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EVALUATING THE IMPACT OF STAFFING RECOMMENDATIONS IN MATERNITY UNITS IN FRANCE

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ABSTRACT

Sufficient midwifery staff is crucial for the quality of maternity care. However, the shortage of staff that France has been facing for several decades creates situations of understaffing. In order to determine the required number of midwives in a given department, several guidelines have been presented in the literature. Yet, we lack evidence on how these guidelines affect quality of care. The main objective of this study is to evaluate staffing guidelines provided by legal texts and the scientific literature. To do so, we observed a French public hospital maternity and built a discrete-event simulation model. The simulation model reproduces the structure, staffing schedules and patient characteristics of the maternity. We use the continuous support ratio as our main performance metric, since it has been shown to have a positive impact on patient outcomes. This ratio measures the amount of time that a midwife is able to provide direct support to labouring women under their care. Using our simulation model, we analyse the impact of different staffing recommendations on quality of care measured by the continuous support ratio. The results highlight the impact of availability and staffing levels on continuous support during labour. As expected, decreasing staffing levels lead to lower values of the continuous support ratio, but adding midwives has diminishing returns. The simulation approach can support trade-offs between ample slack in resources, which ensures that continuous support is always feasible, and tight staffing levels that lead to high workload.

Keywords: Discrete-event simulation, Staffing levels, Maternity units

1 INTRODUCTION AND LITERATURE REVIEW

Ensuring sufficient staffing is crucial for hospitals in general and for delivery units in particular. Evidence that lack of maternity staff has detrimental effects on mothers and babies is accumulating. In

perinatal death enquiries in the UK, understaffing was cited as a contributing factor in up to 25% of cases of stillbirths (Bradley N Manktelow et al., 2016). In understaffed units, professionals must prioritise tasks, which can be at the expense of measuring vital signs, providing emotional support, administering medication, and responding to emergencies (Simpson and Lyndon, 2017). In reverse, higher staffing levels lead to more physically intact deliveries (Sandall et al., 2014). In a recent systematic review, higher midwifery staffing levels were associated with less epidurals, less perineal damage at birth, less postpartum haemorrhage, less maternal readmission, and less neonatal resuscitation (Turner et al., 2021). Recent observational studies show that having more midwives reduces readmission rates (Turner et al., 2024) and harmful incidents (Turner et al., 2024), and improves the mother's experience of care (Turner et al., 2022).

In contrast, we have ample evidence of the benefits of 'continuous support' in labour, i.e., the presence of someone with the labouring mother at all time. Continuous support reduces the duration of labour and caesarean section rate (Hodnett et al., ; Bohren et al., 2017). To ensure continuous support, some countries even enforce a 'one-to-one care' policy in labour, meaning that a woman in labour should always have a midwife by her side. This is the case in the UK: "Maternity services develop the capacity for every woman to have a designated midwife to provide care for them when in established labour for 100% of the time." (Department of Health, 2004). They can provide psychological and physical support, information (especially on the progress of labour), and help assess the mother's needs. In France, the number of midwives that should be present in a delivery unit is stated in a decree from 1998, where staffing ratios are derived from annual numbers of birth (*Décret no 98-900*, 1998). One-to-one care in labour is not mentioned in French regulations or guidelines.

If maternity was a programmed activity, it would be possible to hire the precise number of midwives per room to obtain the desired continuous support ratio. However, most delivery care is actually unscheduled: aside from scheduled caesarean sections and, to a lesser extent, induced labours, the initiation of labor cannot be scheduled. In this situation, where a delivery unit could be empty in the evening and full the next morning, how many midwives should the department employ? If there were many midwives looking for work, and no constraint on budgets, one could simply say: enough to ensure the desired support ratio at all times. Of course, the reality is different, and somehow stark: midwives are leaving maternity units in many countries, trainees drop out before graduating, and supply doesn't keep up with demand. Therefore, choices must be made, so that the limited midwifery workforce is distributed across departments adequately.

In France, we have two main guidelines to calculate how many midwives a maternity unit should employ. The first one is a 1998 decree that sets minimum levels of staff that maternity units should have for unscheduled delivery care (*Décret no 98-900*, 1998). Based on the annual number of deliveries at the hospital, the decree sets a number of midwives to employ. These figures are not optima, they're only legal minima.

The second guideline was produced by national scientific societies in 2020, following expert consultation (Sentilhes et al., 2020). The breakdown of institutions is different from the one used in the decree, but the logic remains similar: based on the annual number of births, a staffing level is recommended for unscheduled maternity care.

In the article, maternities are divided into eight categories, and staffing levels are given for each category. In the decree, there are two cases. For certain professions, such as care managers, their presence is conditional on a certain number of births per year. For others, there is a linear correspondence between the number of births and the staffing levels. For example, it is mandatory to have a midwife at all time for 1,000 births, then a full-time midwife for every additional 200 births.

We are not aware of any empirical evaluation of these French guidelines. Elsewhere, a slightly more elaborate staffing method exists in the UK, the Birth Rate Plus tool. Endorsed by the Royal College of Midwives, the tool uses historical data, but each delivery is weighted based on the mother and the baby's characteristics, to account for factors that justify additional support in labour, and on the duration of labour.

Evidence for the effectiveness of the Birth Rate Plus is weak (Griffiths et al., 2024). Despite its refinement compared to French guidelines, a simulation study showed that Birth Rate Plus recommendations breached the British standard of one-to-one care 37% of the time (Allen and Thornton, 2013). More generally, maternity staffing deserves more attention (Turner et al., 2021).

In this study, we explore the relationship between midwifery staffing levels and continuous support in labour, in a French delivery unit. We model the birthing area of a French maternity and simulate its operation, taking into account midwives' availability for labour care and considering different levels of midwifery staffing. We show the impact of staffing on continuous support, as the number of midwives is positively correlated with continuous support. Then, we highlight the importance of taking availability into account, demonstrating the need to measure midwives' availability in order to build a realistic model.

2 METHODOLOGY

We worked with Hôpital Foch, Suresnes, France. Around 3,500 babies are born in the maternity every year, providing a sufficiently large sample. We built a discrete-event simulation model of the delivery unit, excluding pre- and post-natal care.

To understand the patient's journey and model the service in the most realistic way, we spent time directly in the maternity service at Hôpital Foch. We observed the operation of the service during half a day, and informally asked questions to midwives. The goal of these visits was two-fold. First, we needed to understand the patients' requirements from their perspective to enhance our knowledge of the process. Second, seeing the facilities enabled us to qualify and quantify the architecture of the service.

We defined two pathways. The first is for pregnant women that are going to give birth. The second is for women who come for unscheduled appointments, e.g. because of reduced fetal movements, but then leave the department without giving birth. The first steps of the paths are the same—welcome desk, then they see the reception and guidance nurse (RGN)—, and they use the same monitoring rooms. More importantly, they use common resources, such as the RGN and the emergency midwife. The rooms as well are shared by the two types of patients.

2.1 Pathway and Resources

When a woman comes into the unit, she is welcomed by an agent, then transferred to the reception and guidance nurse (RGN) (Figure 1). After the examination by the RGN, the woman is seen by the emergency midwife and taken to the monitoring room, for fetal heartrate monitoring. There are three phases in this room. At the beginning, the midwife has to be here to setup the monitoring device, and she has to be here at the end as well. Inbetween, there is no need for the midwife to stay.

When the monitoring is over, the woman can either be admitted or leave the service. In the first case, there are once again two possibilities. If she has a scheduled caesarean, she gets changed and goes to the surgical block. When she exits the block, she spends a bit of time in the post-interventional surveillance room (PISR), then leaves the service. If she does not have a scheduled caesarean, she goes to a delivery room. At any time, she can join the caesarean path. If she does not, she gives birth in the delivery room. After this, she normally stays in the room for surveillance, then leaves the system.

We modelled three types of resources: the RGN, the emergency midwife, and the delivery midwives. Obstetricians can be involved in deliveries, e.g. if concerns are escalated that require a medical opinion, or for instrumental deliveries. However, our study focuses on midwifery staffing, so we did not include obstetricians in the model.

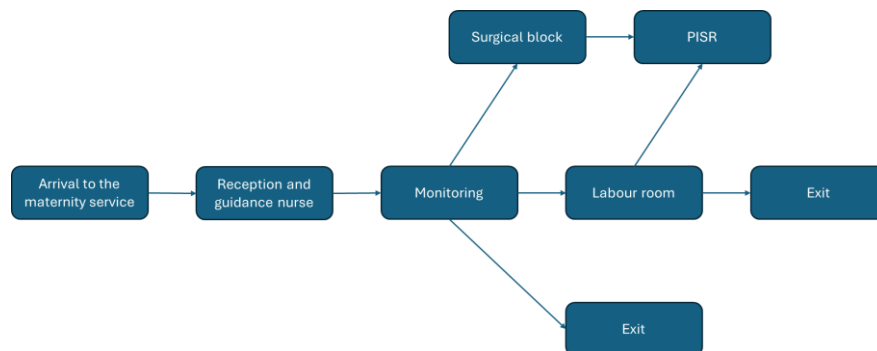


Figure 1 Flowchart of the delivery suite

The number of resources in the service is determined by internal policies, following French regulations. In this case, a single RGN and a single emergency midwife are present at all times. Delivery midwives work 12-hour shifts, from 8:00 am/pm to 8:00 am/pm. In practice, three midwives are present in birthing area at any time (a recent change from three during the day and two at night). This resource allocation constitutes our baseline scenario.

Rooms are also shared resources. The unit has three beds for monitoring, and nine delivery rooms. If all monitoring slots are taken, women wait; if all delivery rooms are taken, women are transferred to the post-interventional surveillance room (PISR). The room there is limited as well, only four places are available.

2.2 Model Parameters

2.2.1 Arrivals

We modelled two types of arrivals: women who will give birth, and women who won't (e.g., they came to check on reduced fetal movements). Arrivals were modelled using exponential laws, as they are considered unscheduled (although in reality this is not strictly the case, e.g. with inductions of labour).

We asked managers to provide information on how many patients were seen by the emergency midwife every day, and we used the annual number of births as well. Then, we were able to determine the daily number of arrivals in the two paths. We made the hypothesis that all days were similar, without weekday or seasonality effect. To model the arrivals distribution through the day, we asked once again the managers. It appears that two periods of the day are more busy than the rest from 8:00 a.m. to 10:00 a.m. and 6:00 p.m. to 8:00 p.m. They correspond to patients that come to the hospital before going to work or after coming back from work. Concerning the rest of the time, managers agreed that daytime was busier than nighttime. A repartition was defined in accordance to these specificities, and was validated by the managers. Table 1 gives the precise distribution of the arrivals.

Table 1 *Distribution of patients arrivals throughout the day*

Hour	Attendance	Distribution for inter-arrival time between births (min)	Distribution for inter-arrival time between emergencies (min)
12:00 a.m. to 08:00 a.m.	Low	Exponential(210)	Exponential(79)
08:00 a.m. to 10:00 a.m.	High	Exponential(70)	Exponential(26.3)
10:00 a.m. to 6:00 p.m.	Medium	Exponential(140)	Exponential(42.6)
6:00 p.m. to 8:00 p.m.	High	Exponential(70)	Exponential(26.3)
8:00 p.m. to 12:00 a.m.	Medium	Exponential(140)	Exponential(42.6)

2.2.2 Routing

Routing probabilities are only needed at the end of the monitoring activity and during the labour activity. In practice, after monitoring, a woman can leave the system, have a scheduled caesarean, or go to the labour room. If she goes to the labour room, she can be transferred to surgical block at any time for an emergency caesarean. To determine the probability of each routing, we used information provided by the hospital.

2.2.3 Activity Durations

To determine the duration of each activity, we used experts' consultation. We interviewed three midwives and asked them for the duration of several steps in the process. We asked for the minimal duration, maximal duration, and the most probable value. Based on these interviews, we took the average of each value to build a triangular distribution. Table 2 synthesises the different activities and

the associated distributions. The obtained values are estimates based on the midwives' knowledge of the system.

Table 2 Distribution of activities' durations (min), based on experts' opinion

Activity	Minimal value	Modal value	Maximal value
Reception and guidance nurse	10	15	25
Monitoring	40	60	80
Labour room	120	180	720
Surgical block	45	60	120

2.3 Output: Continuous Support

We considered the continuous support ratio defined at any time as:

$$\text{Continuous support ratio} = \frac{\text{number of patients}}{\text{number of midwives}} \quad (1)$$

This ratio is inspired from the one-to-one care ratio (Allen and Thornton, 2013), but focuses on the ratio between midwives and patients, while the one-to-one care ratio gives the percentage of time where one-to-one is possible. It is possible to perform one-to-one care when the continuous support ratio is less or equal to one, which corresponds to a situation where there are as least as many midwives as mothers in the delivery unit. This ratio also provides further information, compared to the rate of one-to-one care. If the ratio is close to zero for a long time, there is a chance that the resource allocation is suboptimal because midwives are barely occupied. On the opposite, if the ratio takes great values such as three or more, this means that continuous support is impossible and the workload is high.

2.4 Model Validation

We implemented to model on the Simul8 discrete-event simulation software (Version: 30.0.0.4515). To ensure that the model aligned with reality, we observed the operation of the birthing area and took notes to model the patient's journey. We also collected information via informal discussions with midwives, in order to understand the steps where they intervene and their duration. Finally, we reviewed it with two of the department managers who agreed to take part in this process. Though they were not familiar with the software, the researcher detailed the whole process of admission and the different patients' paths, and the managers were asked to complete the list or correct it if needed. Following correspondence with them via email, the conceptual model was validated. Finally, midwives were asked to evaluate the coherence of the results regarding the main indicator (average time in system), and confirmed that this corresponds to the average time that patients spend in the birthing area.

We ran trial of runs with each run simulating 1 year. To determine the number of runs, the trial calculator of Simul8 was used. This tool gives the minimal number of runs required to satisfy a condition on the model's precision, regarding certain KPIs. We decided to choose a 5% precision on the model, as this value was used in literature (Baril et al., 2017). The main indicator of the model is the average time in the system, and Simul8's trial calculator suggested a minimum of 4 runs to obtain reliable results on this KPI. As the simulation ran quickly, we decided to conduct 10-run trials.

2.5 Experimentation

For each trial, two inputs varied: the number of delivery midwives and their availability. The main output was the support ratio, that was defined previously as the ratio between the number of patients and the number of midwives at all time in the service.

We assessed the impact of two parameters on the continuous support ratio: the number of midwives in the delivery unit, and their availability.

In all scenarios, we had one RGN and one emergency midwife, who were considered available 100% of the time. For delivery midwives, the current policy in Hôpital Foch is to have three midwives

during day and night, and the previous one was to have three midwives during day and two during night. When modifying the number of midwives, we only tried two configurations: an equal number of midwives during day and night, or an additional midwife during day shifts compared to night shifts. We defined five possible configurations (Table 3).

Table 3 Number of midwives in the different scenarios

Scenario	Average number of midwives	Day shift	Night shift
1	2	2	2
2	2.5	3	2
3	3	3	3
4	3.5	4	3
5	4	4	4

The number of midwives is the main topic in this research, but having midwives who would be constantly busy with other tasks than supporting labouring women would be of little use. We needed to take into account the real availability for this key task, as accurate representation of resource availability can lead to huge differences in simulation results (Baril et al., 2017). Since we did not have figures on the distribution of midwives' working time between different tasks (direct care, documentation, administrative tasks...), we defined availability as an independent variable and tried different values.

We defined availability as the percentage of time where they are able to provide direct care to a patient, without being busy filling administrative forms or being called somewhere else. To obtain preliminary insights on the impact of competing tasks, we assessed five values for availability: 20%, 40%, 60%, 80% and 100%. Availability was defined stochastically (no predefined competing tasks), using Simul8's built-in 'availability' module.

3 RESULTS

3.1 Impact of the Number of Midwives

For a fixed availability, we varied the number of midwives in the birthing area from 2 (2 during day and night) to 4 (4 during day and night). The value 3.5 (respectively 2.5) represents the situation where there are 4 midwives (resp. 3) during day and 3 during night (resp 2). The results are presented in Figure 2.

The decree "périnatalité" (*Décret no 98-900*, 1998) gives legal minima to perform obstetrics, depending on the yearly number of births in the service. For Hôpital Foch (3500 births per year), it represents 13.5 full-time equivalent midwives. This corresponds to 2.8 midwives at all time in the service.

The second calculation method given in the literature (Sentilhes et al., 2020) also gives staffing recommendations depending on the number of births. These values are divided into categories. Between 3,000 and 4,500 births, it is recommended that 5.1 to 7.2 midwives are present in the service for unscheduled activity. For 3500 births, under the hypothesis that the relation between the number of births and midwives is affine, this corresponds to 5.8 midwives at all time.

Under the 100% availability hypothesis, there is an improvement of the support ratio when more midwives are added in the system. However, it has to be noted that the gap between 2.5 and 3 midwives is more important than the gaps between 3, 3.5 and 4 midwives. It seems that there is a point where adding midwives in the service is not as beneficial. This could create a suboptimal use of the resources, that would be more useful in another service. Moreover, this would decrease the cost/benefit ratio.

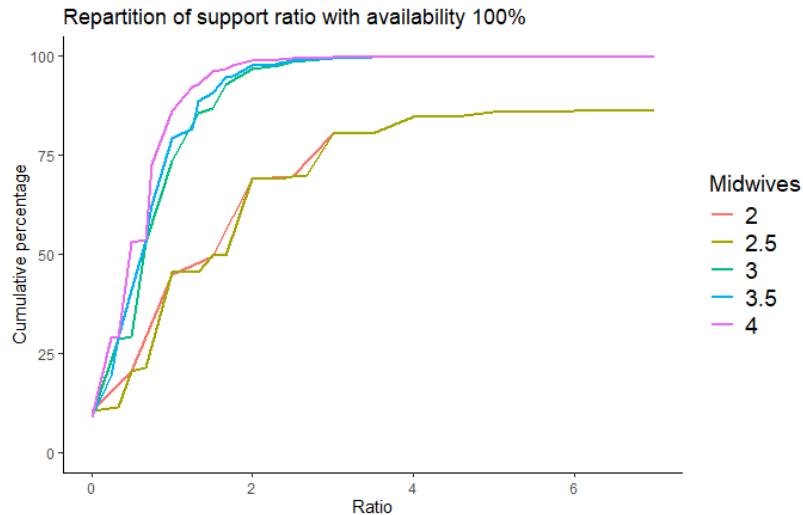


Figure 2 Cumulative percentage of time spent by continuous support ratio, for different numbers of midwives in the unit, with 100% midwife availability

This tendency also appears to be present for lower values of availability. Figure 3 shows the repartition of the support ratio for a 40% availability. Once again, the gain is maximal between 2.5 and 3 midwives. Independently from midwives' availability, there is a point after which adding midwives becomes less and less beneficial (diminishing returns).

Another information provided by this figure is that the finite values of support ratio don't reach 100% of the total time. This means that there is a portion of time where this ratio is infinite, in other words there are no midwives available in the service to provide care to patients. In case the service has two midwives whose availability is 40%, this represents about 17% of the time. For the same availability but a total of four midwives, it is only 9%.

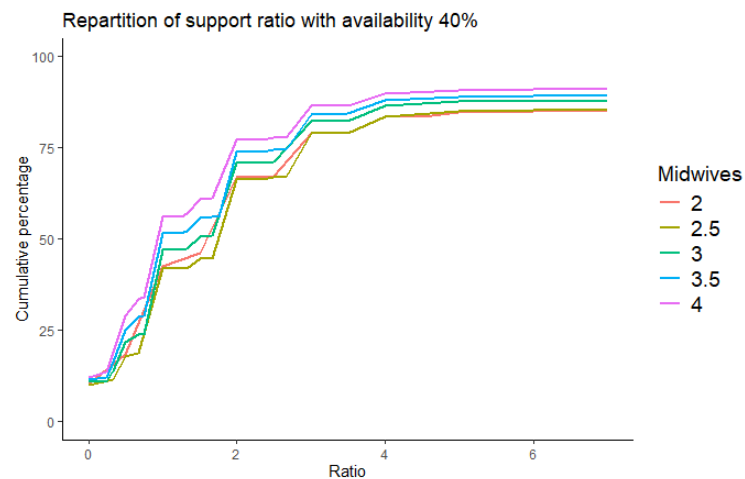


Figure 3 Cumulative percentage of time spent by continuous support ratio, for different numbers of midwives in the unit, with 40% midwife availability

3.2 Impact of Midwives' Availability

We are now interested in the impact of the availability of midwives, for a given staffing level. First, we focused on the current situation in Foch, with three midwives at all time, and another one with three midwives during night and four midwives during day. The first result shown by this graph is that availability has a strong impact on the support ratio. This is especially the case for low values of availability such as 20%, where the support ratio is infinite 31% of the time for a service with three midwives (0.05% for 100% availability).

It is noticeable that there is little difference in the lower values of the ratio between 40% and 60% availability. On the opposite, 20% appears to be extremely detrimental to the operation of the birthing unit. Although we don't know midwives actual availability, the literature suggests that around 15% of caregivers' time is spent on direct care with patient, and 15% is spent on indirect care (Leslie et al., 2021).

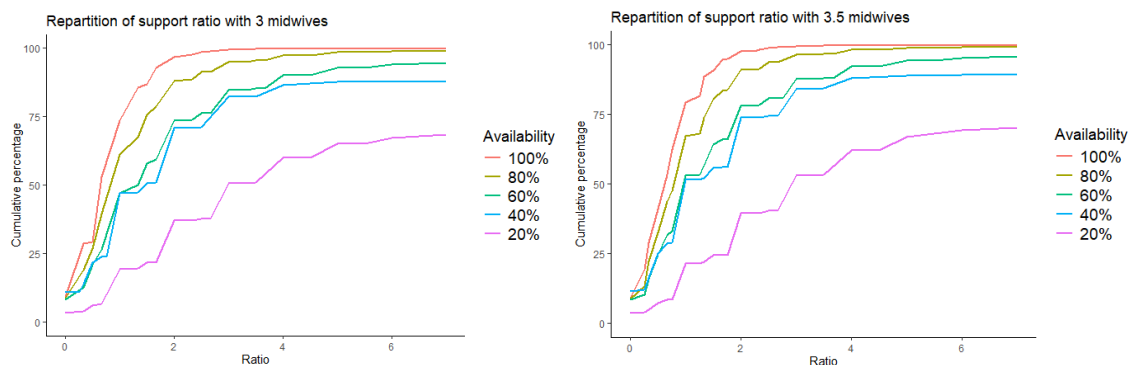


Figure 4 Cumulative percentage of time spent by continuous support ratio, for different numbers of midwives in the unit, with 3 (left) and 3.5 (right) midwives, under different levels of midwife availability

4 DISCUSSION

4.1 Summary

Using a simulation model and data based on experts' opinion, this study showed the consequences of different staffing policies on continuous support during childbirth. It also highlighted the importance of taking midwives' availability into account. Using different values of staffing and availability, we quantified the influence of staffing and midwives' tasks on the support ratio. As expected, continuous support and staffing are positively correlated, as are midwives' availability and continuous support. Our results align with a previous simulation study (Allen and Thornton, 2013). Even high levels of midwifery staff, under the hypothesis of full availability for direct care, cannot ensure one-to-one care.

The disparity between the results, depending on staff's availability, demonstrates the need for a precise modelling and quantification of midwives' tasks. It also calls into question the content of midwives' work, as time-studies in other healthcare professions show that direct care sometimes only occupies a fraction of working time, the rest being distributed between indirect care and administrative and other tasks. For example, Tipping et al. (2010) measured the repartition of hospitalists' time, concluding that only 17% of the time was spent on direct care, while the use of electronic medical record represents 34% of their time.

4.2 Strengths and Limitations

This study has several strengths. First, structural data based on a real French hospital were used, ensuring that the main steps in the patients' journey were respected. Then, the different distributions were determined using several experts' opinion. During the design phase, the whole model was validated as well by managers who work in this service, guaranteeing the adequation between the model and reality.

Our study also has limitations. First, we only focused on midwives. Even though midwives are central in the operation of a birthing unit, providing continuous support during labour may also be the role of nurses or nursing assistants. Their absence in the model lowers the number of people available to provide care, which has an incidence on the support ratio. Second, we used distributions obtained from interviews with experts. This gives less precision to the model than actual data from the hospital's databases, midwives being subjected to biases. It would be beneficial to obtain actual data, in order to

fine-tune the distributions. Seasonal variability in the number of deliveries was not taken into account, despite being present in France (Régnier-Loilier and Rohrbasser, 2011). Finally, as previously mentioned, the exact activities of midwives are not well-known. We need to both qualify and quantify their work, to better understand of it affects the support ratio. In this study, we chose different values for midwives' availability, but further research could help understand the repartition and the duration of their tasks.

4.3 Future Work

In order to tackle some limitations of this study, we plan on developing further perspectives. Three main projects are planned so far.

The first plan is to have access to real data from the hospital. Using the databases of Hôpital Foch, we will be able to fine-tune the different distributions and arrivals. In particular, this will give a better understanding of the frequency and the repartition of arrivals throughout the day, and throughout the year. In addition, the duration of each step in the patient's path will be clarified.

To have a better representation of the situation in France, we plan on doing the same work in several hospitals, using their data to fit distributions.

Finally, in order to qualify and quantify midwives' activity, we will conduct a time-and-motion study in these three maternity units. This will give a more accurate view of the availability of midwives, and the repartition of their tasks during the day.

REFERENCES

- Allen, M., Thornton, S., 2013. Providing one-to-one care in labour. Analysis of "Birthrate Plus" labour ward staffing in real and simulated labour ward environments. *BJOG Int. J. Obstet. Gynaecol.* 120, 100–107. <https://doi.org/10.1111/j.1471-0528.2012.03483.x>
- Baril, C., Gascon, V., Miller, J., Bounhol, C., 2017. The importance of considering resource's tasks when modeling healthcare services with discrete-event simulation: an approach using work sampling method. *J. Simul.* 11, 103–114. <https://doi.org/10.1057/jos.2016.6>
- Bohren, M.A., Hofmeyr, G.J., Sakala, C., Fukuzawa, R.K., Cuthbert, A., 2017. Continuous support for women during childbirth. *Cochrane Database Syst. Rev.* 7, CD003766. <https://doi.org/10.1002/14651858.CD003766.pub6>
- Bradley N Manktelow, Lucy K Smith, Sarah E Seaton, Pauline Hyman-Taylor, Jennifer J Kurinczuk, David J Field, Peter W Smith, Elizabeth S Draper, 2016. MBRRACE-UK Perinatal Mortality Surveillance Report UK Perinatal Deaths for Births from January to December 2014. MBRRACE-UK, Department of Health Sciences, University of Leicester.
- Décret no 98-900, 1998.
- Department of Health, 2004. Maternity Standard, National Service Framework for Children, Young People and Maternity Services.
- Griffiths, P., Turner, L., Lown, J., Sanders, J., 2024. Evidence on the use of Birthrate Plus® to guide safe staffing in maternity services – A systematic scoping review. *Women Birth* 37, 317–324. <https://doi.org/10.1016/j.wombi.2023.11.003>
- Hodnett, E.D., Gates, S., Hofmeyr, G.J., Sakala, C., 2012. Continuous support for women during childbirth. *Cochrane Database Syst. Rev.* <https://doi.org/10.1002/14651858.CD003766.pub4>
- Leslie, H.H., Laos, D., Cárcamo, C., Pérez-Cuevas, R., García, P.J., 2021. Health care provider time in public primary care facilities in Lima, Peru: a cross-sectional time motion study. *BMC Health Serv. Res.* 21, 123. <https://doi.org/10.1186/s12913-021-06117-9>
- Régnier-Loilier, A., Rohrbasser, J.-M., 2011. Y a-t-il une saison pour faire des enfants ?: *Popul. Sociétés* N° 474, 1–4. <https://doi.org/10.3917/popsoc.474.0001>
- Sandall, J., Murrells, T., Dodwell, M., Gibson, R., Bewley, S., Coxon, K., Bick, D., Cookson, G., Warwick, C., Hamilton-Fairley, D., 2014. The efficient use of the maternity workforce and the implications for safety and quality in maternity care: a population-based, cross-sectional study. *Health Serv. Deliv. Res.* 2, 1–266. <https://doi.org/10.3310/hsdr02380>
- Sentilhes, L., Galley-Raulin, F., Boithias, C., Sfez, M., Goffinet, F., Le Roux, S., Benhamou, D., Garnier, J.-M., Paysant, S., Bounan, S., Michel, C., Coudray, J., Rozé, J.-C., Elleboode, B.,

- Ducloy-Bouthors, A.-S., 2020. Staffing needs for unscheduled activity in obstetrics and gynecology. *Eur. J. Obstet. Gynecol. Reprod. Biol.* 245, 19–25. <https://doi.org/10.1016/j.ejogrb.2019.11.020>
- Simpson, K.R., Lyndon, A., 2017. Consequences of Delayed, Unfinished, or Missed Nursing Care during Labor and Birth. *J. Perinat. Neonatal Nurs.* 31, 32–40. <https://doi.org/10.1097/JPN.0000000000000203>
- Tipping, M.D., Forth, V.E., O’Leary, K.J., Malkenson, D.M., Magill, D.B., Englert, K., Williams, M.V., 2010. Where did the day go?—a time-motion study of hospitalists. *J. Hosp. Med.* 5, 323–328. <https://doi.org/10.1002/jhm.790>
- Turner, L., Ball, J., Culliford, D., Kitson-Reynolds, E., Griffiths, P., 2022. Exploring the relationship between women’s experience of postnatal care and reported staffing measures: An observational study. *PloS One* 17, e0266638. <https://doi.org/10.1371/journal.pone.0266638>
- Turner, L., Ball, J., Meredith, P., Kitson-Reynolds, E., Griffiths, P., 2024. The association between midwifery staffing and reported harmful incidents: a cross-sectional analysis of routinely collected data. *BMC Health Serv. Res.* 24, 391. <https://doi.org/10.1186/s12913-024-10812-8>
- Turner, L., Griffiths, P., Kitson-Reynolds, E., 2021. Midwifery and nurse staffing of inpatient maternity services - A systematic scoping review of associations with outcomes and quality of care. *Midwifery* 103, 103118. <https://doi.org/10.1016/j.midw.2021.103118>
- Turner, L.Y., Saville, C., Ball, J., Culliford, D., Dall’Ora, C., Jones, J., Kitson-Reynolds, E., Meredith, P., Griffiths, P., 2024. Inpatient midwifery staffing levels and postpartum readmissions: a retrospective multicentre longitudinal study. *BMJ Open* 14, e077710. <https://doi.org/10.1136/bmjopen-2023-077710>

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