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Opinion

# Prospective geo-modeling in cardiac surgery with extra-corporeal circulation-partial assessment at the Lille University Hospital

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## Background

Faced with the imminent opening of the new competing "Lens/Bois-Bernard" care unit in the Nord - Pas-de-Calais region (4 million inhabitants), a prospective modeling study was carried out in 1999 in response to a request from the Lille University Hospital (LUH), which sought to estimate the positive or negative impact on its recruitment catchment areas and consequently on its 1996 cardiac surgery activity (comprising 2 care units, i.e., 84 beds). In 1996, only 3 care units with the "Clinique du Bois" in Lille showed our regional undersupply of cardiac surgery compared to the national average of 5.96 [1,2]. The objectives were then for the decision-makers of the LUH to evaluate the recruitment of patients with an estimate of the activity at the "Clinique du Bois" before and after the opening of the "Lens/Bois-Bernard" cardiac surgery unit.

### Modeling

Two epidemiological hypotheses and 9 scenarios.

The 1st hypothesis: morbidity is evenly distributed over the region. The 2nd regional hypothesis: in cardiac surgery with Extra-Corporeal Circulation (ECC) procedures, the ECC rates observed are lower than the real needs of the Nord - Pas-de-Calais region [2].

In the LUH: we estimated three levels of ECC activity per 10,000 inhabitants, based on the highest observed prevalence rates of the coronary and valve pathology groups per year: respectively low (the rate at 4.48 (2.65 + 1.83)), medium (national reference rounded to 6 per 10,000 inhabitants) and high (reference of the highest Aquitaine region's rate at 8 per 10,000 inhabitants) respectively, see Table 4 [2]. For "Lens/Bois-Bernard", we had estimated the geographical areas of attraction and the activity in ECC from the three rates above before its opening. Three possible catchment areas were defined for the new unit: the proximity area, the area extended to health sectors 4, 5, and 6 representing the mining basin (see Figure 1 in the article [2]) and the area covering the same sectors and more.

### Visual navigation

This prospective modeling of activity a posteriori would have allowed the decision-makers of the LUH to navigate at sight over time, depending on their position in one of the 9 scenarios. In other words, to navigate at sight is to allow decision-makers (health professionals and politicians) *to respectively keep their minimum* activity *objectives* - the low level at 1776 ECCs per year (1246 and 530, i.e., 1776) or to *readjust their technical platforms* (in terms of paramedical staff, surgical staff, and equipment) in line with the increase in demand



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and consequently the increase in ECC activity. They are then positioned either in the medium level at 2379 ECCs per year or in the high level at 3172 ECCs per year.

If the activities of the LUH decrease, the decision-makers will be able to adapt to the phenomenon of a resurgence of extra-chu or extra-regional[1] leakage, as was the case before 1996. Indeed, clients were leaving for other regions, because of a waiting list that was too long, due to the lack of sufficient care offered (the ideal number of care units for the Nord - Pas-de-Calais region of 4.66 was calculated based on the national average of 5.96 (corresponding to 1 unit per 850,000 inhabitants) [1,2]. It should be noted that Henri WAREMBOURG had calculated in 1996-99 that preoperative mortality at the LUH amounted to 1.6% of patients on the waiting list, although this was an improvement on the 2% in 1993. In comparison, other studies have also sought to study and improve the provision of care in cardiac surgery [3,4].

**Factors leading to greater ECC activity are**

- Regional and extra-regional geographical attractions,[2]
- The reputation of the surgeons and care teams,
- The creation of care units can potentially lead to the recovery of patients fleeing to other regions and stop this phenomenon,
- The creation of a care unit can potentially generate a new phenomenon of additional attraction within the population of the LUH's referral zone.

**Factors leading to lower ECC activity are**

- Closure of care units,
- The departure or loss of a surgeon can lead to a reduction in activity (e.g., at the end of the 1990s at the Lille University Hospital, 10% of the activity was lost, with no possibility in the medium term of remedying this, which represented a volume of 100 ECCs - bearing in mind that the average number of patients produced per surgeon was estimated at 146 ECCs per year) [2].

## Questioning and assessment of the current situation through our 9-scenario model

What has happened since 1996-99 for the University Hospital of Lille? Can we mention all the repercussions on the activity of the LUH following the opening of the "Lens / Bois-Bernard" care unit? Can we position LUH in one of the 9 scenarios with certainty? Have we finally increased the average regional rate of ECC per year referenced in the Nord - Pas-de-Calais region and thus made up for our deficit? As a reminder, the regional ECC rates per 10,000 inhabitants observed in 1994 were 4.53; then in 1996 4.48 according to our study, and finally the national average rate of 5.96 [1,2]? Finally, is there still mortality on the waiting list at the LUH?

We have just collected, since 2005[3], only the number of ECCs per year for the LUH. We would like to recover the observed numbers for the "Clinique du Bois" (to compare the number of ECCs per year, which was then estimated at 530 in the modeling of the 9 scenarios) and the "Lens/Bois-Bernard" unit; access to the data will be facilitated through the DGOS. We also need to check the history of the evolution of the structures of the cardiac surgery care offered (reflecting the ECC activity) in our Nord - Pas-de-Calais region.

The numbers for the LUH in 1996 represented an observation of 1246 ECCs per year and for the "Clinique du Bois", an expert estimate of 530 ECCs, i.e., an overall number of 1776 ECCs in the *low hypothesis* according to the prevalence rate of 4.48 calculated per 10,000 inhabitants. Since LUH between 2005 and 2021 is systematically above 1246 ECCs per year (with an average increase of *around 20%* in the low activity hypothesis 1776) cf. Table 1 based on the study ([2]see Table 5), could well be positioned in one of the scenarios with a chance of gain (contrary to what appears in the first row of Table 5 of scenarios published in 2005) [2]. For the medium and high activities hypothesis, we expect a decrease in the number of ECCs per year *of about 10% and 33%* respectively according to our new calculations. Looking at Table 1, the position of the LUH tends with an average of 2143 ECC / year (over 17 years between 2005-2021) towards an activity of ECC / year positioning itself between the low and medium activity hypothesis. To confirm the evolution and the scenario in which the two Lille establishments (the "CHU of Lille or LUH" and the "Clinique du Bois") would be situated, we need to know the history as well as the real numbers that have occurred in each establishment in the region, i.e., within the 4 care units known in 1999 with "Lens/Bois-Bernard" as the most prominent opening[4].

For the "Lens/Bois-Bernard" unit, the numbers estimated by the same activity rates (low, medium, and high mentioned above) and according to its level of geographical attraction are 405 ECCs per year (in the proximity zone); 542 ECCs per year (mining basin: health sectors 4 + 5 + 6, i.e., approximately 600,000 inhabitants) and 722 ECCs per year (geographical catchment area extended to the mining basin area and beyond). Concerning the average ECC/year observed activity over 17 years for the Lens/Bois-Bernard unit, we do not yet have the information.

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[1]Leakage is defined as patient flows out of their most likely geographical catchment area in order to receive treatment in an external territory.

[2]The extra-regional or supra-regional attraction of a hospital service is defined by the recruitment of patients outside its regional territory.

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[3]We will collect the data and go back to 1996-99.

[4]Date to be specified using history and new data pending



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## Discussion

In Table 1, in rows: we see the trends of average activity over 17 years oscillating between the low and medium assumptions of activity per year. But it is not possible to position the LUH in one of the 9 scenarios with a partially observed database, nor to calculate the number of ECC activity per scenario from 1 to 9. In Table 1, in the columns: on the side of the Lens/Bois-Bernard new unit activity, we do not have the history of its average activity over 17 years, nor even the certainty of its existence now. The regional average ECC rate of 4.48 in 1996 has been exceeded and is estimated from the observed 17-year average activity to be 5.41: [(4.48*2143) / 1776 = 5.4057]. Finally, we need to ask the surgical team about the potential benefits of their visual navigation since 2005, based on the 9-scenario modeling Table 5 [2] and then whether mortality on the waiting list still exists.

### DATABASE_ECC 2005-2021

**Table 1:** Average observed increase and decrease in activities between (2005-2021) in relation to the simulation of variations in the activity of Lille University Hospital according to 9 scenarios (2005).

| Observations between 2005-2021 for the "CHU de Lille" - LUH | | New unit activity | | |
|---|---|---|---|---|
| | | Regional ECC<br>ECC rate 4.48/10,000<br>405 ECC/year | Mean national<br>ECC rate 6/10,000<br>542 ECC/year | Highest national<br>ECC rate 8/10,000<br>722 ECC/year |
| | | Average ECC/year observed ? | Average ECC/year observed ? | Average ECC/year observed ? |
| Overall regional activity | Regional ECC rate 4.48/10,000<br>1776 ECC/year | Scenario 1: - 305 | Scenario 2: -442 | Scenario 3: -622 |
| | ***Average observed increase of +20.71%<br>~2143 ECC/year (1776 + 367 = 2143)*** | ***Scenario 1: ?*** | ***Scenario 2: ?*** | ***Scenario 3: ?*** |
| | Mean national ECC rate 6/10,000<br>2379 ECC/year | Scenario 4: + 298 | Scenario 5: + 161 | Scenario 6: -19 |
| | ***Average observed decrease<br>of -9.90% ~2144 ECC/year<br>(2379 - 235 = 2144)*** | ***Scenario 4: ?*** | ***Scenario 5: ?*** | ***Scenario 6: ?*** |
| | Highest national ECC rate 8/10,000<br>3172 ECC/Year | Scenario 7: + 1,091 | Scenario 8: + 954 | Scenario 9: + 774 |
| | ***Average observed decrease of -32.41%<br>~2143 ECC/year (3172 - 1028 = 2144)*** | ***Scenario 7: ?*** | ***Scenario 8: ?*** | ***Scenario 9: ?*** |

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