ORIGINAL ARTICLE

Queuing management study at the Multidisciplinary Anesthesia and Intensive Care Clinic of CNHU-HKM in April 2022

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Received: August 30, 2022 **Accepted:** October 27, 2022 **Online Published:** November 23, 2022
DOI: 10.5430/jha.v11n2p25 **URL:** https://doi.org/10.5430/jha.v11n2p25

ABSTRACT

Objective: Constant availability of inpatient beds in an intensive care unit (ICU) is part of the resilience of health systems, especially in an emergency context, namely in public health. This study aims to appraise the management of inpatient waiting lines in the ICU of Hubert Koutoukou Maga National Hospital and University Center (CNHU-HKM) in Benin, in March-April 2022.

Methods: This was an analytic cross-sectional study of inpatients or their relatives and staff, selected by convenience and reasoned choice, respectively, carried out from March 21 to April 15, 2022. Logistic regression was used to identify associated factors with queues management.

Results: Altogether 55 patients were surveyed. On a daily basis, 13 ± 1 patients were hospitalized in 18 functional beds for 3 ± 1 admissions and 3 ± 1 discharges. The average bed occupancy rate was $89.8\% \pm 3.8\%$; the average waiting time before patient care was 3.6 ± 1.2 minutes and the traffic intensity were 0.03. Per hour, the odds of having a patient were 33.29%, with a 97% chance of a bed being occupied. The probability that an admitted patient would spend a whole week there was 37%. Only patient arrival flow was significantly associated with insufficient queuing management. There was also a lack of inpatient beds and technical boards. The construction of two wards and the installation of seven additional beds could improve queues management.

Conclusions: The management of AF in our study site depends mainly on the daily flow of arriving patients, but also on the number of available hospital beds, the working organization and the existing technical and structural measures. Addressing these parameters will significantly improve the situation.

Key Words: Waiting lines, Management, Probability, Inpatient, Benin

1. INTRODUCTION

The progress of science has been at the roots of several transformations in the structure, the way of functioning and the management of hospitals. Today, hospitals are forced to face the phenomena of variability of attendance, which causes problems of waiting either at admission or during the stay in hospital of patients.[1] The inpatient stay from entry to discharge already generates a queue. In the field of resuscitation, the patients concerned are serious patients with or likely to have several organ failures involving their vital prognosis.[2] It is a service that fights first for the survival of its admitted patients in an emergency or extreme emergency situation.[3]

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The Multidisciplinary Anesthesia and Intensive Care Clinic (CUPAR) in Benin, is one of the clinics that actively participate in the referral center role of the National Hospital and University Center Hubert Koutoukou MAGA (CNHU-HKM).[4] However, the observation made at the CUPAR is that admission is not always automatic and sometimes for reasons of occupation of hospital beds by third parties, a queue is created. This situation is comparable to the results of Charra et al. who found in Morocco in 2018 that 49.4% of waiting cases are related to the lack of hospital beds in the intensive care unit (ICU).[5] Quite often this clinic records bed occupancy rates of more than 100%.[6] This is also the case in Mali, where Traore et al. observed that occupancy rates of hospital beds exceeding 100%, were similarly found from 2017 to 2019.[7] As a rule, there should never be a shortage of inpatient beds for a critical patient in such a department. The number of patients waiting for admission should be as low as possible. The waiting time for patients before admission should be as short as possible, and the rotation and transfer of patients on inpatient beds should be optimal. Although there is no general consensus on the "optimal" occupancy rate, an occupancy rate of approximately 85% is often considered a maximum to reduce the risk of bed shortages or queue generation in order to have a reserve margin in normal times.[8] This situation then poses the fundamental problem of managing the queue in the clinic. With this in mind, we proposed to study the management of the inpatient queue at the CUPAR of the CNHU-HKM in April 2022.

2. METHODS

This study was conducted at the CNHU-HKM located in Cotonou, the economic capital of Benin. This is a reference hospital, at the top of the health pyramid in Benin and the largest health structure in the country. It is a hospital of international standing that not only serves the population of Benin, but also the West African sub-region and beyond. In our study, we focused on one of the pilot clinics with a high risk of nosocomial infections that the University Hospital Hygiene Clinic (UHC) covers in its activities: the CUPAR.

This was a descriptive and analytical cross-sectional study, with quantitative and qualitative aspects, conducted from March 21 to April 15, 2022 in CUPAR. The primary targets were health care providers and patients. Secondary targets were the carers in cases where the patients were minors or had cognitive or functional deficiency that would interfere with the patient's response.

Inclusion criteria are:

- Patients and carers seen at the site, whether admitted prior to or during data collection, having given their free and informed consent to participate in the study
- Caregivers and service providers, whether professional or in training, who had given their free and informed consent to participate in the study.

Exclusion criteria comprise patients, caregivers and providers who did not give their free and informed consent to participate in this study. All targeted individuals who had misinformed the survey questionnaires, or were unable to complete the survey interview, were excluded from the study.

For the purposes of this study, patients or their carers were chosen by convenience sampling, and providers were chosen by reasoned choice. The dependent variable of our study was the level of queue management at the CUPAR of the CNHU-HKM. Queue management was satisfactory if the average bed occupancy rate was less than or equal to 85%, the average number of patients waiting for an available bed was equal to 0 person, the average waiting time observed before treatment was 0 minute and the average rotation rate of hospital beds was less than or equal to 85%. The independent variables were human, material, financial, informational resources, the organisation of the service itself, behavioural factors, the queuing system, the process of care and patient-related factors.

For data processing and analysis, Epi Info version 7.2.3.0 and Stata version 11.0 were used. We assessed the level of queue management and then conducted a bivariate analysis using logistic regression. This allowed us to determine the associations between queue management and the different factors through the crude Odds-Ratio and their 95% confidence intervals (CI). In the multivariate analysis, the variables that had a p-value of less than 5% in the univariate analysis were introduced into an initial multivariate logistic regression model and we proceeded to a progressive elimination in order to search for the factors influencing the management of the waiting line at the CUPAR of the CNHU-HKM. Then management improvement approaches were analyzed by means of simulations and pressure calculations. The adequacy of the final model was investigated by the Hosmer-Lemeshow test. In carrying out this research, the basic ethical and deontological principles relating to the conduct of research on human beings were taken into account. The agreement of the administrative authorities of the CNHU-HKM and the CUPAR at different levels was obtained prior to the arrival of the collection teams in the field. In accordance with the principle of professional secrecy, the confidentiality of the data collected was rigorously respected during the survey. The free consent of the subjects, whether patients or providers, and the anonymity of the information collected were guaranteed throughout the study and beyond.

3. RESULTS

3.1 Data description

A total of 55 patients were admitted to CUPAR between 21 March 2022 and 08 April 2022.

3.2 Analysis of inpatient queue management at the CUPAR of the CNHU-HKM

- The average occupancy rate of hospitalization beds was 89.8% $\pm$ 3.8%.
- The average number of patients waiting for an available bed was 0.
- The average waiting time before patients were taken into care was 3.6 $\pm$ 1.2 minutes.
- Average inpatient bed turnover rate was 76.6 $\pm$ 2.6.
- The daily patient arrival flow was 3 $\pm$ 1 patients.
- Daily patient discharge flow was 3 $\pm$ 1 patients.
- The average length of stay of patients was 6.0 $\pm$ 1.5 day.
- The utilization rate of the service was 69.3% $\pm$ 1.2%.
- Inter-admission time was 5.0 $\pm$ 1.4 hours.
- The service rate was 100%.
- Traffic intensity was 0.03 patients or less than 1 patient at a time.
- There were no queues outside the clinic, but rather in-house, i.e., inpatient.
- The probability of having a patient every hour was 33.29%.
- The probability that a bed in the UPMC was occupied was 97%.
- The probability that a patient admitted to UARPC would spend a week there was 37% (see Table 1 and Figure 1).

Table 1. Characteristics of daily management and queuing factors at the CNHU-HKM CUPAR from March 21 to April 8, 2022

Variables	Mean	*SD*
Characteristics of daily management		
Bed occupancy rate (%)	89.8	3.8
Number of patients waiting for an available bed (patients)	0	0
Average wait time for patient care (minutes)	3.6	1.2
Inpatient bed turnover rate (%)	76.6	2.6
Build-up factors		
Daily patient arrival flow (patients)	3	1
Daily patient discharge flow (patients)	3	1
Average length of stay of patients (days)	6.0	1.5
Service utilization rate (%)	69.3	1.2
Inter-admission time (hours)	5.0	1.4
Service rate (%)	100	0

3.3 Assessment of daily management of the inpatient queue at the CUPAR of CNHU-HKM

The figures show that there were seven days of satisfactory management compared with twelve days of inadequate management (see Table 2).

Table 2. Assessment of the daily management of the inpatient queue at the CNHU-HKM CUPAR from March 21 to April 8, 2022

Variables	Headcounts	Proportions (%)
Days of satisfactory management	7	36.84
Days of poor management	12	63.16
Total	19	100

As a summary of the organizational factors, the main ones are the lack of hospital beds and technical boards (see Table 3).

3.4 Patient-related factors

- Concerning the severity of the patient's clinical condition, 90.9% of the patients were comatose compared to 9.1% conscious but dependent.
- In terms of the chronicity of the disease, 16.4% of patients were chronically ill compared to 30.9% of patients with sub-acute diseases and 52.7% with acute diseases.
- Regarding the promptness in the payment of healthcare bills, only 18.2% of patients were not prompt in the payment.
- As for the direct payment system, 34.5% of patients

did not have health care coverage, either from the state or from insurance companies, compared to 65.5% who had coverage from a local structure.

- In 12.7% of the patients, there was the problem of non-solvency of health care expenses against 87.3% who did not have it.
- The predominant social positions of the patients were middle class (43.6%), professionals (41.8%), followed by the underprivileged and workers (5.5%) and the privileged and middle class (1.8%).
- From the point of view of beliefs and values about the disease, 27.3% of the patients believed that their illnesses were simply the result of chance, 29.11% believed in a spell and 1.8% in a curse. However, 41.8% of the patients were indifferent to these interpretations.
- There were no other patients waiting for admission on arrival of the 100% patients.
- 50.9% were automatically admitted on arrival, compared to 49.1% who had to wait for about 15 minutes before admission.
- The hospital stay at CUPAR was between 0 days and one week for 81.8% of the patients, and about two weeks for 14.5% of the patients. Only 1.8% of the patients had exceeded three weeks of hospitalization for some and others more than three weeks (see Table 4).

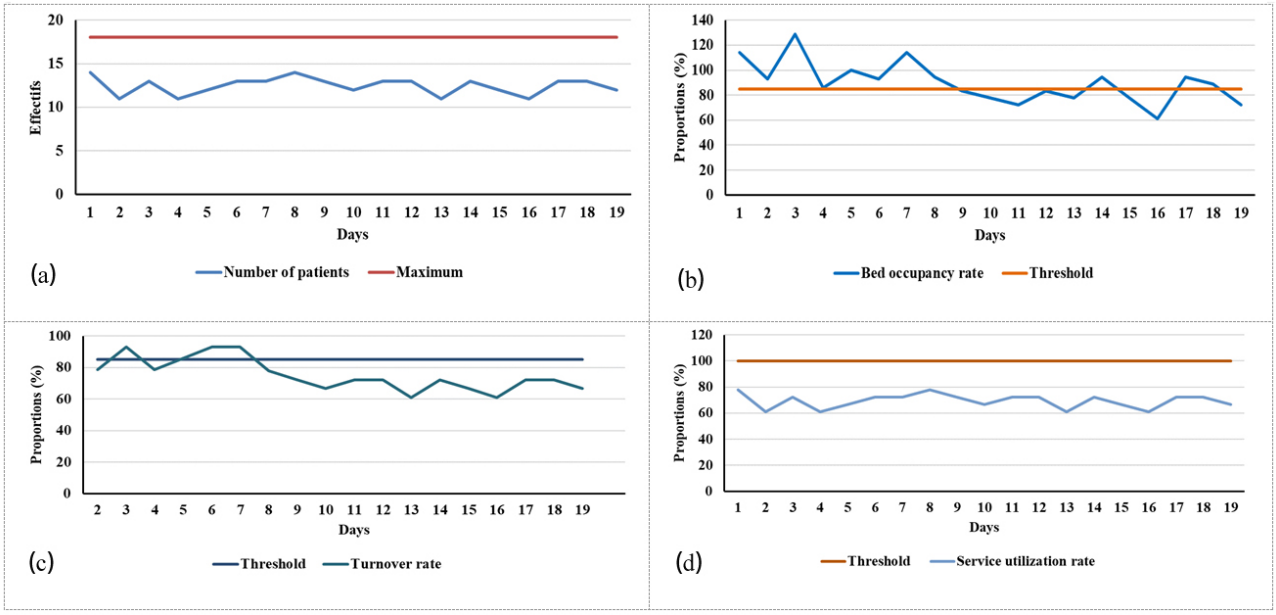

Figure 1. Evolution of inpatient queue management parameters at the CUPAR of the CNHU-HKM from March 21 to April 8, 2022

a: daily number of hospitalized patients; b: bed occupancy rate; c: bed rotation rate; d: service utilization rate

Table 3. Strengths and weaknesses of organizational factors

Strengths	Weaknesses
- The status of reference center of the CNHU-HKM and consequently of its clinics including the CUPAR. - Doctors and nurses are in sufficient number, and organized in teams with ratios (Doctors for beds, Nurses for beds) in the standards of the WHO. - The existence of medical consumables for intensive care on the national pharmaceutical market.	- The capacity of the CUPAR is below the needs of the national population (insufficient number of hospitalization beds) when one considers the status of national reference center of the CNHU-HKM. - The existing essential equipment is in reduced number. - The insufficiency of the technical platform in relation to the real needs of the CUPAR. - The non-existence of a back-up room to compensate for the closure of a hospital room during high-level disinfection or isolation operations. - The lack of a system for forecasting patient attendance.

Table 4. Characteristics of patients on waiting lists at the CUPAR of the CNHU-HKM from March 21 to April 8, 2022

Variables	Headcounts	Proportions (%)
Severity of the patient's clinical condition		
Comatose	50	90.9
Conscious dependent	5	9.1
Self-reliant	0	0
Chronicity of the disease		
Chronic	9	16.4
Subacute	17	30.9
Acute	29	52.7
Promptness in paying bills		
No	10	18.2
Yes	45	81.8
Direct patient payment system		
No	19	34.5
Yes	36	65.5
Non-solvency of care costs		
No	48	87.3
Yes	7	12.7
Social position of the patient		
Disadvantaged	3	5.5
Worker	3	5.5
Middle class	24	43.6
Professional	23	41.8
Privileged	1	1.8
Wealthy	1	1.8
Beliefs and values about the disease		
Hazardous events	15	27.3
Bewitchment	16	29.1
Curse	1	1.8
Indifference	23	41.8
Length of the queue		
0 Person	55	100
1 person	0	0
More than 1 person	0	0
Waiting time		
0 minutes	28	50.9
0 to 15 minutes	27	49.1
15 to 30 minutes	0	0
More than 3 minutes	0	0
Length of stay		
0 to 1 week	45	81.8
2 weeks	8	14.5
3 weeks	1	1.8
More than 3 weeks	1	1.8

3.5 Behavioral factors

Regarding the behavior of the care staff, we observe a lack of motivation. There is also the problem of the psychological support of the staff, given the sensitivity and specificities of the intensive care sector. In addition, we noticed some time wasters during our observations, such as the use of cell phones and unnecessary chattering. But these time suckers did not influence the care since the monitoring was continuous in the ICU.

3.6 The queue building system

To complete the picture, the average length of the inpatient queue was 13 ± 1 persons.

3.7 Bivariate analysis

Five variables were significantly associated with inadequate daily queue management at the CNHU-HKM CUPAR. These were daily patient arrival flow ($p = .05$), average daily patient length of stay ($p = .006$), daily number of patients ($p = .004$), daily time between the admission of two patients ($p = .004$) and patient length of stay in hospital ($p = .02$) (see Table 5).

3.8 Multivariate analysis

Only one factor was significantly associated with inadequate daily queue management at the CNHU-HKM CUPAR. This was daily arrival flow ($p = .05$; 95%CI = 0.06-1.01). The table below illustrates this association (see Table 6).

Inpatient admission to the CNHU-HKM UARC predicted a 0.24-fold risk of inadequate daily queue management.

Table 5. Associated factors with inadequate daily queue management at the CNHU-HKM CUPAR from March 21 to April 8, 2022

Explanatory variables	Headcounts	%	Raw OR	CI-95%	*p*-value
Daily inflow of patients	19	100			
0 patients	1	5.26	1	-	-
More than 0 patients	18	94.74	0.24	0.06 – 1.01	.05
Average daily hospital stays	55	100		-	-
0 to 7 days	13	68.42	1	-	-
More than 7 days	6	31.58	0.8	0.01-0.49	.006
Daily number of patients kept in hospital	19	100			
0 to 12 patients	8	42.11	1	-	-
More than 12 patients	11	57.89	0.06	0.01-0.41	.004
Daily inter-admission time	19	100			
More than 6 hours	4	21.05	1	-	-
0 to 6 hours	15	78.95	26	2.77-243.65	.004
Length of stay depending on the patient/attendant	55	100			
0 to 1 week	44	80.00	1	-	-
More than 1 week	11	20.00	7.81	1.43-42.66	.02

Table 6. Multivariate analysis of factors related to inadequate queue management at the CUPAR of CNHU-HKM from March 21 to April 08, 2022

Explanatory variables	Headcounts	%	Raw OR	CI-95%	*p*-value
Daily inflow of patients	19	100			
0 patients	1	5.26	1	-	-
More than 0 patients	18	94.74	0.24	0.06 – 1.01	0.05

3.9 Approach for improvement of daily queue management at CNHU-HKM CUPAR

During our investigations, we noted that the organization of admission and discharge consultations at the CUPAR was random and depends on the vital emergency. Neither the FCFS/FIFO nor the LCFS/LIFO model was adopted for the discipline of the service in the management of patients. The queueing model in the UCLP was not one based on Markow model (mathematical chains of a stochastic).

Furthermore, the CUPAR had a total of 18 beds with a maximum capacity of 18 patients. However, due to the proliferation of Multi-resistant Bacteria, the intensive care room D was closed and disinfected from 21 to 27 March 2022. Unfortunately, all four beds in room were not usable and not functional during the entire isolation period. Consequently there was an increase in the bed occupancy rate, since the number of functional beds was the common denominator in calculating this rate. In our analysis, several cases were revealed. It is about:

- Initially the number of available beds did not correspond to the patient influx (arrival flow per day was 3 $\pm$ 1 patients) insofar as with these 18 beds the mean occupancy rate was 89.8% $\pm$ 3.8% (> 85%), which was higher than the recommended threshold to avoid any bed shortages. For this purpose, we made simulations. With one more functional bed (19 beds), the result is an average occupancy rate of 77.0% $\pm$ 2.3%. This new rate is within the norms (< 85%) (see Figure 2).
- Subsequently, the closure of Room D with 4 beds for 8 days dealt a major blow to the bed occupancy rate by increasing it. According to our analysis, this rate remained above the norm (from 85.7% to 128.6%) throughout the closure period, and we even recorded super rates exceeding 100%. Clinically, this closure was necessary to prevent the proliferation of multi-resistant bacteria. However, in conditions where the CUPAR would already have a service room with a capacity of 4 beds in compliance with the standards, we would not see an increase in the occupancy rate after the closure of a room.

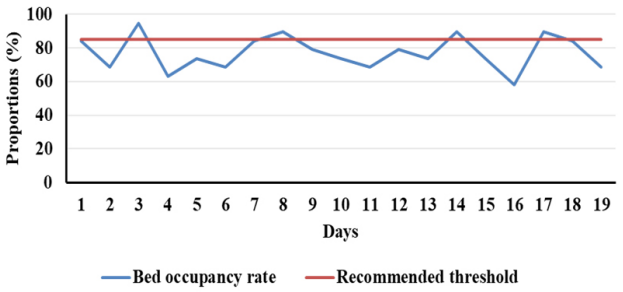

Figure 2. Simulation of the Distribution of bed occupancy rate evolution in the CUPAR of the CNHU-HKM from March 21 to April 8, 2022 with 19 functional beds

From the foregoing, we suggest:

- The construction of a service room with a capacity of 4 beds for high-level disinfection operations.
- The simultaneous organization of consultations at the admission, daily and at the exeat of the patients.

With regard to the number of additional posts to be foreseen, after counting it is necessary to foresee 3 additional beds to avoid any eventuality of shortage of beds even if the number of patients would reach a ceiling.

In total, 2 additional rooms and 7 fully equipped hospitalization beds are required in compliance with the standards in the field of resuscitation.

3.10 Adequacy of the final model

In the Hosmer Lemshow test, a *p*-value of .43 was obtained. This model is adequate since the *p*-value is higher than .05.

4. Discussion

From the findings above, we believe that the objectives of our study have been met and the hypotheses are verified. However, the present study focused on the CUPAR of the CNHU-HKM and took place during a relatively short time. It could have been carried out in several clinics of the CNHU-HKM, over a longer period of time, in order to clarify the real conditions of patients' admission to hospital, the management of patients' flow in the different clinics of the CNHU-HKM and the measures to be taken to avoid any beds shortage.

4.1 Daily patient arrival flow and in-patient queue management

From our study it appears that the average daily flow of patient arrival at CUPAR was about 3 ± 1 patients and the probability of having a patient every hour was 33.29%. Also, the admission of a patient to CUPAR for hospitalization had a 0.24-fold risk of inadequate inpatient queue management at CUPAR (95%CI 0.06 to 1.01, $p = .05$).

This finding could be linked to the fact that the CNHU-HKM has the status of a national reference center, as do its clinics. But also, it should be remembered that CUPAR is not the only clinic of the CNHU-HKM that admits patients in intensive care. Inside the CNHU-HKM, there is at the University Emergency Reception Clinic (CUAU), an ICU which is also a resuscitation service that hospitalizes the most critical cases.

These figures could also be linked to the installation of several resuscitation services in the country with the recent development of the health sector. Thanks to the efforts of the various governments for better national health coverage. Indeed, today Benin has 27 regional hospitals, 5 Departmental Hospitals (CHD), the National University Hospital Centre for Pneumo-phthisiology (CNHU-PP), the University Hospital Centre for Mother and Child Lagoon (CHU-MEL) and an important network of private health centres with resuscitation services.[9] The situation at the CUPAR of the CNHU-HKM can be compared to others.

In Geneva University Hospitals, the average daily flow of patient arrivals was 4 patients per day in the ICU.[10] This number is about 8 patients per day in the ICU of the Erasmus Hospital in Brussels in 2020.[11] In Mali, in the ICU of the Gabriel Touré University Hospital in Bamako in 2017, the daily inflow was an average of 2 patients.[12]

4.2 Insufficient inpatient beds, creation of a service room and management of the inpatient waiting line

The main purpose of the proposal to create a service room is to avoid any shortage of beds by partitioning the CUPAR in a different way and to increase the number of beds available. This facility will be reinforced by an increase of 7 additional beds. Thus, the total number of beds at the CUPAR will be 25. This will result in an improvement in the ratio of intensive care beds to population size.

Currently, the CUPAR has 18 beds in total, which makes a ratio of 0.14 intensive care beds per 100,000 inhabitants when we consider the projected population of Benin in 2021 and the status of national reference center of the CNHU-HKM.[13]

When the results of Chevrolet and Chioléro are compared with the findings inside CUPAR, it is clear that the ratio of resuscitation beds to inhabitants in CUPAR is well below European and North American trends. These authors found that the number of intensive care beds per capita varies from one country to another, from 30.5 intensive care beds per 100,000 inhabitants in the United States to 8.6 beds per 100,000 inhabitants in the United Kingdom. In Switzerland, it is 4.3 beds per 100,000 inhabitants.[14] At the beginning of the COVID-19 outbreak in 2021, France had 7.5 beds per 100,000 inhabitants. In 2017, Germany had 33.7 beds per 100,000 inhabitants, a rate five times higher than in France.[15] CUPAR's numbers are a far cry from these trends.

4.3 Simultaneous organization of consultations and queuing management in hospital

During our investigations, we noted that the organization of admission and discharge consultations at the CUPAR was random and depended on the vital emergency. Neither the FCFS/FIFO nor the LCFS/LIFO model was adopted for the service's patient management discipline. The queuing model in the CUPAR was not the Markow model. Therefore, we propose a parallel organization of consultations at admission, on a daily basis and at the discharge of the patients. This organization involves more active physicians in the ICU (2 physicians). Dureuil posits that for greater efficiency and effectiveness, in an intensive care setting, for greater efficiency and effectiveness, attention cannot be focused exclusively on the management of production and profitability indicators without integrating the organization of work, especially in parallel, communication and attention to the professionals of the technical platform.[16]

4.4 Insufficient technical boards and management of the inpatient waiting line

It appears from our study that there is a real problem of a lack of existing technical equipment. For a whole ICU of 18 hospital beds there was only one monitor, one defibrillator and quite often the problem of lack of oxygen shells. The equipment was not always adapted to the realities since for all radiological examinations, for example, it was necessary to systematically move the patients, even the most critical ones. This situation would undoubtedly be linked to the non-existence or non-operationalization of sustainable investment plans and projects in the field of resuscitation at CNHU-HKM. The risk is that in the event of a large-scale health emergency, all mitigation made, the CNHU-HKM and moreover the CUPAR will probably not be able to provide a satisfactory response to the impact.

It is known that the Covid-19 pandemic has generated a health crisis in several countries on all continents of the

globe. According to the work of Samaké et al in 2020 in Mopti, Mali, there is a link between the worsening of the health status of patients tested positive for SARS-CoV-2 and the existing technical platform. He believes that the decrease in fatality remains dependent on the effective management of severe forms of the disease, which requires the provision of resuscitation equipment and ongoing training of staff.[17] Moussebbih et al in Morocco in a reflection on the Moroccan health system post Covid-19, believes that the field of health is an area increasingly revolutionized by technology. According to him, it is high time to revise certain outdated management procedures at the level of the public hospital and to invest in new technologies (computer infrastructure, equipment...) for a better care of the patients.[18]

5. Conclusions

Managing the waiting line for patients in hospital is a major public health concern to which technical and precise answers must be provided in real time. At the end of our investigations and analysis, we conclude that the management of the queue of patients during hospitalization at the CUPAR of the CNHU-HKM depends above all on the daily flow of patients arriving, the number of hospitalization beds available, the organization of work and the technical and structural measures existing in the clinic.

These factors can be better mastered through a review of the internal organization of the CUPAR, the implementation of a system for forecasting clinic attendance, and the combined action of the competent authorities at various levels. The following suggestions are made along these lines.

Conflicts of Interest Disclosure

The authors declare they have no conflicts of interest.

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