S. Alonso, I. J. Pérez, and E. Herrera-Viedma . (2008), *On Consensus Measures in Fuzzy Group Decision Making*, V. Torra and Y. Narukawa (Eds.): MDAI 2008, LNAI 5285, pp. 86–97.

[6] M. Fedrizzi and G. Pasi, (2008), *Fuzzy Logic Approaches to Consensus Modelling in Group Decision Making*, Studies in Computational Intelligence (SCI) 117, 19–37.

[7] Pierre, Fixmer. Christian Brassac.(2004), *La décision collective comme processus de construction de sens, In C.* , Bonardi, N. Grégori, J.-Y Menard, N. Roussiau (éds), Psychologie sociale appliquée. Emploi, travail, ressources humaines.

[8] R. Ginting. (11/01/2000), *Intégration du système d'aide multicritère et du système d'intélligence économique dans l'ère concurrentielle, application dans le choix de partenaires en Indonésie* ,thèse, Université de droit et des sciences d'Aix-Marseille.

[9] Skibniewski, M. J. and Chao, L, *Evaluation of advanced construction technology with AHP method* Journal of construction Engeneering and Management, ASCE, vol.118, n0 3, 577-93.

[10] T. Gonzalez-Arteaga *Cohesiveness in group decision making problems: ITS measurement and ITS achiement*, Thesis, Vneversidad Dsalamanca, 2016.

[11] T. L. Saaty, *The Analytic Hierarchy Process*, McGraw Hill, New York, NY, p 287 .

[12] Wong, J. K. Li, H. (2007), *Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems*, Building and Environment, vol 43 n0 1, p 108-25, .

[13] Yurdakul, M. and Kansel, Y. (2004), *AHP approach in the credit evaluation of the manufacturing firms in Turkey*, International Journal of Production Economics, Vol. 88, 269-89.

[14] Zoïnabo Savadogo, Longin Somé and Abdoulaye Compaoré: *On new aggregation functions of additive value within the framework of the group decision* , Advances in Differential Equations and Control Processes, Volume 20, Number 2, 2019, Pages 129-141.