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Emergency Department Congestion at Saintemarie University Hospital

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Introduction

In late 2019, Emma Dupont, CEO of Saintemarie University Hospital, had just ended an extremely tense phone conversation with the state secretary of health. The secretary was very concerned about the wait time in the hospital's emergency department (ED). The recent coverage of these problems in the local press, which repeatedly echoed complaints of patients and their families, was making things worse:

> *It took them 18 hours to take care of my mother when she was admitted to the emergency department in the Saintemarie University Hospital* — Saintemarie Tribune *(March 2019)*

> *On September 8, Nancy (86 years old) had to wait eight hours in the ED with a broken leg before seeing a doctor* — Saintemarie Tribune *(September 2019)*

Saintemarie was a midsize European city with a population of 512,000. A few private clinics in the area provided urgent care (i.e., treatment that does not require hospitalization), but they were unable to handle acute emergencies. The hospital's ED was the only emergency care unit available in the Saintemarie metropolitan area. The only alternative to it was a hospital located 50 miles away; patients had to be transferred there by helicopter, which happened rarely because such transfers were extremely expensive. Given its central role, Saintemarie University Hospital was under the constant scrutiny of local and state officials.

ED congestion can have significant repercussions on a hospital's ability to provide quality care for patients, many of whom require immediate attention. The secretary of health recognized that the long delays at the city's primary ED were a substantial public health issue because they jeopardized the public's having timely access to medical treatment. He made his demands

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clear: the status quo was not sustainable and wait times at the hospital's ED had to be reduced. He requested an action plan and measurable progress before the end of the month.

Sitting in her office, Dupont stared at her workforce schedule. In a time of scarce resources in which she was already pressured to limit costs, how could ED wait times be reduced? How many people would she need to hire and how could she balance the cost of such additions? Were there changes she could make without adding more staff?

Dupont's first decision was to task Pat Leterme, the head of the ED, to identify the root causes of the wait time and to devise a concrete set of improvement actions.

Challenges in the Healthcare Industry

Hospitals and other healthcare delivery systems in Europe and other parts of the world had faced strong pressure to reduce costs and improve operations for several years. For example, in the United States, because of a growing and aging population, demand for healthcare had steadily increased. Meanwhile, partially due to an effort to reduce soaring healthcare spending, the supply of hospital beds, physicians, nurses, and other healthcare resources had been relatively stagnant. Indeed, there was already a nursing shortage,[1] and physician shortages were predicted in the coming years.[2] The number of ED visits was increasing even as the number of hospitals and hospital beds was declining. The number of hospitals in the United States fell from about 7,150 in 1975 to roughly 5,700 in 2015, and the number of ED visits rose from 96 million to 136 million from 1995 to 2011.[3] As a consequence of these trends (growing demand and inadequate supply), congestion in the healthcare system continued to grow, resulting in delayed access to care. This problem was most evident in hospital EDs, particularly for patients requiring critical care treatment and management. From 2006 to 2014, the number of critically ill patients treated in EDs increased from 2.8 to 5.2 million, and intubated patients in EDs increased by an estimated 16%.[4] At the same time, the rate and effects of crowding in EDs attracted attention at all levels. In 2009, for example, the issue was raised in a report to the Chairman of the Committee on Finance of the US Senate.[5]

Congestion in the ED and its Effects

While ED wait times plateaued and decreased through the later 2000s and the 2010s, roughly 14% of patients still waited at least an hour to be treated in 2017 (see Exhibit 1).[6] One 2017 study found that wait times for treatment in EDs were more than an hour for about 20% of acute ischemic stroke patients; hypertension control and prolonged imaging were the most common reasons for delay (see Exhibit 2).[7] This was concerning as such delays have been associated with worse outcomes. Numerous studies suggest that ED delays increase mortality and hospital length of stay for critically ill patients (see Exhibit 3).[8] A study of community-acquired sepsis, for example, found that delays in antibiotic administration were associated with increased probability of in-hospital mortality (see Exhibit 4). The odds of a poor outcome potentially increased 3-7% with each one-hour delay in administering antibiotics after ED triage or the onset of organ dysfunction.[9] Another study of nearly one million ED visits at 187

acute care hospitals in California found that, per admission, patients admitted during periods of high ED crowding had 5% increased odds of in-patient death, 0.8% longer length of stay (LOS), and 1% increased costs.[10]

When delays in the ED are long, more patients leave without being seen—even though the percentage of people with a serious illness is similar among those who leave and those who wait.[11] A year-long study conducted at the ED of a large teaching hospital in Australia found that nearly 11% of patients left without being seen (LWBS), and that a long wait time was the most common reason given.[12] Other reasons included "feeling better, too unwell to wait, receiving advice or treatment by triage nurse, other appointments to attend to, leaving to go to other healthcare facility, and staff rudeness." Those who LWBS returned to the ED within 72 hours at twice the rate of those who waited—10% percent versus 5%, respectively. In 2011, the *Wall Street Journal* reported on the impact on hospitals' bottom lines of high rates of patients who LWBS, noting that "revenue of about $450,000 is lost if even 1% of patients walk out of an emergency department with an annual volume of 50,000 patients."[13]

Another effect of overcrowding is ambulance diversion—that is, directing incoming ambulances to other nearby facilities. While ambulance diversion was not a common occurrence at Saintemarie Hospital, the increasing backlogs in EDs had led many hospitals to increase their diversion rates.[14] *Health Affairs* noted that ambulance diversion "can create a domino effect, triggering nearby facilities—now clogged with the diverted patients—to themselves go on diversion status. It can also lead to delays in medical care for patients elsewhere in the healthcare system."[15]

Overall, then, ED boarding, crowding, and delays had negative consequences for patients and hospital systems alike. Boarding and ED crowding led to increased mortality and LWBS rates, longer LOS, and increased costs. As a 2020 survey of the literature noted, "ED boarding reflects symptoms of a systemic healthcare problem with multiple downstream effects."[16] Another study observed that ED "crowding has a variety of undesirable consequences, including increased patient waiting times, decreased ability to protect patient privacy and confidentiality, impaired evaluation and treatment, and difficulties in delivering patient-centered care. These consequences can be understood not just as undesirable or unfortunate but also as violations of widely held, fundamental moral norms."[17]

Saintemarie University Hospital

With more than 2,000 beds, Saintemarie University Hospital was a large healthcare complex, even by global standards. Located in the center of Saintemarie, it was the only hospital in its metropolitan area to provide all ranges of care (from primary to tertiary) in all medical disciplines to all types of patients (pediatric, adult, and geriatric). Working in close collaboration with the faculty of medicine of the State University of Saintemarie, the hospital had a world-class reputation in numerous medical fields. It was able to attract local and international talent, and it was one of the largest employers in the Saintemarie region.

Dupont was appointed CEO in 2005. She was an energetic and charismatic leader. During her first years at the helm of the hospital, she was able to turn around its profitability by cutting costs by more than 15%, while maintaining high standards of quality and good motivation among staff.

EMERGENCY DEPARTMENT

The ED was one of the largest departments in the hospital, employing more than 250 people, including:

- 60 doctors, half of whom were interns who required supervision by the 25 junior specialist doctors and six senior specialist doctors. Every day from 11:00 a.m. to approximately 11:45 a.m., one of the senior doctors gave a lecture to the interns. The rest of the supervision took place in the field. On average, the interns stayed in the ED one year before moving to another service in the hospital.
- 150 nurses, approximately 50% of whom had a specialized degree in emergency care. The nursing team was managed by Christine Colin, a dynamic and experienced specialist nurse, who was highly regarded by her staff. She was assisted by six head nurses, who spent most of their time on planning, staff allocation, and absenteeism management.
- 40 administrative staff, who registered the patients, provided secretarial assistance to the doctors, and took care of administrative follow-ups (such as writing letters to general practitioners).

In addition to the staff formally assigned to the ED, many doctors from other departments contributed to the activity of the service, in particular by giving advice about the most complex cases.

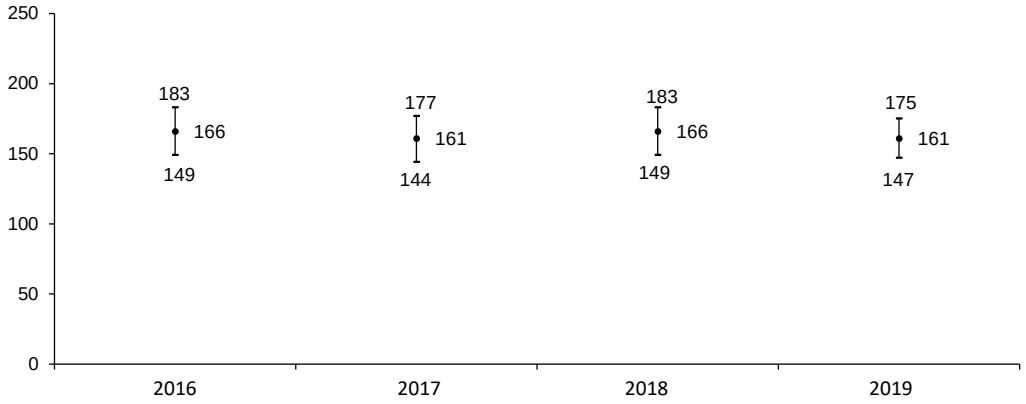
The activity was organized in two 12-hour shifts, one from 7 a.m. to 7 p.m. and the other from 7 p.m. to 7 a.m. Staffing, especially of specialist doctors, was a bit lighter at night. Doctors and nurses met separately at the beginning of each shift, mainly to ensure the transmission of ongoing cases to the next team.

Pat Leterme, the current head of the hospital's ED, had been appointed two years before by the faculty of medicine. Although Pat was a specialist in internal medicine with an outstanding publication record in the field and a strong academic reputation, some hospital staff—mostly surgeons—had opposed Pat's appointment, citing lack of managerial and operational experience.

Patients Coming to the ED

Over the last several years, the inflow of patients coming to the ED of Saintemarie remained relatively stable, at around 165 patients per day, or approximately 60,000 patients per year (see Figure 1). No seasonal or weekly trend was observable in the arrival of patients, except that Mondays tended to be slightly busier, and Sundays tended to be slightly calmer.

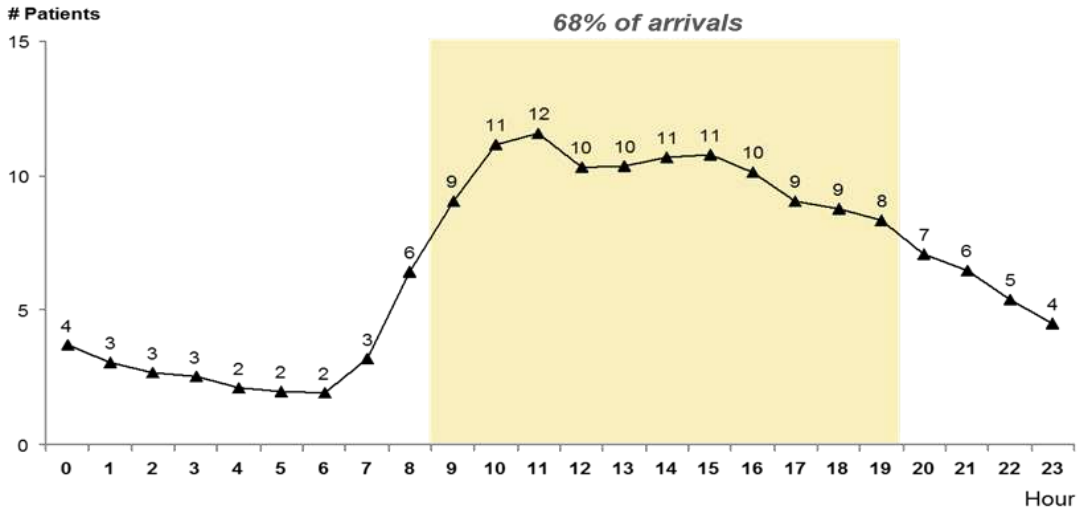
FIGURE 1. PATIENT INFLOW (DAILY AVERAGE PLUS/MINUS ONE STANDARD DEVIATION)



Approximately one-third of the patients arrived to the ED by ambulance; the remaining two-thirds came on their own or were brought in by a relative.

Data on patient arrivals showed a recurrent pattern of inflows during the day (see Figure 2): the number of patients arriving each hour grew steeply in the morning and reached a peak around 11 a.m. The inflow remained high and stable in the afternoon and only started decreasing significantly in the evening. Two-thirds of the patients arrived between 9 a.m. and 7 p.m.

FIGURE 2. HOURLY PATIENT INFLOW



Once patients arrived at the ED, they were all seen by a first-line nurse who performed a task known as triage: he or she determined the patient's degree of emergency and the subsequent type of ED room to which the patient would be assigned (the "path" in the ED). This preliminary examination usually took two to three minutes. Only experienced specialized nurses triaged patients. During the day, physicians were also supposed to triage patients; their role was to redirect nonurgent cases to more appropriate care settings. Unfortunately, the triage physician was often busy taking care of patients in the ED rooms. Moreover, physicians

were quite reluctant to perform this task, which they perceived as bearing huge responsibility. As a physician said in an interview: "[Triage] is at odds with why I am a doctor. My job is not to make quick decisions with minimal information and then tell patients to get treatment elsewhere."

Once triage was performed, patients were officially registered by the administrative staff (which took 10 minutes); registration of acute patients was performed while they were already in a room.

DEGREE OF EMERGENCY

Patients coming to the ED were classified in four groups, depending on the acuteness of the case:

- **Degree 1**: vital emergencies that needed to be treated by doctors immediately (8 patients/day).
- **Degree 2**: acute emergencies with no vital risk that needed to be treated within 20 minutes (33 patients/day).
- **Degree 3**: nonacute emergencies that needed to be treated within two hours (119 patients/day).
- **Degree 4**: patients who did not require any urgent care (5 patients/day).

ED ROOMS (PATHS)

Depending on their symptoms and the degree of emergency, patients were assigned to one of the ED paths:

- **Red path** (70 patients/day): for acute nonambulatory patients who would likely be hospitalized after their stay in the ED. All degree 1 and most degree 2 patients were directed to the red path.
- **Orange path** (40 patients/day): for nonacute patients (mostly degree 3) with nonsevere medical symptoms (e.g., stomach pain or strong headache) who were able to move independently and were unlikely to require hospitalization.
- **Green path** (30 patients/day): for nonacute patients (mostly degree 3) who required light surgical intervention (e.g., bone setting or stitches) but who were unlikely to be hospitalized.
- **Psychiatric path** (10 patients/day): for patients who primarily required psychiatric treatment (e.g., for alcohol abuse or suicidal symptoms).

Over time, a fifth (unofficial) **grey path** emerged, for geriatric patients who required long-term hospitalization (5 patients/day).

Each path had dedicated rooms, nurses, and doctors, but all paths shared technical resources (such as x-ray equipment, CT scanners, and a transportation team). Nursing staff rotated from one path to another on a weekly basis. The ED had a total of 40 examination rooms (also called boxes), 25 for acute and psychiatric care (red and psychiatric paths) and 15 for outpatient care (orange and green paths). Although the ED ran 24/7, the outpatient ("orange" and "green")

rooms were closed from 11 p.m. to 8 a.m., so during those hours all non-psychiatric patients were treated in "red" rooms.

PROCESS MAPPING

The resources and actors involved varied for each patient. Nevertheless, the overall process was similar for all patients; Exhibit 6 provides a summary of the broad process map in the ED.

The full process took an average of five hours and could be divided into three steps:

1. **Initial wait**: after sorting and registration, patients waited in a dedicated area at the entrance of the ED, under the supervision of a nurse, until a room became available. On average, patients waited an hour and 10 minutes for a room, but the wait time could be as high as 10 hours. A nurse was responsible for assigning patients to the ED rooms. That nurse's role was very central, as she or he determined the priority given to each patient and managed the workload of the different areas in the ED. Only experienced specialized nurses with good leadership skills were staffed in this position.

   Management also found that because of the long wait time, approximately five patients per day left the ED before they were seen by a doctor.

2. **Patient management**: the patient-management phase took on average three hours and 10 minutes. This process was highly variable: benign interventions might require only a few minutes, whereas acute cases where resuscitation and stabilization of the patient as well as a complex diagnostic test were necessary might require more than 10 hours.

   Typically, the following steps occurred during the patient-management phase:

   - A nurse brought the patient to a room, took his or her vital signs, and called the intern when the patient was ready for examination.
   - An intern performed a first examination and called a supervisor if necessary. For acute cases, specialist doctors took care of the patient immediately.
   - In approximately 40% of the cases, doctors required laboratory tests to establish their diagnosis. Once the tests had been prescribed, samples were sent to the central laboratories; for cost and quality reasons, those labs performed all the tests. The samples were then processed, and the results were published through the labs' IT application. On average, two hours elapsed between the prescription of the tests and the publication of the results.
   - Some patients required a radiology exam, in most cases either a conventional x-ray (30% of the patients) or a CAT scan (CT) (15% of the patients). The ED had a dedicated CT scanner located close to the examination rooms. The CT itself took about 30 minutes, which was in line with international benchmarks. However, doctors complained that

getting the results took three hours. They blamed both the lack of resources ("one CT is not enough for our ED") and the inefficiency of the technical staff for the delay. The technical staff, however, said that they conducted exams and processed the results as fast as possible, and blamed the nurses for being too slow in transporting patients.
The scanning process was as follows: once the exam was over, the CT technician called the nurse assigned to the patient. The nurse then took the patient out of the scanner, after which the technician called another nurse to bring the next patient in for the exam. As a result, the CT scanner remained empty for ten minutes between each patient.

- For the most complex cases (approximately 25% of the patients), the ED medical staff sought advice from another specialist in the hospital. Each department had a dedicated phone line for the ED, with an intern on call to visit emergency patients. Obtaining advice from a specialist added on average two hours to the patient management time: one hour for the specialist to come down to the ED (generally because he or she had other tasks to perform at the same time) and one hour for the specialist to examine the patient, reach out to a supervisor if necessary, and give advice to the ED medical staff.
- Once all the results had been reported, on average 45 minutes elapsed before the medical team made a decision about the next steps in patient care. Interns were responsible for a few patients at a time and were sometimes busy with patient B when the results arrived for patient A. Moreover, interns generally discussed or backed up their decision with their supervisor, who might also have been busy with another patient.

The mission statement of the ED clearly stated that patient management in the emergency room should be terminated once the patient had been stabilized and a diagnosis had been established. Nonetheless, the teams sometimes initiated treatment steps to improve the quality of patient care or ease the job of the inpatient staff.

3. **Patient discharge:** On average, the actual delay between the diagnostic evaluation and the moment the patient left the examination room was 40 minutes. There were three possible destinations for patients once they had been diagnosed:

    - **Home** (60% of patients): it took on average 30 minutes for the medical and nursing teams to prepare paperwork and provide patients and families with the necessary information for discharge.
    - **The observation unit** (20% of patients): some patients required short-term monitoring before discharge. Instead of occupying a regular inpatient bed, these patients remained in a dedicated area of the ED called the observation unit (OU) for a maximum of one night. Although

it was located within the ED, transferring patients to the OU required heavy administrative paperwork (full transcription of patient status, description of treatment for the night) and coordination between two different teams. As a result, on average one hour was necessary for the transfer. Moreover, in reality many patients who were sent to the OU were waiting to be admitted to the hospital as inpatients to a department that was either full or to which transfers were not possible at the night. As a result, the 32 beds in the OU were often full.

- **Another department of the hospital** (20% of patients): as in many other hospitals, Saintemarie's ED was a major point of entry for inpatient admissions. Each of the six other departments had an administrative team managing patient in- and outflow.

Once the diagnosis had been established, the ED contacted the appropriate team and asked for a bed in that department. However, the hospital had a high occupancy rate (approximately 90%); therefore, as described above, the requested bed was not always immediately available. Transfer procedures varied by service. For instance, despite a general rule that the ED was responsible for determining the destination of the patient, some departments still required that one of their own doctors examine the patient before the transfer. In addition, some services did not accept patient transfers after certain hours. When a bed became available, the ED was informed. ED nurses then called their colleagues in the destination service to briefly explain the patient's diagnosis and medical requirements. (In some instances, nurses in the destination department asked to delay the transfer if their workload did not allow them to receive the patient immediately.) Finally, ED nurses contacted the central transportation team, which was responsible for taking the patient from the ED to the destination service. On average, the full transfer process took slightly more than one hour.

Patients spent an average of three hours and 50 minutes in the ED for patient management and discharge. Because of the variety of cases that were treated, the standard deviation of the time spent in the ED was relatively high (three hours). If wait time was also included, patients spent on average five hours in the ED after they had been registered, excluding time spent in the OU.

Concerns about ED Operations

The inflow of patients had been stable for several years. However, the time spent by patients in the ED had increased considerably, from four hours in 2016 to five hours in 2019.

During a first meeting, Leterme and Dupont identified their key concerns about the ED:

- **Quality**: Although the wait-time targets for highly acute (degree 1) patients were fully met, only two-thirds of degree 2 patients were seen by a doctor

within the established maximum delay period of 20 minutes. This raised patient safety and quality-of-care issues, two elements crucial to the hospital's reputation. The fact that five patients per day left the ED without being seen by a doctor was also a concern.

- **HR**: Morale among the ED staff had recently worsened, and some experienced nurses and young doctors had resigned over the last months. They all mentioned an increase in their stress level as a reason for their decision. They also blamed severe patient dissatisfaction as well as their own frustration at having no control over the situation.
- **Economic**: The long wait time had negative effects on revenues because some profitable outpatient emergency cases went to private clinics and because some patients left without being seen by a doctor. Wait time also raised personnel costs: additional staff was needed to supervise the patients who were waiting, and overtime hours were at a historical high. Moreover, the risk of medical complications was higher when patients had to wait longer, which could significantly increase treatment costs.

Leterme and Dupont were clear about the serious consequences of the wait times in the ED but still struggled to decide which measures they should take to address the issue and to what extent these would mitigate the growing wait times.

Exhibits

Exhibit 1: US Emergency Department Wait Times, 2017

National Hospital Ambulatory Medical Care Survey: 2017 Emergency Department Summary Tables — Table page 1 of 1

Table 4. Wait time at emergency department visits: United States, 2017

Visit characteristic	Number of visits (standard error) in thousands	Percent distribution (standard error)
All visits	138,977 (10,277)	100.0 …
Time spent waiting to see a physician, APRN, or PA[1]		
Fewer than 15 minutes	56,081 (5,879)	40.4 (2.9)
15–59 minutes	45,673 (4,331)	32.9 (1.8)
1 hour, but less than 2 hours	12,485 (1,520)	9.0 (0.8)
2 hours, but less than 3 hours	3,845 (492)	2.8 (0.3)
3 hours, but less than 4 hours	1,319 (192)	0.9 (0.1)
4 hours, but less than 6 hours	1,222 (220)	0.9 (0.2)
6 hours or more	731 (190)	0.5 (0.1)
Not applicable	3,592 (508)	2.6 (0.3)
Blank	14,029 (2,532)	10.1 (1.8)
Patient arrived in emergency department after business hours[2]		
Yes	79,548 (5,956)	57.2 (0.6)
No	57,507 (4,302)	41.4 (0.6)
Blank	*1,923 (661)	1.4 (0.5)

… Category not applicable.
* Estimate does not meet NCHS standards of reliability.
[1]APRN is advanced practice registered nurse. PA is physician assistant. The median wait time to see a physician, APRN, or PA was 16 minutes; the mean wait time to see a physician, APRN, or PA was 37.5 minutes.
[2]Business hours are defined as Monday through Friday, 8 a.m. to 5 p.m.

NOTES: Numbers may not add to totals because of rounding. Visit estimates based on 30 cases or more include an asterisk if the relative standard error of the estimate exceeds 30%.

SOURCE: NCHS, National Hospital Ambulatory Medical Care Survey, 2017.

Source: US Centers for Disease Control, "National Hospital Ambulatory Medical Care Survey (Table 4)," https://www.cdc.gov/nchs/data/nhamcs/web_tables/2017_ed_web_tables-508.pdf.

Exhibit 2: Contributors to Delay in Intravenous Thrombolysis (IVT) among Acute Ischemic Stroke Patients

Contributors	N	Percentage
Prolonged Stroke Imaging (> 20 min)	23	24.00%
Required blood pressure management prior to IVT	22	22.90%
Unclear presentation	20	20.80%
Triage to initiation of imaging scan > 25 min	19	19.80%
Unclear contributor to delay	15	15.60%
Required treatment for other emergent conditions prior to IVT	12	12.50%
MRI of brain completed prior to thrombolysis	11	11.40%
Delay in paging to neurology	11	11.40%
Lengthy consenting for IVT	9	9.40%
Fluctuating neurological deficits	7	7.30%
Logistical/other Issues	6	6.30%
Difficulty in identifying time of symptom onset	5	5.20%

Source: Ashland Mowla et al., "Delays in Door-to-Needle Time for Acute Ischemic Stroke in the Emergency Department: A Comprehensive Stroke Center Experience," Journal of Neurological Sciences 376 (2017): 102-105.

Exhibit 3: Literature Review of the Outcomes of ED Critically Ill Patient Boarding

Author/ Year	Study Design	ED Boarding Definition	Endpoints	Major Findings
Chalfin DB, et.al./ 2007(31)	R, MC (n=50322)	ED boarding time ≥ 6 hours after decision to admit to ICU	ICU and hospital mortality ICU and hospital length of stay	1. ED boarding time ≥ 6 hours increased odds of both ICU mortality (10.7% vs 8.4%, p < 0.01) and hospital mortality (17.4% vs. 12.9%, p<0.001; risk-adjusted OR for survival 0.709, 95% CI 0.561-0.895). 2. For hospital survivors, ED boarding ≥ 6 hours was associated with longer hospital length of stay (7 vs 6 days, p<0.001).
Singer AJ, et.al./ 2011(16)	R, SS (n=41256, 12.1% admitted to ICU)	ED boarding time ≥ 2 hours after the decision to admit	Hospital mortality	1. Boarding time 12 hours or more was associated with increased hospital mortality (4.5% vs 2.5%, p<0.001)and hospital length of stay (8.7 vs 5.6 days, p<0.001) 2. Increased duration of ED boarding associated with increased ICU admissions.
Reznek, et.al/ 2018(20)	P, MC (n=39781, 21.3% admitted to ICU)	Inpatient admission, but boarding in ED	Hospital mortality	1. ICU patients who died in the hospital were not more likely to have had longer ED boarding times (adjusted HR 0.96, 95% CI 0.92-1.01). 2. Non-ICU patients who died in the hospital were more likely to have had longer ED boarding times (adjusted HR 1.19, 95% CI 1.03-1.36). 3. Authors hypothesize mitigation strategies may have contributed to findings: ICU patients had clear delineation of responsibility between ED and admitting teams whereas non-ICU patients cared for under mixed-responsibility model.
Mathews KS, et.al./ 2018(18)	R, SS (n=854)	ED boarding after ICU consultation	Persistent organ dysfunction and/or death (POD-D)	1. Length of ED boarding time post-consultation for ICU admission was associated with an increased odds of POD-D (OR 1.77, 95% CI 1.07-29.5)
Angotti LB, et.al./ 2017(32)	P, MC (n=525)	Duration of MV > 7 hours	Hospital mortality	1. Duration of MV > 7 hours in ED was associated with longer overall duration of MV (4.8 days vs 2.5 days, p=0.011) and increased hospital mortality (45.9% vs 29.4%, p=0.018; HR 1.31, 95% CI 1.03-1.7, 2. ICU or hospital LOS were not affected by duration of MV > 7 hours in the ED. 2. Fewer than 25% of patients had ventilator adjustments made while in the ED.
Cardoso LTQ, et.al./ 2011(39)	R, SS (n=401)	Delayed ICU admission = Admitted to ICU, but bed not immediately available	ICU mortality	1. Delayed ICU admission associated with higher ICU mortality rate (adjusted HR 1.015, 95% CI 1.006-1.023) 2. Each boarded hour in the ED was associated with a 1.5% increased risk of ICU mortality and a 1% increased risk of hospital mortality. 3. Delayed ICU admission had no effect on duration of MV, ICU or hospital LOS.
Agustin M, et.al./ 2017(S3)	R, SS (n=287)	ED boarding time ≥ 6 hours after decision to admit to ICU	Hospital mortality Sepsis protocol compliance Resuscitation	1. ED boarding time ≥ 6 hours was not associated with any difference in hospital mortality (22.6% vs 24.7%, p=0.68, adjusted OR 1.226, 95% CI 0.669-2.247). 2. Sepsis protocol compliance and achievement of resuscitation goals were not different for ED boarders.

Exhibit 3: Literature Review of the Outcomes of ED Critically Ill Patient Boarding (cont.)

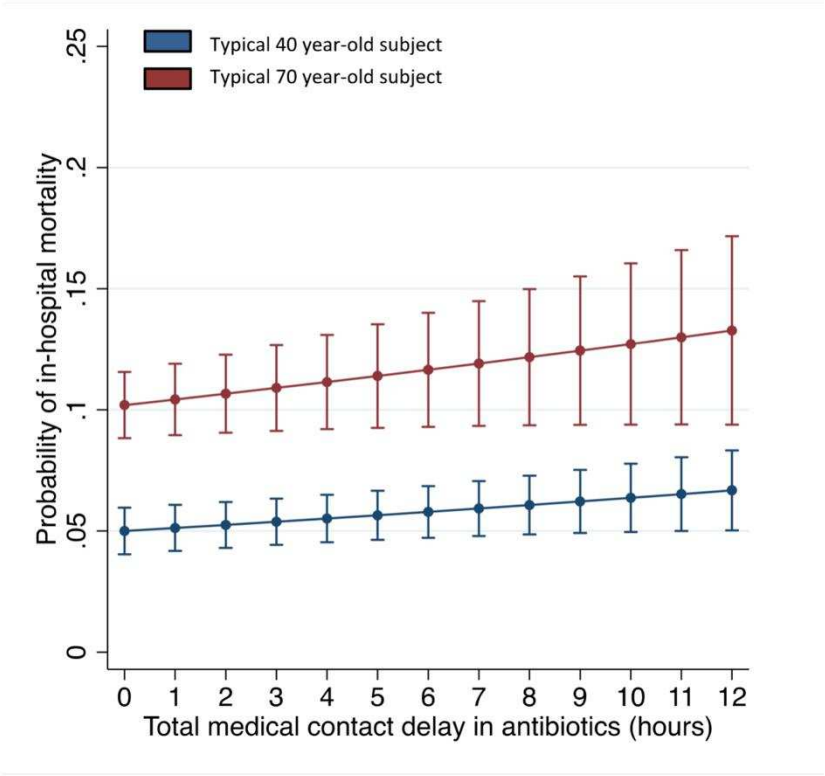
Bhat R, et.al./ 2014(19)	R, SS (n=169)	Boarded in the ED > 2 hours post-intubation	Process variables – post-intubation care	1. Performance of all 6 post-intubation cares achieved in only 2.4% of patients. These cares included ventilator management, sedation, gastric decompression, ABG, chest x-ray and quantitative capnography. 2. None of the 6 post-intubation interventions were associated with differences in ventilator-associated pneumonia, duration of MV or ICU length of stay.
Rincon F, et.al./ 2010(38)	R, SS (n=75)	ED boarding time ≥ 5 hours after decision to admit to ICU	Poor outcome, defined as a modified Rankin score of ≥ 4	1. In critically ill stroke patients, an ED boarding time ≥ 5 hours was an independent predictor of poor outcome (adjusted OR 3.94, 95% CI 1.69-9.14) 2. An ED boarding time ≥ 5 hours did not have effect on discharge NIHSS or hospital length of stay.

R, retrospective; MC, multicenter; ED, emergency department; ICU, intensive care unit; OR, odds ratio; SS, single center; P, prospective; POD-D, persistent organ dysfunction or death; MV, mechanical ventilation; HR, hazard ratio; 95%CI, 95% confidence interval; NIHSS, National Institutes of Health stroke scale.

Source: Nicholas M. Moor et al., "Boarding of Critically Ill Patients in the Emergency Department," Journal of the American College of Emergency Physicians Open 1, no. 4 (Aug. 2020): 423-431. Supplementary Table 2, http://links.lww.com/CCM/F477.

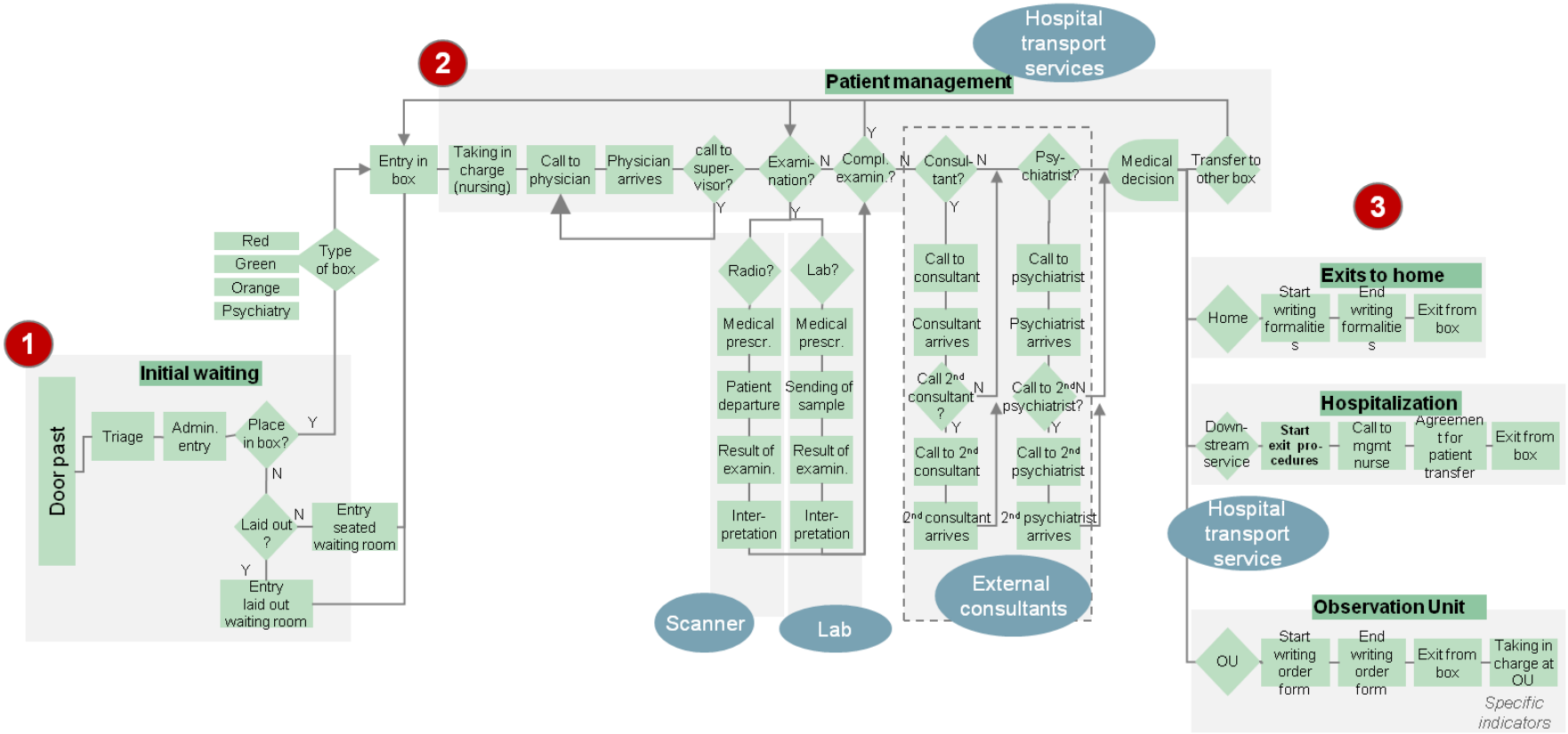
Exhibit 4: Antibiotic Administration, Medical Contact Delay, and Mortality Rates among Patients with Community Acquired Sepsis

eFigure 1. Predicted probability of in-hospital mortality adjusted for covariates across a range of medical contact delay until antibiotic administration for typical, community acquired sepsis patients who are 40 and 70 years old.



Source: Christopher W. Seymour et al., "Delays from First Medical Contact to Antibiotic Administration for Sepsis," Critical Care Medicine 45, no. 5 (2017): 759-765, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6065262/bin/NIHMS959314-supplement-Supplement.docx.

Exhibit 5
Process Map



Source: Company document.

Endnotes

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