HEC MONTRÉAL

Emergency department boarding in Quebec hospitals:
Analysing root causes and seeking improvements

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Emergency department boarding in Quebec hospitals: Analysing root causes and seeking improvements

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Summary in French

CONTEXTE :

D'après la littérature, les délais de transfert de patients entre l'urgence et les unités de soins sont une des principales causes de débordements dans les urgences. Lorsqu'un patient admis à l'urgence est contraint à attendre qu'un lit se libère dans une unité de soins, son parcours hospitalier est considérablement affecté. Cependant, aucune étude n'a été réalisée à ce sujet au Québec jusqu'à ce jour.

OBJECTIFS :

Les objectifs de cette étude sont (1) d'analyser les causes des délais de transfert entre l'urgence et les unités de soins dans trois hôpitaux du Québec, et (2) de trouver des solutions potentielles aux problématiques identifiées.

MÉTHODOLOGIE :

Ce mémoire emploie une approche mixte, utilisant des données qualitatives et quantitatives pour atteindre ces objectifs. Un modèle linéaire généralisé a été développé sur le logiciel SAS v.9.3 en utilisant la procédure GENMOD pour vérifier la signification statistique des données quantitatives recueillies.

PRINCIPAUX RÉSULTATS :

Il a été constaté qu'il existe effectivement des délais de transfert de patients entre l'urgence et les unités de soins dans les hôpitaux participants. Quatre principales causes à cette problématique ont été identifiées: (1) le manque de coordination entre les admissions et les congés, (2) les congés tardifs, (3) l'incapacité pour le personnel soignant de donner congé aux patients, et (4) le manque de communication, de collaboration, et d'information dans les hôpitaux entre les différents acteurs du processus. Plusieurs solutions sont proposées pour répondre à ces constats.

MOTS CLÉS :

Délais de transfert, hôpital, urgence, unités de soins, Québec, gestion des flux

Summary in English

BACKGROUND:

Emergency department boarding, which is "the practice of holding admitted patients in the emergency department (ED) until an inpatient bed becomes available" (Walsh, Cortez, & Bhakta, 2008; 221), is one of the principal causes of ED crowding. Moreover, this practice negatively impacts the entirety of the patient care process. To this day, no research has been conducted on this issue in Quebec.

OBJECTIVES:

The goals of this thesis are to (1) analyse the different causes of emergency department boarding in three Quebec hospitals, and (2) find potential solutions to these causes.

METHODS:

This thesis uses a mixed approach, basing itself on both qualitative and quantitative data to achieve these objectives. A generalised linear model was developed in SAS Software v.9.3 using the GENMOD procedure to verify the statistical significance of the quantitative data obtained.

RESULTS:

ED Boarding was found to be prominent in the studied hospitals. Four root causes of ED boarding were elucidated, which are (1) uncoordinated admissions and discharges, (2) late, discharges, (3) the inability to discharge patients, and (4) a lack of communication, collaboration, and information between the different actors of the patient care process. Many solutions are proposed to improve these issues.

KEY WORDS:

ED boarding, hospital, emergency department, inpatient units, Quebec, boarding

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Adm.: Administration (employee category)

ALC: Alternate Level of Care

AHN: Assistant Head Nurse

BMC: Bed Management Coordinator

C/S: Clinical/Support (employee category)

ED: Emergency Department

HAI: Hospital-Acquired Infection

HSSC: Health and Social Services Center (English version of CSSS)

ICU: Intensive Care Unit

IP: Inpatient

LCSC: Local Community Services Centre (English version of CLSC)

LOS: Length Of Stay

LTCF: Long-Term Care Facility

LWBS: Leaving Without Being Seen

MRSA: Methicillin-Resistant Staphylococcus Aureus (hospital-acquired infection)

OR: Operating Room

PCP: Primary Care Provider

VRE: Vancomycin-Resistant Enterococci (hospital-acquired infection)

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I dedicate this thesis to my spouse Marianne. Thank you for taking me outside of my comfort zone, and for pushing me to be excellent.

1. Introduction

Emergency department (ED) overcrowding has been a threat to public health for numerous years, and continues to cause various deleterious effects on both patients and those involved in the process of care (White, Biddinger, Chang *et al.*, 2013). This issue has been discussed extensively in regards to emergency departments across the United States (Garson, Hollander, Rhodes *et al.*, 2008; Trzeciak & Rivers, 2003), but the problem manifests itself worldwide (Richards, Ozery, Notash *et al.*, 2011). Indeed, regions such as Australia, Great Britain, the Netherlands, and Hong Kong share in this plight (Derlet & Richards, 2000; van der Linden, Reijnen, Derlet *et al.*, 2013; Xu, Wong, Wong *et al.*, 2013).

Canada is also greatly affected by emergency department overcrowding (Derlet & Richards, 2000; Haraden & Resar, 2004; Guttmann, Schull, Vermeulen *et al.*, 2011; A. H. Cheng & Sutherland, 2013; I. Cheng, Lee, Mittmann *et al.*, 2013). As Nippak, Isaac, Ikeda-Douglas *et al.* (2014) wrote, "Emergency departments (EDs) are key entry points to hospital care, and issues of overcrowding and poor patient flow have become a priority in Canada" (p. 12). One of the root causes of ED crowding is emergency department boarding (Moskop, Sklar, Geiderman *et al.*, 2009; Pulliam, Liao, Geissler *et al.*, 2013; Pines & Heckman, 2009; White, Biddinger, Chang *et al.*, 2013; Liu, Chang, Weissman *et al.*, 2011; Gemmel, 2009; Powell, Khare, Venkatesh *et al.*, 2012), and this is the central focus of the current thesis.

Emergency department boarding has been defined in a variety of ways according to the goals of the authors employing the term. For example, Singer, Thode Jr., Viccellio *et al.* (2011) defined patients as "boarders" only after they had waited for more than 2 hours in the ED after admission had been requested by the attending physician. However, the most common definition is the following: "The practice of holding admitted patients in the Emergency Department (ED) until an inpatient bed becomes available [is] commonly called 'boarding' […]" (Walsh, Cortez, & Bhakta, 2008; 221). In this scenario, patients are considered "boarders" as soon as their admission is requested by the ED physician, and are categorised as such until they arrive to their intended inpatient bed. This is the definition that will be used in the context of this thesis.

Causes of emergency department crowding are multifactorial (Schull & Redelmeier, 2002; Kulstad, Sikka, Sweis *et al.*, 2010), and are often interrelated. The patient flow process is composed of smaller processes that are intertwined to form a global patient care stream, which means that any delays or issues relative to one of the parts affects its entirety. Emergency

department boarding is considered to be a throughput factor in the input-throughput-output model, as seen in Asplin, Magid, Rhodes *et al.* (2003). The input-throughput-output model delineates the various parts of the patient flow process in regards to the emergency department.

Input factors relative to ED crowding include "any condition, event, or system characteristic that contributes to the demand of ED services" (Asplin, Magid, Rhodes *et al.*, 2003; 175). This means that increases in demand due to such things as population growth, non-urgent patient flux, or frequent users are considered to be input factors.

Throughput factors are made up of all the different aspects of ED care from patient arrival to patient discharge, transfer, or death. This includes processes such as triage, room placement, physician evaluation, and treatment. ED boarding occurs at a stage which is still within the bounds of emergency department care; because of this, it is categorised as a throughput factor in the input-throughput-output model.

Finally, output factors are comprised of all the different factors that prevent patients from being discharged or transferred from the ED, or that affect hospital and system characteristics. The three factors combine to complete a continuum of patient care, and are all potential causes of emergency department crowding. Emergency department boarding in itself is often affected by output factors, as beds need to be available in order to access inpatient units, but input and throughput factors are also related to the occurrence of boarding periods.

In order to clearly illustrate when emergency department boarding occurs within the patient care process, and where input, throughput and output factors are integrated within this process, a flow chart has been elaborated (Figure 1.1). As the various steps leading up to the admission request are not central to the current thesis, the ones that are shown are quite rudimentary. Once again, it is important to note that input, throughput, and output factors are intertwined within this process, and can all impact emergency department boarding. It is for this reason that they are illustrated within this patient care process flow chart, and for this reason that they will be discussed further in Chapter 2.

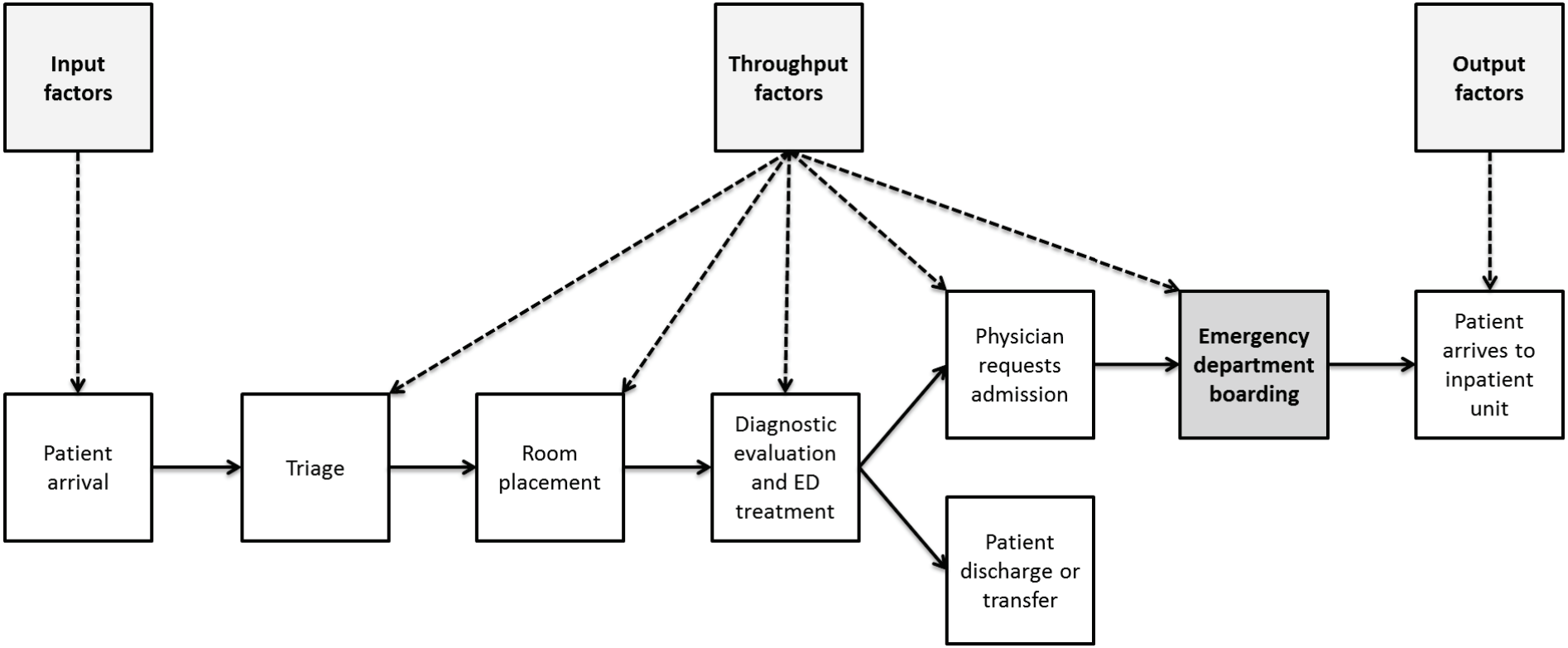

Figure 1.1. Emergency department patient care flow chart

Emergency department boarding is a critical issue in emergency department throughput. As Asplin, Magid, Rhodes *et al.* (2003) wrote, it "may be the most important [area] for immediate research and operational strategies to alleviate ED crowding" (p. 177). As one of the root causes of ED crowding, it has been associated with the various deleterious effects that this issue produces for patients, such as delay of care (Bekmezian, Fee, Bekmezian *et al.*, 2013), patient safety and quality of care issues (Watts, Nasim, Sweis *et al.*, 2013), and increased mortality (Hong, Shin, Song *et al.*, 2013), to name a few. As Falvo, Grove, Stachura *et al.* (2007) wrote, "Until inpatient beds are assigned and the patients can be safely transferred, the ED staff must 'board' those patients in ED treatment beds and provide inpatient nursing services. Boarding inpatients consumes ED resources, prolongs the time all patients wait for medical attention, and reduces the number of ED treatment beds available to accommodate sudden surges in demand" (p. 332). It is because of its important role in causing emergency department crowding and hindering patient care that emergency department boarding needs to be addressed more extensively.

To the author's knowledge, no publications addressing the issue in Quebec exist, which means that there is an important gap in knowledge in this regard. Because of this, it is as of yet unclear how prominent the issue is in the province. Although this thesis aims to analyse this issue within the context of Quebec hospitals, the same analytical process can be used in other locations; this thesis, then, also aims to provide an insightful framework for analysing ED boarding in any hospital, regardless of its whereabouts.

According to guidelines set forth by the Ministry of Health and Social Services, inpatient beds must be assigned within an hour after the admission request is completed by the physician in the emergency department, and the patient must arrive to his intended bed within an hour after a bed has been assigned to him (Guide de gestion de l'urgence, 2006). Given that the cumulative average ED length of stay (LOS) in Quebec hospitals is 16 hours and 42 minutes, based on the annual emergency department rankings published in La Presse (see May 14th 2014 for the latest available results), it is most likely that ED boarding is common in Quebec hospitals. The first objective of this research, then, will be to validate this assumption within the context of the case studies.

Indeed, as no other such research has been conducted in Quebec, the supporting literature will originate from other provinces and countries. These sources will provide a knowledge base

that this thesis will build upon, seeking to confirm or infirm what other authors have found. The current research will attempt to answer three distinct research questions, which are:

- What are the root causes of ED boarding within Quebec hospitals?
- To what extent are these causes similar or different in varying environments?
- How can we improve the process in order to reduce the amount of boarding required?

Although ED boarding has been approached by various authors, few of them have aimed to see how different hospitals perform in regards to this issue. This thesis will approach the subject from different angles, analysing both quantitative and qualitative data, and following both deductive and inductive reasoning. The purpose of this thesis is to answer these research questions within the context of the studied cases, and to generalise the resulting propositions within a theory, which Yin (2009) refers to as analytic generalisation. This theory will be put forth in the form of a conceptual framework for ED boarding, which can then be used in other contexts to validate or invalidate the answers that will have been found. This thesis does not assert that a statistical generalisation can be achieved with the chosen methodology, as the purpose was not to obtain a sample which would be representative of the entire population of Quebec hospitals. By enacting a thorough analysis of the problem, this thesis will attempt to answer these questions, and fulfill the following objectives:

- Pinpoint and understand the various interrelated causes of ED boarding;
- Analyse the resulting information to see patterns and trends within the different cases;
- Elaborate possible solutions to improve this issue.

Following this introductory section is the literature review, within which various topics will be addressed, of which emergency department crowding is the starting point and emergency department boarding is the central focus. After this, Chapter 3 will cover the methodology used in the context of this research to analyse this problem in the field research. Chapter 4 will present the data collected within the three participating hospitals, and the following chapter will be a discussion of these results, whereby a more in-depth understanding of the issue will be demonstrated. Finally, the last chapter will conclude this thesis, and offer insights for managers and cues for further research.

2. Literature review

The following literature review surveys information elucidated by over 110 articles within a period of over 20 years. The articles were obtained from various medical and hospital management journals so as to acquire a global viewpoint from both a clinical and a managerial perspective. Emergency department boarding is an important cause of ED overcrowding, and the literature review is constructed to demonstrate how these two issues are interrelated, progressively narrowing in scope towards the particular portion of the hospitalisation process that the current research project is concerned with.

First, the causes of emergency department crowding will be discussed (Section 2.1). This section is structured according to the input-throughput-output model mentioned above. Input factors (Section 2.1.1), throughput factors (Section 2.1.2), and output factors (Section 2.1.3) will be demonstrated individually. Emergency department boarding (Section 2.1.2.1) receives its own subsection within the throughput factors, as it belongs within this category, and is the central focus of this thesis.

Second, the deleterious effects caused by these different factors will be discussed at length. Eight distinct negative effects were elucidated within the literature. Although they are all interrelated in some fashion, they will each receive individual sections detailing the research that has been conducted in their regard, as they belong within a continuum of patient care. The consequences of emergency department crowding and its constituent causes are structured as they occur chronologically in a patient flow process, starting with ambulance diversion (Section 2.2.1), and following with delay of care (Section 2.2.2), patients leaving without being seen (Section 2.2.3), patient safety and quality issues (Section 2.2.4), increase hospital length of stay (Section 2.2.5), increased mortality (Section 2.2.6), revenue and cost issues (Section 2.2.7), and lower patient satisfaction (Section 2.2.8).

Finally, solutions to emergency department boarding (Section 2.3) will be discussed; the solutions proposed within the academic literature have been categorised according to their approach, that is to say, as solutions modifying resources (Section 2.3.1) or modifying management systems (2.3.2). Figure 2.1 shows a structural representation of the review. This framework is a conceptualisation of the cause, effect, and solution sequence; arrows are employed to demonstrate this sequence.

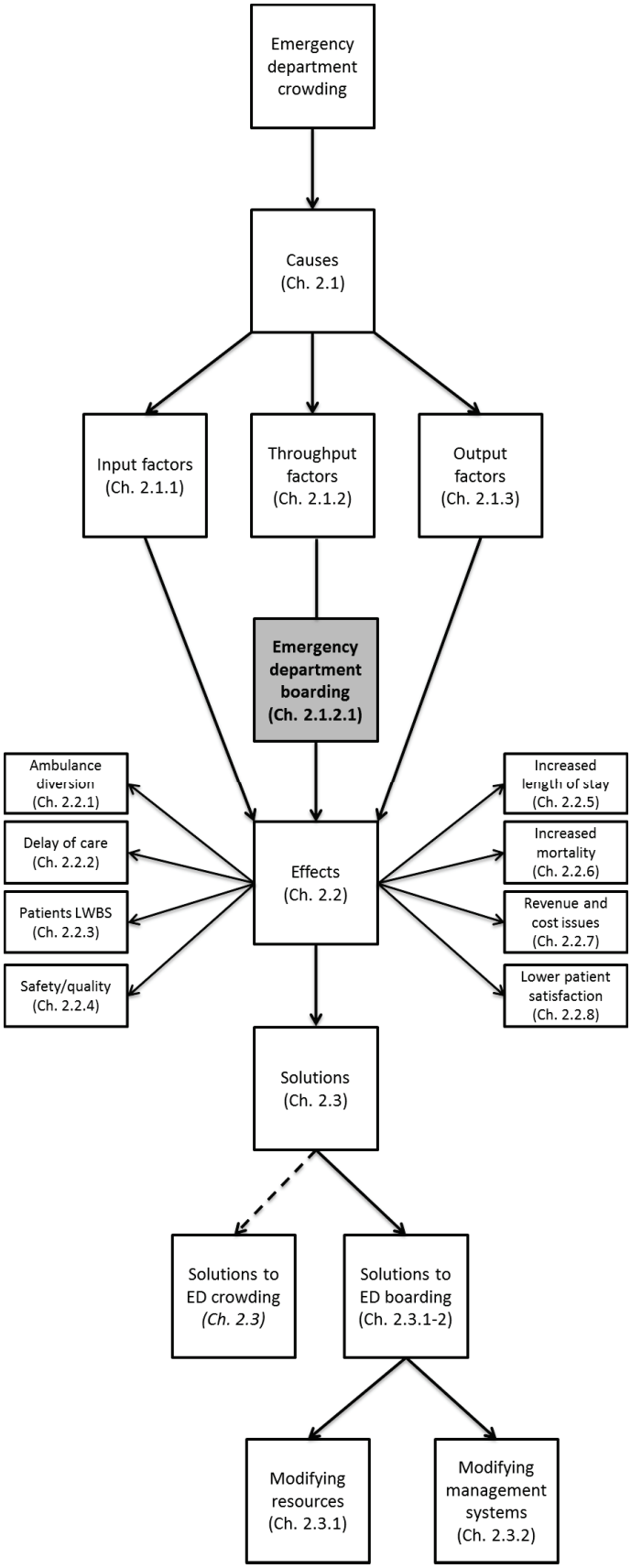

Figure 2.1. Conceptual framework for causes, effects, and solutions of ED crowding

2.1. Causes of emergency department crowding

2.1.1. Input factors

As previously mentioned, ED crowding is a global problem, and the steady increase in demand that has been seen over the years contributes to the problem. In Sweden, a study was conducted surveying data from 1995 to 1999, and the results were published in 2001 (Andersson & Karlberg, 2001). In this particular study, the authors noticed an increase in visits of 21% within the studied range; this was not seen to be associated with the population growth of Stockholm during the same period (4.5%). The number of visitors, in turn, was seen to lead directly to increases in waiting times, as well as lower quality care. Another study looked at data covering 12 years for a major teaching hospital in Perth, Australia (Fatovich & Hirsch, 2003). Important surges in demand were seen to have happened 141 times within the studied range. The average number of patients in the ED during these times of increased demand represented an occupancy rate of 174%, and patients were often placed in ED corridors, which compromised the ability of staff to answer promptly and adequately to the needs of these patients, thus contributing to ED crowding. Entry block was a common occurrence, as was ambulance diversion.

Non-urgent patients also cause crowding, as per a study conducted in Quebec in 2004 (Afilalo, Marinovich, Afilalo *et al.*, 2004). Non-urgent patients would ideally present themselves in primary care providers instead of hospital emergency departments, but the contrary is a common occurrence. The authors analysed data from five tertiary care hospitals over a 7-month period. Non-urgent patients were categorised according to their receiving a triage code of 5 (triage levels increase in severity as they become lower; code 5 is non-urgent; codes 2, 3 and 4 are semi-urgent; and code 1 is very urgent). Patients in the non-urgent group were on average younger than patients in the semi-urgent group. Only 22% of the non-urgent patients had sought care from a primary care provider prior to presenting themselves to the emergency department. The authors concluded “non-urgent ED patients are different from semi-urgent patients and also heterogeneous as a group […] This may help explain why various diversion strategies have been unsuccessful in the past” (Afilalo, Marinovich, Afilalo *et al.*, 2004; 1308).

Non-urgent patients causing crowding in the emergency department is a well-known fact, as per articles such as the one written by Afilalo and his colleagues. What is less easily distinguishable is why people with non-urgent needs end up in the emergency department. This

was the central question in Howard, Davis, Anderson *et al.* (2005). Through interviews, the authors found three major themes that explained why these patients had come to an ED rather than a primary care provider (PCP). Firstly, many were unable to obtain appointments with a PCP. Secondly, others had been told to go to the ED by non-physician personnel at a PCP's office. Finally, many believed it was less of a hassle to go directly to the ED rather than going to a PCP and being referred to an emergency department afterwards. According to the authors, unless PCPs can offer timely and efficient primary care, emergency departments will continue to be crowded by non-urgent cases.

Another input factor that causes emergency department crowding is frequent ED users (J. A. Huang, Tsai, Chen *et al.*, 2003). In this article, the authors analysed a hospital ED in Taiwan to see how frequent users contributed to ED crowding and increases in health care costs. Patients were categorised as frequent users when they visited the ED four or more times a year. 800 patients were surveyed, of which 200 were frequent users. The results were that frequent ED users (3.5% of total ED patients) accounted for 14.3% of total ED visits. Frequent users accounted for a disproportionate amount of total visits, and were generally patients with important medical issues, such as chronic diseases, cancer, or pulmonary disease, to name a few. The same year, another study was conducted analysing a similar issue (Dent, Phillips, Chenhall *et al.*, 2003). The authors reviewed a database concerning the 500 most frequent users of an ED to see whether their cases could be diverted to PCPs. These patients accounted for 8.4% of total ED visits. According to the authors, 59.5% of these visits were appropriate for the ED, and 28.5% could have been diverted to PCPs. Frequent users can account for an important and disproportionate amount of total ED visits; addressing this issue could reduce ED crowding. This issue is particularly important in Quebec, where it has been found that frequent users (25% of patients frequenting EDs) use up 75% of hospital resources (Lacoursière, 2011).

When discharged inpatients return to the emergency department, this also contributes to ED crowding. An article was published in 2001 that aimed to assess the impact of these discharged patients on ED crowding (Baer, Pasternack, & Zwemer, 2001). The authors conducted a retrospective study of records of all patients that had presented themselves at the ED within 7 days of inpatient discharge. Out of the visits monitored during the study period, 3% were returning discharged inpatients. These patients had higher rates of admission than regular ED

visitors, had a longer length of stay, and represented additional costs for the hospital. Returning patients strain ED resources and are a contributing cause to ED crowding.

Many different input factors, thus, can be potential causes for ED crowding. An aging population, as well as people developing several different illnesses, can lead to greater general demand in healthcare resources. Non-urgent patients, who could otherwise see primary care providers, are a second input factor that can cause ED crowding. A lack of information in regards to proper first-line healthcare resources can also lead to people going to the ED instead of more appropriate centers. Frequent users, who find themselves going to the ED several times a year, often for the same illness, also greatly contribute to ED crowding. Finally, discharged inpatients that pass through the ED on their way out, or that come back because no external resources could offer continued care, are a potential cause of emergency department crowding as well.

2.1.2. Throughput factors

Issues related to throughput factors, such as triage, room placement, physician evaluation and treatment are also causes of ED crowding. These throughput factors can also be affected by global decisions, such as governmental or state-wide policies. This was analysed by Lambe, Washington, Fink *et al.* (2002) following restructuring efforts in California. Data was collected from every available emergency department in the state over the course of a decade, which provided for an extensive and comprehensive study. The goal was to find out how fluctuations in resources could have affected the system's efficiency and contributed to ED crowding. During the study period, the number of emergency departments in the state decreased by 12%, while the number of treatment stations increased by 16%. Although overall resources, in terms of beds and other areas where patients could receive treatment, increased within the period, the demand was spread out over fewer hospitals, and on average, the remaining EDs received 27% more visits. Simultaneously, critical visits to the ED increased on average by 59%. Statewide changes in resources contributed to ED crowding, and also contributed, according to the authors, to "the perception that ED capacity is inadequate to meet growing demand" (Lambe, Washington, Fink *et al.*, 2002; 390). Delays in the use of ancillary services, such as CT scans and special procedures in radiology, can be a contributing cause to ED crowding. Davis, Sullivan, Levine *et al.* (1995) analysed data from an ED to understand the extent to which delays in this respect

would influence ED crowding. The authors found that this had a strong correlation with patient ED LOS.

Staffing levels, which are commonly associated with ED crowding in Quebec, were found to have an impact on ED crowding in the literature as well (Schneider, Gallery, Schafermeyer *et al.*, 2003). The authors surveyed 90 emergency departments in the United States for their research. On average, there were more patients than treatment spaces (1.1) and 52% of surveyed EDs had more than one patient per space. Staffing levels were also low; nurses had an average of 4.2 patients each, with 49% of EDs having more than 4 patients per nurse. The physician ratio was higher, with 9.7 patients per doctor on average. Aside from staffing levels, ED boarding was seen to contribute to ED crowding, as 22% of patients in the surveyed EDs were waiting to be admitted to inpatient units. Another study, this time conducted in Korea, aimed at assessing the impacts of staffing levels on ED crowding as well (J. I. Hwang, 2006). Data was collected from 106 hospitals nation-wide. In their analysis, the authors concluded that nurse staffing and the number of inpatients per bed significantly affected levels of ED crowding. Balancing staffing levels according to trends in demand is an important challenge, as this can significantly affect patient throughput. This topic will be discussed in relation to the hospitals studied for this thesis.

Polevoi, Quinn, and Kramer (2005) found that one of the causes of ED crowding, at least in their institution, was physician training. “Physician factors, especially emergency medicine training, also appear to be important […]” (Polevoi, Quinn, & Kramer, 2005; 232). Changes in resources, delays in the use of ancillary services, staffing levels and physician training are all factors that were found to cause ED crowding.

2.1.2.1. Emergency department boarding

Emergency department boarding, the focus of the current research project, is a central cause of emergency department crowding. Extensive literature has addressed the topic, and this section will detail the various articles associated with this throughput factor. As early as 1993, Fromm, Gibbs, McCallum *et al.* (1993) conducted a prospective study aimed at analysing the impact of ED boarding on ED crowding. Data was analysed for patients waiting to be admitted to the ICU or to special care units from the ED. Many of the patients “boarding” in the ED within the surveyed period were discharged patients waiting to leave (61.1%), a type of boarding that is separate from that regarding patients waiting inpatient beds. The other patients were either

critically ill patients awaiting ICU beds (8.5% – average LOS 145.3 ± 89.6 minutes) or non-critically ill patients awaiting inpatient beds (30.4% – average LOS 154.1 ± 91.9 minutes). The authors found that 154 patient-days of ED care were provided for critically ill patients while they were waiting to access ICU beds. Lengthy periods of boarding were associated with ED crowding.

Schull, Lazier, Vermeulen *et al.* (2003) studied this phenomenon as well, and found that there were on average 3.2 admitted patients boarding in the ED during each time interval studied. Hospitalisation rates were quite high in the studied ED (22%), and patients found themselves boarding for an average of 3.5 hours. The authors also found that ambulance diversion increased with the amount of patients boarding in the ED while awaiting inpatient beds. Similar outcome metrics were measured in a 2005 study, which focused on the impact of ED boarding, or access blocking, on ED crowding, ambulance diversion, and occupancy rates in emergency departments (Fatovich, Nagree, & Sprivulis, 2005). Patients who experienced access blocking were defined as such when they had spent more than 8 hours in the ED before being transferred to inpatient beds. Ambulance diversion, emergency department overcrowding, and emergency department waiting times were found to be strongly correlated with high levels of boarded patients.

A nation-wide analysis of ED boarding was completed in the United States in 2010, surveying data from 2003 to 2005 (Carr, Hollander, Baxt *et al.*, 2010). The authors aimed to calculate patient-care hours to understand the extent to which hospital resources are invested in treating boarded patients. Although the number of patient-hours dedicated to boarded patients decreased over the studied period, the numbers were still quite high. In some EDs, up to 17.1% of patient-hours were dedicated to boarded patients in 2003; this number decreased to 15.3% in 2004 and 12.0% in 2005. Boarding was found to account for a notable portion of overall patient-care hours in the United States during this period. Both boarded patients and discharged patients staying in the ED were found to contribute significantly to ED crowding, as per a recent study (Henneman, Nathanson, Li *et al.*, 2010). This study looked at both of these groups, and aimed to find out how patients who stay for more than six hours in the ED affected crowding. In 60% of cases where at least one patient was staying for more than six hours in the ED, one person was stuck in the waiting room unable to gain access to an ED bed. Crowding ensued when patients stayed for more than six hours in the ED, and this resulted in patients leaving without being seen in much greater amounts (226% increase). Ambulance diversion was also seen to be a consequence of this practice.

Various other studies were conducted analysing how ED boarding caused ED crowding. Felton, Reisdorff, Krone *et al.* (2011) surveyed 109 EDs in Michigan and found that 47% of them had admitted patients boarding in their EDs at a given moment in time, averaging at 3.7 hours of boarding time. The majority of EDs boarding patients were experiencing periods of crowding. Hodgins, Moore, and Legere (2011) found that more than half of the patients having to be admitted in their sample stayed for more than two hours in the ED, which was more frequent during weekdays and night shifts. Fogarty, Saunders, and Cummins (2014) studied data covering a two-year period in their own hospital, and found that there were on average 9.2 boarders in the ED at 8:00AM on any given day. The authors observed that every boarder reduced overall compliance with the hospital's 6-hour standard by 0.37%.

Boarding in the ED can also cause patients to experience longer length of stay throughout their process of care. Many studies have sought to determine the relationship between emergency department LOS and inpatient LOS. Increased IP LOS has an impact on the necessity for emergency department boarding, as patients staying longer in inpatient units leads to more infrequent bed availabilities, which in turn hinders patient flow and promotes ED crowding. Liew and Kennedy (2003) found that there was a proportionate increase in IP LOS for patients having boarded for longer periods in the ED (< 4 hours: 3.73 days; 4-8 hours: 5.65 days; 8-12 hours: 6.60 days; and > 12 hours: 7.20 days). Li, Chiu, Kung *et al.* (2013) found that patients experiencing periods of boarding longer than 8 hours had the longest overall LOS in their sample, and that ED boarding greatly contributed to ED crowding. Nippak, Isaac, Ikeda-Douglas *et al.* (2014) studied this effect in a Canadian emergency department, and also found a significant correlation between emergency department length of stay and inpatient length of stay. Patient flow was also significantly affected by this, as prolonged periods in the emergency department, whether related to waiting times, delays in care, or emergency department boarding all contribute to ED crowding.

As Moskop, Sklar, Geiderman *et al.* (2009) wrote, "the inability to transfer emergency patients to inpatient beds and the resultant 'boarding' of admitted patients in the ED for long periods, are most commonly associated with ED crowding" (p. 607). This is a complex issue, as all parts of the hospitalisation process are intertwined; nevertheless, it is possible to elucidate certain root causes. This issue has been researched very little in Quebec hospitals, and is thus relatively under-documented. Moreover, as guidelines produced by the Minister of Health and

Social Services are approached in varying manners, not all hospitals approach this problem in the same fashion.

2.1.3. Output factors

The most important output factor which hinders patient flow in our context is hospital bed shortages. Schull, Szalai, Schwartz *et al.* (2001) wrote about this particular issue in their article which focused on emergency departments in Toronto. A restructuring plan was carried out as of 1997, which changed the configuration of various hospitals and their relationships with one another. Closures, mergers, and investments in other services such as home care were the focus of this restructuring effort. In order to analyse the effects of this plan, the authors surveyed information ranging from 1991 to 2000 taken from twenty hospital emergency departments. The authors found that overcrowding increased during and after restructuring. Severe overcrowding occurred between 0.5% and 9.0% of the time each month before restructuring; these numbers increased to 6.0% and 23.0% respectively during and after restructuring. A second study conducted in 2006 aimed to analyse the impact of similar structural changes; hospital closures and changes in hospital characteristics were used as metrics to measure changes in ED crowding (Sun, Mohanty, Weiss *et al.*, 2006). 80 hospitals were included in the research; 9 of which were closed within the study period. Average monthly diversion hours increased over time, from 57 hours in 1998 to 190 hours in 2004. Hospital closure was seen to increase average monthly diversion hours by a mean of 56 hours at the nearest ED. Public hospitals were seen to have significantly more diversion hours registered, with an average of 150 supplemental diversion hours each. System-wide effects were seen, as the closest EDs often diverted ambulance as well due to the increased influx of demand.

Hospital bed shortages were one among many outcome measures analysed when 63 emergency departments in The Netherlands were studied in 2013 (van der Linden, Reijnen, Derlet *et al.*, 2013). The average number of ED visits per emergency department was 24,936 with a mean length of stay for admitted patients of 146 ± 49 minutes. The most cited causes for emergency department crowding were hospital bed shortages for patients needing admission, laboratory and radiology delays, and consultation delays. Admitted patients had a longer LOS because of lack of inpatient bed availabilities.

Inpatient discharges from inpatient units are an important output cause of emergency department crowding. ED boarding occurs often because of tardy discharges, and the balance between admissions and discharges needs to be more accurately controlled. Vermeulen, Ray, Bell *et al.* (2009) sought to analyse this issue in Toronto EDs. Data regarding the ratio of admissions to discharges was collected over a 3-year period and examined according to next-day ED LOS. The authors found that, as the ratio changed, so did next-day ED LOS. Ratios higher than 1.4 or 1.5 were significantly associated with increases in ED LOS and ED crowding; admitted patients boarding in the ED were significantly affected by these additional delays.

Helge Holmås, Kamrul Islam, and Kjerstad (2013) conducted a research project in Norway to analyse the influence of delayed discharges on emergency department LOS and crowding. Through complex modelling, the authors found that bed blocking constitutes a large share of the total costs of inpatient care, as additional resources are necessary to treat admitted patients who are held up in the emergency department while awaiting inpatient bed availabilities. The authors also found that patients who attend PCPs with no hospitals in the area experience shorter stays than when PCPs can use hospital resources as a buffer for capacity constraints. Khanna, Boyle, Good *et al.* (2011) sought to assess the impact of discharge timing and hospital admissions on emergency department crowding. Data was obtained from 23 hospitals in Queensland, Australia. They found that, on most days, the admission surges occurred 5 or more hours prior to discharge surges, which caused tremendous amounts of access blocking for newly admitted patients, as well as increased delays for patients attending the ED.

Hospital restructuring efforts, bed shortages, tardy or delayed discharges, and uncoordinated admissions and discharges are all causes of ED crowding. Patient input is growing considerably over time; if flow is interrupted by output factors, EDs become overcrowded. Additionally, output factors are all directly related to emergency department boarding. When patients are not being discharged, and beds are unavailable, admitted patients are blocked in the ED. When patients are discharged and admitted without thoughtful coordination, patients can find themselves waiting in the ED even though beds could have become available in inpatient units had discharges been granted earlier. All of these factors, then, cause ED boarding. Output factors are most often the bottleneck in the continuum of patient care for admitted patients.

ARTICLE	PRIMARY FINDINGS
Input factors	
Andersson & Karlberg, 2001	Increase in demand
Fatovich & Hirsch, 2003	Increase in demand
Afilalo, Marinovich, Afilalo *et al.*, 2004	Non-urgent patients
Howard, Davis, Anderson *et al.*, 2005	Non-urgent patients
J. A. Huang, Tsai, Chen *et al.*, 2003	Frequent ED users
Dent, Phillips, Chenhall *et al.*, 2003	Frequent ED users
Baer, Pasternack, & Zwemer, 2001	Discharged patients
Throughput factors	
Lambe, Washington, Fink *et al.*, 2002	Changing resources
Davis, Sullivan, Levine *et al.*, 1995	Delay in ancillary services
Schneider, Gallery, Schafermeyer *et al.*, 2003	Staffing levels
J. I. Hwang, 2006	Staffing levels
Polevoi, Quinn, & Kramer, 2005	Physician training
Output factors	
Schull, Szalai, Schwartz *et al.*, 2001	Hospital restructuring
Sun, Mohanty, Weiss *et al.*, 2006	Hospital restructuring
van der Linden, Reijnen, Derlet *et al.*, 2013	Hospital bed shortages
Vermeulen, Ray, Bell *et al.*, 2009	Tardy discharges
Helge Holmås, Kamrul Islam, & Kjerstad, 2013	Discharges and admissions
Khanna, Boyle, Good *et al.*, 2011	Discharges and admissions
Emergency department boarding	
Fromm, Gibbs, McCallum *et al.*, 1993	Emergency department boarding
Schull, Lazier, Vermeulen *et al.*, 2003	Emergency department boarding
Fatovich, Nagree, & Sprivulis, 2005	Emergency department boarding
Carr, Hollander, Baxt *et al.*, 2010	Emergency department boarding
Henneman, Nathanson, Li *et al.*, 2010	Emergency department boarding
Felton, Reisdorff, Krone *et al.*, 2011	Emergency department boarding
Hodgins, Moore, & Legere, 2011	Emergency department boarding
Fogarty, Saunders, & Cummins, 2014	Emergency department boarding
Moskop, Sklar, Geiderman *et al.*, 2009	Emergency department boarding
Liew & Kennedy, 2003	Emergency department boarding
Li, Chiu, Kung *et al.*, 2013	Emergency department boarding
Nippak, Isaac, Ikeda-Douglas *et al.*, 2014	Emergency department boarding

Table 2.1. Synthesis of articles regarding the causes of ED crowding

2.2. Effects of emergency department crowding

Emergency department crowding is notorious for causing various negative impacts on both patients and resources. Eight distinct effects of emergency department crowding have been elucidated in the literature reviewed. In the following section, these negative outcomes of high occupancy rates will be discussed in a sequential manner, following the patient flow process.

When EDs are overcrowded, they often refuse additional patients from lack of resources to treat them, which leads to ambulance diversion (Eckstein & Chan, 2004), in itself a dangerous experience for the patients concerned. For patients who do arrive at the ED, waiting times are often a deterrent. Many patients leave without being seen by a physician (Bair, Song, Chen *et al.*, 2010), which can have important impacts on their health, as well as on hospital input factors when patients return on subsequent days.

When patients enter the process of care, they often experience delays in care, whether related to critical care or non-critical treatments (Sri-On, Chang, Curley *et al.*, 2014). Along with delays in care, ED crowding can compromise patient safety and reduce the quality of care given (Zhou, Pan, Zhou *et al.*, 2012). Being able to promptly offer high-quality care is the primary goal of an emergency department, and ED overcrowding significantly impedes this objective. These two outcomes are responsible for many of the downstream effects of ED crowding.

Patients may stay in the emergency department for long periods of time, which has a negative impact on their health and on hospital resources. Longer emergency department length of stay (LOS) is also an effect on overcrowding (Derose, Gabayan, Chiu *et al.*, 2014), as patients may experience delays in care or medical errors requiring continued surveillance. One of the most significant impacts of ED crowding is increased mortality (Singer, Thode Jr., Viccellio *et al.*, 2011). Out of all the possible outcomes or delays, this is the most important factor to consider.

Finally, decreased revenues and increased costs are related to emergency department crowding (Sun, Hsia, Weiss *et al.*, 2013). Along with all these costs on the quality of care provided to patients and on hospital resources, patient satisfaction is significantly hindered by overcrowded EDs as well (Tekwani, Kerem, Mistry *et al.*, 2013).

Each of these eight factors will be discussed individually in the following section to demonstrate their prevalence within different hospital contexts. These problems are experienced worldwide, and have all been found to increase relative to the occupancy rate of the emergency department. ED crowding must be reduced in order for patients to receive the best care available.

2.2.1. Ambulance diversion

As early as 1994, research started being conducted on the link between emergency department overcrowding and ambulance diversion (Neely, Norton, & Young, 1994; Redelmeier, Blair, & Collins, 1994). Redelmeier and his colleagues analysed 13 hospitals in Northern California over a period of four years, and found that diversions increased by 453% within their study period, wherein diversion was defined as the circumstance when a patient is transported elsewhere than the hospital where he was intended due to undercapacity or crowding at the initial destination. Crowding became more problematic within this period, which explains why such a significant increase was elucidated.

The same problem was found to occur in Canada, whereby a group of researchers sought to understand how crowding affected transport delays for patients experiencing chest pain, a symptom which is taken particularly seriously in emergency departments (Schull, Morrison, Vermeulen *et al.*, 2003a). The authors, as others before them, found that ED crowding had a direct influence on both transport delays and delays in care. Many of the same authors collaborated for a second time that year to study this issue (Schull, Morrison, Vermeulen *et al.*, 2003b). They studied two four-month periods, one of which represented a low crowding period and the other a high crowding period. Patient characteristics were similar in both cases; however, transport intervals increased by 28.4% between the two periods. Emergency department crowding lead to a notable increase in response time.

A year later, Begley, Chang, Wood *et al.* (2004) examined the relationship between ambulance diversion caused by ED crowding and trauma death rates. The results showed that on days with higher rates of ambulance diversion, death rates were consistently higher than on days with lower rates of ambulance diversion. This was particularly pronounced with more severe trauma patients who needed immediate medical attention. Eckstein and Chan took a different but similar route by studying the effect of emergency department crowding on paramedic ambulance availability (Eckstein & Chan, 2004). When ambulance are not diverted in the case of high levels of ED occupancy, many times the paramedics find themselves waiting at the hospital for a free ED bed. In their study, 8.4% of ambulance paramedics had to wait for an excess of 1 hour to drop off the patient. Waiting times increased according to seasons, and by association, with ED crowding. The authors state that this phenomenon has an important impact on timely care and system availability for patients requiring emergency transportation and care.

Obtaining access to the ED is the first step of the hospitalisation process, and its timeliness can seriously affect a patient's health. Patients requiring an ambulance often present more severe symptoms than ambulatory patients, and thus, any additional delays in obtaining medical attention have negative effects on their possible outcomes.

2.2.2. Delay of care

Delay of care is the third major negative effect of emergency department crowding. Many different studies have analysed the different types of delays of care experienced by patients, as well as the different possible outcomes that result from this issue. In most cases, studies focus on a particular patient type in order to see how their process of care was affected by emergency department crowding. According to Pines (2006) "[w]aiting times for evaluation, test ordering, test results, treatments, and inpatient beds are often caused by crowding and, in the case of time-sensitive care, can directly lead to poor outcomes" (Pines, 2006; 807). Indeed, the author's focus in this and several other of his studies (Pines, Hollander, Localio *et al.*, 2006; Pines, Localio, Hollander *et al.*, 2007) was on delays of care experienced by patients due to crowding. More specifically, the author looked at how patients suffering from pneumonia arriving at the ED received medical care in a delayed fashion in regards to time-to-antibiotics. In their 2007 study, the authors found that, in their sample, there was a 72% chance that patients would either not receive antibiotics at all or had to wait more than 4 hours to receive them, compared with a 31% chance when the ED was not crowded.

Pneumonia was the frame within which a study was conducted by Fee, Weber, Maak *et al.* (2007) as well, and their results were similar. The authors calculated that every additional patient in the ED lead to additional waiting for these patients, regardless of whether or not maximum capacity was attained. This was further explored by Liu, Chang, Weissman *et al.* (2011) directly in relation with emergency department boarding. The authors sought to establish whether or not there were additional delays in care for patients boarded in the ED versus patients having obtained a bed in an inpatient units, and if this varied according to the length of time patients were boarded in the ED. The main finding of this research was that ED boarding was associated with delays in the administration of home medication to the patients. However, ED care was better in another respect; that is when required care was related to normal ED care practices. "Care for boarded patients worsens in areas for which the ED is not designed […] By contrast,

ED care is better in areas that are more consistent with typical ED practice" (Liu, Chang, Weissman *et al.*, 2011; 1346). What this research demonstrates is that, in this case, EDs can offer more prompt care in acute situations, but falter in cases of non-acute care, which are more appropriately catered to by inpatient units.

Two studies aimed to analyse how this issue was experienced according to the severity of the patients' illnesses. Liu, Hobgood, and Brice (2003) found that low-severity patients experienced greater delays, while McCarthy, Zeger, Ding *et al.* (2009) found that high-severity, or acute patients experienced greater delays. However, patients in the latter study experienced fewer delays in care once they had accessed an ED bed, and rather experienced delays in care in a different manner, according to greater waiting times in the ED in general. Ultimately, low-acuity patients seem to experience this issue in a more significant way, as clinical staff inevitably prioritises patients presenting more pressing symptoms. Nevertheless, McCarthy, Zeger, Ding *et al.* (2009) also elucidated an issue relative to emergency department boarding in their study. As the number of patients boarding in the ED increased, the authors found that boarding times increased as well, which slowed down patient flow and increased crowding as an effect, thus delaying care in a more substantial manner. When the number of boarded patients increased from the 50^{th} to the 90^{th} percentile, a 15% to 47% increase in boarding times was seen to occur.

This problem is present in Canada as well. In 2004, a study was conducted in 25 Canadian hospitals to analyse how patients necessitating thrombolysis following a suspected acute myocardial infarction experienced delays in care according to the occupancy rate of the ED (Schull, Vermeulen, Slaughter *et al.*, 2004). Diversion levels were categorised in three levels, and the findings showed that as diversion levels (or crowding) increased, patients increasingly experienced delays in being thrombolysed. This issue was deemed by the authors to be a limiting factor the development of cardiac care in Canadian hospitals. In the past two years, other studies have also found that care is significantly delayed when EDs are crowded, or when many patients are being boarded in the ED (Bekmezian, Fee, Bekmezian *et al.*, 2013; Sri-On, Chang, Curley *et al.*, 2014). Within the continuum of ED care, delay of care is perhaps what is most commonly associated with emergency department care by patients (Rowe, Channan, Bullard *et al.*, 2006).

2.2.3. Patients leaving without being seen

Baker, Stevens, and Brook (1991) attempted to analyse the consequences of ED crowding on the rate of patients leaving without being seen by a physician. One of the major issues regarding patients leaving without being seen (LWBS) is that some of these patients may require serious medical attention. The other important issue is that many of these patients will return to the emergency department, whether warranted or not, at another time. On the one hand, public health is neglected as patients do not receive proper medical attention, and on the other hand, crowding is enhanced by return patients, which contributes to the initial problem once again. In their study, the authors contacted those people who left without receiving medical attention in order to see how these two issues developed. Of the people surveyed, 46% needed immediate medical attention, and 29% needed less urgent but prompt care. 11% of those who left were hospitalised within a week, and some required emergency surgery. Long waiting times due to crowding lead these patients to leave prior to seeing a physician, and this had consequences on patient health.

Similar researches were conducted by other authors (Bindman, Grumbach, Keane *et al.*, 1991; Stock, Bradley, Lewis *et al.*, 1994). Bindman and his colleagues found that there was a significant increase in the rate of patients leaving without being seen when EDs were crowded (up to 15%), and also found that 27% of patients having left within the surveyed period returned to the ED. In the case of these authors, major health issues were less rampant within the sampled patients; however, hospital resources were used on multiple occasions, which ultimately leads to increased crowding and a repeating environment. Stock and his team analysed data from a larger sample, covering 30 hospitals across California, and obtained similar results, whereby crowded emergency departments significantly increased the amount of patients who left without being seen. The rate was less important within their sample (4% of overall patients left without being seen), but an important correlation was nonetheless found between crowding and patients LWBS.

More recently, a research was conducted in 2005 to analyse how multiple factors influenced the rate of patients who LWBS (Polevoi, Quinn, & Kramer, 2005). Some of the factors that were taken into consideration were ED capacity, patients awaiting ED beds, length of stay of discharged patients in the ED, and inpatient capacity, to name a few. The same year, Weiss, Ernst, Derlet *et al.*, 2005 completed a study attempting to correlate ED overcrowding and the rate of patients who LWBS by using the National Emergency Department Overcrowding

Scale (NEDOCS). Similarly to their predecessors, both groups of authors found a direct correlation between the occupancy rate of an emergency department and the number of patients who left without being seen.

Although these studies originated in the United States, the problem is also present in Canada (Rowe, Channan, Bullard *et al.*, 2006). The authors surveyed two Canadian EDs, and found that the greatest cause of patients LWBS was waiting time (44.8%). Like other studies conducted before, many of the patients – 60% of the 15,660 included within the study – sought medical attention within the following week. As the results suggest, crowding was an important factor in influencing the number of patients who left without being seen. Moreover, returning patients, of which there were many, often became sicker by delaying their care, which negatively impacted their health and potential clinical outcomes, as well as the use of hospital resources. Moreover, contributing to greater patient inputs at a later time also perpetuates the issue further.

Other authors analysed this problematic since then (Kulstad, Hart, & Waghchoure, 2010; Bair, Song, Chen *et al.*, 2010), and the results were the same. Bair and his colleagues measured not only the link between ED crowding and patients LWBS, but also how ED boarding affected this outcome. The authors used discrete-event simulation to model patient flow, and found that there was a significant negative impact on patients leaving without being seen created by emergency department boarding, the central focus of the current thesis. Indeed, as ED boarding occupies many ED beds, each boarder limits the amount of patients that can be seen by an emergency physician. This generates an increase in waiting time, which is, as has been illustrated above, perhaps the most important factors in determining the number of patients who leave without being seen. Over the last twenty years, numerous different studies analysed the link between ED crowding and patients leaving without being seen, using various methodologies and different outcome metrics. Although the approaches varied, the results were consistently the same: periods of crowding, and periods where ED boarding was an important occurrence, greatly affected the number of patients who left without being seen.

2.2.4. Patient safety and quality of care issues

When clinical staff is overwhelmed with more patients than what their ED's capacity can take-in, patient safety and quality of care are often compromised. Patients can receive untimely care, as mentioned previously, but may also receive improper or suboptimal care. This was the

object of many studies conducted in the past years. As with other such effects, researchers usually seek to analyse this effect according to a particular type of patient. One such type of patient is those experiencing pain. U. Hwang, Richardson, Sonuyi *et al.* (2006) measured pain care for older patients in American hospitals, and evaluated quality according to the administration of proper medicine in a timely fashion. Higher occupation ratios were found to be significantly linked with less adequate pain management in these patients. Many of the same authors pushed this research further with a second study in this regards, and their results were similar (U. Hwang, Richardson, Livote *et al.*, 2008). What they found was that, out of 1068 patients, fewer patients received pain medication during periods of crowding. Quality was affected by crowding levels, and delays in care were also discerned. The number of patients boarding in the ED while awaiting inpatient beds significantly contributed to delays in care and lower quality of care. A third study, conducted by Pines and Hollander (2008), confirmed that ED crowding negatively impacted the quality of care for patients experiencing pain. Out of 13,758 patients that were included in their study, less than half (49%) received pain medication. Of those who received treatment, most (59%) experienced delays in treatment.

Patients experiencing symptoms of pneumonia and presenting signs of acute myocardial infarction were the subject of two additional studies. Pines, Hollander, Localio *et al.* (2006) surveyed 24 hospitals in the United States, and concluded that patients presenting signs of AMI received proper care according to the established quality metrics; however, quality of care for pneumonia patients was significantly affected by ED crowding. The following year, Pines, Pollack Jr., Diercks *et al.* (2009) evaluated the influence of emergency department crowding on patient outcomes for the same patient type. Adverse cardiovascular outcomes could be heart failure, cardiac arrest, and cardiac dysrhythmias, among other possibilities. When the waiting room census was at its highest, patients experienced more deleterious outcomes than when the ED had a normal patient volume. Patients with non-ACS (acute coronary syndrome) chest pain experienced more negative outcomes when the ED was crowded than their counterparts.

Medication errors are also common during periods of high occupancy rates in the emergency department. Kulstad, Sikka, Sweis *et al.* (2010) found a positive correlation between ED crowding and medication errors; during their period of study, 283 medication errors were found, of which the vast majority occurred during periods of crowding. Last year, a group of researchers conducted a follow-up research to confirm the disproportionately high levels of

medical errors censed during crowded periods in their previous study (Watts, Nasim, Sweis *et al.*, 2013). The authors hypothesised that medical errors would happen much more frequently according to levels of ED crowding. They concluded that medical errors increase linearly rather than exponentially as they had previously assumed, but that there was indeed a direct correlation between the two factors. Medication errors, whether related to home medication being improperly administered or other forms of medication not being administered or being delayed, can cause serious complications, and negatively impact patient outcomes.

Emergency department boarding was found to have a negative impact on quality of care by a study completed in 2009 (Liu, Thomas, Gordon *et al.*, 2009). The authors analysed data from a tertiary care academic establishment and sought to find a correlation between patients being boarded in the ED and outcomes such as missed lab test results, missed home medication administration, and other deleterious events. Out of the charts used, 27.8% had an undesirable event. The authors concluded that "a substantial percentage of boarding patients experienced an undesirable event, largely as a result of processes such as regular medication administration that are essential to basic inpatient orders" (Liu, Thomas, Gordon *et al.*, 2009; 385). A research project lead by the same author in 2011 found the same discrepancy, whereby patients generally receive improper non-acute care while boarding in the ED (Liu, Chang, Weissman *et al.*, 2011). ED boarding was found to have deleterious effects on quality of care in a more recent study as well (Zhou, Pan, Zhou *et al.*, 2012). Serious complications happened 13.62 times per 1000 patients when hospital occupancy was lesser or equal to 90%, but this number increased to as much as 22.52 times per 1000 patients when hospital occupancy was greater or equal to 95%. As the article demonstrates, boarding patients in the ED can have important negative effects on the quality of care received by these patients.

2.2.5. Increased length of stay

When EDs are overcrowded, patients that have already been seen by a physician in the emergency department will tend to stay for longer periods of time before either being admitted to the hospital or being discharged. This is the object of a variety of studies, which aimed to find the level of influence ED occupancy rates had on lengthening a patient's ED LOS. Rathlev, Chessare, Olshaker *et al.* (2007) found that elective surgical admission, patient admissions through the ED, and increase in overall hospital occupancy all negatively affected patient LOS in the ED.

Nevertheless, hospital occupancy was the factor having the highest effect on the average length of stay.

A year later, a study was formulated to study the effects of ED boarding time and ED census on ED LOS at a pediatric hospital emergency department (Timm, Ho, & Luria, 2008). Over a 4-year period, the authors reviewed these two factors for every day, and measured them according to length of stay, among other outcome measures. They discovered that additional patients directly affect not only overall length of stay, but the various parts of the patient care process related to an ED visit, such as time to triage and time to physician. LOS was increased, and delays in care became more frequent with additional crowding rates. A year later still, a group of researchers teamed up in the same purpose as the previous authors, and aimed to display the link between ED crowding and ED LOS (Lucas, Farley, Twanmoh *et al.*, 2009). The authors studied five different hospitals, analysing data on 27,325 patients across 161 days, and found a significant positive correlation between the percentage of ED patients admitted each day and average ED LOS. Pines, Prabhu, Hilton *et al.* (2010) also sought to determine the impacts of emergency department crowding on ED length of stay, but also on time to ordering medication for patients with cases of asthma exacerbation, as this could have influenced ED LOS as well. The authors found that patients who were present at the most crowded times spent on average 75 minutes more in the ED than during times with a normal patient volume.

In 2014, a group of researchers used data from 445 EDs over a 5-year period, and additional data over a 6-year period (Handel, Fu, Vu *et al.*, 2014). This comprehensive study gives perhaps the greatest insight into the problem, as the sheer volume of data is tremendous. The characteristics analysed included ED volume, percentage of patients admitted, and percentage of patients arriving by ambulance, among others. The results of this extensive research were that crowding was found to affect both the LBTC rate and the average ED LOS. Also this year, another group completed a study assessing data from 13 different emergency departments (Derose, Gabayan, Chiu *et al.*, 2014). They found that both emergency department crowding and emergency department boarding has an important impact on ED LOS. Patients being boarded in the ED caused an obstruction within the hospitalisation process, leading to much longer admission LOS. When these patients' boarding times increased, admission LOS increased by as much as six hours.

2.2.6. Increased mortality

Ultimately, any hospital's primary objective is to limit patient mortality. As a result, this issue is the most serious of all negative effects produced by emergency department crowding. This effect was the study of numerous articles over the past years, of which most confirmed a significant link between ED crowding and increases in mortality rates. Miró, Antonio, Jiménez *et al.* (1999) found a significant positive correlation between the number of weekly visits and mortality rates in their research, as did Richardson (2006). Richardson completed a retrospective analysis over three 48-week periods. The results of his study were that out of 34,377 overcrowded patient admissions, 144 resulted in death, and out of 32,231 non-overcrowded patient admissions, there were 101 deaths. According to the author, the relative risk of death at 10 days was 1.34 during overcrowded periods. Mortality rate increased with more severe triage categories, as can be expected.

The same year, Sprivulis, Da Silva, Jacobs *et al.* (2006). also aimed to examine the relationship between ED occupancy and increased patient mortality after admission to the emergency department. The study surveyed admissions at three hospitals over three years, and found that the rate of patient mortality at the 2- and 7-day increased by 30% during overcrowded periods, and, importantly, "this increase in mortality appears to be independent of patient age, season, diagnosis or urgency" (Sprivulis, Da Silva, Jacobs *et al.*, 2006, 211). Hollander and Pines (2007) also analysed this effect, and found that ED crowding was linked with increased mortality in patients requiring antibiotic administration for cases of pneumonia or fibrinolytic administration for cases of myocardial infarction.

Last year, a group of authors completed a research project to find out if emergency department crowding had effects on delayed resuscitation efforts that would result in increased mortality rates (Hong, Shin, Song *et al.*, 2013). Out of 1296 patients who were resuscitated, 226 were classified as having been delayed in undergoing resuscitation procedures. Delayed resuscitations efforts (DREs) were much higher on days where the ED was crowded, and mortality was much higher within the DRE group. Sun, Hsia, Weiss *et al.*, 2013 also conducted a research observing this topic, and it was quite extensive. They used data from 187 hospitals, covering 995,379 ED visits, and found that there was a 5% greater chance of patient death during overcrowded periods. Other outcome measures that were validated were longer length of stay and increased cost per admission. Increases in mortality related to ED crowding was also studied

abroad, namely in South Korea (Jo, Jin, Lee *et al.*, 2014). These authors also found a significant correlation between crowding and mortality, particularly at the 1- and 3-day mark.

Emergency department boarding was also importantly linked with increases in mortality. Chalfin, Trzeciak, Likourezos *et al.* (2007) associated ED boarding with poor outcomes for patients waiting to be transferred from the ED to the intensive care unit (ICU). They defined patients as being "delayed" in their transfer from the ED to the ICU when they waited for periods longer than 6 hours in the ED. In their study period, ICU patient mortality rate was of 10.7% versus 8.4% for non-delayed patients, and the in-hospital mortality rate was of 17.4% versus 12.9% for non-delayed patients. ED boarding was also found to be linked with increased mortality rates in a more recent study (Singer, Thode Jr., Viccellio *et al.*, 2011). In this study, boarding was defined according to a LOS longer than two hours in the ED being experienced after admission was decided upon. Mortality was found to increase according to the length of time spent boarded in the ED. In patients having spent less than two hours boarded in the ED, the mortality rate was 2.5%, while the mortality rate for patients having spent 12 hours or more boarded in the ED was 4.5%. Overall hospital length of stay was also seen to increase substantially according to the number of hours boarded in the ED. Patients having spent less than two hours in the ED had an average LOS of 5.6 days, while patients having spent 24 hours or more in the ED had an average LOS of 8.7 days.

2.2.7. Revenue and cost issues

Patients who receive lengthy care evidently cost more in resources, and hospitals receive funding according to their activities, which means that, although hospitals are public in Canada, the concepts of revenue and cost are still appropriate. As Haraden and Resar (2004) wrote, "the ED is a source of revenue and an important care site for patients; when it is not accessible and patients are diverted, both patient's future care and potential revenue are lost" (p. 7). Indeed, when crowding leads to the diversion of ambulances or to patients walking out, activities are lower than they could have been, and thus hospital may receive less funding than they could have otherwise. Simultaneously, when the process of care is affected by crowding, additional costs arise. Bayley, Schwartz, Shofer *et al.* (2005) sought to determine how lengthy ED LOS caused by hospital crowding affected costs. To measure this, the authors calculated costs according to patient LOS. According to the authors' calculations, the overall cost associated with patients who

stayed for over 3 hours in this particular case was $168,300. Sun, Hsia, Weiss *et al.* (2013), whose study was mentioned previously in relation to increased mortality rates due to ED crowding, also studied the effects of ED crowding on hospital cost as a secondary outcome measure. This extensive study found that, in their 187 hospital sample, there was a 1% increase in cost per patient admission during crowded days, which amounted to a $17 million US dollars in costs during the studied period.

2.2.8. Lower patient satisfaction

When patients experience delays in care, medication errors, negative outcomes, and other such deleterious effects within their process of care, it is inevitable that their satisfaction will decrease. This effect was the focus of various studies completed in the past years, among which Pines, Iyer, Disbot *et al.* (2008). The authors surveyed patients covering a 2-year period in an academic hospital, attempting to validate the impact of ED crowding factors, such as waiting times, boarding times, and hallway placement on patients' satisfaction with hospitalisation and ED care. 1469 patients produced 1501 hospitalisations, and the results of surveying these patients were that ED boarding times and treatment times lead to low patient satisfaction not only of ED care, but also of hospitalisation overall. ED wait times did not necessarily affect the patients' opinion on hospitalisation itself, but directly affected the opinion of ED care. According to the authors, "[e]fforts to reduce ED crowding may improve patient satisfaction in the ED and satisfaction with overall hospital care" (Pines, Iyer, Disbot *et al.*, 2008, 830). Another study was conducted last year studying the same effect (Tekwani, Kerem, Mistry *et al.*, 2013), and the result of the study was that patient satisfaction was considerably lower when patients had experienced periods of crowding, and the related effects.

ARTICLE	PRIMARY FINDINGS
Neely, Norton, & Young, 1994	Ambulance diversion
Redelmeier, Blair, & Collins, 1994	Ambulance diversion
Schull, Morrison, Vermeulen *et al.*, 2003a	Ambulance diversion
Schull, Morrison, Vermeulen *et al.*, 2003b	Ambulance diversion
Begley, Chang, Wood *et al.*, 2004	Ambulance diversion
Eckstein & Chan, 2004	Ambulance diversion
Pines, 2006	Delay of care
Pines, Hollander, Localio *et al.*, 2006	Delay of care
Pines, Localio, Hollander *et al.*, 2007	Delay of care
Fee, Weber, Maak et al., 2007	Delay of care
Liu, Chang, Weissman *et al.*, 2011	Delay of care
Liu, Hobgood, & Brice, 2003	Delay of care
McCarthy, Zeger, Ding *et al.*, 2009	Delay of care
Schull, Vermeulen, Slaughter *et al.*, 2004	Delay of care
Bekmezian, Fee, Bekmezian *et al.*, 2013	Delay of care
Sri-On, Chang, Curley *et al.*, 2014	Delay of care
Rowe, Channan, Bullard *et al.*, 2006	Delay of care
Baker, Stevens, & Brook, 1991	Patients LWBS
Bindman, Grumbach, Keane *et al.*, 1991	Patients LWBS
Stock, Bradley, Lewis *et al.*, 1994	Patients LWBS
Polevoi, Quinn, & Kramer, 2005	Patients LWBS
Weiss, Ernst, Derlet *et al.*, 2005	Patients LWBS
Rowe, Channan, Bullard *et al.*, 2006	Patients LWBS
Kulstad, Hart, & Waghchoure, 2010	Patients LWBS
Bair, Song, Chen *et al.*, 2010	Patients LWBS
U. Hwang, Richardson, Sonuyi *et al.*, 2006	Patient safety & quality of care
U. Hwang, Richardson, Livote *et al.*, 2008	Patient safety & quality of care
Pines & Hollander, 2008	Patient safety & quality of care
Pines, Hollander, Localio *et al.*, 2006	Patient safety & quality of care
Pines, Pollack Jr., Diercks *et al.*, 2009	Patient safety & quality of care
Kulstad, Sikka, Sweis *et al.*, 2010	Patient safety & quality of care
Watts, Nasim, Sweis *et al.*, 2013	Patient safety & quality of care
Liu, Thomas, Gordon *et al.*, 2009	Patient safety & quality of care
Liu, Chang, Weissman *et al.*, 2011	Patient safety & quality of care
Zhou, Pan, Zhou *et al.*, 2012	Patient safety & quality of care
Rathlev, Chessare, Olshaker *et al.*, 2007	Increased length of stay
Timm, Ho, & Luria, 2008	Increased length of stay
Lucas, Farley, Twanmoh *et al.*, 2009	Increased length of stay
Pines, Prabhu, Hilton *et al.*, 2010	Increased length of stay
Handel, Fu, Vu *et al.*, 2014	Increased length of stay
Derose, Gabayan, Chiu *et al.*, 2014	Increased length of stay
Miró, Antonio, Jiménez *et al.*, 1999	Increased mortality
Richardson, 2006	Increased mortality
Sprivulis, Da Silva, Jacobs *et al.*, 2006	Increased mortality
Hollander & Pines, 2007	Increased mortality
Hong, Shin, Song *et al.*, 2013	Increased mortality
Sun, Hsia, Weiss *et al.*, 2013	Increased mortality
Jo, Jin, Lee *et al.*, 2014	Increased mortality
Chalfin, Trzeciak, Likourezos *et al.*, 2007	Increased mortality
Singer, Thode Jr., Viccellio *et al.*, 2011	Increased mortality
Haraden & Resar, 2004	Revenue and cost issues
Bayley, Schwartz, Shofer *et al.*, 2005	Revenue and cost issues
Sun, Hsia, Weiss *et al.*, 2013	Revenue and cost issues
Pines, Iyer, Disbot *et al.*, 2008	Lower patient satisfaction
Tekwani, Kerem, Mistry *et al.*, 2013	Lower patient satisfaction

Table 2.2. Synthesis of articles regarding the effects of ED crowding

2.3. Solutions to emergency department boarding

In this section, solutions proposed in the literature to improve emergency department boarding will be discussed at length. Since all parts of the hospitalisation process are interrelated, and since input, throughput and output factors have been discussed in the current literature review, solutions proposed to address these peripheral issues will be briefly illustrated in this introductory section as a means of providing an overview of what has been proposed to cope with these challenges. Many hospitals in Quebec, the rest of Canada and abroad are plighted with these problems, and although they are not central to the current thesis, this introductory section was elaborated in order to benefit readers with potential solutions to other problems that may be ailing their healthcare establishments.

Various solutions have been proposed to address the different issues that cause emergency department crowding. For example, the creation of new acute-care units (Kelen, Scheulen, & Hill, 2001; Moloney, Bennett, O'Riordan *et al.*, 2006) or observation units (Ross, Naylor, Compton *et al.*, 2001) in the ED, changing staffing levels (Bucheli & Martina, 2004; Paul & Lin, 2012; Best, Dixon, Kelton *et al.*, 2014) or having emergency-trained physicians (Donald, Smith, Doherty *et al.*, 2005), and using different bed types within the ED (McNaughton, Self, Jones *et al.*, 2012), among others. These studies sought to see how modifying resources could influence ED crowding, and many obtained favourable results.

Solutions related to management systems, procedures and protocols were also put forth in the literature. Shaw and Lavelle (1998) sought to analyse how additional on-call staff could contribute to reducing ED crowding, while Khanna, Boyle, and Zeitz (2014) aimed to evaluate the extent to which a capacity alert call could influence occupancy rates; other studies were conducted to observe how changing the triage process could improve flow (Connelly & Bair, 2004; I. Cheng, Lee, Mittmann *et al.*, 2013); pay-for-performance programs were implemented in Canadian hospitals to see if positive incentives could increase performance (A. H. Cheng & Sutherland, 2013); alternative pathways of care, such as mid-track or fast-track pathways were seen to improve patient flow in two additional studies (Grouse, Bishop, Gerlach *et al.*, 2014; Soremekun, Shofer, Grasso *et al.*, 2014); Asha and Ajami (2014) created a new nursing role (emergency journey coordinator) to involve nurses in managing patients' hospitalisation process; and Healy-Rodriguez, Freer, Pontiggia *et al.* (2014) analysed the impact of having a systematic logistics management system on ED crowding.

All of these solutions produced favourable outcomes; each solution impacted overall patient flow, as their improvement influenced other parts of the process. As mentioned above, these sources are included within this introductory section so as to provide a brief overview of potential solutions for factors that are peripheral to ED boarding. Nevertheless, all of these subjects can impact ED boarding, as the various issues are interrelated within the patient care continuum. The following section, then, will detail various different approaches that have been put forth in order to reduce the negative impact of emergency department boarding in itself.

2.3.1. Emergency department boarding solutions: modifying bed resources

"Resources" is an all-encompassing term employed in the current thesis to designate efforts aiming to alter the amount of physical resources available (e.g. adding more beds) or how physical space is used (e.g. putting inpatient beds in hallways). The following solutions have been categorised as such for the sake of simplicity.

One of the common solutions proposed is to add hospital beds. McConnell, Richards, Daya *et al.* (2005) analysed the influence of adding additional ICU beds on levels of boarding. The mean ED LOS for patients being admitted to the ICU decreased from 257 to 232 minutes. Other boarded patients, however, did not increase a significant decrease in LOS, and discharged patients saw their LOS increase. Adding more ICU beds affected the LOS of patients being transported to the ICU, but did not positively impact any other type of ED patients. Khare, Powell, Reinhardt *et al.* (2009) used a simulation model to see how varying the amount of ED beds, discharge rates of admitted patients, and ED occupancy rates would influence emergency department length of stay. The metric found to have the highest positive impact on ED LOS was the increase of discharge rates. Trends were similar when occupancy rates were increased, up to a 15% increase in the number of ED visits. ED LOS was seen to increase when additional hospital beds were input into the simulation model. Mumma, McCue, Li *et al.* (2014) also aimed to study how adding beds could influence boarding times. The authors surveyed two 11-month periods in a "before-and-after" model where the amount of beds increased from 33 to 53. In their research, they found that ED expansion did not improve their primary metric, which was the amount of patients who left without being treated, and had an unintended consequence of increasing average ED boarding time from 160 to 180 hours per day. They concluded that ED expansion was not an adequate solution to emergency department crowding.

All three of these studies show that adding hospital beds does not seem to be an optimal solution; managing beds in a more adequate manner seems to offer a more positive outcome, as we can see from the second study, whereby discharge rates had the most significant positive effect on patient flow. Adding beds in a specific unit may lower boarding times for patients of that particular type, but inevitably require additional resources to maintain, and do not present benefits for other patient types. Moreover, capacity cannot so easily be increased; more beds will often lead to using them in an inefficient way. The goal is to use the resources available in a more optimal way, and it is by altering how resources are used that this goal will be achieved. This is demonstrated by yet another study, which analysed the impact of adding holding units for inpatient units boarding in the ED (Delgado, Meng, Mercer *et al.*, 2013). Although it improved ED flow by freeing beds for new patients, boarding time did not decrease, and the number of boarders did not decrease.

Alternatively, many authors have explored the possibility of using inpatient hallways for boarding rather than keeping patients in the ED. Garson, Hollander, Rhodes *et al.* (2008) found that patients would prefer being boarded in inpatient hallways rather than within the ED, as did Richards, Ozery, Notash *et al.* (2011) and P. Viccellio, Zito, Sayage *et al.* (2013). These three studies surveyed patients having experienced ED boarding, and the results were overwhelmingly positive towards using inpatient hallways rather than the ED to board patients. While this was found to have no negative impact on patient care, and seemed to offer greater satisfaction to patients, these authors did not analyse the impact of this practice on ED boarding. A. Viccellio, Santora, Singer *et al.* (2009), however, monitored how sending patients to hallways rather than keeping them in the ED affected throughput and patient care. Within their studied period, 4% of patients were sent to a hallway. Naturally, patients who were sent to hallways experienced longer boarding times, as the hospital would normally wait for beds to become available, and would only later send patients to hallways when none had become available. A protocol was instituted which provided guidelines for this process. Mortality rates were found to be higher within the group of patients having received traditional beds, as were ICU transfers. This does not in any way demonstrate that traditional beds are less optimal than hallways, but it does show that the rate of negative outcomes is not increased with this practice. Nevertheless, this practice did not directly affect overall boarding time, and is thus not a valid solution to ED boarding issues.

2.3.2. Emergency department boarding solutions: modifying management systems

"Management systems" is an all-encompassing term employed in the current thesis to designate efforts aiming to alter processes, procedures, and protocols, rather than physical resources. The following solutions have been categorised as such for the sake of simplicity.

White, Brown, Sinclair *et al.* (2012) implemented the Supplemented Triage and Rapid Treatment (START) program, which is characterised by having a team of clinicians who initiate diagnostic work-ups and accelerate the disposition of a subset of patients, and measured the impact in a before-and-after model. The primary outcome metrics used were overall LOS, ED LOS for discharged patients and boarded patients, and the rate of patients leaving without a complete assessment. Patient volume increased by 9% between the two study periods; nevertheless, boarding hours decreased by 1.3% and the average ED LOS decreased by 8%. The mean LOS decreased by 7% for discharged patients and also by 7% for admitted patients. Similarly, Amarasingham, Swanson, Treichler *et al.* (2010) observed how a rapid admission protocol could reduce prolonged emergency department boarding times for admitted patients. They reduced the amount of steps in the admission process from 50 to 10, and instituted clear and concise roles and boundaries for all staff members involved in the process. Within their study period, average boarding time decreased from 360 to 270 minutes, and the time between patient arrival and treatment and the decision to admit decreased from 210 to 75 minutes. Patients requiring specific care, such as telemetry or ICU beds, did not experience an improvement.

Another study sought to see if a new bed management initiative could improve ED boarding (Howell, Bessman, Kravet *et al.*, 2008). The new management strategy aimed to promote proactive management of resources and included two bed management rounds per day in the ICU as well as regular visits to the ED to estimate flow and occupancy rates. The system also aimed to facilitate the admissions process and to speed up transfers from the ED to inpatient units, and to support the director of bed management by mobilising additional resources when throughput issues were detected. Admitted patient throughput time decreased by 98 minutes during the study period, but it did not significantly change for non-admitted patients. The frequency of "yellow alerts" (whereby ambulances carrying priority 2 or priority 3 patients are diverted elsewhere due to an overload in capacity) and "red alerts" (whereby ambulances carrying patients requiring critical care are diverted elsewhere due to an overload in capacity) in

the ED decreased by 6% and 27% during the period, even though ED census rates were higher during the study period than prior to that.

Liu, Hamedani, Brown *et al.* (2013) focused on improving ED crowding overall, but found that within the surveyed hospitals in their study, inpatient discharge coordination was the most commonly used method to smooth and reduce ED boarding, and that this approach proved to be beneficial on throughput for admitted patients. Coordinating admissions and discharges in a more systematic way can be very beneficial for hospital throughput, as can be seen in a second study by Powell, Khare, Venkatesh *et al.* (2012). Patients are often discharged later in the day, and in this study, the authors aimed to analyse how changing this practice could benefit ED boarding occurrences. The authors used simulation modelling, and input discharge times between 8:00 am and 4:00 pm. Their study concluded that shifting peak inpatient discharge timing 4 hours earlier eliminated boarding within the surveyed period, and that discharging patients between 8:00 am and 4:00 pm, rather than between 12:00 pm and 00:00 am, as was previously the case, reduced the total number of boarding hours from 77.0 per day to 3.0 per day.

Levin, Dittus, Aronsky *et al.* (2008) created a stochastic discrete event simulation to see how cardiology inpatient beds could become more accessible to boarded patients. The authors observed that scheduling and bed management practices had the biggest positive impact on ED boarding. Adding beds in an inpatient unit did not provide as beneficial an outcome as scheduling certain elective procedures earlier in the day. Changing as little as one elective catheterization case to the morning improved overall boarding for patients destined for this unit by 20 minutes.

While solutions proposing to improve ED boarding by modifying resources have not provided adequate results to legitimise the investments required to fulfill them, solutions modifying management systems have been found to be greatly beneficial to ED boarding. Improving the admission process, coordinating discharges and admissions, improving inpatient bed management strategies, and smoothing elective surgery schedules have all been proven to improve ED boarding, as demonstrated by the previous articles.

ARTICLE	PRIMARY FINDINGS
Solutions to ED crowding	
Kelen, Scheulen, & Hill, 2001	Modifying resources
Moloney, Bennett, O'Riordan *et al.*, 2006	Modifying resources
Ross, Naylor, Compton *et al.*, 2001	Modifying resources
Bucheli & Martina, 2004	Modifying resources
Paul & Lin, 2012	Modifying resources
Best, Dixon, Kelton *et al.*, 2014	Modifying resources
Donald, Smith, Doherty *et al.*, 2005	Modifying resources
McNaughton, Self, Jones *et al.*, 2012	Modifying resources
Shaw & Lavelle, 1998	Modifying management systems
Khanna, Boyle, & Zeitz, 2014	Modifying management systems
Connelly & Bair, 2004	Modifying management systems
I. Cheng, Lee, Mittmann *et al.*, 2013	Modifying management systems
A. H. Cheng & Sutherland, 2013	Modifying management systems
Soremekun, Shofer, Grasso *et al.*, 2014	Modifying management systems
Grouse, Bishop, Gerlach *et al.*, 2014	Modifying management systems
Asha & Ajami, 2014	Modifying management systems
Healy-Rodriguez, Freer, Pontiggia *et al.*, 2014	Modifying management systems
Solutions to ED boarding: resources	
McConnell, Richards, Daya *et al.*, 2005	Adding hospital beds
Khare, Powell, Reinhardt *et al.*, 2009	Adding hospital beds
Mumma, McCue, Li *et al.*, 2014	Adding hospital beds
Delgado, Meng, Mercer *et al.*, 2013	Adding holding units
Garson, Hollander, Rhodes *et al.*, 2008	Using inpatient hallways
Richards, Ozery, Notash *et al.*, 2011	Using inpatient hallways
P. Viccellio, Zito, Sayage *et al.*, 2013	Using inpatient hallways
A. Viccellio, Santora, Singer *et al.*, 2009	Using inpatient hallways
Solutions to ED boarding: management	
White, Brown, Sinclair *et al.*, 2012	Rapid treatment protocol
Amarasingham, Swanson, Treichler *et al.*, 2010	Rapid admission protocol
Howell, Bessman, Kravet *et al.*, 2008	Improving bed management
Liu, Hamedani, Brown *et al.*, 2013	Admission/discharge coordination
Powell, Khare, Venkatesh *et al.*, 2012	Admission/discharge coordination
Khare, Powell, Reinhardt *et al.*, 2009	Admission/discharge coordination
Levin, Dittus, Aronsky *et al.*, 2008	Smoothing elective surgery schedule

Table 2.3. Synthesis of articles regarding the solutions to ED crowding and ED boarding

2.4. Synthesis and discussion

The literature review has illustrated that emergency department boarding, in relation with emergency department crowding, causes a variety of deleterious effects on patients and hospital resources. Ambulance diversion, patients leaving without being seen, delay of care, patient safety and quality of care issues, increased length of stay, increased mortality, revenue and cost issues, and patient satisfaction issues are all negative outcomes generated by the crowding ED boarding creates. Various interrelated factors – input, throughput, and output – can cause these effects, among which ED boarding takes a central role. Many solutions have been proposed to improve occurrences of ED boarding; solutions aiming to modify resources have been found unsuccessful, while solutions modifying management systems offer a much more beneficial outlook.

This literature review has validated that ED boarding is an important issue and that its prevalence is worldwide. Hospitals, whether private or public, are struggling to deal with this issue, and there is an important gap in knowledge regarding this process in many healthcare systems, namely in Quebec and the rest of Canada. The numerous effects related to ED boarding are catastrophic, as it compromise patient safety, quality of care, patient outcomes and hospital resources. Quebec's healthcare system is operating under budgetary constraints, as would any public healthcare system, and additional resources are out of the question. Even if it were possible, the literature tends to show that solutions modifying resources are rarely beneficial. Therefore, management processes must be analysed and optimised in order to improve the effects of this practice. Solutions such as rapid admission processes, admission and discharge coordination, improved IP bed management strategies and smoothed elective surgery schedules are solutions that have been tried and tested elsewhere, and may be beneficial here as well. This research will use the data collected from the literature to validate the problem, to understand the stakes and interrelated factors, and to find possible solutions with the help of hospital staff.

Using the information collected in the literature review, a conceptual framework was developed (Figure 2.2). The causes of ED crowding are all interrelated, and can thus potentially be causes of ED boarding as well; this is demonstrated with dotted lines underneath the input, throughput, and output factors within the analytical model. With the information contained in this framework, a basis for research within hospitals becomes available. This research will attempt to validate these potential causes and solutions of ED boarding with deductive reasoning, and other causes and solutions will be obtained through the field research by inductive reasoning. The goal

of this framework is to provide a comprehensive overview of the potential factors affecting ED boarding that will be used in the field work. Concrete field research will seek to validate whether these factors are potential causes within Quebec hospitals or not, which will then be used to alter the model and provide an adapted version that is perhaps more narrowly applicable to their particular context.

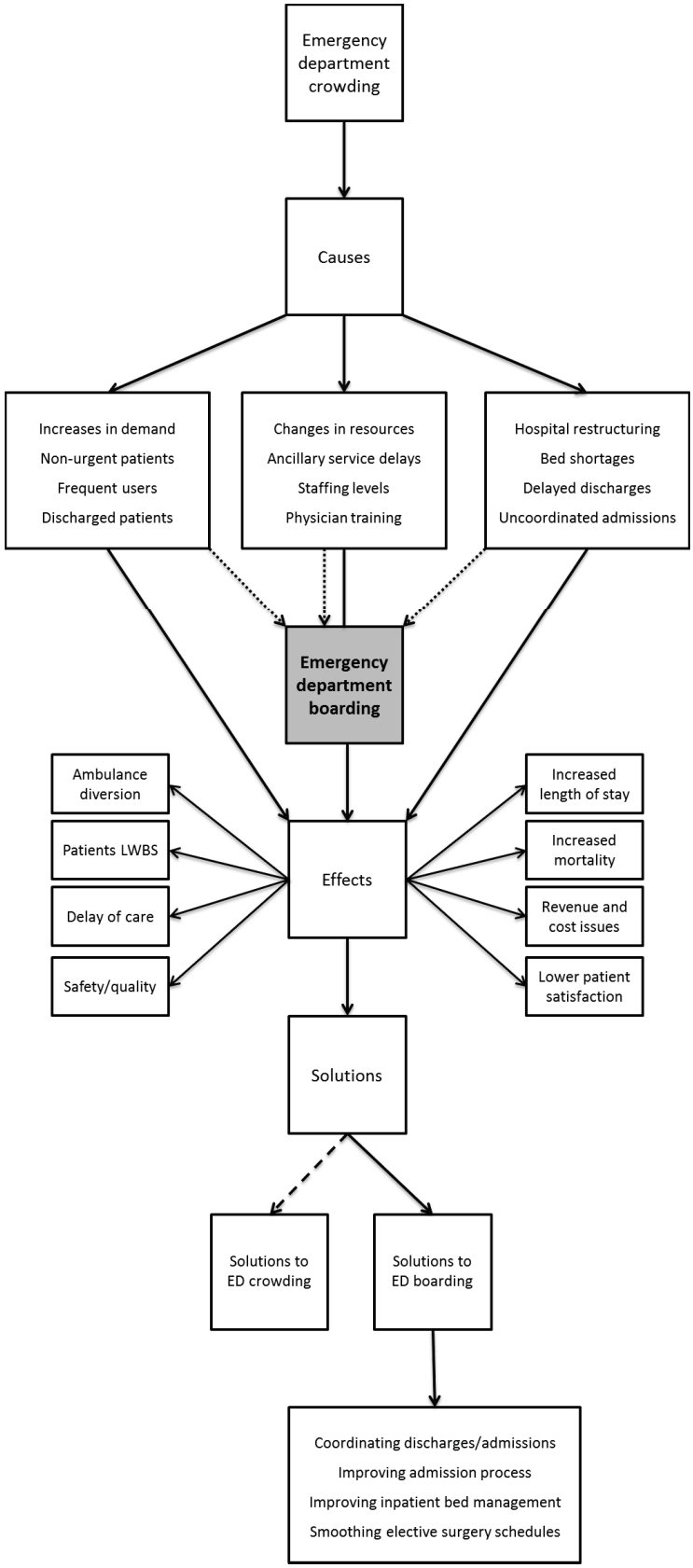

Figure 2.2. Initial conceptual framework demonstrating the potential causes and solutions of ED boarding as per the literature

3. Methodology

With the knowledge gained through the literature review, a conceptual framework was established that allows for a better understanding of the root causes and possible solutions to ED boarding. This thesis, then, aims to base itself on this conceptual framework to analyse this issue within the context of three Quebec hospitals in order to answer its initial research questions:

- What are the root causes of ED boarding within Quebec hospitals?
- To what extent are these causes similar or different in varying environments?
- How can we improve the process in order to reduce the amount of boarding required?

In order to answer these research questions, a multiple case study approach was undertaken. This methodology was chosen according to the guidelines put forth by Yin (2009). Firstly, the nature of the research questions is explanatory, comprised mostly of "how," "what," and "why" questions. Secondly, the research requires no control of behavioral events. Finally, the research focuses on contemporary events, and on an ongoing issue whose "operational links [need] to be traced over time, [and are not] mere frequencies or incidence" (Yin, 2009; 9).

This thesis uses the knowledge acquired from the literature review as a "template with which to compare the empirical results of the case study" (Yin, 2009; 38). The purpose of this thesis is to answer the proposed research questions within the context of the studied cases, and to generalise the resulting propositions within a theory, which Yin (2009) refers to as analytic generalisation. This theory will be put forth in the form of a conceptual framework for ED boarding, which can then be used in other contexts to validate or invalidate the answers that will have been found. This thesis does not assert that a statistical generalisation can be achieved with the chosen methodology, as the purpose was not to obtain a sample which would be representative of the entire population of Quebec hospitals. According to Yin (2009), "If two or more cases are shown to support the same theory, replication may be claimed. The empirical results may be considered yet more potent if two or more cases support the same theory […]" (Yin, 2009; 39). Taking this into consideration, three cases were chosen to corroborate the information acquired from the literature within Quebec's context.

In choosing the three hospitals that would participate in this study, the main concern was obtaining sufficient access to both quantitative and qualitative data. Many hospitals did not have the means to provide employees for interviews, because of either budgetary or time constraints. Because of this, hospitals that had the means to provide the necessary resources were prioritised.

Moreover, this research in itself experienced resourcing limitations as well (Kvale, 1996). Cases were also chosen according to the willingness and ability of hospitals to participate. Ultimately, this lead to the choosing of three cases. Each hospital operates within a particular context that differs from the two others, which is beneficial for this research, as one of the three research questions pertains to the root causes of ED boarding in different environments. The participating hospitals are distributed as follows:

1. Hospital A: Large (approx. 550 IP beds) urban hospital;
2. Hospital B: Small (approx. 200 IP beds) urban hospital; and
3. Hospital C: Small (approx. 250 IP beds) regional hospital.

The number of case studies was limited to three given time and budgetary constraints. However, the number of actors within the hospital participating in the study was increased in order to obtain a more in-depth viewpoint of the situation. These actors, numbering 25 in total, were each met with individually for a semi-structured interview, having few set questions and using mainly probing questions in order to obtain accurate information as to the issues causing ED boarding and their possible solutions. A more detailed profile of each hospital will be elaborated in Chapter 4. Demographic information obtained from each participant can be found in Section 3.1. The questionnaire used for these interviews is supplied in the Annexe; a discussion of its elaboration and content can be found in Section 3.2.

In order to corroborate this qualitative information with concrete evidence, quantitative data was collected as well. This thesis uses a mixed approach, compiling both types of data in order to provide a more elaborate perspective of ED boarding within Quebec hospitals. Data was obtained through statistical software used by each hospital. Not all hospitals operated with the same statistical software, but the information required was generally available regardless. Information regarding the type of quantitative data obtained and how it was treated can be found in Section 3.2.

3.1. Participants

Participants were chosen in collaboration with the participating hospitals. An initial list of possible candidates to be interviewed was supplied to the hospitals, which then scheduled interviews accordingly. Criteria for inclusion in the study was fairly straight-forward; employees became eligible provided they interacted with the patient flow process from the ED to inpatient

care units. The goal was to obtain an equal amount of participants within two categories: Administration and Clinical/Support. Each hospital was asked to arrange interviews with 4 employees from each category. It was decided upon to segment participants in this manner in order to understand whether or not employees interacting with patients on an operational level had similar or different perspectives from those interacting with the process on a decisional level. Although a high degree of flexibility was granted to hospitals as to who they would chose to participate, the following list of potential interviewees was supplied:

Administration

- Bed Management Coordinator
- Head of the Emergency Department
- Head of an Inpatient Care Unit (2)

Clinical/Support staff

- Assistant Head Nurse, ED
- Assistant Head Nurse, IP unit
- Other Clinical/Support (2)

Not all hospitals were able to provide these exact employees, but in general these guidelines were followed. In some cases, hospitals did not schedule enough interviews, or scheduled too few with one of the two target categories of individuals (i.e. either Administration or Clinical/Support). When this occurred, additional participants were found via the snowball sampling method. Scheduled participants were solicited to find other participants that were implicated in the process of transferring patients from the ED to inpatient care units. This method was used to find 5 out of the 25 participants.

As the healthcare system in Quebec is almost entirely administrated in French, and because the hospitals visited were francophone, official titles are in French. The various employee titles were grouped according to their fundamental traits in order to limit the amount of employee types within the qualitative data. The groupings are illustrated in Figure 3.1, Figure 3.2, Figure 3.3, Figure 3.4, and Figure 3.5. Other employee types were not grouped together because no other positions had similar roles and responsibilities; these are Orderly, Social Worker, Assistant Director, Head of Service and Administrative Assistant. Since the Assistant Director and the Head of Service had unique titles within their establishments, their official title has been reduced so as to maintain confidentiality. Compiled and categorised information can be seen in Table 3.1.

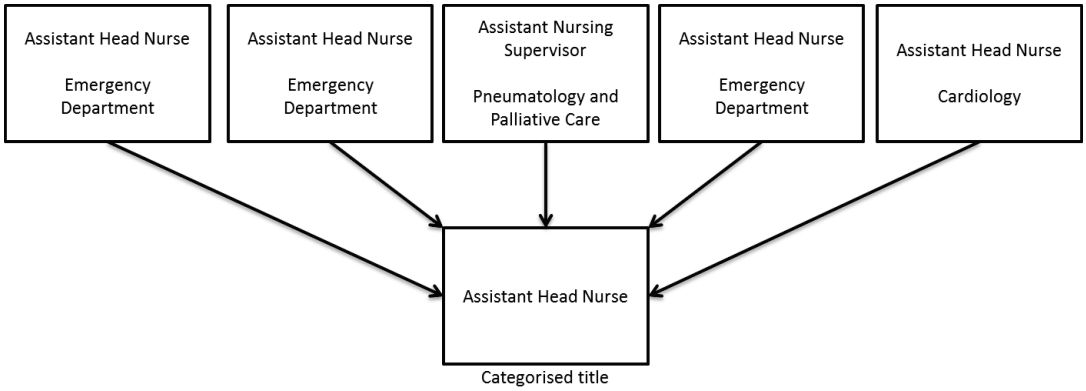

Figure 3.1. Interview participant categorisation: Assistant Head Nurse

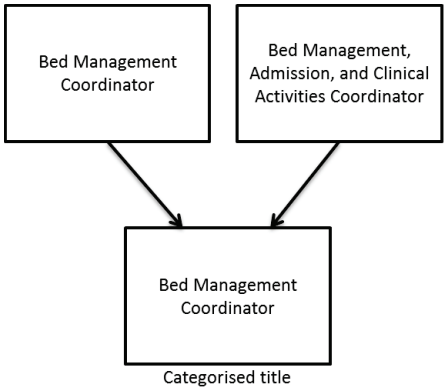

Figure 3.2. Interview participant categorisation: Bed Management Coordinator

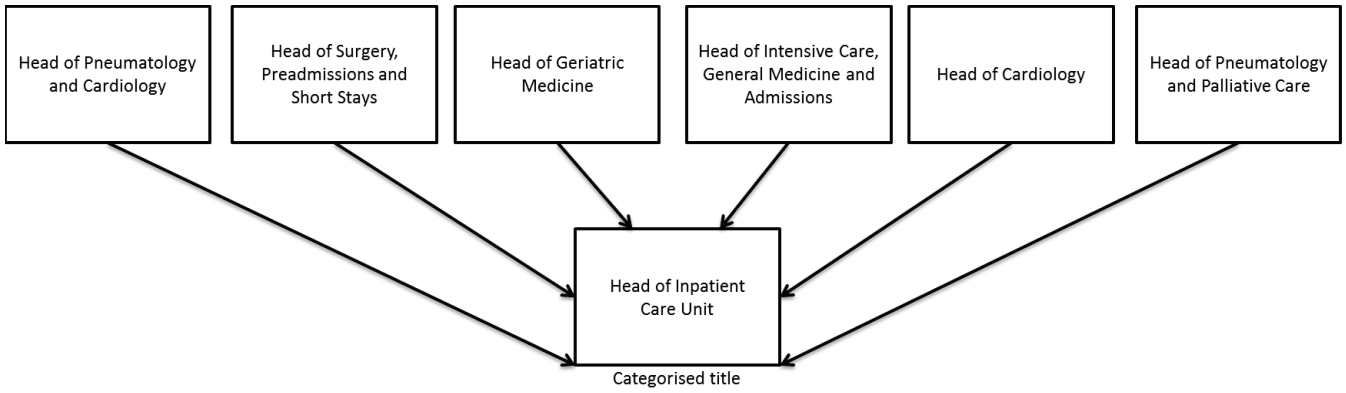

Figure 3.3. Interview participant categorisation: Head of Inpatient Care Unit

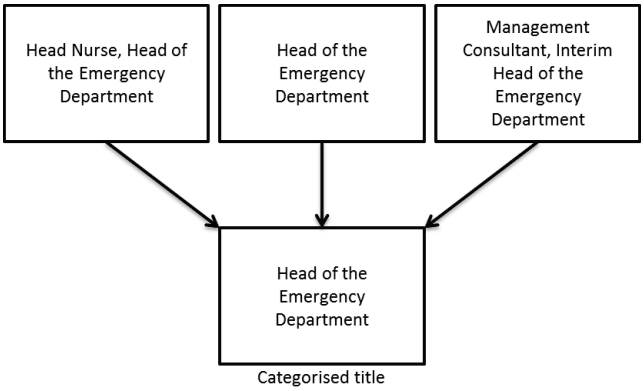

Figure 3.4. Interview participant categorisation: Head of the Emergency Department

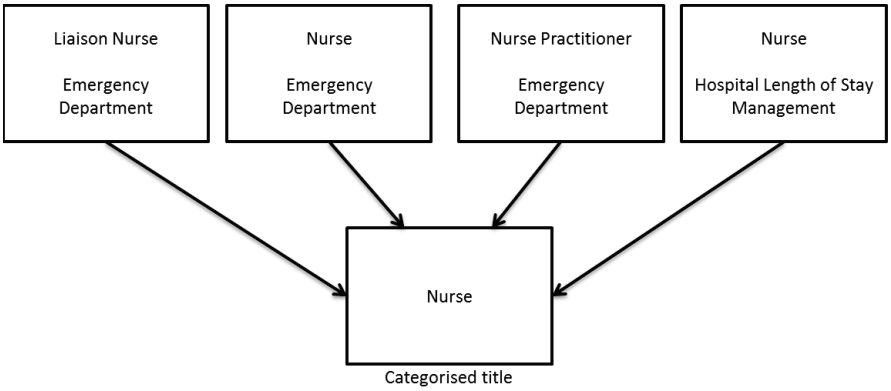

Figure 3.5. Interview participant categorisation: Nurse

COMPILED DEMOGRAPHIC INFORMATION		
Categorised title	**Type of participant**	**Number of participants**
Administrative Assistant	Clinical/Support	1
Assistant Director	Management	1
Assistant Head Nurse	Clinical/Support	5
Bed Management Coordinator	Management	2
Head of Inpatient Care Unit	Management	6
Head of Service	Management	1
Head of the Emergency Department	Management	3
Nurse	Clinical/Support	4
Orderly	Clinical/Support	1
Social Worker	Clinical/Support	1

Table 3.1. Compiled and categorised demographic information for all participants

3.2. Preparations and data collection

A qualitative interview guide, a consent form, and a socio-demographic data sheet were elaborated prior to the interviews. The interviews were semi-structured, with very few set questions; probing questions were used to elaborate upon the base questions. The interview sought to validate whether the 12 possible causes of ED boarding elucidated in the conceptual framework were present within the participating hospitals. However, in order to reduce possible biases, they were not mentioned explicitly by the author in the fashion of a closed question (i.e., is this a problem here, yes or no?). This would most likely not have produced valuable data in any case. Ultimately, the interviewees were asked to emphasise 4 key issues causing ED boarding out of everything that they had mentioned, and possible solutions that could improve ED boarding times. Not all participants were able to find solutions to the problems they had mentioned, and some participants gave solutions to issues they had not enumerated within their 4 key issues. Ultimately, this thesis will recommend possible solutions according to both the qualitative and quantitative data obtained in this regard, as well as from the literature. Interviews were conducted in October and November 2014.

In terms of how the research itself was prepared, first, hospitals were solicited so as to find possible participants. Contacts were obtained through the director of this thesis, and initial contact was made via e-mail. An initial research proposition was supplied to contacted hospitals. When interest was shown, hospital representatives were contacted via phone to develop upon the initial proposition. A final proposition, including possible benefits for hospitals was then provided, and the final participants were chosen.

Once the hospitals were chosen, multiple sources of data were exploited in order to thoroughly analyse the issue of ED boarding within the case studies. As Yin (2009) wrote, "[…] the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation and corroboration […] Thus, any case study finding or conclusion is likely to be more convincing and accurate if it is based on several different sources of information, following a corroboratory mode" (Yin, 2009; 115-116). For this reason, interviews and direct observation were planned, quantitative data regarding patient flow was obtained, and official documents were consulted.

Hospitals chose the interviewees that would participate, according to the guidelines provided above, and then set interview dates and times. Interviews were then conducted, and data

was collected. Direct observation was also conducted to understand the reality of each hospital. This direct observation lasted generally one day, and the content differed in each case. In all three cases, the emergency department was visited. In Hospital A and Hospital B, daily bed management meetings were observed. In Hospital A, the bed management administrative assistant was observed for 4 hours in order to see how beds were attributed within this hospital. In all three cases, the patient flow process was observed first-hand.

Quantitative information was obtained through the hospital contacts. Each hospital used information technology software that collected statistical data. The data available was imperfect, and presented a variety of different issues, which will be discussed to a greater extent in Section 3.3. The data requested was as follows:

- Date/time of admission request at the emergency department for each patient for 2013
- Date/time of arrival to the inpatient unit for each patient for 2013

With this data, it was possible to calculate average boarding times according to various metrics. Average boarding time was calculated according to the date/time of the admission request; for example, the average boarding time for a patient whose admission was requested on a Monday, or in January, or at 22:00, was calculated. Average boarding time was calculated according to:

- the season;
- the month;
- the day of the week; and
- the time of day on an hourly basis

Since patient arrivals to inpatient units were obtained in order to calculate boarding time, it was possible to see within which periods most arrivals occurred. Arrivals were calculated according to the same contexts as admission requests, in order to see how admissions and arrivals were balanced. Additional data was also requested from the hospitals to develop a global perspective:

- Date/time of every discharge request from inpatient units for 2013
- Date/time that patients left inpatient units for every discharge for 2013

With this data, it was possible to understand the flow process more adequately. This data was categorised according to the same constraints as the previous data in order to see how admission requests, arrival to inpatient units, discharge request from inpatient units and exit from the inpatient unit were balanced. Finally, official documents (each hospital's annual report for 2012-

2013 and for 2013-2014, the Minister of Health and Social Services' guidelines regarding hospital management, etc.) were consulted to obtain additional information about the cases.

3.3. Quantitative data analysis

In order to better understand trends related to ED boarding, a generalised linear model was created in SAS Software v.9.3. using the GENMOD procedure. The dependant variable, boarding time (measured in minutes) was compared with the various independent variables illustrated above; that is to say, seasons, months, days of the week, and the time of day. Seasons, months, and days of the week were modelled as categorical independent variables, and a reference point was chosen for each as a baseline; respectively, Winter, January, and Monday. In other words, all others variables within their respective categories were weighed against these reference points to compare their impact on boarding time. The time of day was modelled as a continuous independent variable, and as such, no reference point within this variable type was required. All four independent variables were also weighed globally to understand whether or not they had a significant impact on boarding time. Scaled Deviance was 1.0025 for Hospital A, 1.0042 for Hospital B, 1.0042 for Hospital C, and 1.0012 for the combined analysis of all three hospitals, which means that the model was an excellent fit, and that the data is sound. Data was established as statistically significant if the Wald 95% Confidence Limits did not include 0 within their boundaries and if $p < 0.05$.

Additional quantitative data obtained regarding discharge request times and discharge times were not modelled within SAS, as they could not be related to the key variable that is being observed within this thesis, that is to say boarding time. More patients are discharged from inpatient units than admitted from the ED, as many are surgical patients or otherwise hospitalised. Therefore, boarding time could not be directly corroborated with this data, and as such, the additional quantitative data is used to validate qualitative data obtained from the interviews.

3.4. Qualitative data analysis

Within the qualitative interviews, participants were asked to elucidate 4 key issues that may cause ED boarding within their respective institutions. The problems that they mentioned were categorised when possible within the 12 possible causes found within the literature. When their answers were unrelated or too different from the 12 proposed categories, a new category

was created. Since this thesis also follows inductive reasoning, additional categories were expected. Ultimately, the categories created (all output factors) were as follows:

1. Unbalanced surgical schedule;
2. Specific patient needs (e.g. telemetry);
3. Specific patient dispositions related to hospital-acquired infections (e.g. VRE);
4. Inability to discharge patients, for example:
    - Patient cannot leave because his means of returning home are unavailable (e.g. family, adapted transportation, etc.);
    - Patient is waiting for external resource placement (e.g. long-term care facility (LTCF), rehabilitation center, etc.) and is being housed in the hospital;
    - Patient is deconditioned because of his stay within the hospital, and requires physiotherapy or other such supportive means to be able to leave.
5. Lack of communication/collaboration/information, for example:
    - Difficulty communicating between the ED and inpatient units because of the difference in realities between the two environments;
    - Lack of collaboration between the different professionals within the patient care process (physicians, nurses, physiotherapists, respiratory therapists, etc.);
    - Employees responsible for attributing beds are lacking information (e.g. strain of VRE, particular patient needs, etc.);

While balancing the surgical schedule was one of the proposed solutions to ED boarding within the literature, it had not been explicitly described as a cause within other sources, which explains why it was not incorporated within the 12 initial causal categories. Other added categories were too distinct to be included within any other categories, which prompted the creation of new ones. The qualitative data was segmented according to the hospital, categorised employee titles, and employment category (administration or Clinical/Support) in order to understand the causes of ED boarding within different institutions and according to different actors. When possible, quantitative data was interpreted to validate the answers obtained within the qualitative interviews. As will be discussed within the following section, this was not always possible because of the nature of the data available.

Data was also collected from the qualitative interviews as to potential solutions to emergency department boarding. Participants were not asked to pinpoint only 4 possible

solutions, as they had been asked to do for causes, but were rather encouraged to propose as many solutions or improvements as they could think of, regarding the causes they had elucidated or other problems that they thought needed attention. The data was compiled and segmented by hospital, categorised employee titles, and employment category, as it had been for the potential causes. Many of the proposed solutions did not fit within the categories created from the literature review, and as such, 5 more categories were created. They are as follows:

1. Improving communication/collaboration/information, for example:
    - Improving communication practices between the ED and IP units;
    - Increasing collaboration with doctors and other professionals;
    - Making information more readily accessible.
2. Improving resource management, for example:
    - Monitoring the use of telemetry more adequately;
    - Managing the use other of rare resources (such as negative pressure rooms for tuberculosis, or rooms equipped with harnesses for obese patients);
    - Using resources in a more adequate way (e.g. if a patient's heart rate as already been monitored in the ED for 40 hours with no arrhythmias, include this length of time within the doctor's request for 72 hours of monitoring).
3. Improving infectious disease management, for example:
    - Obtaining more adequate information regarding patient disposition (i.e., which strain they are infected with);
    - Changing protocols related to infectious disease prevention (more complicated, as it involves public health; this will be discussed in the next chapter);
    - Obtaining test results more quickly.
4. Preparing patient discharge more extensively, for example:
    - Creating a discharge plan for patients as soon as they are admitted;
    - Planning discharge ahead, limiting the amount of "surprise discharges;"
    - Reconditioning patients having lost certain capabilities during their stay more systematically.
5. Improving external resources, for example:
    - Increasing partnerships with LTCFs, rehabilitation centers, etc.;
    - Increase the level of care nurses are allowed to give in LTCFs;

- Increase the visibility of primary care providers (PCP) so as to encourage people from obtaining care before their illnesses require them to be admitted;

Although infectious disease management could have potentially been included within the "improving inpatient bed management" category obtained from the literature, its uniqueness within the hospital context required more specific categorisation. Along with these created categories, other categories were used more broadly than they could have been illustrated in the literature review, particularly the "improving admission process" category. The most important components included within this category were tardy or batched admissions. As with the potential causes, potential solutions were corroborated with quantitative data when available. Limitations in this regard are discussed more extensively in the following section.

3.5. Data limitations

As there is a good deal of human intervention within the data obtained, both qualitative and quantitative, there are some limitations to the information acquired. Some of the data obtained from the qualitative interviews was impossible to corroborate with the quantitative data within the context of the current thesis, because the required quantitative data was unavailable. Patient disposition (e.g. infected with VRE), and particular needs (e.g. cardiac monitoring) were only accessible by analysing each patient file individually. Because of confidentiality issues, this was impossible, and the sheer amount of files to be accessed to obtain this information (20,000+) was far too large. This information was initially requested in order to see how these issues affected bed/resources shortages, one of the possible causes of ED boarding elucidated within the literature, as these particular situations present additional constraints upon those coordinating admissions and bed attributions.

The quantitative data had some limitations as well. Time stamps are approximate, as the person who is interacting with the software is the one who enters it. For example, a doctor can sign an admission request at 03:43, but the person who inputs this data within the software only does so at 04:01. In some cases, different steps (e.g. admission request and departure from the ED) were recorded to have happened at the same time, or not having happened at all. In some cases, the patient was recorded as arriving to the inpatient unit before his admission had been requested in the ED. Faulty data such as these were discarded as outliers. In two cases (Hospital A and Hospital B), "the date/time of every discharge request from an inpatient unit" variable was

generally incomplete. This variable was unavailable for 61.08% of patients in Hospital A, and 60.56% of patients in Hospital B, and could thus not be used, as it presented too high a bias. Moreover, the hospital's data regarding the time where a patient arrived to an inpatient unit could not be used either, as it represented the time when a transfer was approved, and not when the patient arrived. This was understood when patients were seen to leave the ED later than they had been "admitted" to the inpatient unit. Because of this, instead of using the moment when patients arrived to the inpatient unit as the variable to calculate boarding time and patient arrivals, departure from the ED was used. This variable was also used in the context of Hospital B. Because of this, there is a certain degree of inaccuracy in the boarding times calculated. However, these inaccuracies are minimal, as they only represent the time it took to move the patient from the ED to the inpatient unit, which is generally a few minutes. Nevertheless, this presents a certain limitation.

3.6. Ethical considerations

A consent form was presented and explained to each participant prior to the interviews. The interviews were conducted either in French or in English, depending on the participant's native (or most comfortable) language. Each participant was asked to give his/her explicit consent for the recording of the interview, and will have the possibility of interrupting the recording at any point in time. Moreover, each participant was permitted to ask for the omission of any comments that they could have made during the interview. They were also allowed to remove themselves from the study at any point for whatever reason. A copy of the consent form was given to the participant. No questions were asked on the participant's personal life or on unrelated professional matters (e.g. his/her relationship with management, supervisors, colleagues, etc.). Recorded interviews as well as other information gathered from the participants (demographic and professional information) will be kept until June 2016, after which it will be destroyed. Participants will be referred to by their categorised title henceforth in order to protect the confidentiality of their answers.

4. Presentation of data

This chapter's first objective is to present the quantitative and qualitative data that was collected from the different case studies. The quantitative data obtained was segmented according to seasons, months, days of the week, and hours of the day. The qualitative data obtained was segmented according to categorised employee titles and employment types. Data regarding the admission process of each hospital, which situates itself as illustrated in Figure 4.1, an adapted version of the figure seen in Chapter 1, was collected through the qualitative interviews and through direct observation; these processes were then modelled into flow charts for each hospital, and can be seen in their respective sections. These various types of data will be interpreted in Chapter 5.

The second objective of this chapter is to answer the three research questions that were put forth previously in this thesis. Although the interpretation of the data in itself will be presented in the next chapter, the current chapter nevertheless demonstrates an unbiased and objective picture of the answers to each of the research questions. The research questions are:

- What are the root causes of ED boarding within Quebec hospitals?
- To what extent are these causes similar or different in varying environments?
- How can we improve the process in order to reduce the amount of boarding required?

The chapter is constructed to showcase information about each case one at a time, starting with Hospital A, a large urban hospital, followed by Hospital B, a small urban hospital, and ending with Hospital C, a small regional hospital. A general profile of each hospital is first put forth so as to provide information about each hospital's mission, specialisations and population served. Moreover, the hospitals' performance concerning issues surrounding ED boarding, employees, physicians and other such information is also demonstrated. The amount of beds in each hospital, as well as their general configuration is then explained. Each hospital's admission process is demonstrated in a flow chart. The data tables used to create the figures presented in this chapter can all be seen in the Annexe. Additionally, data tables demonstrating the results obtained from the SAS general linear model, as well as the range and variance of boarding time according to the various segmentations, can also be seen in the Annexe.

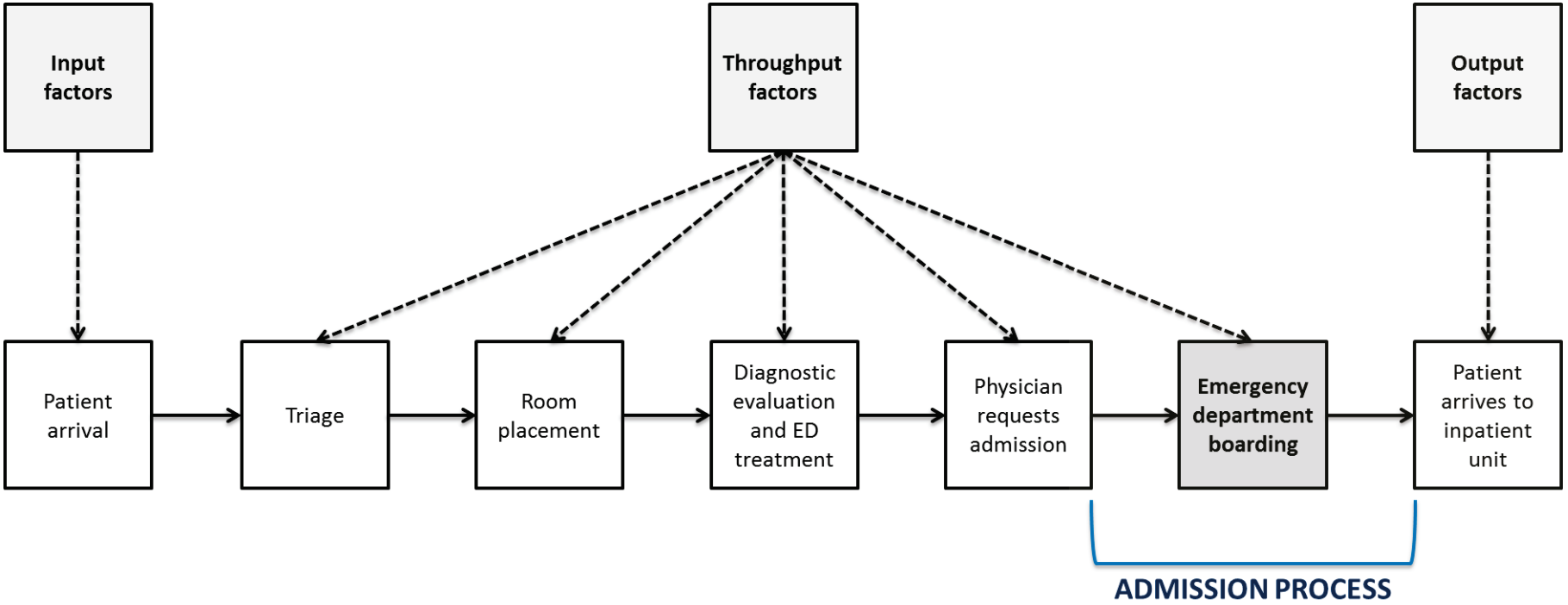

Figure 4.1. Adapted ED flow chart for admitted patients

4.1. Hospital A

Hospital A is a large urban hospital. Its mission is to provide general, specialised and highly specialised care, and to promote teaching and research. The hospital focuses on four strategic areas, which are trauma (acute care and critical care), cardiovascular health, respiratory health, and mental health. Moreover, it is one of the leading hospitals in tertiary orthopedics and minimally invasive bariatric surgery. The hospital contributes to the training of doctors and healthcare professionals from diverse disciplines through its university affiliation. The hospital's first role is to provide care to the population living in neighbouring areas; however, patients may also come from farther off for tertiary care, as Hospital A excels in various medical specialties. Much of the clientele is made up of elderly people, and the hospital officially serves a population base of over 1,800,000 people.

Information was obtained from both the 2012-2013 and the 2013-2014 annual reports, as the data that is used in this thesis covers the period between 01/01/2013 and 31/12/2013, which is part of two separate financial years. According to the 2012-2013 annual report, the hospital counted 4151 employees as well as 411 doctors in 2013, of which 283 (69%) were specialists and 128 (31%) were general practitioners. During that period, 29.8% of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 9.2% stayed for more than 48 hours. The average occupancy rate of the 46 ED beds at 08:00 was 117.6%. 6968 surgeries requiring hospitalisation were performed during this period. According to the 2013-2014 annual report, 31.2% (+1.4%) of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 9.3% (+0.1%) stayed for more than 48 hours. The average occupancy rate of the 46 ED beds at 08:00 was 120.8%. 7270 (+4.3%) surgeries requiring hospitalisation were performed during this period. Within the period between 01/01/2013 and 31/12/2013, 189 281 people came to the emergency department to receive care, of which 9402 (4.97%) were hospitalised. The hospital contains 554 beds, of which 440 are for physical health, 89 are for mental health, and 25 are beds officially being used by patients waiting to be placed in long-term care facilities. Physical health beds are distributed in 16 different areas, of which the most important are orthopedics, neurology, cardiology and internal medicine. Patients are attributed beds according to the specialty related to their health issues; pooling resources is usually avoided. Hospital A's admission process is illustrated in Figure 4.2.

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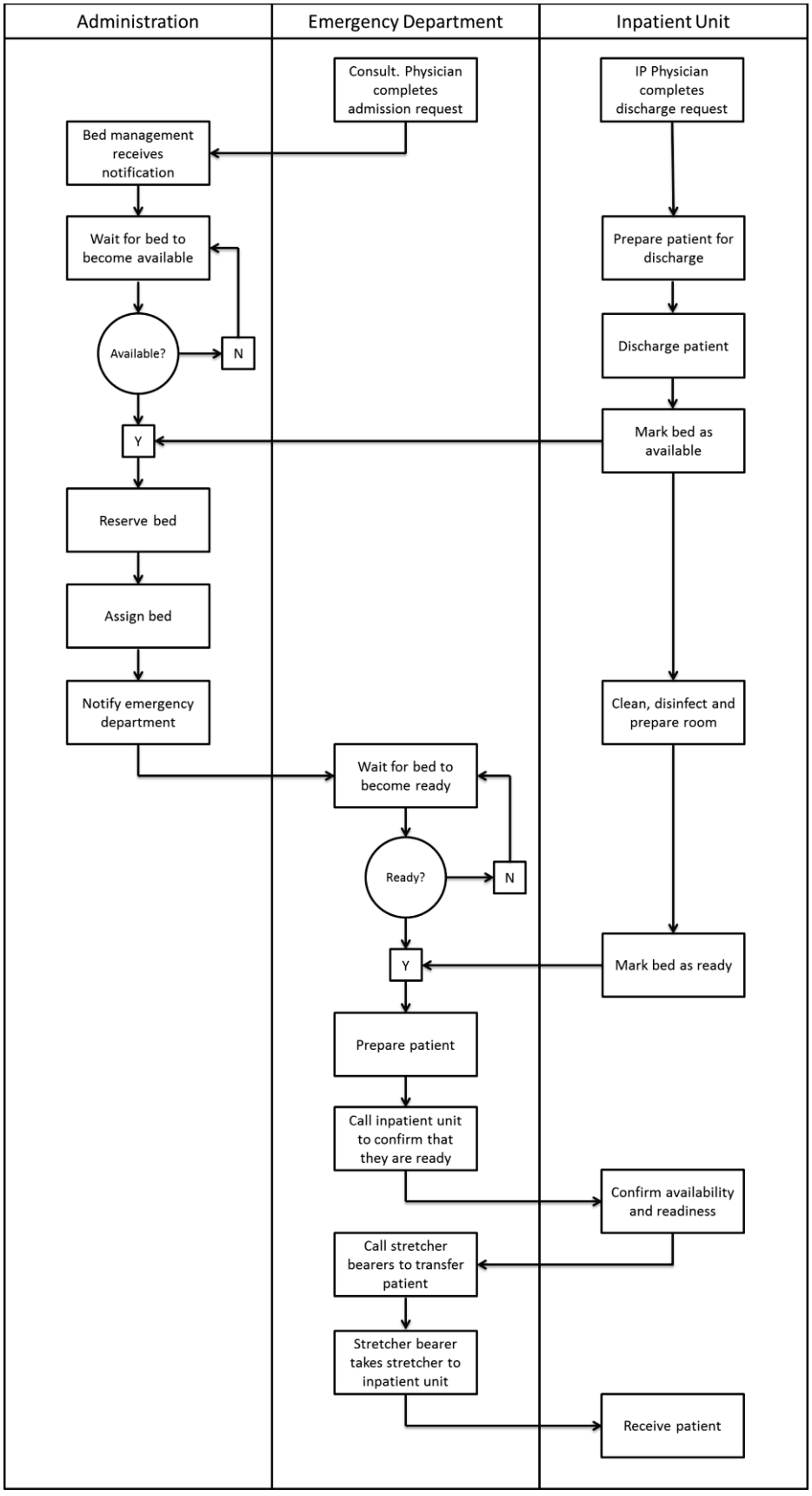

Figure 4.2. Hospital A: Admission process

4.1.1. Presentation of quantitative data

The following data was obtained from the analysis of data covering the period between 01/01/2013 and 31/12/2013. As mentioned in the Introduction, the Ministry of Health and Social Services has set forth a guideline that patients should not wait more than 2 hours between the time that their admission is requested and their arrival to an inpatient bed. For this reason, the distribution of patients was established according to 120 minute intervals, as is illustrated in Figure 4.3. Overall, Hospital A had an 18.85% compliance level with this standard.

Data was first segmented according to seasons in order to understand trends in admissions, average boarding time and compliance levels according to this variable. Spring was the season within which most admissions were requested (26.60%), while Winter saw the least admission requests (23.75%). The season with the poorest performance in terms of average boarding time was Winter (1291.04 minutes), while Spring had the lowest average boarding time of all seasons (822.28 minutes). This data is illustrated in Figure 4.4. Finally, Spring had the highest compliance level with Ministry standards (22.67%), while Summer had the lowest compliance level (15.82%). This data can be seen in the Annexe (Table 7.2). Data concerning all individual patients and their respective boarding times was modeled into SAS in a general linear model using Winter as a reference point. Seasons were found to be statistically significant in affecting boarding times ($p = 0.0001$).

Data was then segmented according to months using the same metrics as for the previous variable. May was the month within which most admissions were requested (8.99%), while February saw the least admission requests (7.55%). The month with the poorest performance in terms of average boarding time was January (1454.47 minutes), while May had the lowest average boarding time of all months (723.39 minutes). This data is illustrated in Figure 4.5. Finally, May had the highest compliance level with Ministry standards (24.85%), while September had the lowest compliance level (12.06%). This data can be seen in the Annexe (Table 7.3). Data concerning all individual patients and their respective boarding times was modeled into SAS using January as a reference point. Months were found to be statistically significant in affecting boarding times ($p = <.0001$).

Data was then segmented according to days of the week using the same metrics. Tuesday was the day of the week within which most admissions were requested (15.95%), while Sunday saw the least admission requests (13.32%). The day of the week with the poorest performance in

terms of average boarding time was Friday (1138.31 minutes), while Monday had the lowest average boarding time of all days of the week (967.36 minutes). This data is illustrated in Figure 4.6. Saturday had the highest compliance level with Ministry standards (23.41%), while Wednesday had the lowest compliance level (16.42%). This data can be seen in the Annexe (Table 7.4). Finally, Friday saw the most discharges (20.75%), while Sunday had the least (6.85%). This data is illustrated in Figure 4.8. Data concerning all individual patients and their respective boarding times was modeled into SAS using Monday as a reference point. Days of the week were not found to be statistically significant in affecting boarding times ($p = 0.0720$).

Finally, data was then segmented on an hourly basis using the same metrics. 16:00-16:59 was the hour within which most admissions were requested (8.85%), while 05:00-05:59 saw the least admission requests (0.71%). The hour with the poorest performance in terms of average boarding time was 11:00-11:59 (1200.24 minutes), while 06:00-06:59 had the lowest average boarding time of all hours (799.13 minutes). This data is illustrated in Figure 4.7. 03:00-03:59 had the highest compliance level with Ministry standards (37.61%), while 11:00-11:59 had the lowest compliance level (11.28%). This data can be seen in the Annexe (Table 7.5). Finally, 14:00-14:59 had the most discharges (11.97%), while 06:00-06:59 had the least (0.20%). This data is illustrated in Figure 4.9. Data concerning all individual patients and their respective boarding times was modeled into SAS; hours were modeled as continuous variables. Hours were not found to be statistically significant in affecting boarding times ($p = 0.1299$).

53.50% of admissions were requested between 08:00 and 15:59, the period within which the hospital has the most personnel. 46.50% of admissions were requested outside of this period, and there was an important peak between 10:00 and 13:59, wherein 31.79% of admissions were requested. 30.70% of arrivals occurred between 08:00 and 15:59. 65.30% of patients arrived to their inpatient beds outside of this period, and there was an important peak between 20:00 and 23:59, wherein 25.05% of arrivals occurred. 65.23% of discharges happened between 08:00 and 15:59. 34.77% of discharges occurred outside of this period, and there was an important peak between 13:00 and 16:59, wherein 40.94% of discharges happened. This data is illustrated in Figure 4.9.

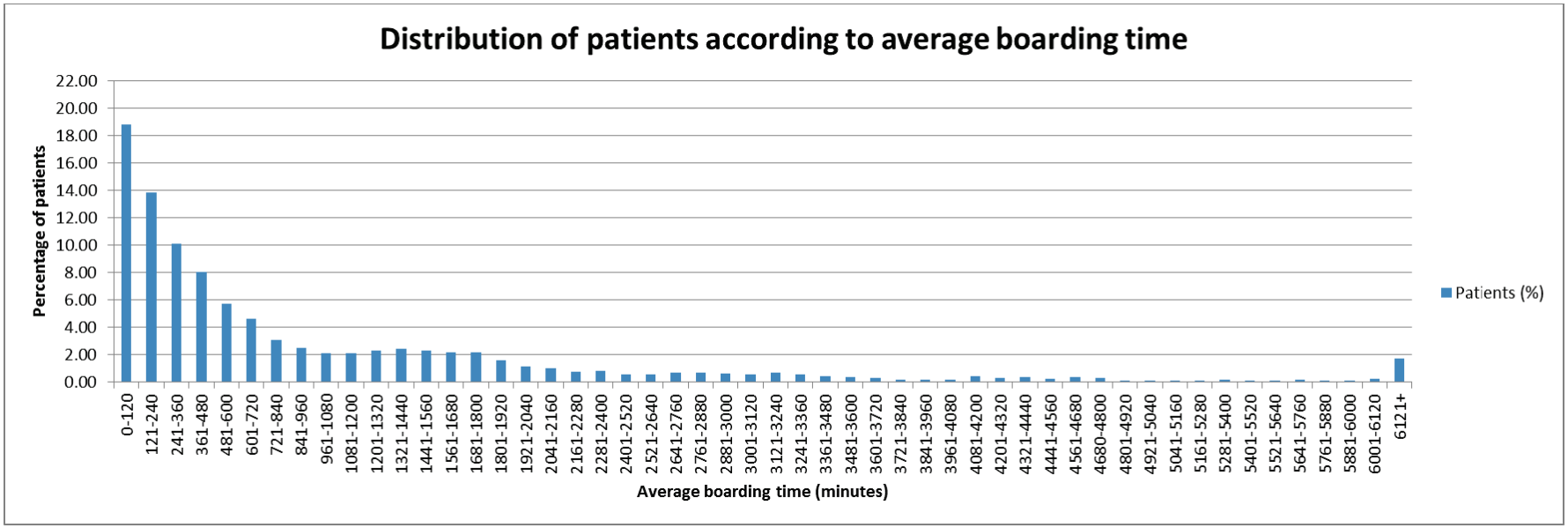

Figure 4.3. Hospital A: Distribution of patients according to boarding time

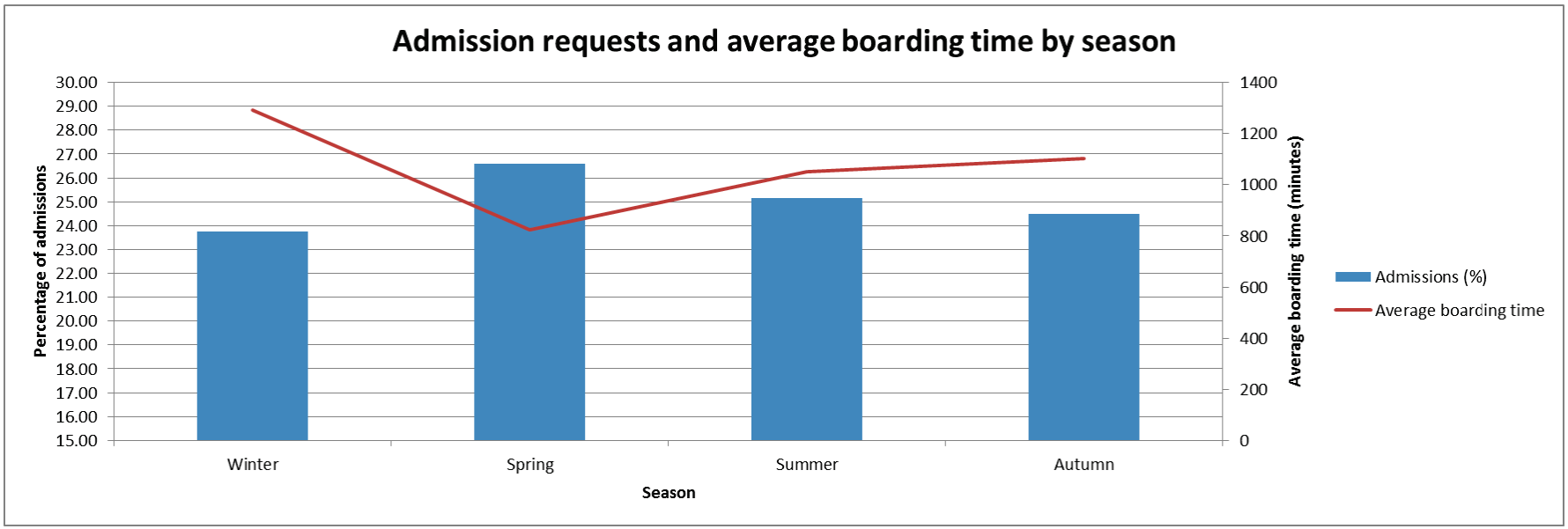

Figure 4.4. Hospital A: Admission request and average boarding time by season

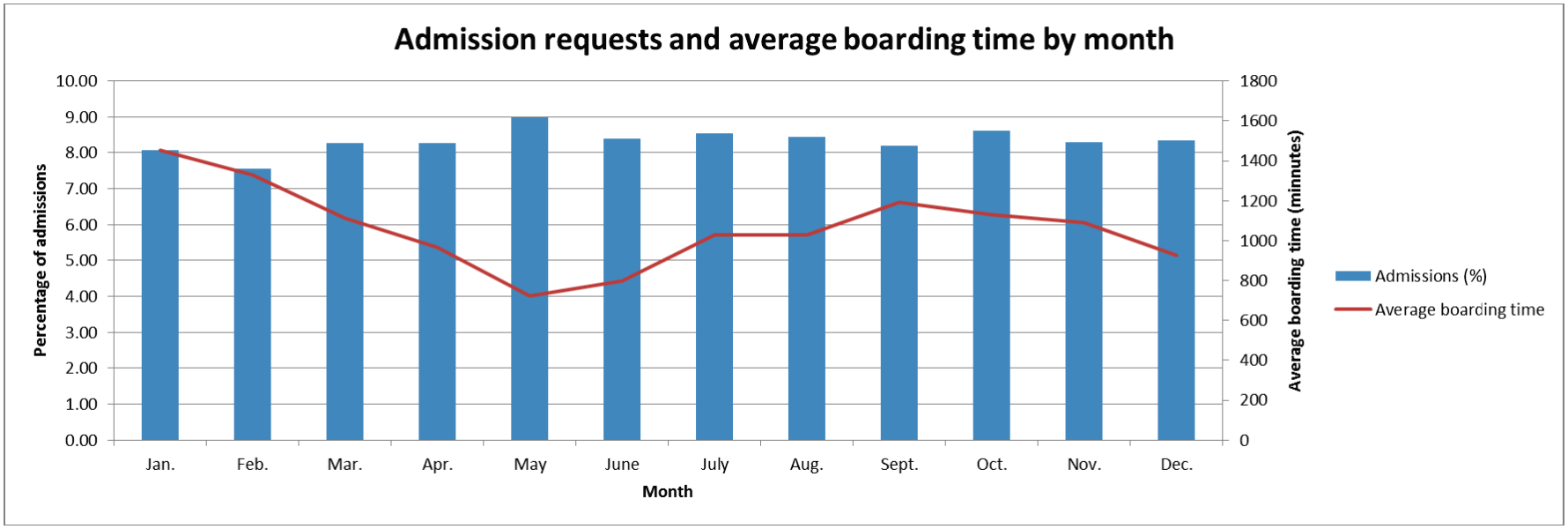

Figure 4.5. Hospital A: Admission request and average boarding time by month

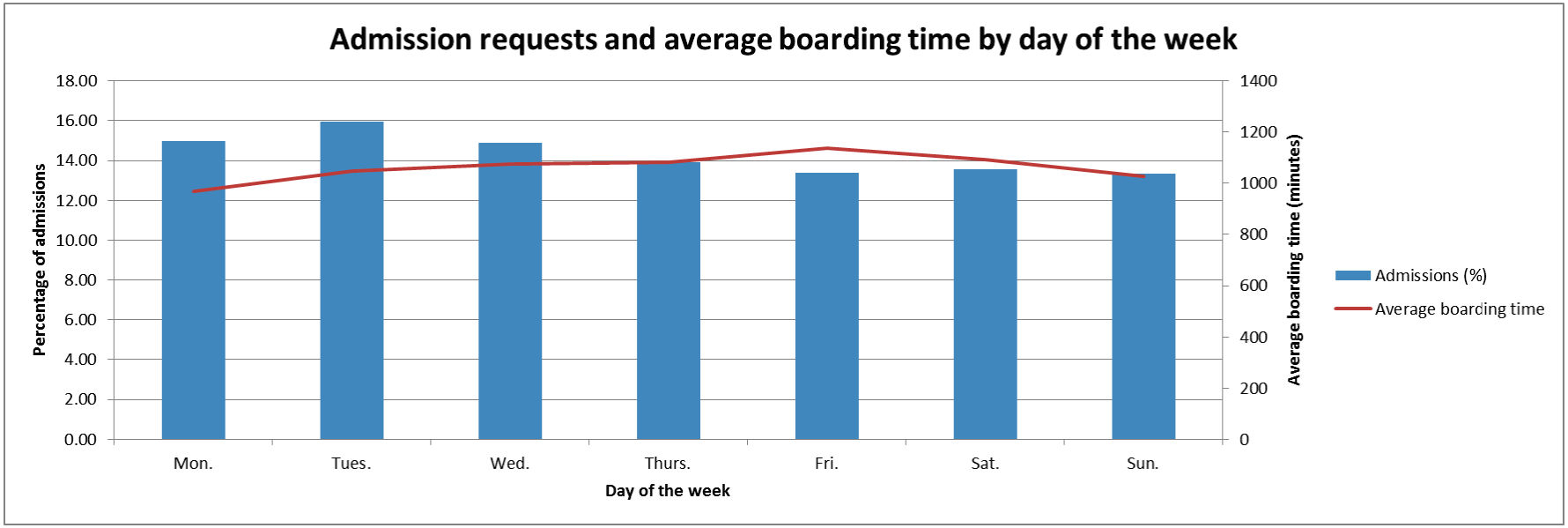

Figure 4.6. Hospital A: Admission request and average boarding time by day of the week

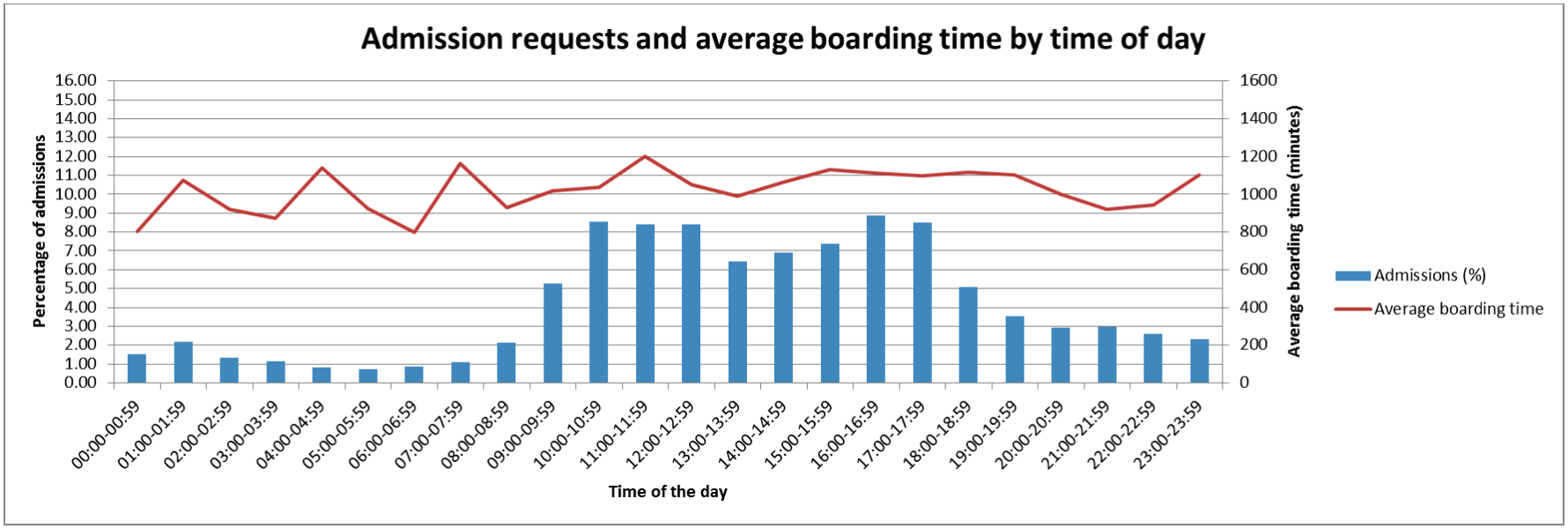

Figure 4.7. Hospital A: Admission request and average boarding time by time of day

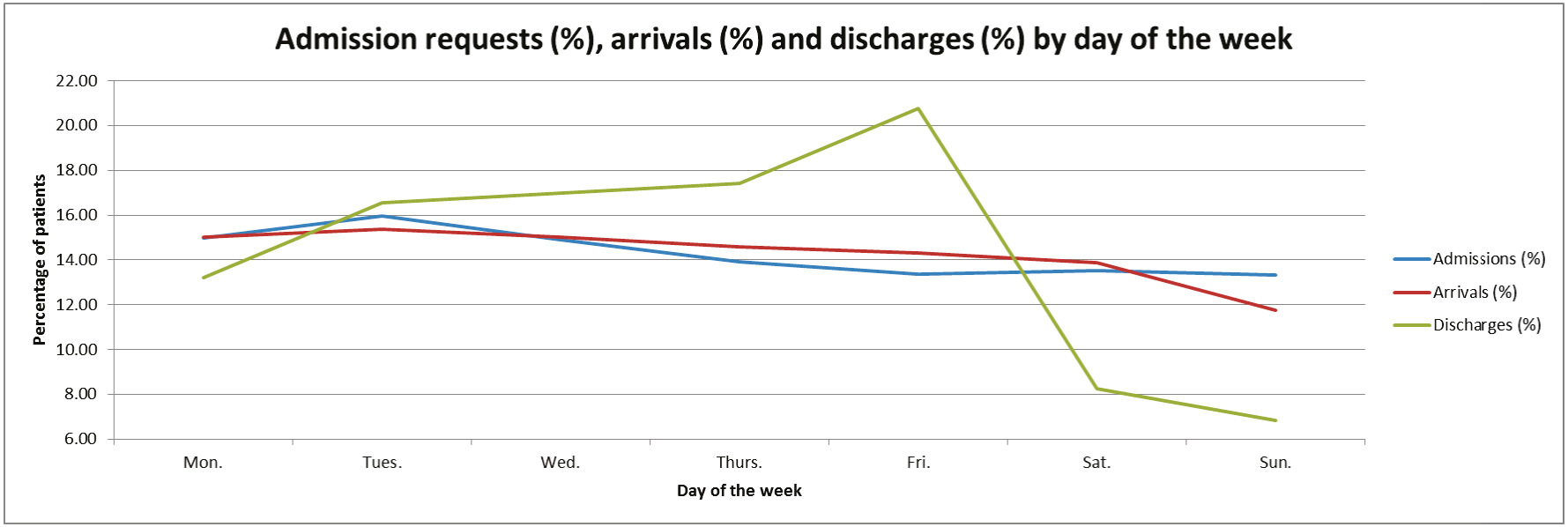

Figure 4.8. Hospital A: Admission requests, arrivals and discharges by day of the week

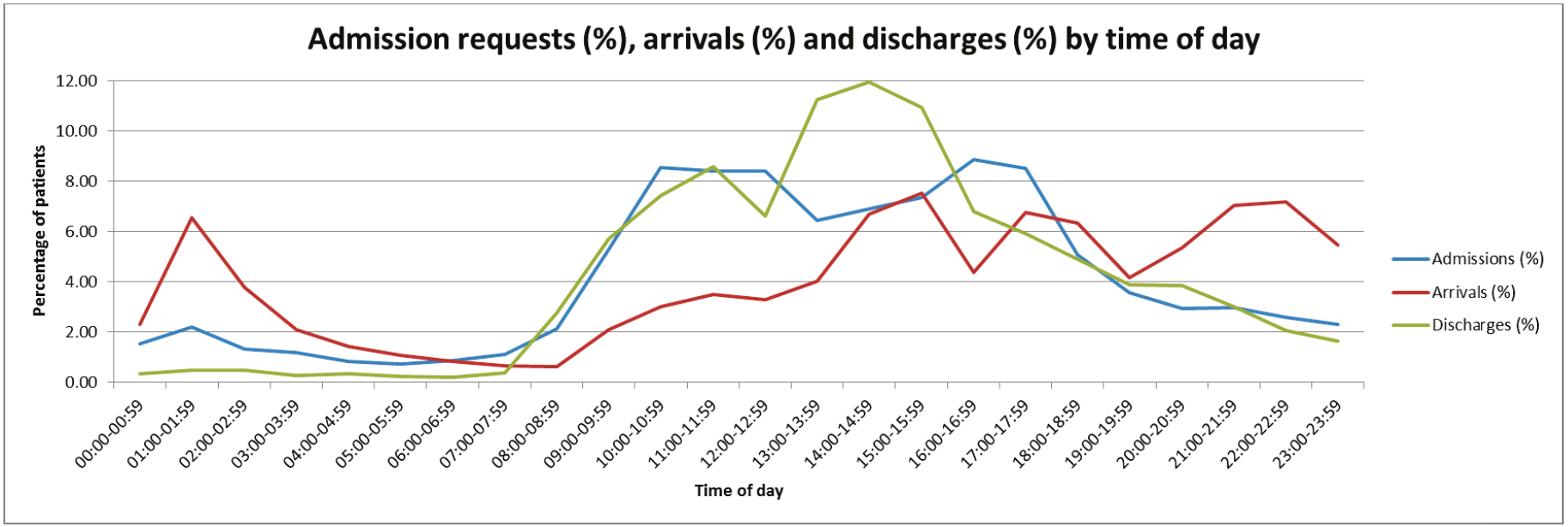

Figure 4.9. Hospital A: Admission requests, arrivals and discharges by time of day

4.1.2. Presentation of qualitative data

The following data was obtained from semi-structured qualitative interviews conducted with Hospital A's employees in November 2014. Five interviewees were categorised as having "Administration" as an employment type. Two of these interviewees were Heads of Inpatient Care Units; one was a Head of Service; one was the Head of the Emergency Department; and one was a Bed Management Coordinator. Four interviewees were categorised as having "Clinical/Support" as an employment type. Two of these interviewees were Assistant Head Nurses; one was a Nurse; and one was an Administrative Assistant. Interviewees were asked to pinpoint 4 key issues causing ED boarding, but were not limited in the amount of solutions they could propose.

The data concerning the causes of ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.1). The causes mentioned are displayed according to the frequency with which they were mentioned:

1. Inability to discharge patients (**5/5** Administration; **2/4** Clinical/Support staff)
2. Specific patient dispositions (**2/5** Adm.; **4/4** C/S)
3. Lack of communication/collaboration/information (**4/5** Adm.; **1/4** C/S)
4. Late discharges (**2/5** Adm.; **3/4** C/S)
5. Specific patient needs (**1/5** Adm.; **4/4** C/S)
6. Imbalance in surgical scheduling (**3/5** Adm.; **1/4** C/S)
7. Uncoordinated admissions and discharges (**2/5** Adm.; **0/4** C/S)

The data concerning the solutions to ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.2). The solutions proposed are displayed according to the frequency with which they were mentioned:

1. Improving communication/collaboration/information" (**5/5** Adm.; **4/4** C/S)
2. Preparing discharge more extensively (**5/5** Adm.; **4/4** C/S)
3. Coordinating discharges/admissions (**5/5** Adm.; **3/4** C/S)
4. Smoothing the elective surgery schedule (**5/5** Adm.; **1/4** C/S)
5. Improving inpatient bed management (**3/5** Adm.; **1/4** C/S)
6. Improving the admission process (**1/5** Adm.; **1/4** C/S)

Outlying data (i.e., causes and solutions mentioned by only one individual) are not displayed above; however, they will be included in the overall analysis in Chapter 5.

		Administration					Clinical/Support staff				
		Head IP	Head IP	Head Serv.	Head ED	BMC	AHN	AHN	Nurse	Assistant	Total (#)
Input	Increase in demand										0
	Non-urgent patients										0
	Frequent users										0
	Discharged patients returning										0
Throughput	Changes in resources										0
	Ancillary service delays										0
	Staffing levels								X		1
	Physician training										0
Output	Hospital restructuring										0
	Hospital bed shortages				X						1
	Late discharges		X			X	X		X	X	5
	Uncoordinated admissions/discharges	X	X								2
Field causes	Specific patient needs (e.g. telemetry)	X					X	X	X	X	5
	Specific patient disposition (e.g. VRE+)	X		X			X	X	X	X	6
	Inability to discharge patients	X	X	X	X	X	X	X			7
	Lack of communication/information		X	X	X	X		X			5
	Imbalance in surgical scheduling			X	X	X				X	4

Table 4.1. Hospital A: Qualitative interview results – causes

		Administration					Clinical/Support staff				
		Head IP	Head IP	Head Serv.	Head ED	BMC	AHN	AHN	Nurse	Assistant	Total (#)
Literature	Coordinating discharges/admissions	X	X	X	X	X	X		X	X	8
	Improving admission process				X			X			2
	Improving inpatient bed management	X	X	X			X				4
	Smoothing elective surgery schedules	X	X	X	X	X				X	6
Field solutions	Improving communication/collaboration	X	X	X	X	X	X	X	X	X	9
	Improving resource management										0
	Improving inf. disease management							X			1
	Preparing discharge more extensively	X	X	X	X	X	X	X	X	X	9
	Improving external resources	X									1

Table 4.2. Hospital A: Qualitative interview results – solutions

4.2. Hospital B

Hospital B is a small urban hospital. It is part of a HSSC (Health and Social Services Center), holding partnerships with three LCSCs (Local Community Services Centres) and seven long-term care facilities. Its mission is to provide general, specialised and highly specialised care, and to promote teaching and research. It has several areas of expertise, namely nephrology, surgery, oncology, palliative care, family medicine, gastroenterology and chronic disease care. It is committed to continuous improvement of both healthcare practices and healthcare practitioners. The hospital aims to ensure the health and well-being of the people living in neighbouring areas by contributing to community development and offering an interdisciplinary range of treatments and services. Its clientele comes mainly from the surrounding boroughs, and as such, the hospital officially serves a population base of over 145,000 people.

Information was obtained from both the 2012-2013 and the 2013-2014 annual reports, as the data that is used in this thesis covers the period between 01/01/2013 and 31/12/2013, which is part of two separate financial years. According to the 2012-2013 annual report, the 11 institutions making up the HSSC counted 3341 employees as well as 250 doctors in 2013. During that period, 33.59% of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 5.66% stayed for more than 48 hours. 1599 surgeries requiring hospitalisation were performed during this period. According to the 2013-2014 annual report, 32.9% (-0.69%) of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 6.3% (+0.64%) stayed for more than 48 hours. 2208 (+38.09%) surgeries requiring hospitalisation were performed during this period. Within the period between 01/01/2013 and 31/12/2013, 46 300 people came to the emergency department to receive care, of which 5498 (11.87%) were hospitalised. The hospital contains 209 inpatient beds, of which 15 are for intensive care. Patients are attributed beds according to the specialty related to their health issues, but pooling happens quite frequently. Pooling is possible when patient disposition and specific needs allow. For example, if a patient is hospitalised for surgical purposes, he will be attributed an inpatient bed in the surgical wing, and cannot be pooled elsewhere. However, a patient hospitalised by gastroenterology can be pooled in various units. Patients requiring specific care (e.g. telemetry) cannot be pooled in units which do not have the required equipment. Hospital B's admission process is illustrated in Figure 4.10.

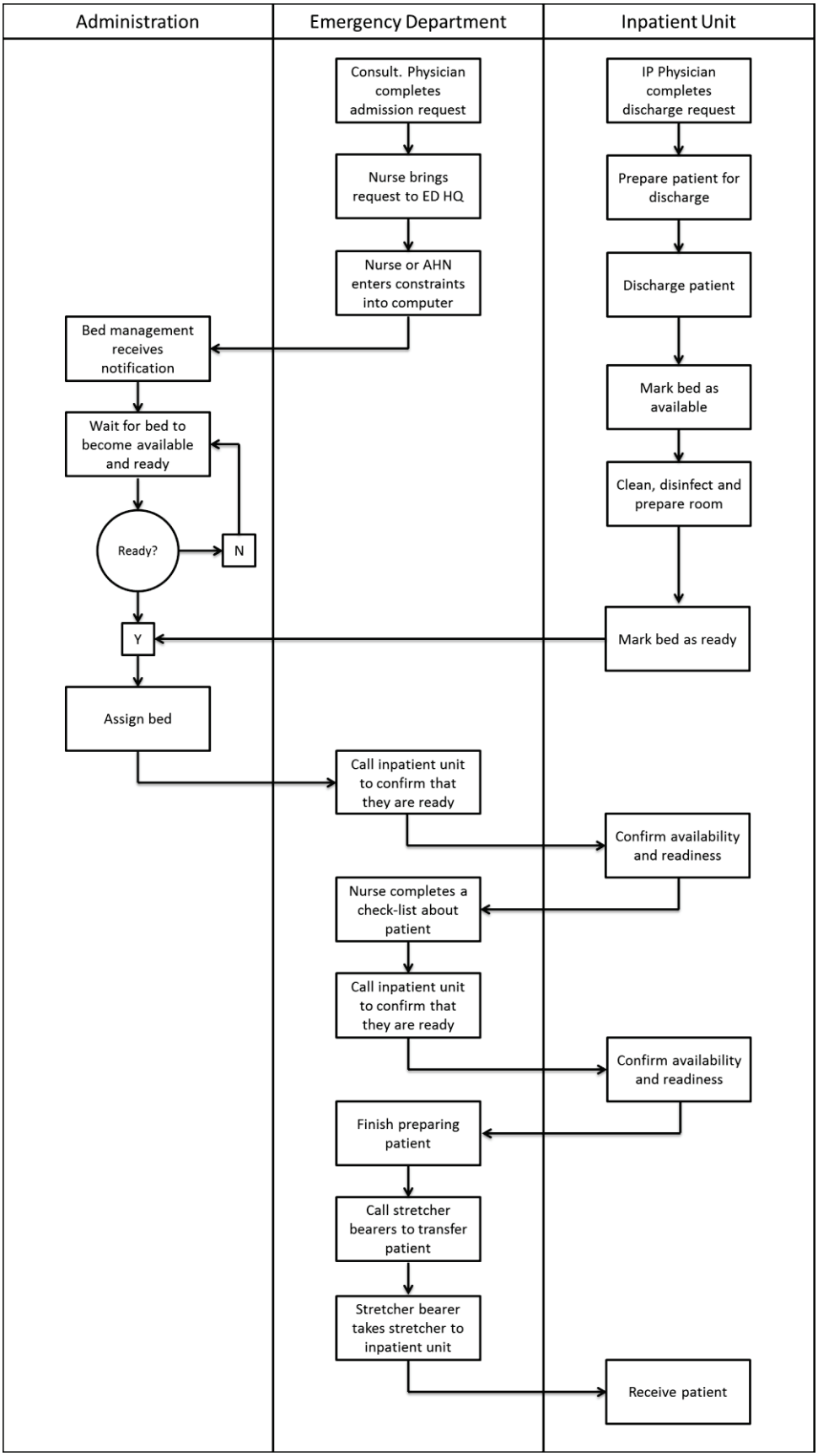

Figure 4.10. Hospital B: Admission process

4.2.1. Presentation of quantitative data

The following data was obtained from the analysis of data covering the period between 01/01/2013 and 31/12/2013. As mentioned in the Introduction, the Ministry of Health and Social Services has set forth a guideline that patients should not wait more than 2 hours between the time that their admission is requested and their arrival to an inpatient bed. For this reason, the distribution of patients was established according to 120 minute intervals, as is illustrated in Figure 4.11. Overall, Hospital A had a 21.00% compliance level with this standard.

Data was first segmented according to seasons in order to understand trends in admissions, average boarding time and compliance levels according to this variable. Spring was the season within which most admissions were requested (25.82%), while Summer saw the least admission requests (23.10%). The season with the poorest performance in terms of average boarding time was Summer (1005.35 minutes), while Autumn had the lowest average boarding time of all seasons (478.19 minutes). This data is illustrated in Figure 4.12. Finally, Autumn had the highest compliance level with Ministry standards (29.96%), while Spring had the lowest compliance level (13.29%). This data can be seen in the Annexe (Table 7.14). Data concerning all individual patients and their respective boarding times was modeled into SAS in a general linear model using Winter as a reference point. Seasons were found to be statistically significant in affecting boarding times ($p = <.0001$).

Data was then segmented according to months using the same metrics as for the previous variable. December was the month within which most admissions were requested (9.62%), while June saw the least admission requests (6.84%). The month with the poorest performance in terms of average boarding time was June (1383.13 minutes), while November had the lowest average boarding time of all months (245.61 minutes). This data is illustrated in Figure 4.13. Finally, November had the highest compliance level with Ministry standards (46.08%), while September had the lowest compliance level (9.37%). This data can be seen in the Annexe (Table 7.15). Data concerning all individual patients and their respective boarding times was modeled into SAS using January as a reference point. Months were found to be statistically significant in affecting boarding times ($p = <.0001$).

Data was then segmented according to days of the week using the same metrics. Tuesday was the day of the week within which most admissions were requested (15.67%), while Sunday saw the least admission requests (11.55%). The day of the week with the poorest performance in

terms of average boarding time was Monday (937.13 minutes), while Friday had the lowest average boarding time of all days of the week (460.82 minutes). This data is illustrated in Figure 4.14. Saturday had the highest compliance level with Ministry standards (32.91%), while Monday had the lowest compliance level (13.98%). This data can be seen in the Annexe (Table 7.16). Finally, Friday saw the most discharges (22.65%), while Sunday had the least (6.63%). This data is illustrated in Figure 4.16. Data concerning all individual patients and their respective boarding times was modeled into SAS using Monday as a reference point. Days of the week were found to be statistically significant in affecting boarding times ($p = <.0001$).

Finally, data was then segmented on an hourly basis using the same metrics. 16:00-16:59 was the hour within which most admissions were requested (15.44%), while 05:00-05:59 saw the least admission requests (0.07%). The hour with the poorest performance in terms of average boarding time was 23:00-23:59 (1021.11 minutes), while 06:00-06:59 had the lowest average boarding time of all hours (360.06 minutes). This data is illustrated in Figure 4.15. 01:00-01:59 had the highest compliance level with Ministry standards (36.84%), while 06:00-06:59 had the lowest compliance level (11.11%). This data can be seen in the Annexe (Table 7.17). Finally, 14:00-14:59 had the most discharges (14.81%), while 03:00-03:59 had the least (0.16%). This data is illustrated in Figure 4.17. Data concerning all individual patients and their respective boarding times was modeled into SAS; hours were modeled as continuous variables. Hours were found to be statistically significant in affecting boarding times ($p = <.0001$).

45.56% of admissions were requested between 08:00 and 15:59, the period within which the hospital has the most personnel. 54.44% of admissions were requested outside of this period, and there was an important peak between 15:00 and 18:59, wherein 51.54% of admissions were requested. 27.67% of arrivals occurred between 08:00 and 15:59. 68.33% of patients arrived to their inpatient beds outside of this period, and there was an important peak between 18:00 and 21:59, wherein 35.10% of arrivals occurred. 67.56% of discharges happened between 08:00 and 15:59. 32.44% of discharges occurred outside of this period, and there was an important peak between 13:00 and 16:59, wherein 49.47% of discharges happened. This data is illustrated in Figure 4.17.

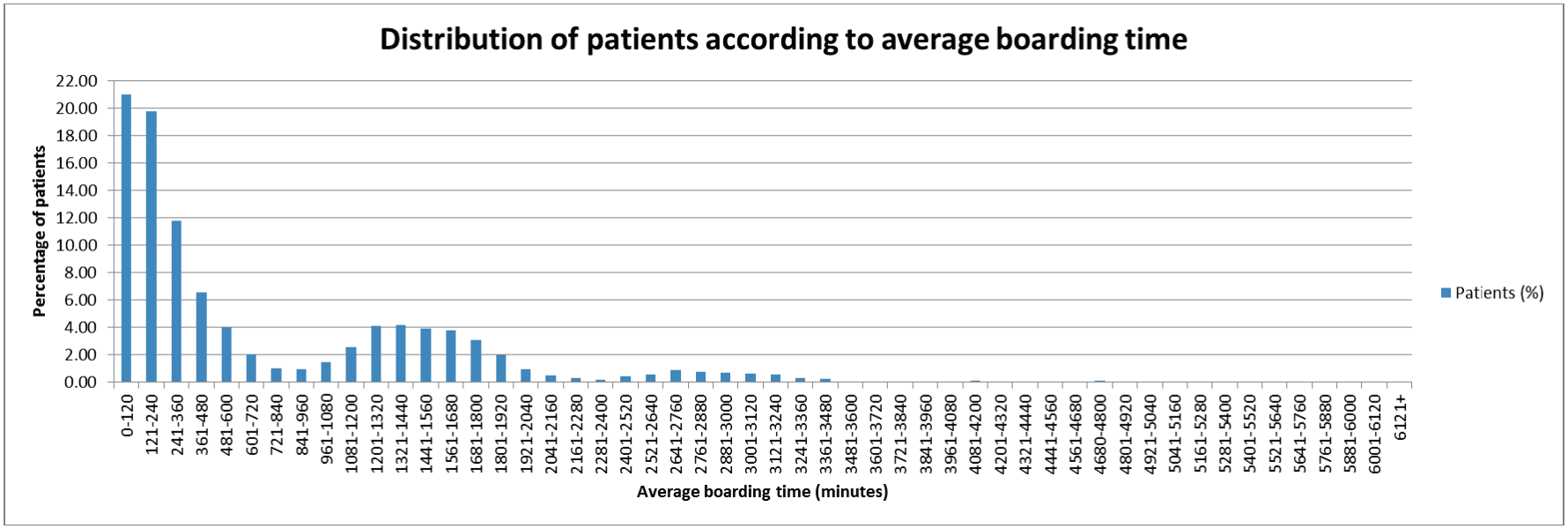

Figure 4.11. Hospital B: Distribution of patients according to boarding time

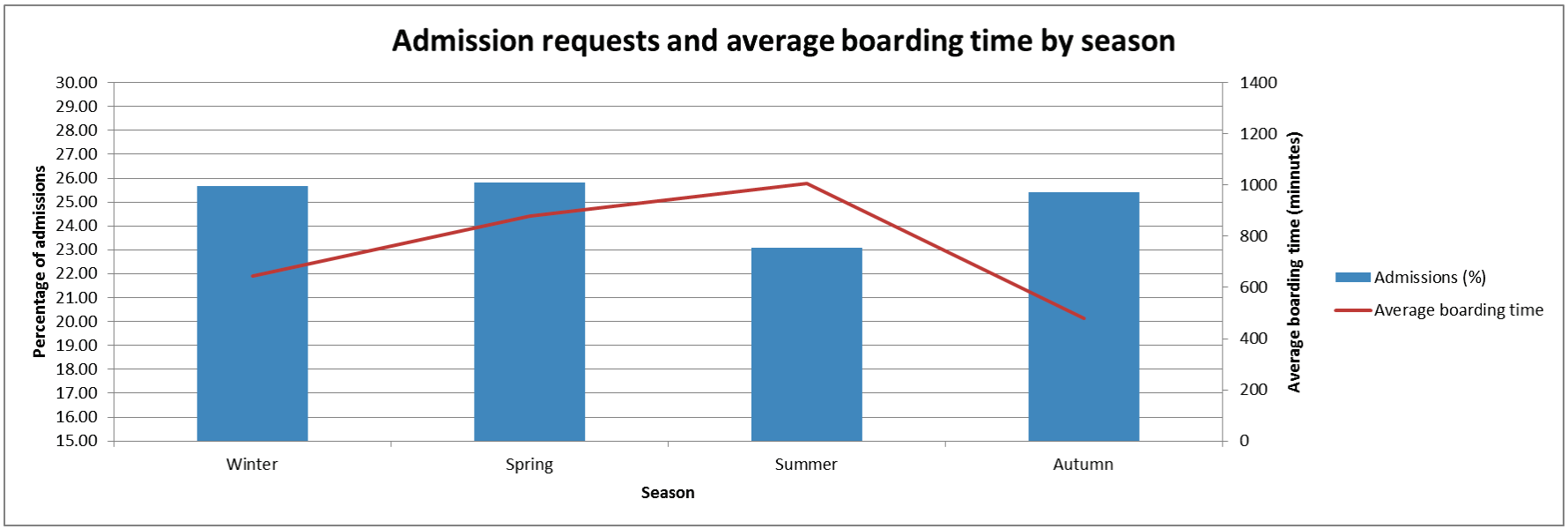

Figure 4.12. Hospital B: Admission request and average boarding time by season

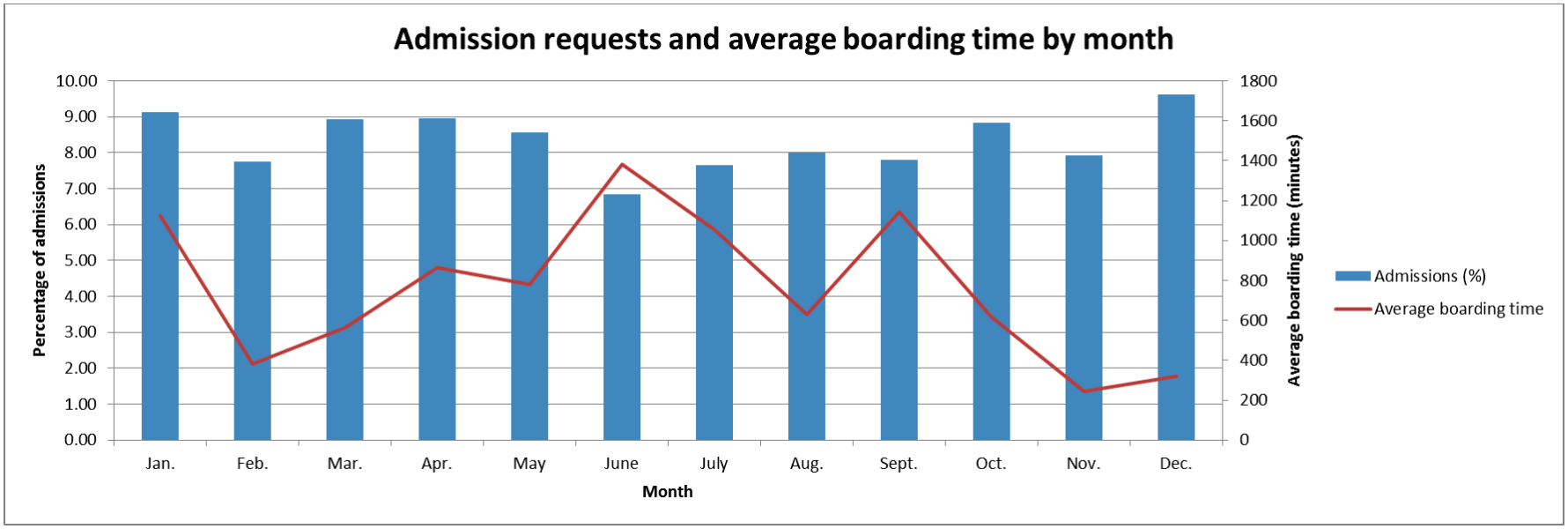

Figure 4.13. Hospital B: Admission request and average boarding time by month

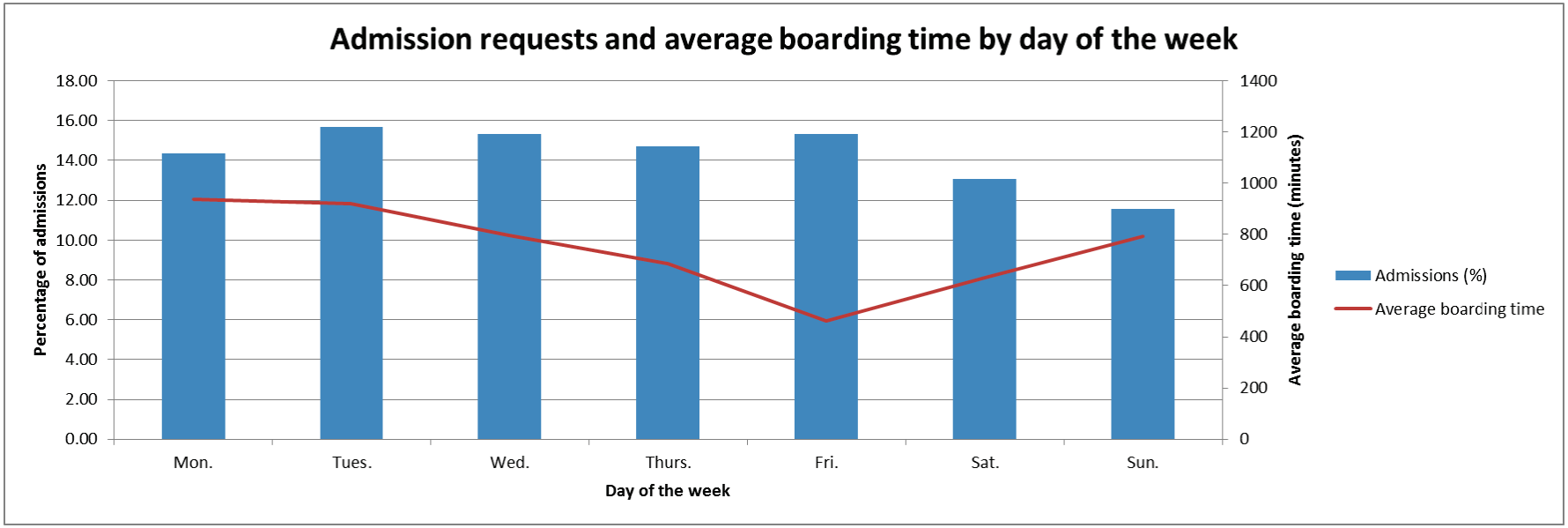

Figure 4.14. Hospital B: Admission request and average boarding time by day of the week

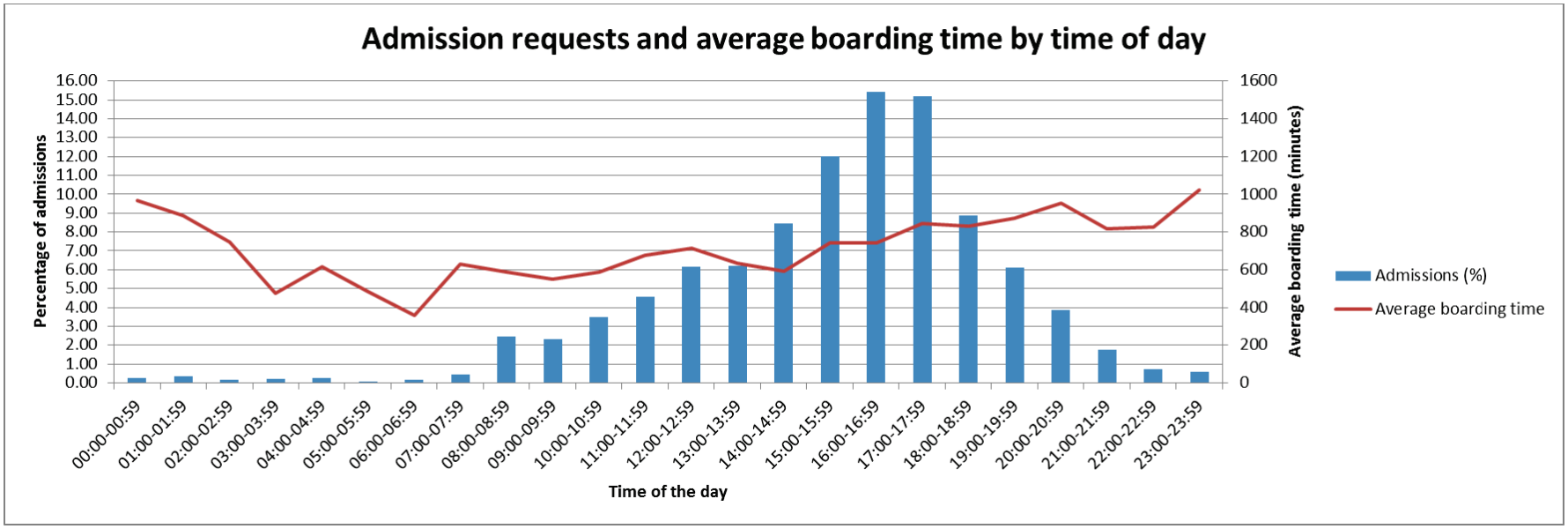

Figure 4.15. Hospital B: Admission request and average boarding time by time of day

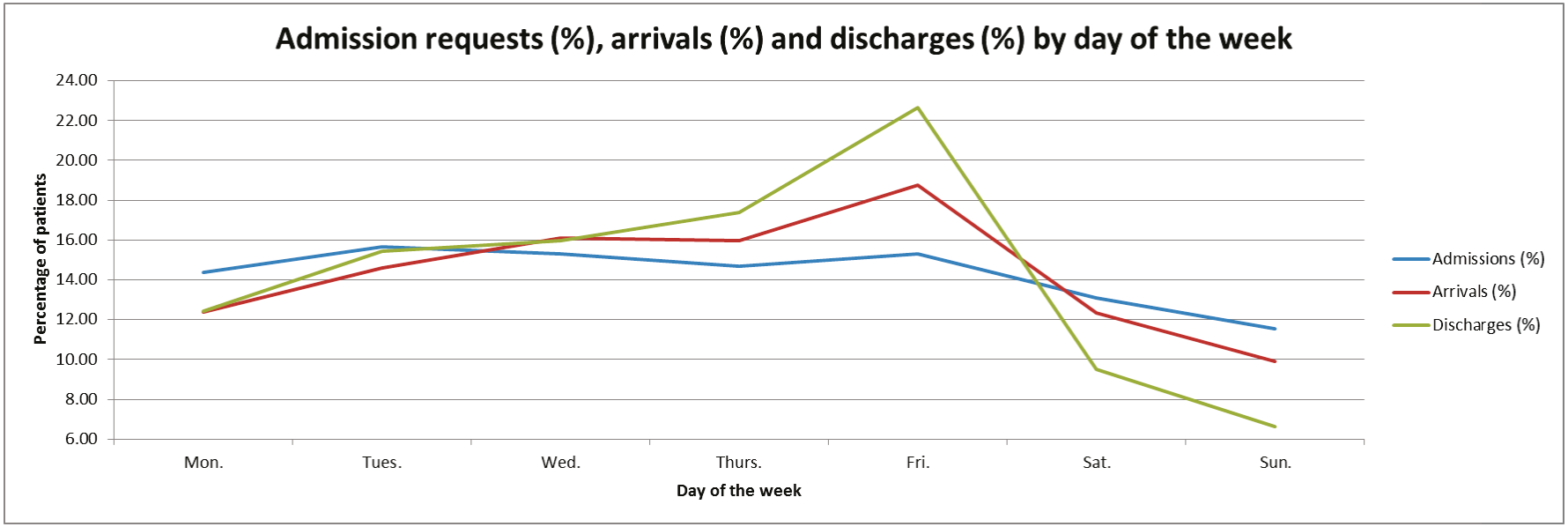

Figure 4.16. Hospital B: Admission requests, arrivals and discharges by day of the week

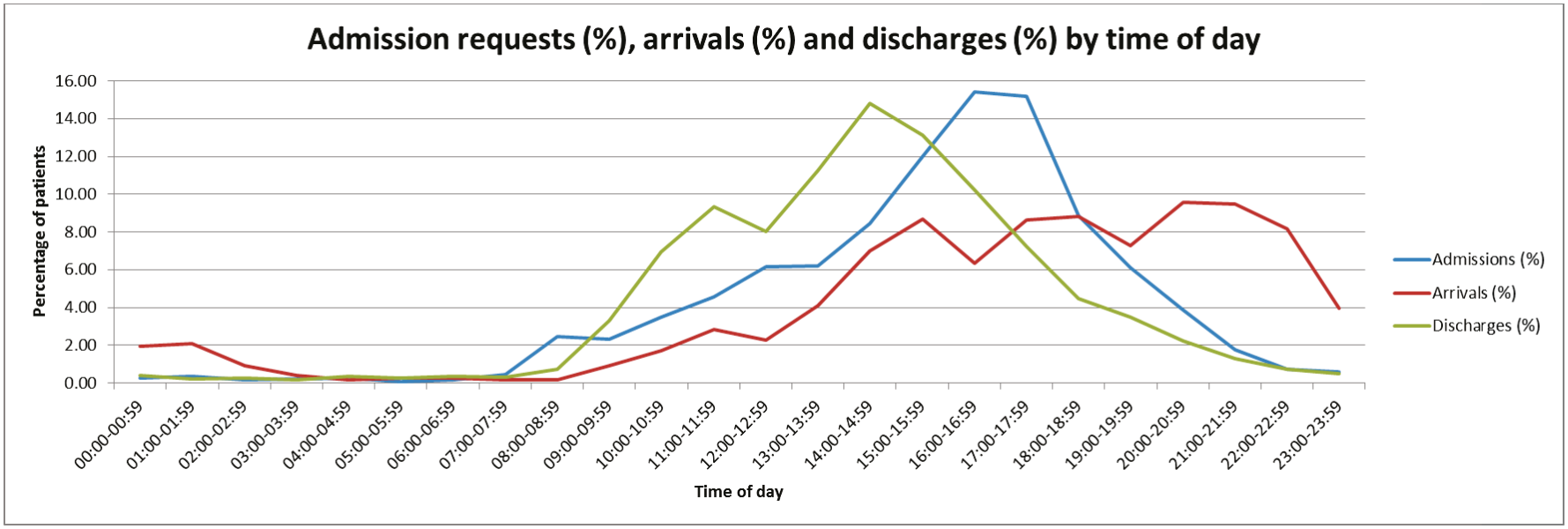

Figure 4.17. Hospital B: Admission requests, arrivals and discharges by time of day

4.2.2. Presentation of qualitative data

The following data was obtained from semi-structured qualitative interviews conducted with Hospital B's employees in October 2014. Four interviewees were categorised as having "Administration" as an employment type. Three of these interviewees were Head of Inpatient Care units; one was the Head of the Emergency Department. Four interviewees were categorised as having "Clinical/Support" as an employment type. One of these interviewees was an Assistant Head Nurse; one was a Nurse; one was an Orderly; and one was a Social Worker. Interviewees were asked to pinpoint 4 key issues causing ED boarding, but were not limited in the amount of solutions they could propose.

The data concerning the causes of ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.3). The causes mentioned are displayed according to the frequency with which they were mentioned:

1. Lack of communication/collaboration/information (**4/4** Adm.; **3/4** C/S)
2. Late discharges (**3/4** Adm.; **2/4** C/S)
3. Uncoordinated admissions/discharges (**4/4** Adm.; **1/4** C/S)
4. Inability to discharge patients (**2/4** Adm.; **3/4** C/S)
5. Staffing levels (**1/4** Adm.; **2/4** C/S)
6. Ancillary service delays (**1/4** Adm.; **1/4** C/S)
7. Specific patient needs (**1/4** Adm.; **1/4** C/S)
8. Specific patient disposition (**0/4** Adm.; **2/4** C/S)

The data concerning the solutions to ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.4). The solutions proposed are displayed according to the frequency with which they were mentioned:

1. Improving communication/collaboration/information (**4/4** Adm.; **4/4** C/S)
2. Coordinating discharges/admissions (**4/4** Adm.; **2/4** C/S)
3. Preparing discharge more extensively (**4/4** Adm.; **2/4** C/S)
4. Improving infectious disease management (**3/4** Adm.; **1/4** C/S)
5. Improving admission process (**2/4** Adm.; **1/4** C/S)
6. Improving resource management (**1/4** Adm.; **2/4** C/S)
7. Improving external resources (**1/4** Adm.; **1/4** C/S)

As mentioned in Section 4.1.2, outlying data is only included in the overall analysis in Chapter 5.

		Administration				Clinical/Support staff				
		Head IP	Head IP	Head IP	Head ED	AHN	Nurse	Orderly	Social W.	**Total (#)**
Input	Increase in demand									0
	Non-urgent patients									0
	Frequent users							X		1
	Discharged patients returning									0
Throughput	Changes in resources									0
	Ancillary service delays		X				X			2
	Staffing levels			X		X		X		3
	Physician training									0
Output	Hospital restructuring									0
	Hospital bed shortages									0
	Late discharges	X	X		X		X		X	5
	Uncoordinated admissions/discharges	X	X	X	X				X	5
Field causes	Specific patient needs (e.g. telemetry)	X				X				2
	Specific patient disposition (e.g. VRE+)					X		X		2
	Inability to discharge patients			X	X		X	X	X	5
	Lack of communication/information	X	X	X	X	X	X		X	7
	Imbalance in surgical scheduling									0

Table 4.3. Hospital B: Qualitative interview results – causes

		Administration				Clinical/Support staff				
		Head IP	Head IP	Head IP	Head ED	AHN	Nurse	Orderly	Social W.	**Total (#)**
Literature	Coordinating discharges/admissions	X	X	X	X		X		X	6
	Improving admission process	X		X			X			3
	Improving inpatient bed management									0
	Smoothing elective surgery schedules									0
Field solutions	Improving communication/collaboration	X	X	X	X	X	X	X	X	8
	Improving resource management	X				X		X		3
	Improving inf. disease management	X	X	X			X			4
	Preparing discharge more extensively	X	X	X	X		X		X	6
	Improving external resources				X				X	2

Table 4.4. Hospital B: Qualitative interview results – solutions

4.3. Hospital C

Hospital C is a small regional hospital. Its mission is to promote, maintain and improve the health and well-being of the people living within the boundaries of over twenty different municipalities. Thirteen different institutions make up this HSSC: one hospital, four LCSCs, three long-term care facilities and five other healthcare-related establishments. The hospital currently cares for fewer elderly people than most other hospitals in Quebec (about 13% of its population base is over 65 years old), although the local demographic is aging quite rapidly. Also, its clientele comes mainly from the surrounding areas, and as such, the hospital officially serves a population base of over 205,000 people.

Information was obtained from both the 2012-2013 and the 2013-2014 annual reports, as the data that is used in this thesis covers the period between 01/01/2013 and 31/12/2013, which is part of two separate financial years. According to the 2012-2013 annual report, the 13 institutions making up the HSSC counted 2574 employees as well as 226 doctors in 2013. During that period, 39.1% of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 6.9% stayed for more than 48 hours. According to the 2013-2014 annual report, 40.7% (+1.6%) of patients entering the ED, whether to be admitted or discharged, stayed for more than 24 hours, and 10.1% (+3.2%) stayed for more than 48 hours. Within the period between 01/01/2013 and 31/12/2013, 42 574 people came to the emergency department to receive care, of which 5517 (12.96%) were hospitalised. The hospital has 241 inpatient beds, 256 counting overflow beds. The majority of beds are attributed to general medicine (118 beds), and the remaining are attributed to surgery, psychiatry, intensive care, neo-natal, and transitional care. Most patients are admitted to general medicine, as the hospital offers little tertiary care. Pooling is possible when patient disposition and specific needs allow, although very little pooling is required given the sectors that are available in the hospital. Hospital C's admission process is illustrated in Figure 4.18.

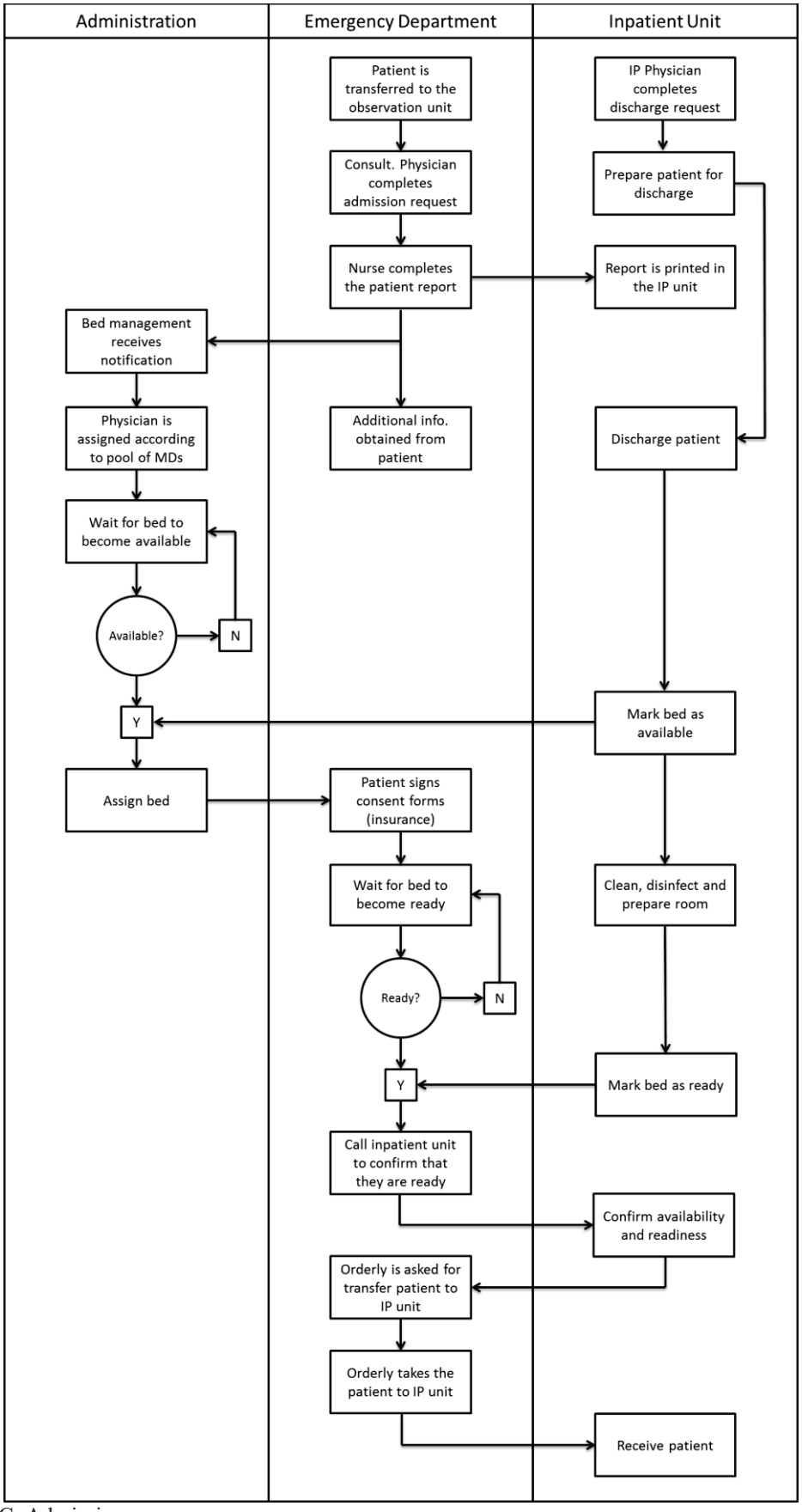

Figure 4.18. Hospital C: Admission process

4.3.1. Presentation of quantitative data

The following data was obtained from the analysis of data covering the period between 01/01/2013 and 31/12/2013. As mentioned in the Introduction, the Ministry of Health and Social Services has set forth a guideline that patients should not wait more than 2 hours between the time that their admission is requested and their arrival to an inpatient bed. For this reason, the distribution of patients was established according to 120 minute intervals, as is illustrated in Figure 4.19. Overall, Hospital C had an 11.94% compliance level with this standard.

Data was first segmented according to seasons in order to understand trends in admissions, average boarding time and compliance levels according to this variable. Spring was the season within which most admissions were requested (25.81%), while Winter saw the least admission requests (24.29%). The season with the poorest performance in terms of average boarding time was Spring (1165.97 minutes), while Summer had the lowest average boarding time of all seasons (737.58 minutes). This data is illustrated in Figure 4.20. Finally, Summer had the highest compliance level with Ministry standards (13.81%), while Spring had the lowest compliance level (10.28%). This data can be seen in the Annexe (Table 7.27). Data concerning all individual patients and their respective boarding times was modeled into SAS in a general linear model using Winter as a reference point. Seasons were found to be statistically significant in affecting boarding times ($p = <.0001$).

Data was then segmented according to months using the same metrics as for the previous variable. January was the month within which most admissions were requested (8.76%), while February saw the least admission requests (7.80%). The month with the poorest performance in terms of average boarding time was April (1569.35 minutes), while July had the lowest average boarding time of all months (638.57 minutes). This data is illustrated in Figure 4.21. Finally, August had the highest compliance level with Ministry standards (15.34%), while May had the lowest compliance level (8.16%). This data can be seen in the Annexe (Table 7.28). Data concerning all individual patients and their respective boarding times was modeled into SAS using January as a reference point. Months were found to be statistically significant in affecting boarding times ($p = <.0001$).

Data was then segmented according to days of the week using the same metrics. Friday was the day of the week within which most admissions were requested (15.63%), while Sunday saw the least admission requests (12.38%). The day of the week with the poorest performance in

terms of average boarding time was Sunday (1194.37 minutes), while Friday had the lowest average boarding time of all days of the week (769.27 minutes). This data is illustrated in Figure 4.22. Thursday had the highest compliance level with Ministry standards (14.67%), while Monday had the lowest compliance level (9.37%). This data can be seen in the Annexe (Table 7.29). Finally, Friday saw the most discharges (19.15%), while Sunday had the least (10.00%). This data is illustrated in Figure 4.24. Data concerning all individual patients and their respective boarding times was modeled into SAS using Monday as a reference point. Days of the week were found to be statistically significant in affecting boarding times ($p = <.0001$).

Finally, data was then segmented on an hourly basis using the same metrics. 14:00-14:59 was the hour within which most admissions were requested (8.71%), while 04:00-04:59 saw the least admission requests (0.80%). The hour with the poorest performance in terms of average boarding time was 03:00-03:59 (1488.93 minutes), while 13:00-13:59 had the lowest average boarding time of all hours (813.30 minutes). This data is illustrated in Figure 4.23. 21:00-21:59 had the highest compliance level with Ministry standards (22.28%), while 06:00-06:59 had the lowest compliance level (2.67%). This data can be seen in the Annexe (Table 7.30). Finally, 14:00-14:59 had the most discharges (12.87%), while 02:00-02:59 had the least (0.31%). This data is illustrated in Figure 4.25. Data concerning all individual patients and their respective boarding times was modeled into SAS; hours were modeled as continuous variables. Hours were found to be statistically significant in affecting boarding times ($p = <.0001$).

41.83% of admissions were requested between 08:00 and 15:59, the period within which the hospital has the most personnel. 58.17% of admissions were requested outside of this period, and there was an important peak between 14:00 and 17:59, wherein 32.10% of admissions were requested. 23.94% of arrivals occurred between 08:00 and 15:59. 76.06% of patients arrived to their inpatient beds outside of this period, and there was an important peak between 19:00 and 22:59, wherein 36.39% of arrivals occurred. 59.49% of discharges happened between 08:00 and 15:59. 40.51% of discharges occurred outside of this period, and there was an important peak between 13:00 and 16:59, wherein 40.84% of discharges happened. This data is illustrated in Figure 4.25.

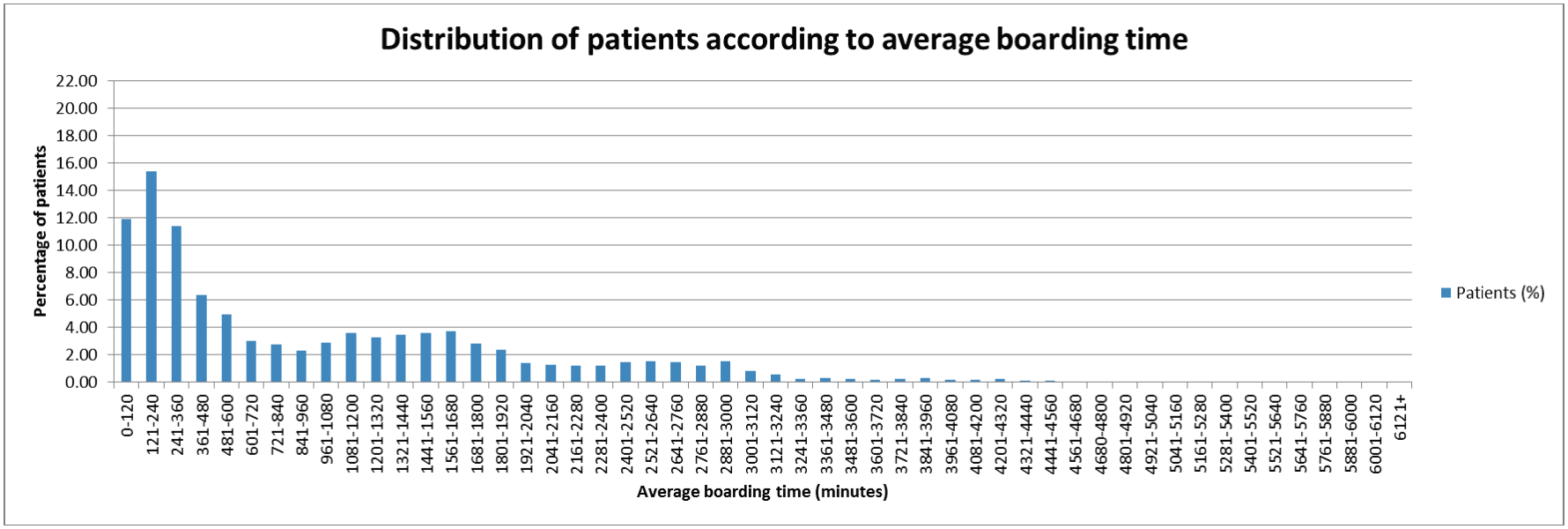

Figure 4.19. Hospital C: Distribution of patients according to boarding time

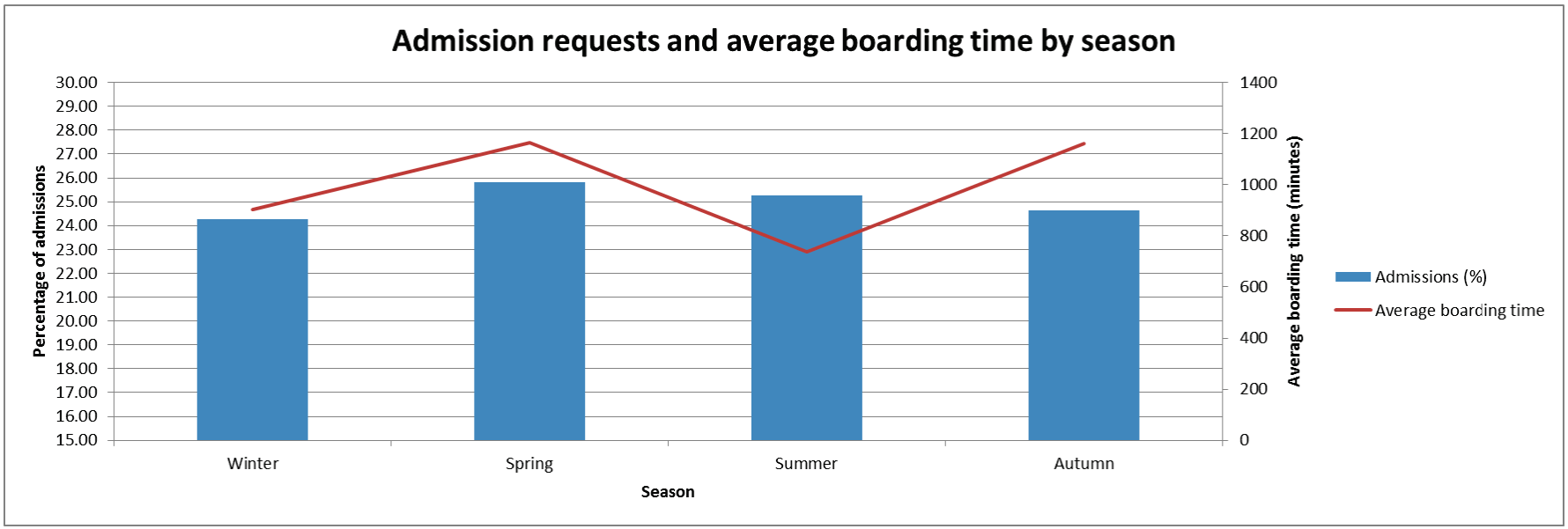

Figure 4.20. Hospital C: Admission request and average boarding time by season

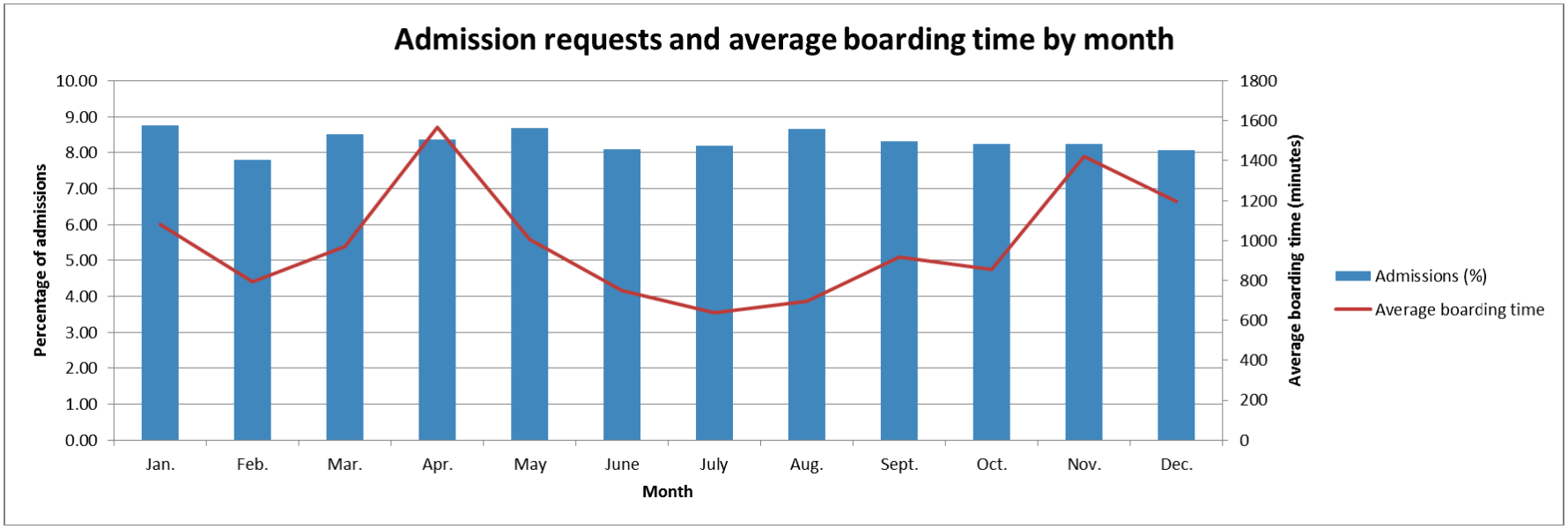

Figure 4.21. Hospital C: Admission request and average boarding time by month

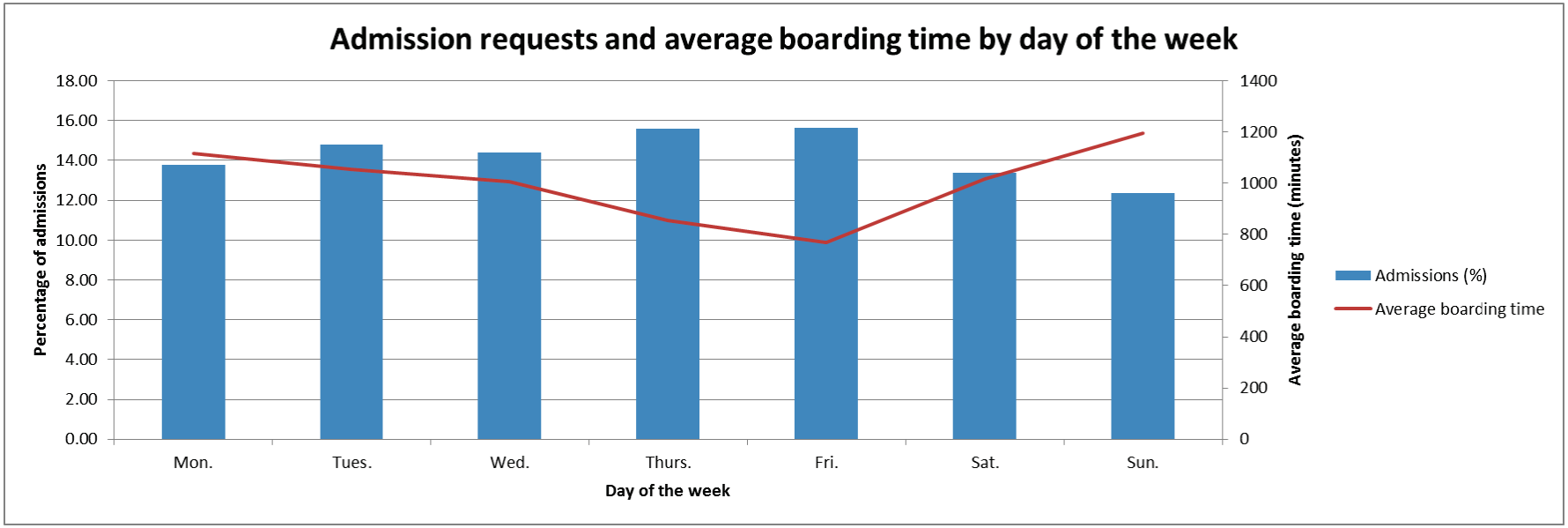

Figure 4.22. Hospital C: Admission request and average boarding time by day of the week

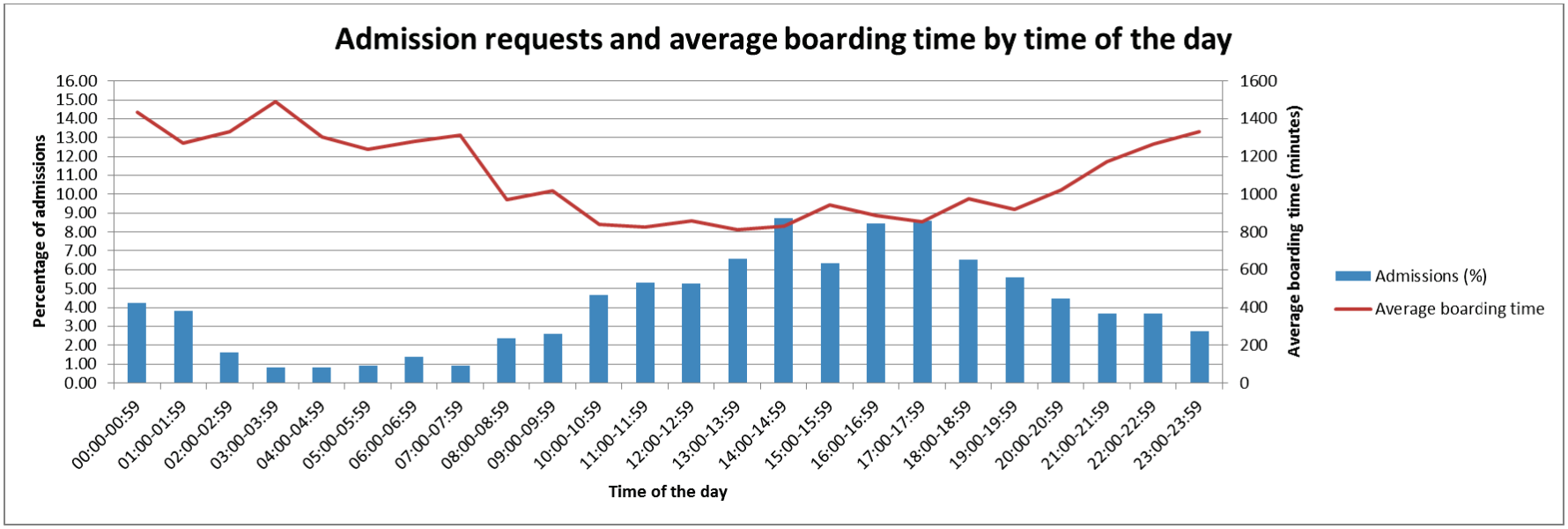

Figure 4.23. Hospital C: Admission request and average boarding time by time of day

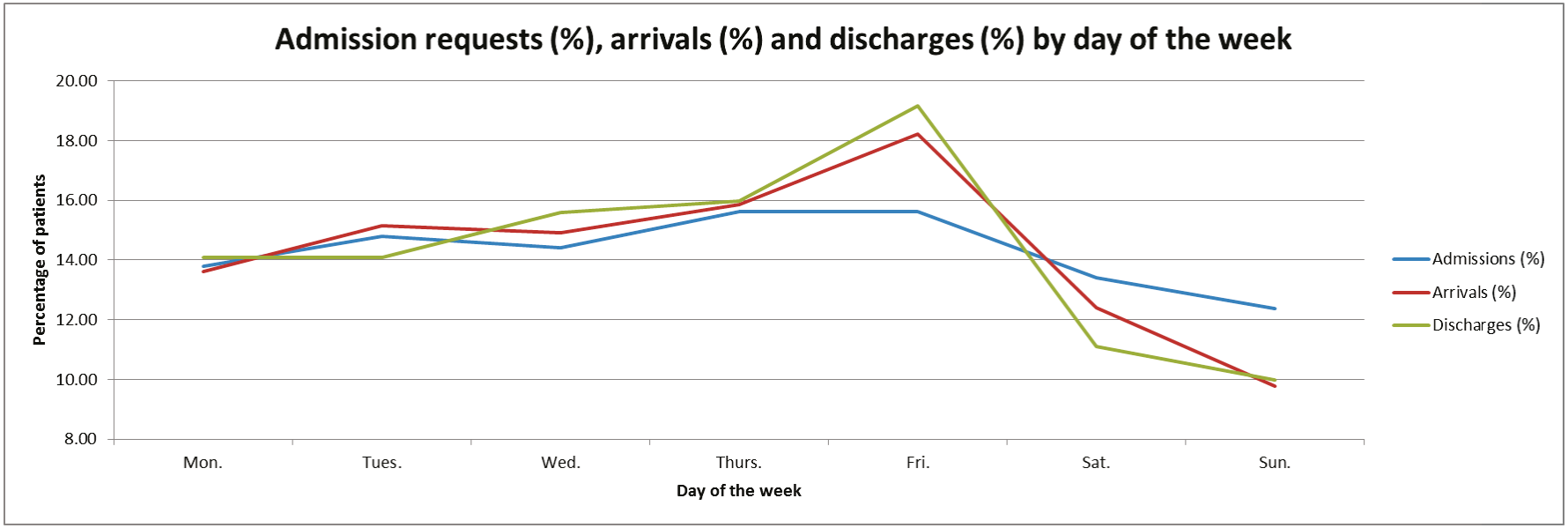

Figure 4.24. Hospital C: Admission requests, arrivals and discharges by day of the week

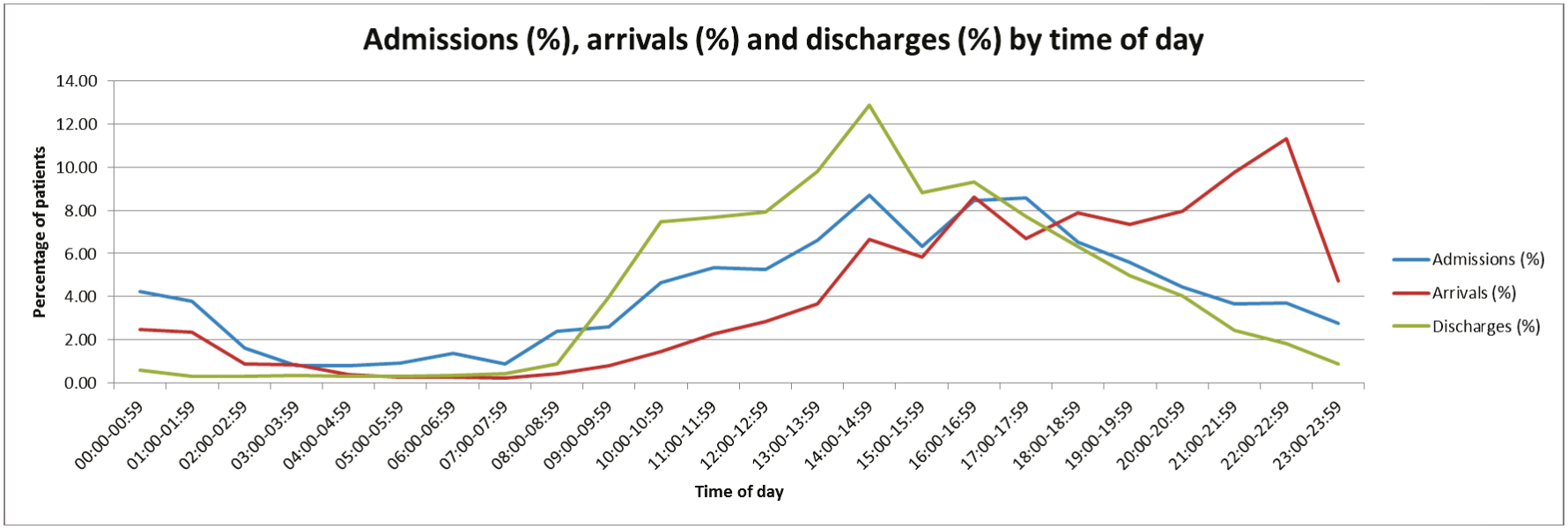

Figure 4.25. Hospital C: Admission requests, arrivals and discharges by time of day

4.3.2. Presentation of qualitative data

The following data was obtained from semi-structured qualitative interviews conducted with Hospital C's employees in October 2014. Four interviewees were categorised as having "Administration" as an employment type. One of these interviewees Head of an Inpatient Care Unit; one was the Head of the Emergency Department; one was an Assistant Director; and one was a Bed Management Coordinator. Four interviewees were categorised as having "Clinical/Support" as an employment type. Two of these interviewees were Assistant Head Nurses; and two were. Interviewees were asked to pinpoint 4 key issues causing ED boarding, but were not limited in the amount of solutions they could propose.

The data concerning the causes of ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.5). The causes mentioned are displayed according to the frequency with which they were mentioned:

1. Specific patient needs (**3/4** Adm.; **3/4** C/S)
2. Late discharges (**3/4** Adm.; **2/4** C/S)
3. Specific patient disposition (**3/4** Adm.; **2/4** C/S)
4. Lack of communication/collaboration/information (**2/4** Adm.; **3/4** C/S)
5. Uncoordinated admissions/discharges (**2/4** Adm.; **2/4** C/S)
6. Inability to discharge patients (**2/4** Adm.; **2/4** C/S)

The data concerning the solutions to ED boarding obtained from the qualitative interviews was compiled and segmented according to employment type (Table 4.6). The solutions proposed are displayed according to the frequency with which they were mentioned:

1. Coordinating discharges/admissions (**4/4** Adm.; **3/4** C/S)
2. Improving communication/collaboration/information (**3/4** Adm.; **4/4** C/S)
3. Improving admission process (**3/4** Adm.; **3/4** C/S)
4. Preparing discharge more extensively (**2/4** Adm.; **3/4** C/S)
5. Improving resource management (**1/4** Adm.; **3/4** C/S)
6. Improving infectious disease management (**2/4** Adm.; **2/4** C/S)
7. Improving external resources (**2/4** Adm.; **1/4** C/S)
8. Improving inpatient bed management (**1/4** Adm.; **1/4** C/S)

As mentioned in Section 4.1.2, outlying data is only included in the overall analysis in Chapter 5.

		Administration				Clinical/Support staff				
		Head IP	Head ED	Ass. Dir.	BMC	AHN	AHN	Nurse	Nurse	**Total (#)**
Input	Increase in demand									0
	Non-urgent patients									0
	Frequent users									0
	Discharged patients returning									0
Throughput	Changes in resources									0
	Ancillary service delays									0
	Staffing levels								X	1
	Physician training									0
Output	Hospital restructuring									0
	Hospital bed shortages					X				1
	Late discharges	X	X		X		X	X		5
	Uncoordinated admissions/discharges			X	X		X		X	4
Field causes	Specific patient needs (e.g. telemetry)	X		X	X	X		X	X	6
	Specific patient disposition (e.g. VRE+)	X	X		X	X			X	5
	Inability to discharge patients		X	X			X	X		4
	Lack of communication/information	X		X		X	X	X		5
	Imbalance in surgical scheduling		X							1

Table 4.5. Hospital C: Qualitative interview results – causes

		Administration				Clinical/Support staff				
		Head IP	Head ED	Ass. Dir.	BMC	AHN	AHN	Nurse	Nurse	**Total (#)**
Literature	Coordinating discharges/admissions	X	X	X	X	X	X	X		7
	Improving admission process	X	X	X		X		X	X	6
	Improving inpatient bed management				X		X			2
	Smoothing elective surgery schedules		X							1
Field solutions	Improving communication/collaboration	X	X	X		X	X	X	X	7
	Improving resource management	X				X		X	X	4
	Improving inf. disease management	X	X			X			X	4
	Preparing discharge more extensively			X	X		X	X	X	5
	Improving external resources		X	X				X		3

Table 4.6. Hospital C: Qualitative interview results – solutions

5. Interpretation of data

Based on the results presented in the previous chapter, the current chapter aims to deepen the understanding of ED boarding within the context of the studied hospitals. With the help of the qualitative and quantitative data collected, as well as the results of direct observations, additional available documentation and academic literature, this chapter aims to answer in a more elaborate fashion the following research questions:

- What are the root causes of ED boarding within Quebec hospitals?
- To what extent are these causes similar or different in varying environments?
- How can we improve the process in order to reduce the amount of boarding required?

In this chapter, two different frameworks are displayed. The first, as a reminder, is the one that was established through the literature review, and which helped find potential causes and solutions that would later be validated in the field work. This framework, as posited in Chapter 2, is illustrated in Figure 5.1. The second framework was adapted from the initial framework, and is solely centered around ED boarding. In this figure, the causes and solutions of ED boarding that were validated in the field work are displayed. This framework is illustrated in Figure 5.2. It is important to note that a new factor category, dubbed "Global," was added by the author, as one of the causes found in the field work interacted with various parts of the process which overlapped input, throughput, and output factors. The "Effects" section within the framework presented in Chapter 2 has been subtracted, as it was not the primary purpose of this thesis's fieldwork and analysis to validate the effects of ED boarding. Solutions are categorised according to the part of the process that they affect. In order to be integrated within this framework, causes had to be mentioned as a key issue by at least two of the interviewed participants; solutions had to be mentioned by at least two of the interviewed participants as well, although participants were not asked to pinpoint only four solutions as they had been for causes. The only cause that was included within the framework without being validated by interviewees is the "Fluctuations in demand" cause, categorised within input factors. The reason why this cause was included is because it is heavily documented in the literature, and because the quantitative data demonstrated that fluctuations in demand affect average boarding time in a statistically significant way.

Through this chapter, the various causes and solutions of ED boarding will be discussed, and along the way, will be either validated or subtracted from the framework. After having completed this process, a final framework of ED boarding's cause and solutions will be proposed

in Chapter 6, displaying those issues that will have been deemed crucial according to the qualitative and quantitative data, as well as hospital documentation and the literature.

Using Figure 5.2 as a framework for illustrating the causes and solutions of ED boarding, this chapter is separated into four sections. The first section addresses causes and solutions within the input category (Section 5.1). The second section analyses causes and solutions within the throughput category (Section 5.2). The third section discusses causes and solutions within the output category (Section 5.3), within which most of the validated causes and solutions of ED boarding were found. Finally, the fourth section addresses causes and solutions within the global category (Section 5.4), which was added to the initial framework after having completed the field work. Within each section, causes and their related solutions (when applicable) will be discussed one after the other. Not all sections are of equal length or importance, as their prominence depends on the validation of their influence on ED boarding by the field work.

Figure 5.1. Initial conceptual framework demonstrating the potential causes and solutions of ED boarding as per the literature

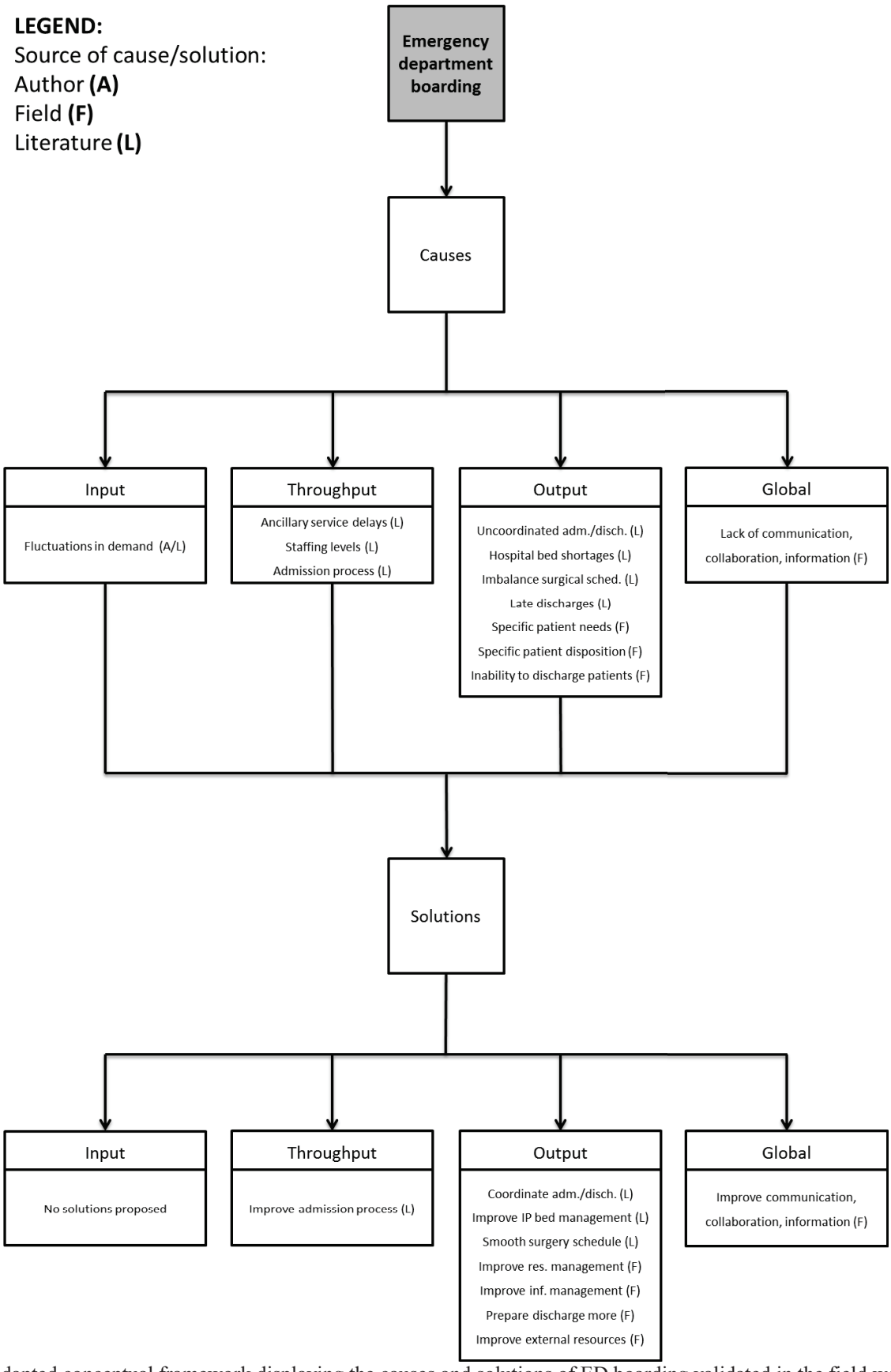

Figure 5.2. Adapted conceptual framework displaying the causes and solutions of ED boarding validated in the field work

5.1. Causes and solutions: input category

As was stated previously in this thesis, input factors relative to the emergency department include "any condition, event, or system characteristic that contributes to the demand of ED services" (Asplin, Magid, Rhodes *et al.*, 2003; 175). This means that fluctuations in demand due to such things as population growth, non-urgent patient flux, or frequent users are considered to be input factors.

5.1.1. Seasonal and monthly fluctuations in demand

In the literature review, we saw that Fatovich and Hirsch (2003), and Andersson and Karlberg (2001) wrote about the importance of fluctuations in demand for healthcare services. Many different factors can influence fluctuations in demand, which are generally visible according to more macroscopic data segments, such as years, seasons or months. Using additional academic sources, as well as quantitative data, this problem will be explored in greater detail in this section. Friesner, Roseman, and McPherson (2008) found that hospital efficiency varied greatly according to seasons, as did Thompson, Nunez, Garfinkel *et al.* (2009). Littig and Isken (2006) observed important changes in demand according to months, and McCarthy, Zeger, Ding *et al.* (2008) distinguished significant variations according to seasons and years. The literature on this topic is extensive, and it is to be expected that there are many surges in a given year that can affect the levels of ED boarding. While none of the interviewed participants pinpointed fluctuations in demand as a key issue in ED boarding, the quantitative data demonstrates that it has a significant effect on the levels of boarding time. In the SAS general linear model, the effect of seasons and months on ED boarding time was found to be statistically significant for every hospital:

	Hospital A	Hospital B	Hospital C
Season (p)	0.0001	<.0001	<.0001
Month (p)	<.0001	<.0001	<.0001

Additionally, the combined general linear model which compared each hospital to one another also found both of these variables to be statistically significant (p = <.0001). When combining the data for average boarding time of every hospital, it is visible that there are important seasonal and monthly fluctuations Figure 5.3 and Figure 5.4.

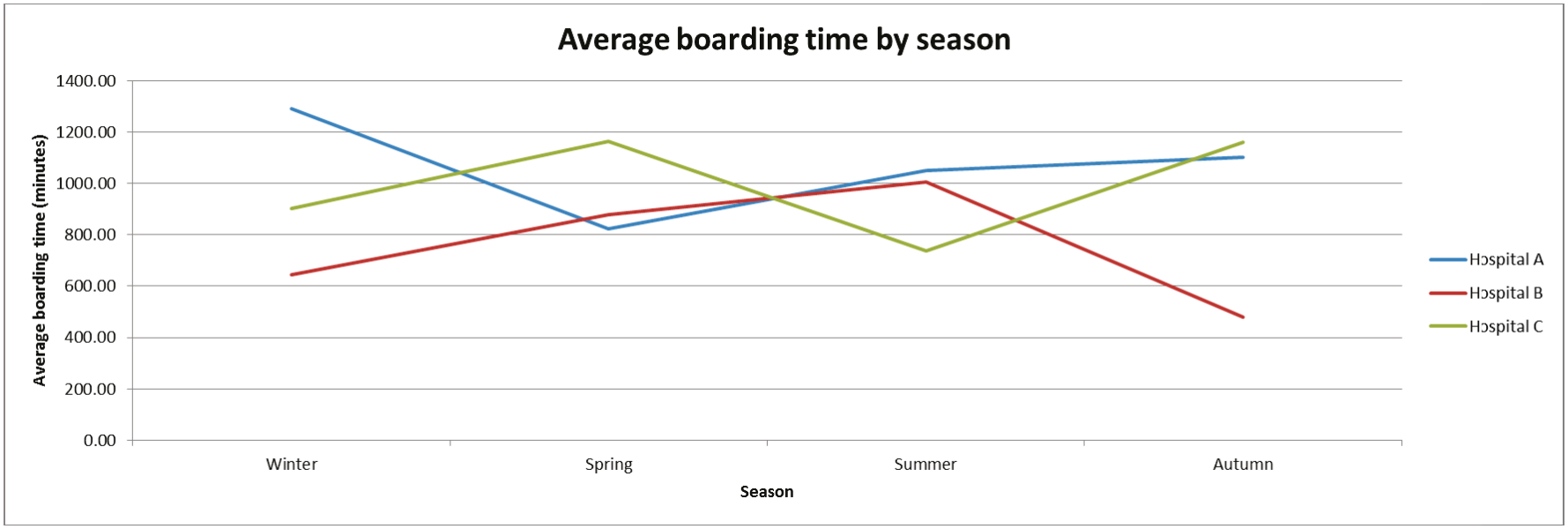

Figure 5.3. Average boarding time by season for all hospitals

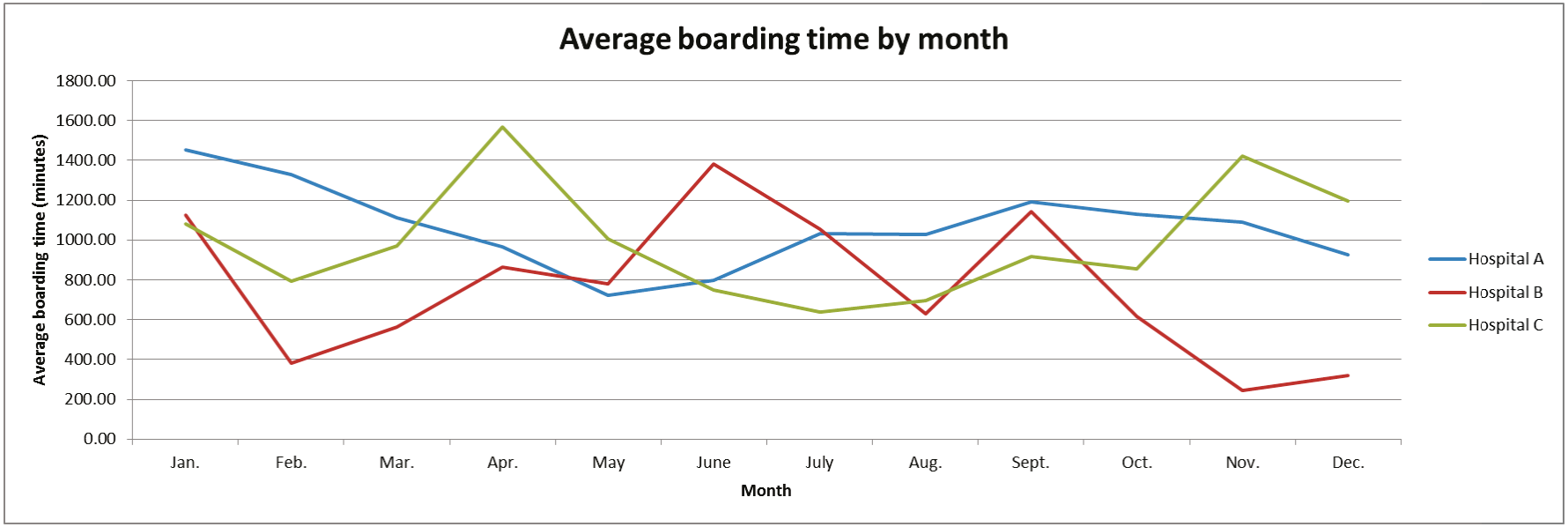

Figure 5.4. Average boarding time by month for all hospitals

There are many different factors that can cause fluctuations, which are generally related to public health (e.g. flu season, epidemics), and can sometimes be predicted (Littig & Isken, 2006). It is difficult to say what particular factors influenced the important changes visible in boarding times for Hospitals A-C, as they could be related to public health issues, external factors, staffing changes, the nature of the patients entering the hospital, and many other issues. One particular variation visible in Hospital A's performance can, however, be explained, and will act as an example for other such variations that could occur elsewhere. According to their 2012-2013 annual report, and according to the qualitative interviews conducted, Hospital A had a tremendous amount of patients who were infected with VRE, a hospital-acquired infection (HAI), during the beginning of the year, where the hospital's performance was at its poorest. As a consequence, numerous beds and rooms had to be closed to prevent further infections, which reduced the amount of available beds, and thus contributed in increasing the bottleneck effect already experienced at this level of the admission process. The number of patients infected with VRE increased by 63.18% compared to the previous year, and this issue is clearly related to the hospital's performance for the beginning of 2013. Patients can be infected by this virus prior to their stay in a hospital, and can thus be categorised as a temporal fluctuation in this context. Infectious disease management on a daily basis will be discussed more extensively in Section 5.3.6.

Seasonal and monthly fluctuations are evidently an important factor in affecting ED boarding, and as such, were integrated within the framework presented above. Both the literature and the quantitative data support this as a key issue in ED boarding; however, this thesis does not present any particular solutions to this problem, as the issues causing the variations can be multifactorial, whether related to public health, health policies, or other such factors that are outside of the boundaries of this research. This thesis focuses on management practices seeking to improve ED boarding on an intra-hospital level; however, many studies have been conducted related to disease prevention, public health, health policies, and the importance of informing the population about primary care providers and courses of action for illnesses treatable without consulting a physician (e.g. fluctuations related to flu-season could be prevented in this manner). Nevertheless, even though no solutions are proposed, fluctuations in demand are posited as a key issue in causing ED boarding in this thesis.

5.2. Causes and solutions: throughput category

As was stated previously in this thesis, throughput factors are made up of all the different aspects of ED care from patient arrival to patient discharge, transfer, or death. This includes processes such as triage, room placement, physician evaluation, and treatment. The admission process in itself is also part of throughput factors.

5.2.1. Ancillary service delays

Ancillary service delays were mentioned as a key issue in causing ED boarding by 2 interviewees, both from Hospital B, one being from the Administration category, and one being from the Clinical/Support category. Ancillary services are traditionally defined as "procedures required prior to visiting a physician" (Y. L. Huang, 2013; 746), such as x-rays or laboratory analyses; however, for the purpose of this thesis, other tests that are requested by a physician, sometimes after admission is requested but before the patient is transferred, are qualified as such as well. Davis, Sullivan, Levine *et al.* (1995) found that ancillary services can experience considerable delays, increasing patient LOS in the emergency department, and this was found to be a common occurrence in the studied hospitals. There are two main types of ancillary service delays experienced by boarded patients, as per the information obtained from the qualitative interviews.

The first is related to infectious disease prevention, whereby patients are screened for various infectious diseases (VRE, MRSA, Clostridium, etc.); patients arriving to the ED from long-term care facilities, or from other hospitals, are obligatorily screened for these infections, and can thus experience considerable delays after their admission is requested before arriving to an inpatient unit. Test results will determine which rooms or beds a patient can be assigned to; because of this, they are required before transferring the patient to an inpatient unit. Delays in obtaining these tests results can extend boarding time. The second is related to physician requests; on some occasions, consulting physicians will request a patient be admitted, but also request additional tests be conducted prior to his arrival to the inpatient unit. This most often occurs when patients are unstable.

Patient disposition and tests requested are not hardcoded in the hospital databases, and as such, this data could not be corroborated with quantitative data. However, there are many articles in the academic literature that link ancillary service delays with increased ED length of stay

(LOS), such as Hancock and Walter (1984), Fernandes, Walker, Price *et al.* (1997), Nagarkar, Gandhi, DeGennaro *et al.* (2004), and Nagula, Lander, Rivero *et al.* (2006). As per these authors, ancillary service delays can be caused by laboratory assistant availability, recollection rate, volume of tests for ED patients, and order processing time. No solutions were posited by the interviewees in this regard, however, the literature offers many alternatives, such as the use of continuous improvement practices (Nagula, Lander, Rivero *et al.*, 2006) and optimisation modelling to find which aspects of ancillary services are causing delays (Hancock & Walter, 1984; Nagarkar, Gandhi, DeGennaro *et al.*, 2004). Globally, prioritising admitted patients to reduce overall boarding times could also be beneficial for hospital performance, as the number of patients staying for more than 24/48 hours is a performance metric for every hospital in Quebec; interviewees mentioned that prioritisation could be done on a subjective basis, but perhaps a systematised approach could prove more effective. This is an interesting track for further research. Ancillary service delays were mentioned in the qualitative interviews and corroborated with the literature, and are thus counted as a key issue in causing ED boarding in the context of this thesis.

5.2.2. Staffing levels

Staffing levels were mentioned as a key issue in causing ED boarding by 5 interviewees, one from Hospital A, three from Hospital B, and one from Hospital C. One was from the Administration category, and four were from the Clinical/Support category. Many authors have addressed staffing levels (Malone & Anderson, 2014; Schreuders, Bremner, Geelhoed *et al.*, 2014; Foster, 2014), generally regarding nursing levels and the number of physicians available per patient. Additionally, the literature review had shown the link between staffing levels and emergency department crowding (Schneider, Gallery, Schafermeyer *et al.*, 2003; J. I. Hwang, 2006). As per the literature, proper staffing levels are required in order to promote patient flow and ensure that proper care is given. This topic will then briefly be discussed here as a potential cause for emergency department boarding.

The main concern of interview participants in this regards was that batching of admissions, transfers (arrivals) or discharges was too frequent, and that during these periods, the staff available had difficulties coping with the amount of work that ensued. In this sense, the problem is more related to other factors, which will be discussed further in this chapter. Staffing levels are designed following guidelines set forth by the Ministry of Health and Social Services,

and could potentially be sufficient in the studied hospitals if the flow of work was more adequately distributed. Admissions and discharges are not coordinated (Section 5.3.1) and most patients are discharged too late in the day (Section 5.3.4); in both cases, everything is done in batches, and there are important peak days and times, which greatly influence the workload for the staff available during those times. Staffing levels, then, are most likely not the central issue causing ED boarding within this context; it is rather other related factors which influence this perception. Moreover, no quantitative data could corroborate the influence of staffing levels on ED boarding, and no solutions were proposed by any of the interview participants. Given these circumstances, staffing levels are not defined as a key issue causing ED boarding within the context of this thesis.

5.2.3. Admission process

Improving the admission process was mentioned as a key solution to ED boarding by 11 interviewees, of which two were from Hospital A, three were from Hospital B, and six were from Hospital C. Six of these participants were from the Administration category, and five were from the Clinical/Support category. While it was not mentioned as a key cause to ED boarding, it received an important amount of comments in regards to possible solutions to this issue; given that direct observation allowed for a detailed analysis of the admission process in each hospital, this issue will be discussed further in order to analyse the validity of this issue as a key cause for ED boarding.

The admission process differs in each of the studied hospitals. One of the interesting aspects of these processes is the employee who is responsible for moving the patient. In Hospital A, there are stretcher-bearers available 24 hours a day. In Hospital B, stretcher-bearers are only available from 8:00 to 16:00, after which orderlies from the ED are asked to move patients. In Hospital C, there are no official stretcher-bearers; patients are moved by orderlies throughout the day. The prominence of this factor can be speculated through the SAS model. No statistical significance was found between the time of day and average boarding times in Hospital A, the hospital which has stretcher-bearers available at any given time of day. In the two other hospitals, however, the time of day did have a significant impact on average boarding times, and perhaps this can be explained by, among other factors, the availability of those employees responsible with transferring patients to inpatient care units. Evidently, there are many interrelated factors

that influence this statistical significance, and it is no solely because of stretcher-bearers that Hospital A has a more fluid performance in terms of average boarding times throughout the day. More such factors will be discussed in this chapter, which are to be taken more as hypothetic influencers in a variable and complex process rather than factual influencers. In order to validate this factor, a study of its own could be conducted; this was not the central purpose of this thesis, but is an interesting track for further research.

The steps within the admission process vary as well, as can be seen in the flow charts put forth in Chapter 4. One of the main concerns voiced by the interviewees was that in order for a patient to be transferred to an inpatient unit, the Assistant Head Nurse (AHN) from the ED has to speak directly to the AHN from the inpatient unit. They cannot transfer a patient until the two have dialogued as to the readiness of the inpatient unit to receive the patient. Evidently, this can cause problems and delay the patient's transfer; many of the interviewees said that during periods where AHNs were on break, this process could not be completed, and that many times AHNs participated in patient care activities, and as such were not present at the desk to receive the calls for confirmation. In Hospital B, beds are attributed to patients only when they are marked as ready (after being cleaned and sanitised), while beds are assigned to patients as soon as whomever was occupying it previously is discharged in Hospital A and Hospital C. This can perhaps have an impact on the readiness of ED staff to prepare the patient for transfer. Moreover, in the case of Hospital B, two confirmation calls are completed between the ED's AHN and the inpatient unit's AHN, one prior to preparing the patient and one once the patient is prepared. There is a certain redundancy in this process that could be avoided, and could potentially impact ED boarding in a positive way.

Avoiding redundancies and creating a leaner more efficient admission process was also suggested in the literature. White, Brown, Sinclair *et al.* (2012) implemented the Supplemented Triage and Rapid Treatment program in their hospital, and saw the average length of stay for boarded patients decrease by 7%. Total boarding hours also decreased by 1.3% after having implemented this program. Similarly, Amarasingham, Swanson, Treichler *et al.* (2010) implemented a rapid admission protocol in their establishment, which reduced the number of steps in the admission process from 50 to 10. Average boarding time decreased from 360 to 270 minutes, and the "preliminary boarding time" (i.e., the time spent by the patient in the ED before admission is requested) decreased from 210 to 75 minutes. Overall, ED LOS for admitted

patients significantly improved with this process. Standardising the admission process to a greater extent could also benefit these hospitals, as can be seen in Ortiga, Salazar, Jovell *et al.* (2012). In this study, the average number of boarders at 08:00 decreased from 5 to 3 after having standardised the admission process in a more efficient and leaner way. Ensuring that the process is as easy and comprehensive as possible could benefit the studied hospitals and help them reduce the number of boarders and their average boarding time.

The results of the qualitative interviews, direct observation, and information obtained from the literature all show that the admission process is an important factor in causing emergency department boarding. For this reason, it is included as a key issue within the context of this thesis.

5.3. Causes and solutions: output category

As was stated previously in this thesis, output factors are comprised of all the different factors that prevent patients from being discharged or transferred from the ED, or that affect hospital and system characteristics.

5.3.1. Uncoordinated admissions/discharges

The lack of coordination between admissions and discharges was mentioned as a key cause of emergency department boarding by 11 interviewees, of which two were from Hospital A, five were from Hospital B, and four were from Hospital C. Of these 11 interview participants, eight were from the Administration category, and three were from the Clinical/Support category. This issue appears to be of prime importance with members of the Administration category, as 8 out of the 13 interviewed participants named this as a key issue in causing ED boarding. Uncoordinated admissions are observed on a day of the week basis within the context of this thesis; hourly coordination of patient transfers and patient discharges is discussed in Section 5.3.4. Liu, Hamedani, Brown *et al.* (2013) found that coordinating admissions and discharges was the most beneficial approach for limiting levels of emergency department boarding, and the amount of interview participants who shared this point of view was considerable. Coordinating admissions and discharges was mentioned as a potential solution to ED boarding by 21 out of the 25 interview participants, of which 8 were from Hospital A, 6 were from Hospital B, and 7 were from Hospital C. Employees in the Administration category all mentioned this as a potential

solution (13/13) and most employees in the Clinical/Support category mentioned this as a potential solution (8/12).

This prominence of this issue is validated by the quantitative evidence when comparing the three hospitals. Let us look at how all three hospitals perform according to the days of the week. In Figure 5.5, it can be seen that admission requests are fairly static on any given day. The standard deviation for admission levels in each hospital is fairly low:

	$\bar{x}$ admissions (%)	Stdev	$\bar{x}$ admissions (#)	Stdev
Hospital A	14.29%	0.93	25.83	1.68
Hospital B	14.29%	1.37	15.06	1.45
Hospital C	14.29%	1.10	15.11	1.17

However, in Figure 5.6, we can observe that there is an important peak in patient discharges on Friday, and that the number of patients discharged decreases significantly on Saturday and Sunday. The standard deviation for discharge levels in each hospital is fairly high:

	$\bar{x}$ discharges (%)	Stdev	$\bar{x}$ discharges (#)	Stdev
Hospital A	14.29%	6.46	25.85	8.57
Hospital B	14.29%	8.36	19.05	6.54
Hospital C	14.29%	4.86	30.91	6.16

The hospitals that most often mentioned the lack of coordination between admissions and discharges as a key issue (Hospital B and Hospital C) are also those which were found to be significantly affected by days of the week in the SAS model. The extent to which each hospital's boarding time is affected by days of the week is illustrated in Figure 5.7. Standard deviation for boarding times was much higher in the two hospitals significantly affected by days of the week:

	$\bar{x}$ boarding time (minutes)	Stdev
Hospital A	1061.27 minutes	50.23
Hospital B	746.07 minutes	155.81
Hospital C	1001.77 minutes	135.51

Hospital B and Hospital C's performance in terms of boarding time is visibly related to discharge levels, as average boarding time decreases significantly on Friday when most patients are discharged and increases on Saturday and Sunday when the fewest are discharged. Although

Hospital A's boarding times were not found to be significantly affected by days of the week, it is clear that there is a lack of coordination in admissions and discharges in this hospital as well, as is illustrated in Figure 5.8. This is an interesting track for further research, as additional factors are inevitably related to this discrepancy in performance. As this issue was mentioned by many interviewees as a key cause and by most as a pathway for possible improvements, and because it is corroborated by quantitative data and the literature, uncoordinated admissions and discharges are included as key factors in causing ED boarding within the context of this thesis.

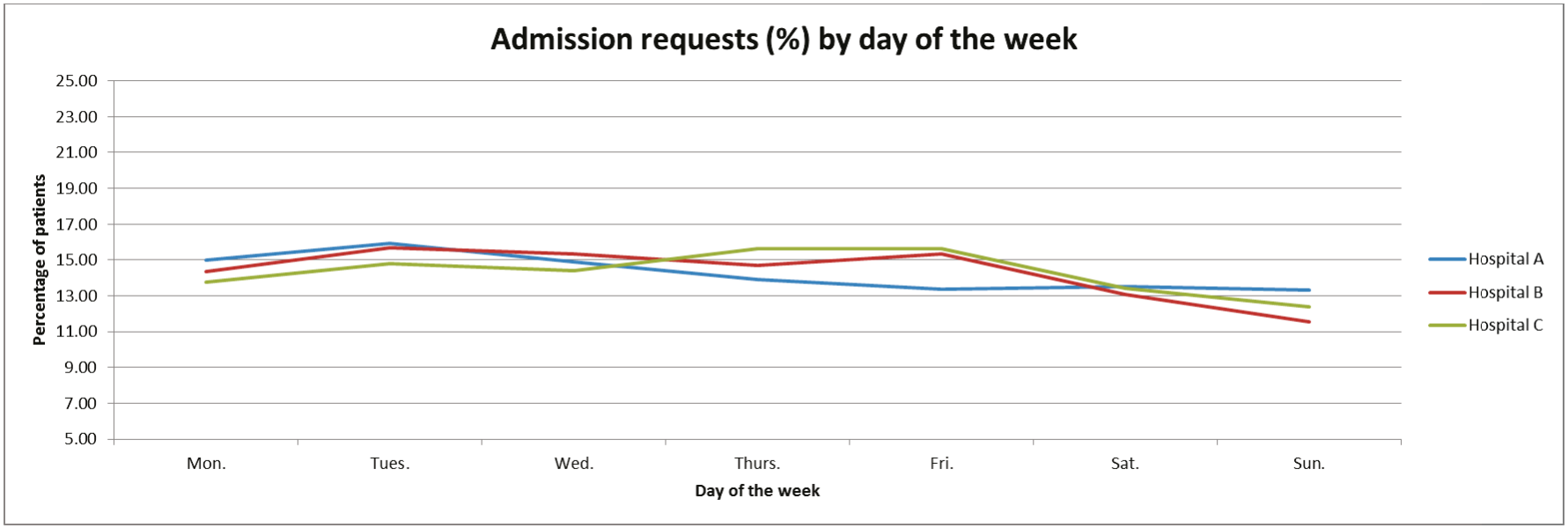

Figure 5.5. Admission requests (%) by day of the week - All hospitals

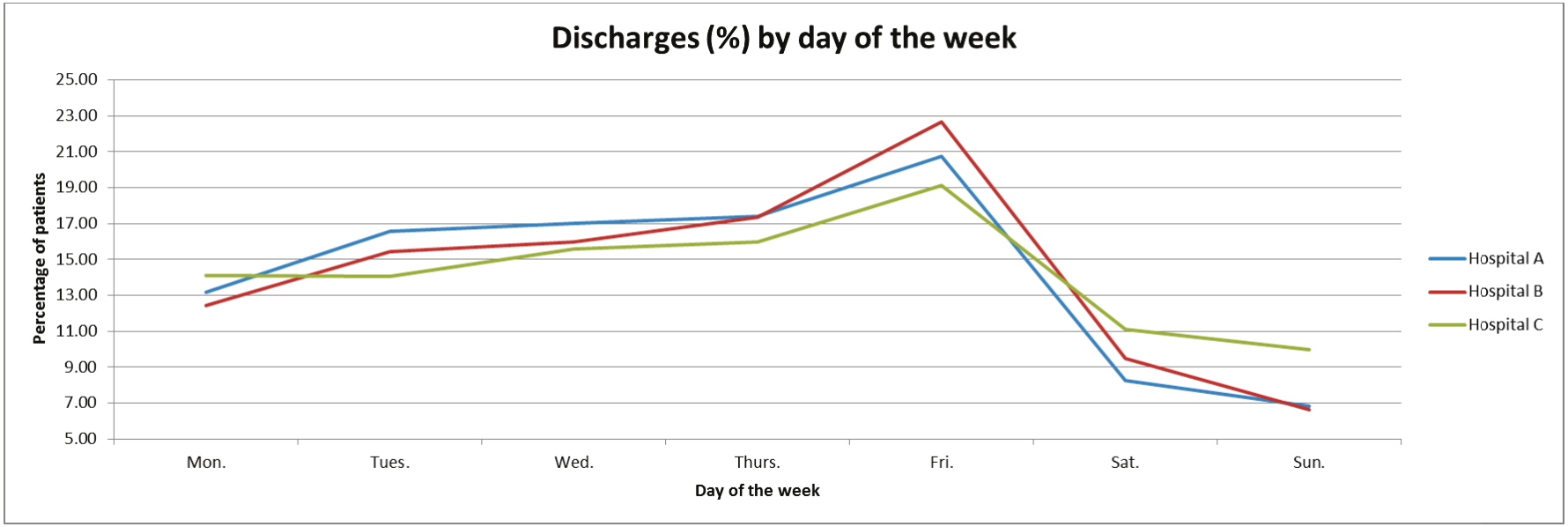

Figure 5.6. Patient discharges (%) by day of the week - All hospitals

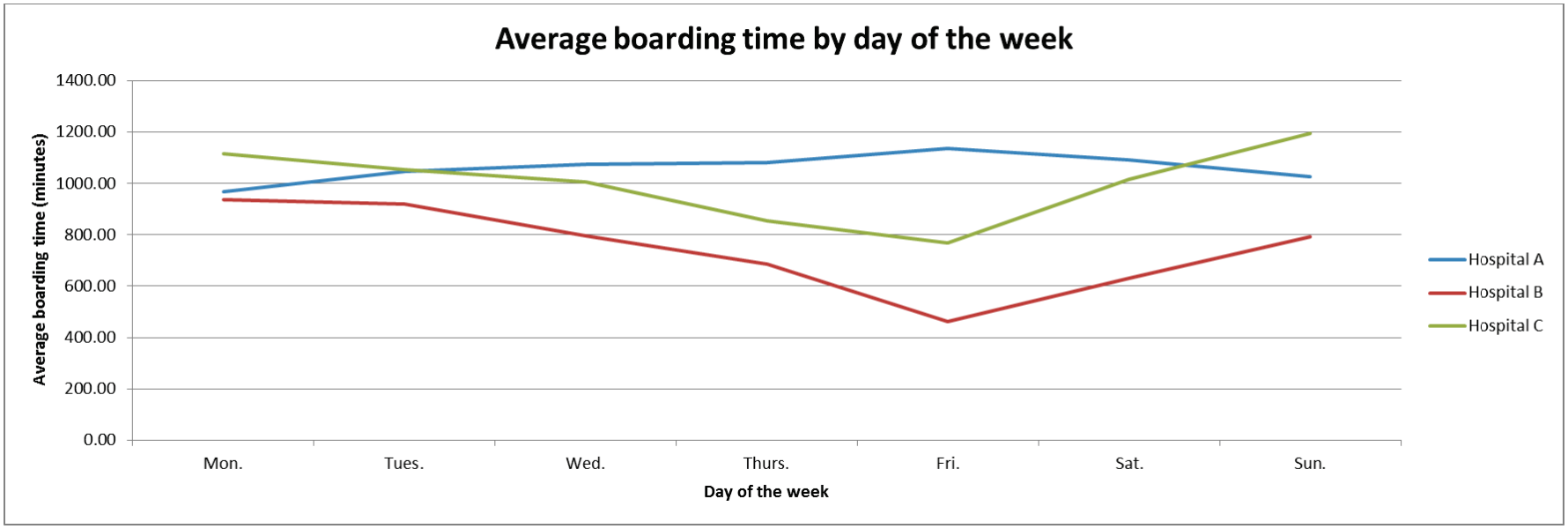

Figure 5.7. Average boarding time by day of the week - All hospitals

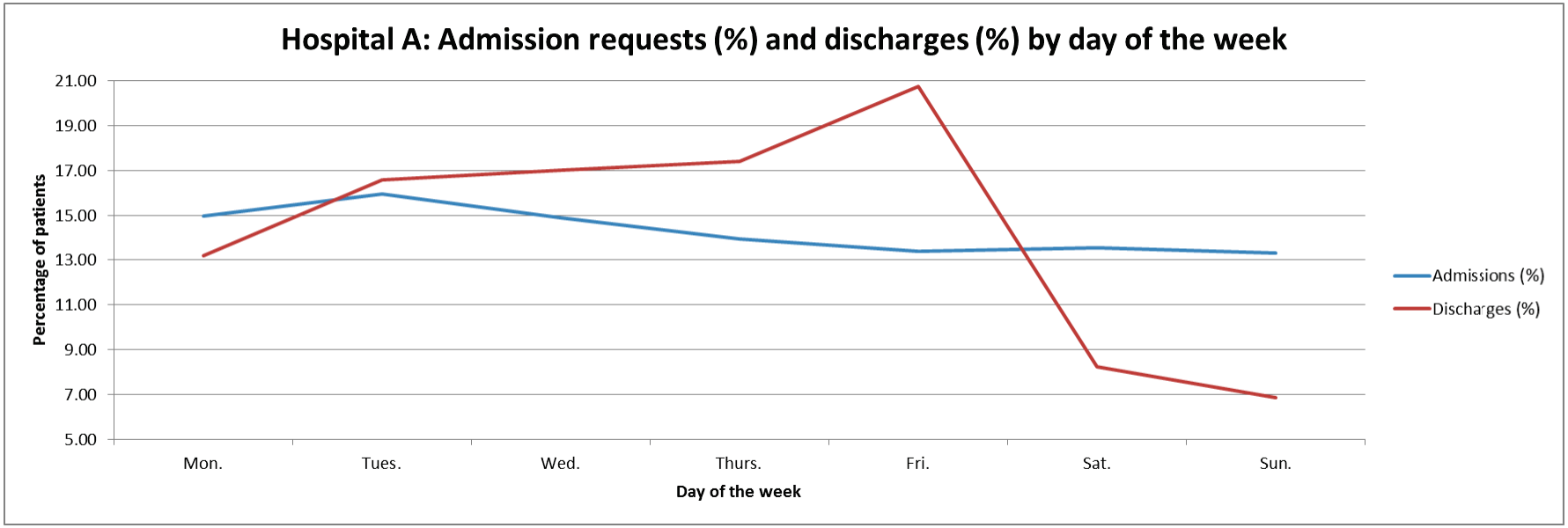

Figure 5.8. Admission requests (%) and discharges (%) by day of the week - Hospital A

5.3.2. Hospital bed shortages

Hospital bed shortages were mentioned as a key issue in causing ED boarding by 2 interviewees, one from Hospital A, and one from Hospital C. One was from the Administration category, and one was from the Clinical/Support category. As it was only mentioned by one person per hospital, this issue had been rejected as an outlying issue in Chapter 4. However, as it was mentioned by more than one participant globally, it will briefly be discussed here. In the current context, "bed shortages" is related to physical resources. As per the literature review, we know that adding more beds generally does not solve issues related to patient throughput within the patient care process. McConnell, Richards, Daya *et al.* (2005), Khare, Powell, Reinhardt *et al.* (2009), and Mumma, McCue, Li *et al.* (2014) all attempted to find a beneficial link between adding more hospital beds and ED boarding, but in each case their studies proved that adding more beds did not improve the issue. Indeed, even having beds in inpatient hallways to add capacity was found to have negative effects on patients (A. Viccellio, Santora, Singer *et al.*, 2009). Adding beds in a specific unit may lower boarding times for patients of that particular type (McConnell, Richards, Daya *et al.*, 2005), but inevitably require additional resources to maintain, and do not present benefits for other patient types. Moreover, capacity cannot so easily be increased; more beds will often lead to using them in an inefficient way. The goal is to use the resources available in a more optimal way, and it is by altering how resources are used that this goal will be achieved. This issue did not come up in any additional documentation and could not be corroborated with quantitative data. Given that very few participants mentioned hospital bed shortages as an issue in causing ED boarding, and given that the literature demonstrates that management is more important than the amount of physical resources available for hospital beds, hospital bed shortages are not considered to be a key issue in causing ED boarding in this thesis.

5.3.3. Imbalance in the surgical schedule

Imbalance in the surgical schedule was mentioned as a key issue in causing ED boarding by 5 interviewees, four from Hospital A, and one from Hospital C. Of these participants, four were from the Administration category, and one was from the Clinical/Support category. The participants which mentioned this as a key issue all interact with surgical schedules directly. Rathlev, Chessare, Olshaker *et al.* (2007) found that imbalanced surgical schedules had a link with decreases in throughput, and this was corroborated with the qualitative data. With the

number of surgeries requiring hospitalisation growing in the participating hospitals (Hospital A: 4.3% increase in 2013-2014; Hospital B: +38.09% in 2013-2014; Hospital C: N/A), imbalanced surgery schedules become more and more of a factor in causing ED boarding.

Imbalanced surgery schedules can affect ED boarding in two ways. First, when the amount of surgeries requiring hospitalisation is very high on a given day, many beds are reserved for these patients, and as such, cannot be used for admitted ED patients. Moreover, these beds are often empty for long periods of time while patients are in surgery; given the limited amount of resources available, this is not an optimal allocation of these resources. Second, when surgeons are in the operating room (OR) for an entire day, this is a lengthy period of time within which they are not discharging patients that were attributed to them, which means that beds that could otherwise have been attributed to ED patients are not available. While a day-by-day distribution of surgeries was not supplied by the participating hospitals, comments from the qualitative interviews showed that this was a particularly prominent issue. This issue was not brought up in Hospital B, but participants from Hospital A and Hospital C discussed how one day could have upwards of 20 surgeries requiring hospitalisation while the next could have as little as 4 or 5 even though the same surgeons were in the hospital on both days.

While 5 interviewees mentioned imbalanced surgery schedules as a key issue in causing ED boarding, 7 interviewees said that balancing the elective surgery schedule could improve ED boarding times. These two additional participants were from Hospital A, and were both Heads of an Inpatient Care Unit (Administration). The solution to this problem is rather evident, and that is to smooth the surgery schedule so as to decrease the large fluctuations in bed reservations that can be experienced currently. Although the solution is evident, the approach can be complex, as there are many different factors that play into scheduling. In the literature, Santibáñez, Begen, and Atkins (2007) developed a mixed integer program to optimise scheduling in their studied hospitals, and Pulido, Aquirre, Ortega-Mier *et al.* (2014) developed a simulation modelling aiming to do the same. Guerriero and Guido (2011) completed a comprehensive literature review of Operational Research articles addressing OR scheduling, and is also a valuable source of information for hospitals aiming to optimise their surgery schedules to reduce ED boarding. Even though no participants from Hospital B mentioned elective surgery schedules as an important factor in causing ED boarding, the literature, as well as additional documentation and direct observation have shown that imbalanced elective surgery schedules can have an important effect

on ED boarding levels, and is thus considered to be a key issue in the context of this thesis. Nevertheless, since the hospital environments are vastly different in all three cases, it could be that Hospital B is less affected by this problem, although it could also be a sampling bias.

5.3.4. Late discharges

Late discharges were mentioned as a key issue in causing ED boarding by 15 interview participants, equally distributed between hospitals A, B, and C. It was the third most commonly elucidated issue. Of these participants, eight were from the Administration category, and seven were from the Clinical/Support category. In the current context, late discharges refer to discharges that are done late in the day, and not discharges that are delayed because of external or patient-related factors; that particular aspect is discussed in Section 5.3.7.

The prominence of late discharges was validated through the quantitative evidence. The combined data from all three hospitals is illustrated in Figure 5.9. All three hospitals experience the same peak discharge time, which is 14:00-14:59 (Hospital A: 11.97%; Hospital B: 14.81%; Hospital C: 12.87%), and all three hospitals experience the same peak 4-hour period, which is from 13:00 to 16:59 (Hospital A: 40.94%; Hospital B: 49.47%; Hospital C: 40.84%). In the interviews, participants said that this hindered patient flow, as patients are generally transferred from the ED to an inpatient care unit 2 hours after a bed has been vacated, the period within which the bed and room are cleaned and sanitised, and the patient is prepped to leave the ED. What we see, then, is an equally important spike in patient arrivals that happens late in the day, when there are fewer staff members (after 15:59) and resources available. This is illustrated in Figure 5.10. Peak arrival times differ in the three hospitals. In the SAS model, Hospital A's performance in terms of average boarding time was found not to be significantly affected by hour of the day, and this can be explained through their coordination of arrivals and discharges.

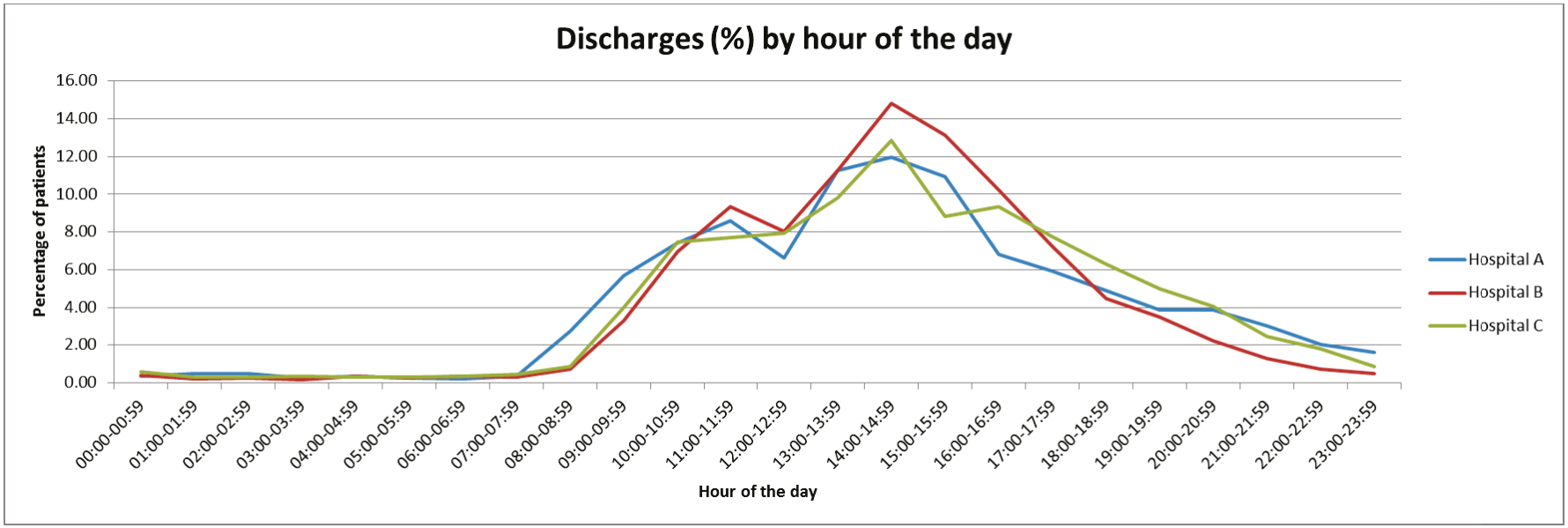

Figure 5.9. Discharges (%) by hour of the day - All hospitals

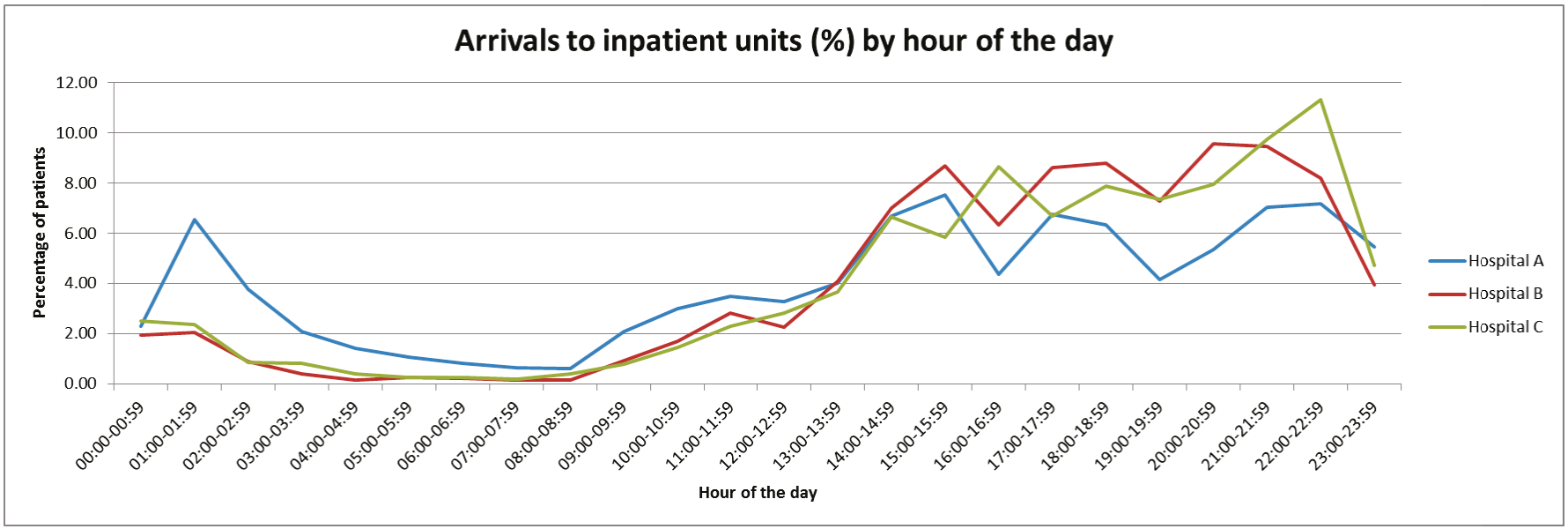

Figure 5.10. Arrivals (%) by hour of the day - All hospitals

The peak discharge time occurs at 14:00-14:59, like in all the other hospitals, but their peak arrival time occurs only one hour later, at 15:00-15:59; moreover, their peak 4-hour period for discharges, which is from 13:00 to 16:59 is closely followed by their peak 4-hour period for arrivals, which occurs from 14:00 to 17:59 (25.35% of patients). Hospitals B and C, whose performance is significantly affected by time of day according to the SAS model, respond to their peak discharge times much later. Both hospitals have the same peak in discharge time, and the same peak 4-hour period as Hospital A; however, their peak arrival times for arrivals occur much later, as do their peak 4-hour periods for arrivals:

	Peak arrival hour	Peak arrival period (4 hours)
Hospital A	15:00-15:59 (7.55%)	14:00-17:59 (25.35%)
Hospital B	20:00-20:59 (9.59%)	18:00-21:59 (35.10%)
Hospital C	22:00-22:59 (11.33%)	19:00-22:59 (36.39%)

Both the qualitative and the quantitative data show that this is an important issue in causing ED boarding, and this is further corroborated by the literature (Panero, Gruden, Zucco *et al.*, 2013). In Powell, Khare, Venkatesh *et al.* (2012), the authors found that shifting their peak inpatient discharge timing by 4 hours, from 12:00-23:59 to 08:00-19:59 reduced the total number of boarding hours per day from 77.0 to 3.0. Evidently, discharging patients earlier in the day can have a significant positive impact on ED boarding. Although we cannot speculate how much the process could improve by doing something similar in the case studies, it is certain that having peak periods that occur later in the day when less staff and resources are available is not beneficial for throughput. If we look at each hospital's trends according to the same parameters (number of discharges between 12:00 and 23:59), we can see that the vast majority of patients are currently discharged within this period:

	% discharges between 12:00 and 23:59
Hospital A	72.84%
Hospital B	77.41%
Hospital C	76.97%

Quite often, patients are discharged but cannot leave immediately of one reason or another (this will be discussed further in Section 5.3.7), which is yet another reason to discharge patients earlier, in order to ensure that they can leave as soon as possible. Patients with reduced mobility or other medical issues generally have to stay in the room even after being discharged until

adapted transportation or a family member can pick them up. None of the visited hospitals have "waiting rooms" for discharged patients, although some of them experimented with this concept, but found that it was not beneficial. Through the literature review, we've found that having more physical resources often does not solve the problems experienced by hospitals, and this is another example of such an issue.

The main solution, then, is to shift the peak, as Powell, Khare, Venkatesh *et al.* (2012) did in a simulation, earlier in the day. Improving inpatient bed management was posited as a potential solution to ED boarding by 6 interview participants, of which four were from Hospital A, and two were from Hospital C. There are many authors who wrote about "discharge by noon" initiatives, which address this issue as well (Goodson, DeGuzman, Honeycutt *et al.*, 2014; Wertheimer, Jacobs, Bailey *et al.*, 2014; Beck & Gosik, 2014). Complementarily, it could be beneficial to standardise the discharge process more extensively. Ortiga, Salazar, Jovell *et al.* (2012) found that standardising the discharge process in their hospital reduced the average length of stay of patients, reduced the number of cancelled elective surgeries, and considerably increased the number of planned discharges (from 43.05% to 86.01%), which is also an important factor in hospital throughput. Because of its significant importance, late discharges are counted as a key issue in causing ED boarding in the context of this thesis.

5.3.5. Resources related to specific patient needs

Specific patient needs (e.g. telemetry, harness for obese patients, etc.) were mentioned as a key issue by 13 interview participants, of which five were from Hospital A, two were from Hospital B, and six were from Hospital C. Of these participants, five were from the Administration category, and eight were from the Clinical/Support category. This issue was brought up more commonly by Clinical/Support employees, perhaps because of their proximity with the clinical needs of patients.

Specific patient needs were not hardcoded within the hospital software, and thus could not be extracted to understand how this affected the allocation of beds. However, this issue can affect the boarding time of patients, particularly those requiring particular care. Most mentions of this issue originated from Hospital A and Hospital C. In Hospital A, resources are pooled only as a last resort, which means that patients have a clear destination upon admission, and they are very rarely diverted from this target. What this means is that there is an added level of complexity in

attributing a bed to a patient within this hospital. Not only is the destination dependent on specific patient needs, but it is also dependent on the specialty which admitted the patient. Additional constraints such as these decrease the amount of beds a patient can be attributed to, and increase the complexity of bed management tasks. In Hospital C, pooling is standard, but they nonetheless have to manage particular patient needs. The main concern brought forth by interviewees was the management of telemetries. The hospital has very few telemetries (±10) available, and they have difficulties in managing this scarce resource.

Interviewees mentioned that one of the main reasons why they struggle in managing this resource is clinical. Patients are monitored on similar equipment in the emergency department, often for numerous hours and even days, but this period of monitoring is not included when a physician asks for a patient to be monitored for a certain number of hours. For example, a patient is monitored in the ED for 48 hours with no cardiac arrhythmias, and the consulting cardiologist requests his admission with 72 hours of telemetry monitoring. The initial 48 hours will not be counted within the physician's request; an additional 72 hours of monitoring will be conducted. Evidently, this example is clinical, and cannot be discussed at length by the author given the absence of competencies in this area. Nevertheless, the amount of participants (13) which mentioned particular patient needs (particularly telemetry) as a key issue in causing ED boarding demonstrates that this is not a negligible factor. As with any scarce resource, improving resource management is an important solution to this problem. This solution was proposed by 7 interviewees, of which three were from Hospital B and four were from Hospital C.

The allocation of scarce resources in healthcare has received considerable interest in the academic world. Optimising resource use or reducing the demand for particular resources (Timbie, Ringel, Fox *et al.*, 2013), and choosing which patients receive particular resources according to guidelines (Knebel, Sharpe, Danis *et al.*, 2014; Daugherty Biddison, Gwon, Schoch-Spana *et al.*, 2014) or according to the patient's degree of need (Rogowski, Grosse, Schmidtke *et al.*, 2014) are all solutions proposed to this issue. Given that many interview participants mentioned specific patient needs as a key issue in causing ED boarding, and because the literature corroborates the importance of allocating scarce resources such as the ones put forth by the interviewees, specific patient needs are considered to be a key cause of ED boarding in the context of this thesis.

5.3.6. Specific patient disposition

In this thesis, specific patient disposition is related to hospital-acquired infections, also known as nosocomial infections, or other such infectious diseases (e.g. tuberculosis). This issue was mentioned as a key cause by 13 interview participants, of which six were from Hospital A, two were from Hospital B, and five were from Hospital C. Of these participants, five were from the Administration category, and eight were from the Clinical/Support category.

Many articles have been written on the factors influencing the spread of HAIs and the possible solutions to limit this issue (Beggs, Knibbs, Johnson *et al.*, 2014; Dancer, 2014; Everett, Sitton, & Wilson, 2014; Tao, Qian, Li *et al.*, 2014; George, Boehme, Siegler *et al.*, 2013; Ceballos, Waterman, Hulett *et al.*, 2013), however, these are more oriented towards public health and clinical factors than management factors, and as such, will not be discussed at length in this thesis. Currently, the Ministry of Health and Social Services requires that all patients coming from long-term care facilities (LTCF) be tested for nosocomial infections upon arrival at hospitals, and this is a legitimate concern, as studies have shown that people coming from LTCFs have a higher rate of infection than others (Garg, Mirza, Girotra *et al.*, 2013). Confronting this issue is not easy, as there are strict guidelines regarding infectious diseases put forth by the Ministry, and as such, there are very few steps that can be taken within a hospital to improve this process. Nevertheless, there are some improvements that can be made.

New hospitals being constructed in Montreal (e.g. CHUM and MUHC) only have private rooms, and as such, it will be possible to isolate any infected patient without much trouble. However, the three hospitals studied have very few private rooms; in fact, Hospital A has some rooms that hold up to 6 people. When a patient is admitted and is found to have a HAI, he must be isolated in order to prevent the infection from spreading to other patients. Employees in charge of bed management have to find an appropriate bed for this patient, and often have to transfer patients within inpatient units to free up a bed that will be adequate, which creates a chain of transfers and requires considerable effort and time. Improving infectious disease management related to this process was mentioned as a possible solution by 9 different interviewees. The main way to improve this problem is to increase cooperation between bed management employees and infectious disease prevention employees. More information has to be made available in relation to the patient's disposition (e.g. what strain of VRE he is infected with, and how long he has been infected) in order to know for certain which patients can be matched with other patients. Patients

infected with VRE can be bunked together according to certain guidelines, but only provided they have the same strain of VRE; on many occasions, as was seen from direct observation and was heard from the interviews, this information is not relayed to bed management employees, and as such, some patients are attributed beds that are inadequate for them, which means that these patients must be moved again, and the bed and room cleaned once again as well. Increasing the flow of information will help with this issue considerably.

Creating protocols related to hand hygiene and such efforts are also a possible improvement to this issue (Beggs, Knibbs, Johnson *et al.*, 2014); however, most hospitals already have similar procedures. Nosocomial infections are becoming more and more important in hospital environments in Quebec, as was discussed previously in this thesis regarding the proliferation of VRE in Hospital A. When patients require isolation, often times beds are lost, as semi-private rooms are used for single patients. This has a considerable impact on bed management practices, and on average boarding times. At the current time, patients who come in contact with VRE positive patients are automatically isolated as well, and categorised as "contact isolation" patients. This process is mandated by the Ministry, and cannot be altered; however, Hospital A is conducting a pilot project with the help of the Public Health Agency to see if this isolation is really required. The project will be done in a few months, and if the results are positive, Hospital B and Hospital C will be able to adopt this protocol, which will greatly reduce the amount of testing required and reduce the amount of isolated patients as well.

Given the importance of the subject in the qualitative interviews, in direct observation, and in the literature, specific patient disposition in regards to HAIs and other infections is included as a key issue in causing ED boarding within the context of this thesis.

5.3.7. Inability to discharge patients

The inability to discharge patients was mentioned by 16 interview participants as a key cause for ED boarding, of which seven were from Hospital A, five were from Hospital B, and four were from Hospital C. It was the second most commonly elucidated issue. Of these interviewees, nine were from the Administration category, and seven were from the Clinical/Support category. The inability to discharge patients is segmented into three categories:

1. Patients are awaiting a place in a long-term care facility, or other external resources, and are using a short-term occupancy bed in the meanwhile from lack of availabilities;

2. A patient's discharge is requested without notice, and the availability of adapted transportation, the patient's family, or other resources prevents him from leaving; and
3. Patients are medically ready to leave, but have been deconditioned through a lengthy stay in the hospital, and as such require rehabilitation or physiotherapy.

First, let us look at patients awaiting a place in a LTCF or other external resources. Improving partnerships with external resources was mentioned as a key solution to this problem by 6 interview participants, of which one was from Hospital A, two were from Hospital B, and three were from Hospital C. Looking at the available data on the average number of patients occupying short-term beds per day awaiting external resources, we see that there are many in each hospital:

	2012-2013		**2013-2014**	
	Awaiting LTCF	Total ALC	Awaiting LTCF	Total ALC
Hospital A	N/A	N/A	N/A	N/A
Hospital B	10	35	4	19
Hospital C	10.7	18.2	8.3	19.7

ALC refers to "alternate level of care" patients (Costa, Poss, Peirce *et al.*, 2012); these patients are using beds that would otherwise be attributed to admitted patients, and potentially boarders. ALC patients can be awaiting a room in a rehabilitation center, a palliative care establishment, a convalescence unit, a long-term care facility, or non-institutional resources (i.e., private care). Data was unavailable for Hospital A, but we can see that many beds are being used for this purpose in Hospital B and Hospital C. In 2012-2013, as many as 16.75% of the available beds in Hospital B were occupied by patients that could not be discharged for these reasons. Costa, Poss, Peirce *et al.* (2012) found that in their studied hospitals, ALC patients awaiting a place in a LTCF accounted for 41.5% of total ALC bed days, even though they only represented 8.8% of total ALC patients. Increasing partnerships with LTCF, as proposed by the interviewees, could benefit this segment of the issue related to the inability to discharge patients. Bryan (2010) validated this proposition in his article seeking to understand the importance of collaboration between health and social services to prevent delayed discharges related to ALC patients.

The second segment of this cause of ED boarding is when a patient's discharge is requested without prior notice. When a physician requests a patient's discharge, many different factors come into play within the discharge process. Paperwork must be completed, forms must be signed by the patient, and the patient must have the means to leave the hospital, either via

adapted transportation or via family members or other means of transportation. This issue was brought up on numerous occasions by the interviewees; 20 out of the 25 interview participants suggested that planning discharge more extensively could significantly improve the problem that is ED boarding. Their most common comments related to the fact that patients who are discharged without notice often stay an additional night, as many of the patients that are hospitalised are elderly and often have mobility issues.

Many patients still require medical attention after being discharged, and as such, continue to occupy an inpatient bed for lengthy periods of time after their discharge is requested. This problem is also corroborated with the literature. Ali Pirani (2010) wrote an article on the importance of planning a patient's discharge as of his admission, and ensuring that resources are made available the day of his discharge in order to free up inpatient beds more quickly. The author found that age and medical factors had an important influence on this process, as was also demonstrated in the qualitative interviews. In Hospital A and Hospital B, there are Nurses which are attributed to ensuring patient flow; however, these Nurses are only available during the day shift (08:00-16:00), and as such, this principle does not carry over during the rest of the day. According to Ali Pirani (2010), it is important to improve Nurse participation in discharge planning and to involve both patients and clinical staff within this process to ensure fluidity. It would thus be beneficial for the hospital to instil this culture in other Nurses and medical practitioners as well, and to share information more frequently with patients as well.

The final segment is related to patients being deconditioned during their stay in an inpatient care unit. This is also quite clinical, and will thus not be discussed at length in this thesis; however, the problem was prominent in discussions with interviewees, and the literature also corroborates this issue as significant in terms of patient discharges. Challis, Hughes, Xie *et al.* (2014) wrote that "Improved services and structures to systematically assess and treat patient needs in hospital, together with the timely provision of services providing post-discharge services tailored to individual circumstances, are required" (p. 160). Indeed, having a complete treatment plan that is enacted in a timely fashion in collaboration with the required medical practitioners and healthcare professionals is an improvement that could reduce patient deconditioning and thus decrease the amount of delayed discharges related to this issue. Many of the studied hospitals have multidisciplinary team meetings, but collaboration seems to be a significant issue regardless, as will be displayed in the following Section 5.4.1.

This factor was mentioned as a key issue in causing ED boarding by 16 interviewees, and was corroborated with the literature and hospital documentation. Because of the prevalence of this issue in the studied hospitals, the inability to discharge patients is included as a key cause of ED boarding within the context of this thesis.

5.4. Causes and solutions: global category

In the current context, global factors are described as such when they influence multiple parts of the patient flow process, that is to say, input, throughput, and output factors. Within the qualitative interviews, only one such factor was elucidated, and that is the lack of communication, collaboration, and information between different actors in the healthcare institutions.

5.4.1. Lack of communication, collaboration, and information

Lack of communication, collaboration, and information was the most commonly mentioned cause of emergency department boarding in the qualitative interviews, having been pinpointed as one of the 4 major key issues by 17 participants. Of these participants, five were from Hospital A, seven were from Hospital B, and five were from Hospital C. Ten of these participants were from the Administration category, and seven were from the Clinical/Support category. Even more participants mentioned this as a key solution to emergency department boarding; in fact, 24 out of 25 interview participants said that the issue of ED boarding could be improved by increasing communication, collaboration, and information within the hospital and between the different actors within the patient care process.

Communication plays a crucial role in the transmission of information and as a means of creating a community within the work environment (Elving, 2005). However, many different interviewees suggested that there was an important lack of communication between the ED and IP units. Employees from the emergency department often said that employees working in inpatient units had very little perspective about the intensity of the workload in the ED, and as such, perceived them as working against them by not promoting patient throughput as extensively as would be required to help the ED admit patients and free beds. In interviews with both ED and IP employees, interviewees mentioned that there was a tense relationship between the two units, and that there was an important lack of communication between them. As Leonard, Graham, and

Bonacum (2004) wrote, “Effective communication and teamwork is essential for the delivery of high quality, safe patient care. Communication failures are an extremely common cause of inadvertent patient harm” (p. 85). These authors also wrote that effective communication is often personality dependent. It is important for hospitals to promote communication methods that can work through this factor, so as to provide an approach by which the ED and IP units can communicate adequately regardless of who is working at the time.

Hospitals are faced with an important organisational hardship, namely that of managing professionals who adhere to “external controls [that] can act to minimize the influence of managers” (Lewis & Brown, 2012; 2). Due to the nature of professional service provision, there is often very little leeway for management to introduce certain performance boundaries in order to evaluate the quality of the services provided. This problem, which is well represented in the literature (Harvey, 1990; Kiely & Armistead, 2004; Lewis & Brown, 2012), was also commonly mentioned in the interviews. Within hospitals in Quebec, there are many different practitioners who are members of professional orders: physicians, nurses, physiotherapists, respiratory therapists, social workers, etc. This means that there are many boundaries to collaboration, and this is an important challenge that needs to be addressed. In the interviews, most participants mentioned that there was very little dialogue possible between the hospital and its physicians. Physicians in Quebec are not hospital employees; they bill the government directly for their services, and as such, are not accountable to the hospitals within which they operate. To many of the interviewees, this means that the hospital cannot ask them to change their practices or habits in order to better suit the hospital’s needs. Although physicians were most commonly associated with a lack of collaboration, other professionals were also mentioned; interview participants suggested that increasing collaboration between different professionals could increase hospital throughput. Looking to the literature for possible solutions, Sebrant (2014) posits that the emotional experiences of healthcare professionals must be supported by the organisation so as to avoid the development of regressive relationships. Janus (2014), on the other hand, proposes that professionals’ motivation must be supported, with particular attention to three distinct areas, which are “relationship to work,” “relationship to colleagues,” and “relationship to organisation.” Based on the qualitative interviews and direct observation, it appears that the first step in improving this issue would be to increase the availability of forums for discussion between the different professionals.

Finally, a lack of information was felt by most of the participants that were interviewed. Different actors encountered this problem differently, but all had issues with the information that was available to them, and found that this could compromise hospital throughput and patient care. For example, bed management employees often had missing information as to a patient's particular disposition, such as the strand of VRE with which he was infected. Moreover, it was often unspecified whether or not a patient infected with a HAI could be paired with another patient infected with the same HAI. Another common comment was that IP employees had a lack of information as to what was occurring in the ED. Hospital B had screens in each unit showing the levels of occupancy at the emergency department, but Hospital A and Hospital C did not. Although Hospital B had an advantage in this respect, many employees said that they did not know what the information displayed meant, and as such, the value of this tool was greatly reduced. Information was also found to be lacking about patients (e.g. what their situations were at home, what means they could use to return home after discharge), and towards the patients themselves. For example, interviewees said that patients often did not know when or by what means they would be discharged. Interview participants suggested that information be transmitted more effectively through these different streams. These types of problems seem to occur frequently, as many academics have addressed the topic of lacking information in healthcare environments. Hesselink, Schoonhoven, Plas *et al.* (2013) surveyed physicians, nurses, and patients, and found that the different parties all perceived information to be insufficient. Hellesø and Sogstad (2014) and Kannampallil, Jones, Patel *et al.* (2014) found that different actors (physicians, nurses, etc.) use different strategies to obtain information, and that it is important to cater to these differences when planning the spread of information. Overall, hospitals should aim for information to be as accurate and detailed as possible (or necessary), so that errors related to these issues be minimised.

The results of the qualitative interviews, direct observation, and information obtained from the literature all show that a lack of communication, collaboration, and information is an important factor in causing emergency department boarding. For this reason, it is included as a key issue within the context of this thesis.

6. Conclusion

In this final chapter, the answer to the research questions posited throughout this thesis will be illustrated first. Then, the contributions of this thesis to both research and management practitioners will be discussed, followed by the limitations of this research, further research, and closing statements.

6.1. Answers to the research questions posited in this thesis

With the help of the of the data that was collected and interpreted from the various case studies, the three research questions that were proposed in the beginning of this thesis can be answered. As a reminder, the questions were as follows:

- What are the root causes of ED boarding within Quebec hospitals?
- To what extent are these causes similar or different in varying environments?
- How can we improve the process in order to reduce the amount of boarding required?

The purpose of this thesis was to answer the proposed research questions within the context of the studied cases, and to generalise the resulting propositions within a theory, which Yin (2009) refers to as analytic generalisation. This thesis does not assert that a statistical generalisation can be achieved with the chosen methodology, as the purpose was not to obtain a sample which would be representative of the entire population of Quebec hospitals. The causes for ED boarding within the case studies have been found, and these causes can now be validated through additional research in other institutions so as to validate their prominence throughout the province. The causes that were found are:

Validated causes of ED boarding in the studied hospitals			
Input	Throughput	Output	Global
○ Fluctuations in demand	○ Ancillary service delays ○ Admission process	○ Uncoordinated admissions and discharges ○ Imbalanced surgical schedule ○ Late discharges ○ Patient needs ○ Patient disposition ○ Inability to discharge patients	○ Lack of communication, collaboration, and information

Table 6.1. Validated causes of ED boarding in the studied hospitals

All of these causes were validated with multiple sources of data, whether qualitative, quantitative, academic or documentary. The prominence of each cause differed within the various hospital environments, as was demonstrated in Chapter 4 and Chapter 5. In Table 6.2, these causes are ranked according to the number of times they were mentioned in the qualitative interviews by each hospital's employees in order to demonstrate the extent to which these causes are different in varying hospital environments, according to the qualitative data:

	Hospital A	Hospital B	Hospital C
Rank 1	Inability to discharge patients	Lack of communication/information	Specific patient needs (e.g. telemetry)
Rank 2	Specific patient disposition (e.g. VRE+)	Late discharges	Late discharges
Rank 3	Late discharges	Uncoordinated admissions/discharges	Lack of communication/information
Rank 4	Lack of communication/information	Inability to discharge patients	Specific patient disposition (e.g. VRE+)
Rank 5	Specific patient needs (e.g. telemetry)	Staffing levels	Uncoordinated admissions/discharges
Rank 6	Imbalance in surgical scheduling	Specific patient needs (e.g. telemetry)	Inability to discharge patients

Table 6.2. Causes of ED boarding by hospital according to qualitative ranking

Of course, Table 6.2 is based solely on the qualitative information, and is demonstrated simply to show the difference in qualitative results between the different hospitals. The importance of each cause was measured according to all the different streams of data that were obtained, and with the results, a final conceptual framework was established. In order to follow this thesis' methodology, which asked interview participants to pinpoint the 4 key issues causing ED boarding, this thesis distinguished the 4 root causes of ED boarding and formulated them with their respective solutions in this framework. Figure 6.1 is the product of this analysis. In order to demonstrate the framework's application within the studied hospitals, operational steps leading to the implementation of these solutions will be demonstrated in Section 6.2.

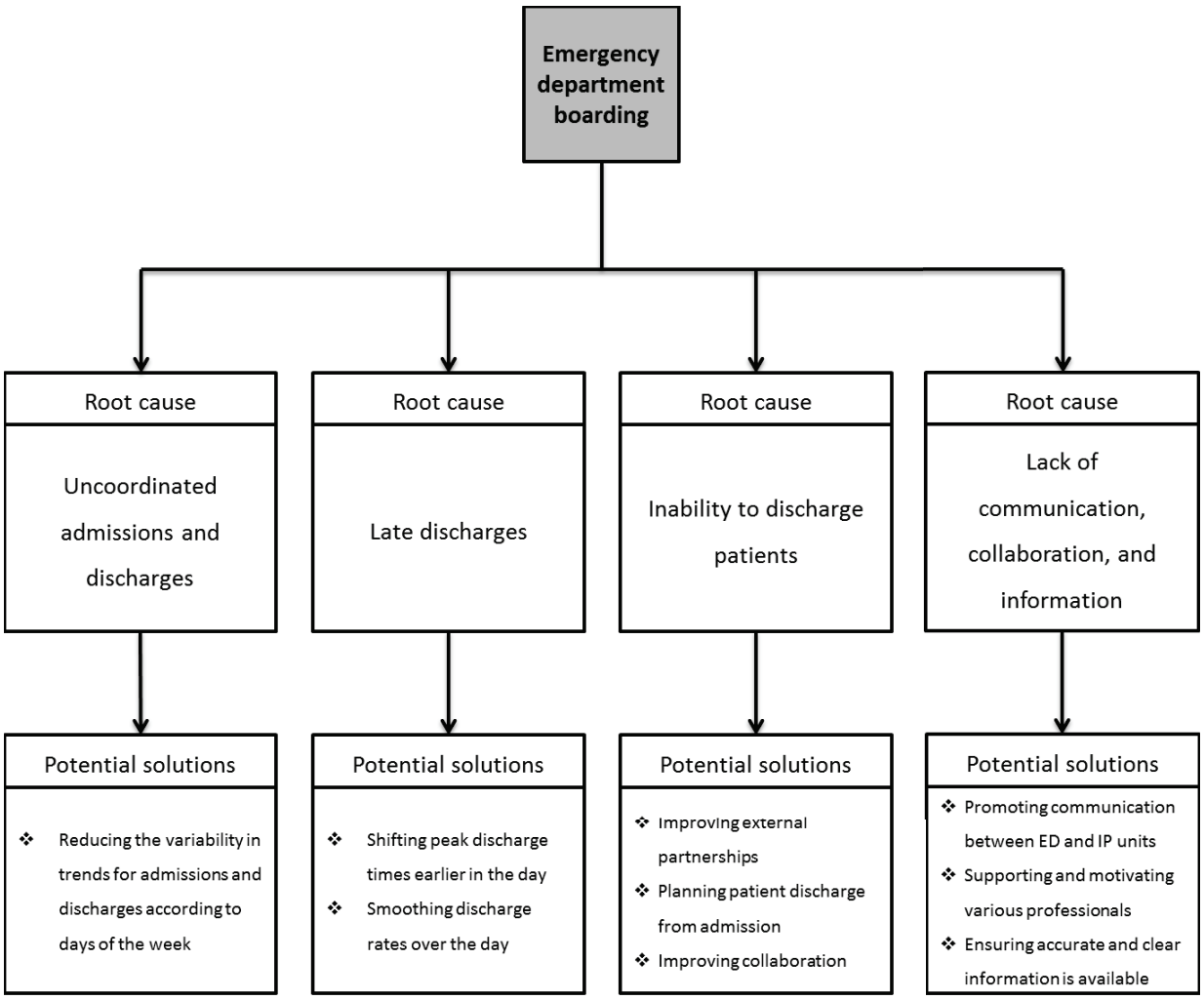

Figure 6.1. Final conceptual framework displaying the 4 root causes of ED boarding and their potential solutions

These root causes were chosen according to their prominence and validity in the qualitative, quantitative, academic and documentary data. While other causes had been validated through different streams of data as well, these were the 4 major key issues that arose from the interpretation of data. Importantly, these causes were significant in each of the hospitals studied, which leads to believe that perhaps these causes can be deciphered in other hospitals in Quebec.

6.2. Contributions to research and management practitioners

Through the analysis of various types of data, this thesis was able to pinpoint key issues causing emergency department boarding in three Quebec hospitals. Using this information, a final conceptual framework for ED boarding was elaborated, which offers perspective for other hospitals and management practitioners as to what may be causing this issue within their own

institutions. Rather than starting from scratch, these individuals now have a framework demonstrating probable causes for ED boarding, which provides a starting point for analysis within other establishments. Moreover, if these root causes are seen to be significant in other institutions, pathways to improvement are demonstrated as well, which will help managers to reduce ED boarding. In order to demonstrate the framework's application, recommendations will be made for each hospital as to the steps that they can take in order to implement these solutions (Table 6.3, Table 6.4, and Table 6.5).

Hospital A	
Root cause	Hospital-adapted recommendations using the framework solutions
• Uncoordinated admissions and discharges	❖ In order to reduce the variability on a day of the week basis, first look at why so many patients are being discharged on Friday (20.75%). It is unlikely that the reasons are medical, and are more likely organisational or based on habits of medical practitioners and staff members.
• Late discharges	❖ At the current moment, 40.94% of patients are discharged between 13:00 and 16:59; this causes a variety of issues. First, this leads to a peak period in patient transfers from the ED which occurs between 14:00 and 17:59 (25.35%); half of this period happens during the day shift, and the other happens during the evening shift. Transferring patients in between shift can be problematic and cause additional delays. Moreover, there is less staff available after 16:00. Look first at why so many patients are being discharged during this time. It is unlikely that the reasons are medical, and are more likely organisational or based on habits or preferences of medical practitioners and staff members.
• Inability to discharge patients	❖ Hospital A currently has Nurses who follow the patient care process throughout its evolution and prepare discharge as of admission (obtaining information about the patient, his home situation, etc.); however, this type of employee is only present during the day shift, and as such, this is generally only done during the day. The first step to improving this issue is to instil this attitude in Nurses who work in the evening and at night, so as to ensure flow is constant. Also, continue working on discharges that occur without notice, you have improved considerably in this area.
• Lack of communication, collaboration, information	❖ It is important to ensure that accurate and clear information is supplied for bed management employees; the strain of VRE, for example, is crucial in knowing whether two patients can be paired together or not. Ensure that they have all the information that is required so as to assign beds as promptly as possible. Continue having daily bed management meetings, and perhaps, as many of you have suggested, have them earlier in the day so that information is more easily transferred throughout the hospital.

Table 6.3. Hospital A – Adapted recommendations using the final framework

Hospital B	
Root cause	Hospital-adapted recommendations using the framework solutions
• Uncoordinated admissions and discharges	❖ In order to reduce the variability on a day of the week basis, first look at why so many patients are being discharged on Friday (22.65%). It is unlikely that the reasons are medical, and are more likely organisational or based on habits of medical practitioners and staff members.
• Late discharges	❖ At the current moment, 49.47% of patients are discharged between 13:00 and 16:59; this causes a variety of issues. First, this leads to a peak period in patient transfers from the ED which occurs between 18:00 and 21:59 (35.10%); this entire period is during the evening shift, and there is less staff available after 16:00 – for example, there are no more stretcher-bearers at this time, and orderlies from the ED must transfer patients. Look first at why so many patients are being discharged during this time. It is unlikely that the reasons are medical, and are more likely organisational or based on habits or preferences of medical practitioners and staff members.
• Inability to discharge patients	❖ Hospital B currently has Nurses who follow the patient care process throughout its evolution and prepare discharge as of admission (obtaining information about the patient, his home situation, etc.); however, this type of employee is only present during the day shift, and as such, this is generally only done during the day. The first step to improving this issue is to instil this attitude in Nurses who work in the evening and at night, so as to ensure flow is constant. Also, start working on discharges that occur without notice, this is an area that could be improved considerably.
• Lack of communication, collaboration, information	❖ Right now, inpatient unit employees have access to information regarding the ED and its occupancy rate, but have difficulty interpreting the data that is available. It is important that you provide additional knowledge on this subject so that they can understand when important peaks are happening in the ED. Continue having multi-disciplinary meetings and daily bed management meetings; these are excellent initiatives.

Table 6.4. Hospital B – Adapted recommendations using the final framework

Hospital C	
Root cause	Hospital-adapted recommendations using the framework solutions
• Uncoordinated admissions and discharges	❖ In order to reduce the variability on a day of the week basis, first look at why so many patients are being discharged on Friday (19.15%). It is unlikely that the reasons are medical, and are more likely organisational or based on habits of medical practitioners and staff members.
• Late discharges	❖ At the current moment, 40.84% of patients are discharged between 13:00 and 16:59; this causes a variety of issues. First, this leads to a peak period in patient transfers from the ED which occurs between 19:00 and 22:59 (36.39%); this entire period is during the evening shift, and there is less staff available after 16:00 – for example, there are no more orderlies attributed to patient transfers at this time, and orderlies from the ED must transfer patients. Look first at why so many patients are being discharged during this time. It is unlikely that the reasons are medical, and are more likely organisational or based on habits of medical practitioners and staff members.
• Inability to discharge patients	❖ Hospital C currently does not have Nurses who follow the patient care process throughout its evolution and prepare discharge as of admission (obtaining information about the patient, his home situation, etc.); this is something that could be developed, as it appears to function very well for Hospital A and Hospital B. Preparing discharge more extensively, and as of admission, will lead to less patients who stay overnight because of delayed discharge or because they have no means of returning to their homes.
• Lack of communication, collaboration, information	❖ Currently, information about the emergency department is not broadcast in inpatient units, and according to the interviewees, there is an important disconnect between ED employees and IP employees. Increasing the proximity of these two units could be beneficial for patient throughput. Having multi-unit meetings, similarly to the multidisciplinary meetings that occur in Hospital B, could prove useful. Attempt to increase collaboration between professionals as well, as it is preferable for a patient to receive the different types of care needed in a coordinated way.

Table 6.5. Hospital C – Adapted recommendations using the final framework

In terms of contributions to research in particular, this thesis offers many. First, the literature review encompasses academic material covering various aspects of both ED boarding and ED crowding, which have been displayed in comprehensive tables so as to make this information readily available for other researchers. Second, the methodology demonstrated can be reproduced and applied to other hospitals elsewhere in the world in order to understand how ED boarding functions in these environments; moreover, while this thesis relied on a conceptual framework established from the literature review alone, further research can be conducted using the final conceptual framework that was established above, which demonstrates validated causes rather than potential or hypothetical causes. Furthermore, many different paths to further research were elucidated in Chapter 5, and will be grouped together in Section 6.4.

In terms of contributions to management practitioners in particular, this thesis offers many as well. At the moment, there are many different improvement initiatives being conducted within the healthcare network in Quebec. Many institutions have received funding for Lean projects from the Ministry of Health and Social Services, and are often using Kaizen workshops to find improvements to various issues that have been identified. To the author's knowledge, emergency department boarding has not been a topic addressed yet by any of these initiatives, and thus, this thesis demonstrates an additional area for improvement which can be addressed in the future. Using the final framework put forth above, managers can now pinpoint particular causes and address them so as to improve this issue within their establishments.

6.3. Limitations of this research

There are various limitations to this research, of which those related to the nature of the data available can be found in Chapter 3. Since the qualitative categories were created by the author, and the data collected from the qualitative interviews was interpreted and categorised by the author as well, the nature of the data has a certain innate bias. Other researchers may have categorised the answers differently, or created categories that were more, or less, precise.

Another limitation is linked with the author himself. During periods of direct observation on the field or in bed management meetings, much of what is discussed is clinical in nature; diagnostics, treatment plans, and other such topics are discussed with terms that are often unfamiliar to the author, as he has no background in medicine or any related field. Given these circumstances, it is possible that some relevant information was lost in the process.

One of the most important limitations of this research is that not all of the actors within the patient care process were represented in the qualitative interviews. Moreover, there were a limited number of interviews conducted, and a limited number of time possible for each interview, given that they were conducted during the interviewees' shifts. No physicians were interviewed because of time and availability constraints, which is unfortunate given the importance that they have in many of the elucidated causes. Also, interviews were conducted with different actors in each hospital, which increases the variability of the answers. In order to limit the subjectivity of qualitative interviews, other parameters must be controlled; however, this issue could not be controlled within the studied hospitals. Interviews were scheduled by hospital contacts, and although a list of individuals was produced to guide their decisions, ultimately the decision was made by the hospital contact as to who would be interviewed for this thesis.

A final limitation is related to the quantitative data obtained. There is a great deal of variability found in the boarding time experienced by patients. Some are boarded for as little as 0 minutes, while others are boarded for as long as 12 000 minutes. Since there is a degree of human intervention within this process, perhaps the 0 minutes that are demonstrated in the statistics are not representative of reality. Nevertheless, outlying results such as these were scarce, and thus had very little impact on the overall analysis.

6.4. Further research

Given the exploratory nature of this thesis, many important topics for further research were elucidated. In essence, each particular cause can be explored more thoroughly; the primary goal of this thesis was to find the causes of ED boarding in the studied hospitals, but not to understand each cause more in-depth. For example, we know that patients with particular needs can experience longer periods of boarding time. Patients requiring telemetry, for example, were often mentioned as being problematic in the qualitative interviews. In the studied hospitals, whether or not a specific patient required telemetry was not a variable included within the statistical software, and could thus not be analysed. Further research could be conducted to understand how patients requiring telemetry in particular are affected by ED boarding. According to the interviewees, on some occasions patients were put on telemetry when it was not particularly relevant (e.g. if the patient was already monitored for 72 hours in the ED without any cardiac arrhythmias); the author could not verify this claim, and as such, could be researched

further in itself. Each particular cause is subject to research, and it would be highly beneficial to understand them all individually in a more elaborate way so as to provide more specific solutions.

Another source of further research that was produced by this thesis is related to information that could not be explained. For example, the effect of hours of the day and days of the week were not found to be statistically significant in Hospital A, while Hospital B and Hospital C were significantly affected. Hospital A's performance in terms of average boarding time was fairly linear in these two categories even though there were large fluctuations in admissions, discharges, or arrivals. It is difficult to understand how this is possible, given the comparison with the other two hospitals. Evidently, many interrelated factors influence this performance, and as such, it would be interesting to analyse patterns and trends of average boarding time more thoroughly.

One of the most prominent causes for ED boarding in this thesis was found to be the lack of communication, collaboration, and information experienced by hospital staff. The methods by which the hospital communicates with its employees, the methods by which employees communicate together, the nature of collaborative efforts, and other such topics were not addressed within the context of this thesis, and could all be used as research topics. Understanding the nature of these interpersonal problems is an important step in improving this problem.

There are many other sources of further research found in this thesis. One, perhaps, that would be most interesting to the author, would be to validate the framework created in this thesis in other hospitals. Since no such framework was established in the literature beforehand, and since no research on ED boarding in Quebec has been published up to date, applying this model in other contexts could prove to be very interesting.

6.5. Closing statement

The undertaking of this thesis has proven to be an extraordinary challenge, and it is with a great sense of fulfillment that I now conclude its content. To my fellow students who will undertake this path well, I say that that there is no greater pride than the completion of this arduous journey. One thing I've learned while writing this thesis is that it is incredibly important to think critically when producing a research project of this scope. We receive a great deal of information from the organisations that we collaborate with, and we must not only find what is

relevant within this information, but also question ourselves as to the nature of this information, its validity, and its possible biases. It is truly a skill to be able to perform these tasks, and I believe that this is something that I've learned and developed thanks to this endeavour. Moreover, this thesis has also taught me the importance of perseverance. On many occasions, I felt as if certain challenges or obstacles were insurmountable, and it was easy to become demoralised in the face of these tests. However, having overcome these trials, I now see the fruit of my labour, and am greatly appreciative of the fact that I was able to persevere through this voyage. Lastly, I've learned the importance of the support we receive from loved ones, friends, colleagues, family members, and teachers, on maintaining morale (or perhaps, sanity), and I am deeply thankful to the people that helped me throughout this venture.

7. Annexes

Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients
0-120	18.85	1561-1680	2.21	3121-3240	0.68	4680-4800	0.30
121-240	13.84	1681-1800	2.17	3241-3360	0.57	4801-4920	0.13
241-360	10.13	1801-1920	1.62	3361-3480	0.43	4921-5040	0.12
361-480	8.04	1921-2040	1.18	3481-3600	0.36	5041-5160	0.10
481-600	5.72	2041-2160	1.04	3601-3720	0.30	5161-5280	0.14
601-720	4.65	2161-2280	0.76	3721-3840	0.20	5281-5400	0.18
721-840	3.11	2281-2400	0.81	3841-3960	0.15	5401-5520	0.14
841-960	2.49	2401-2520	0.57	3961-4080	0.19	5521-5640	0.13
961-1080	2.13	2521-2640	0.56	4081-4200	0.45	5641-5760	0.16
1081-1200	2.08	2641-2760	0.68	4201-4320	0.31	5761-5880	0.13
1201-1320	2.30	2761-2880	0.72	4321-4440	0.35	5881-6000	0.14
1321-1440	2.44	2881-3000	0.66	4441-4560	0.28	6001-6120	0.27
1441-1560	2.34	3001-3120	0.58	4561-4680	0.40	6121+	1.74

Table 7.1. Hospital A: Distribution of patients according to boarding time

Season	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Winter	23.75	1291.04	19.08	0	12989	1805.61
Spring	26.60	822.28	22.67	0	11107	1223.39
Summer	25.14	1050.18	15.82	0	12130	1423.32
Autumn	24.51	1103.33	17.53	0	10370	1429.89

Table 7.2. Hospital A: Admission requests and boarding time by season

Month	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
January	8.07	1454.47	15.15	0	11941	1909.51
February	7.55	1327.55	20.99	0	12989	2020.68
March	8.27	1113.51	19.92	0	8769	1423.72
April	8.27	967.89	19.02	0	11107	1323.66
May	8.99	723.39	24.85	0	10606	1152.49
June	8.40	798.84	22.03	0	9639	1197.27
July	8.55	1030.39	17.41	0	9645	1425.36
August	8.43	1027.72	16.52	0	12130	1484.18
September	8.20	1192.33	12.06	0	10259	1396.83
October	8.60	1131.32	15.95	0	7757	1395.52
November	8.31	1089.63	19.97	0	10370	1509.38
December	8.34	927.31	21.81	0	8713	1300.66

Table 7.3. Hospital A: Admission requests and boarding time by month

Day of the week	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Monday	14.98	967.36	17.68	0	12226	1429.87
Tuesday	15.95	1046.38	17.47	0	10702	1423.50
Wednesday	14.90	1075.94	16.42	0	9968	1402.20
Thursday	13.93	1080.67	17.71	0	11827	1545.31
Friday	13.38	1138.31	17.81	0	12989	1610.21
Saturday	13.54	1092.47	23.41	0	12977	1623.16
Sunday	13.32	1027.73	22.04	0	10606	1369.40

Table 7.4. Hospital A: Admission requests and boarding time by day of the week

Time of day	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
00:00-00:59	1.53	800.99	34.03	7	5838	1048.38
01:00-01:59	2.19	1072.12	36.41	0	11107	1776.60
02:00-02:59	1.33	918.12	33.60	0	8313	1256.11
03:00-03:59	1.16	873.83	37.61	0	8149	1284.58
04:00-04:59	0.81	1139.78	31.58	1	9645	1804.97
05:00-05:59	0.71	924.97	26.87	0	6801	1393.92
06:00-06:59	0.86	799.13	30.86	0	8939	1365.41
07:00-07:59	1.12	1161.02	20.95	0	8078	1576.12
08:00-08:59	2.14	927.20	22.39	0	10411	1743.34
09:00-09:59	5.29	1019.16	19.11	0	12989	1480.61
10:00-10:59	8.54	1037.17	15.19	0	10441	1447.55
11:00-11:59	8.39	1200.24	11.28	0	12130	1673.99
12:00-12:59	8.41	1048.83	14.41	0	10271	1389.68
13:00-13:59	6.45	988.88	20.46	0	9786	1409.50
14:00-14:59	6.91	1063.62	17.54	0	12977	1582.39
15:00-15:59	7.37	1130.03	14.86	0	9821	1465.62
16:00-16:59	8.85	1111.61	13.82	0	9228	1357.23
17:00-17:59	8.50	1099.51	13.27	0	10702	1407.78
18:00-18:59	5.08	1116.14	15.27	1	10606	1560.21
19:00-19:59	3.55	1102.83	23.35	0	10185	1506.42
20:00-20:59	2.95	999.99	25.27	0	10010	1572.52
21:00-21:59	2.97	918.28	35.13	0	11430	1466.02
22:00-22:59	2.58	943.55	30.04	0	8576	1353.95
23:00-23:59	2.31	1100.84	25.81	0	7899	1572.51

Table 7.5. Hospital A: Admission requests and boarding time by hour of the day

Season – Statistical significance of each component variable								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1293.732	83.5504	1129.976	1457.487	239.77	<.0001
Season	Autumn	1	98.7381	94.2227	-85.9350	283.4112	1.10	0.2947
Season	Spring	1	-359.549	94.0834	-543.949	-175.149	14.60	0.0001
Season	Summer	1	-90.1670	111.2112	-308.137	127.8029	0.66	0.4175

Table 7.6. Hospital A: General linear model results seasonal segmentation

Month – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1293.732	83.5504	1129.976	1457.487	239.77	<.0001
Month	April	1	-113.878	120.6527	-350.353	122.5965	0.89	0.3452
Month	August	1	-335.629	134.0445	-598.352	-72.9071	6.27	0.0123
Month	December	1	-575.404	94.3044	-760.237	-390.571	37.23	<.0001
Month	February	1	-120.611	76.9108	-271.353	30.1317	2.46	0.1168
Month	July	1	-327.803	133.9739	-590.387	-65.2188	5.99	0.0144
Month	June	1	-376.310	116.3023	-604.258	-148.361	10.47	0.0012
Month	March	1	-185.013	84.9233	-351.460	-18.5668	4.75	0.0294
Month	May	1	-371.213	119.4666	-605.363	-137.062	9.65	0.0019
Month	November	1	-461.832	120.5404	-698.087	-225.577	14.68	0.0001
Month	October	1	-418.688	120.1420	-654.162	-183.214	12.14	0.0005
Month	September	1	-222.028	122.1315	-461.401	17.3457	3.30	0.0691

Table 7.7. Hospital A: General linear model results monthly segmentation

Day of the week – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1293.732	83.5504	1129.976	1457.487	239.77	<.0001
Day of week	Friday	1	169.8604	57.2692	57.6147	282.1060	8.80	0.0030
Day of week	Saturday	1	136.9575	57.1622	24.9217	248.9934	5.74	0.0166
Day of week	Sunday	1	60.3317	57.3405	-52.0537	172.7171	1.11	0.2927
Day of week	Thursday	1	120.2113	56.7309	9.0207	231.4020	4.49	0.0341
Day of week	Tuesday	1	78.9862	54.7212	-28.2654	186.2377	2.08	0.1489
Day of week	Wednesday	1	116.6471	55.7488	7.3815	225.9127	4.38	0.0364

Table 7.8. Hospital A: General linear model results day of the week segmentation

Time of day – Analysis of maximum likelihood parameter estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Time of day	1	4.5597	3.0109	-1.3415	10.4610	2.29	0.1299

Table 7.9. Hospital A: General linear model results hourly segmentation

Overall statistical significance of variable category			
Source	**DF**	**Wald Chi-Square**	**Pr > ChiSQ**
Season	3	20.31	0.0001
Month	11	63.05	<.0001
Day of the week	6	11.58	0.0720
Day the month	1	0.04	0.8336
Time of day	1	2.29	0.1299

Table 7.10. Hospital A: General linear model results global

	Admissions (%)	**Arrivals (%)**	**Discharges (%)**
Monday	14.98	15.04	13.19
Tuesday	15.95	15.39	16.56
Wednesday	14.90	15.01	17.00
Thursday	13.93	14.60	17.41
Friday	13.38	14.33	20.75
Saturday	13.54	13.88	8.25
Sunday	13.32	11.75	6.85

Table 7.11. Hospital A: Admission requests, arrivals and discharges by day of the week

Time of day	**Admissions (%)**	**Arrivals (%)**	**Discharges (%)**
00:00-00:59	1.53	2.29	0.34
01:00-01:59	2.19	6.53	0.48
02:00-02:59	1.33	3.78	0.49
03:00-03:59	1.16	2.07	0.28
04:00-04:59	0.81	1.41	0.33
05:00-05:59	0.71	1.07	0.24
06:00-06:59	0.86	0.84	0.20
07:00-07:59	1.12	0.63	0.35
08:00-08:59	2.14	0.60	2.75
09:00-09:59	5.29	2.10	5.71
10:00-10:59	8.54	2.99	7.41
11:00-11:59	8.39	3.49	8.58
12:00-12:59	8.41	3.28	6.63
13:00-13:59	6.45	4.00	11.25
14:00-14:59	6.91	6.69	11.97
15:00-15:59	7.37	7.55	10.94
16:00-16:59	8.85	4.37	6.79
17:00-17:59	8.50	6.75	5.92
18:00-18:59	5.08	6.35	4.91
19:00-19:59	3.55	4.16	3.88
20:00-20:59	2.95	5.36	3.86
21:00-21:59	2.97	7.05	3.01
22:00-22:59	2.58	7.19	2.05
23:00-23:59	2.31	5.45	1.64

Table 7.12. Hospital A: Admission requests, arrivals and discharges by time of day

Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients
0-120	21.00	1561-1680	3.78	3121-3240	0.55	4680-4800	0.09
121-240	19.81	1681-1800	3.07	3241-3360	0.33	4801-4920	0.04
241-360	11.79	1801-1920	1.95	3361-3480	0.24	4921-5040	0.00
361-480	6.59	1921-2040	0.93	3481-3600	0.07	5041-5160	0.02
481-600	4.00	2041-2160	0.53	3601-3720	0.07	5161-5280	0.00
601-720	2.04	2161-2280	0.33	3721-3840	0.02	5281-5400	0.00
721-840	0.99	2281-2400	0.20	3841-3960	0.05	5401-5520	0.00
841-960	0.93	2401-2520	0.42	3961-4080	0.04	5521-5640	0.02
961-1080	1.46	2521-2640	0.57	4081-4200	0.11	5641-5760	0.00
1081-1200	2.57	2641-2760	0.88	4201-4320	0.02	5761-5880	0.02
1201-1320	4.14	2761-2880	0.78	4321-4440	0.05	5881-6000	0.00
1321-1440	4.16	2881-3000	0.68	4441-4560	0.07	6001-6120	0.00
1441-1560	3.92	3001-3120	0.62	4561-4680	0.07	6121+	0.00

Table 7.13. Hospital B: Distribution of patients according to boarding time

Season	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Winter	25.69	645.71	26.56	0	4775	823.54
Spring	25.82	877.44	13.29	3	5809	847.68
Summer	23.10	1005.35	13.59	3	5593	946.49
Autumn	25.40	478.19	29.96	1	4455	611.27

Table 7.14. Hospital B: Admission requests and boarding time by season

Month	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
January	9.12	1123.79	9.40	0	4775	1033.72
February	7.75	379.47	33.41	4	3320	516.33
March	8.94	565.07	23.27	1	4120	646.96
April	8.96	865.01	12.22	10	4441	866.55
May	8.58	777.90	13.19	15	5809	753.65
June	6.84	1383.13	11.20	3	5593	1150.02
July	7.64	1053.07	10.26	8	5142	856.89
August	8.01	630.41	21.64	3	3163	675.29
September	7.79	1144.39	9.37	7	4455	916.10
October	8.83	618.45	21.49	1	3359	684.06
November	7.92	245.61	46.08	7	2909	352.81
December	9.62	317.89	38.33	9	2666	408.94

Table 7.15. Hospital B: Admission requests and boarding time by month

Day of the week	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Monday	14.36	937.13	13.98	0	4775	907.32
Tuesday	15.67	920.73	14.67	11	4865	917.45
Wednesday	15.33	795.83	16.19	1	3501	796.03
Thursday	14.69	684.81	18.63	3	3049	648.53
Friday	15.33	460.82	26.90	3	4680	643.14
Saturday	13.08	631.09	32.91	1	5809	929.59
Sunday	11.55	792.07	26.38	3	5142	890.12

Table 7.16. Hospital B: Admission requests and boarding time by day of the week

Time of day	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
00:00-00:59	0.27	966.83	33.33	29	4096	1146.08
01:00-01:59	0.35	888.90	36.84	25	3934	1042.18
02:00-02:59	0.15	745.92	12.50	35	2316	682.88
03:00-03:59	0.20	476.89	36.36	4	1190	409.02
04:00-04:59	0.26	615.95	14.29	62	1740	438.67
05:00-05:59	0.07	483.17	25.00	101	670	224.34
06:00-06:59	0.16	360.06	11.11	116	942	275.38
07:00-07:59	0.46	631.85	12.00	50	2142	532.78
08:00-08:59	2.44	585.69	14.93	17	3681	670.76
09:00-09:59	2.32	548.95	17.32	28	3695	670.35
10:00-10:59	3.47	588.98	21.05	8	3585	702.12
11:00-11:59	4.54	678.32	14.86	11	4894	825.32
12:00-12:59	6.15	714.29	15.43	16	4669	810.31
13:00-13:59	6.19	633.94	33.33	0	4775	807.44
14:00-14:59	8.43	593.11	29.00	7	4757	780.51
15:00-15:59	12.02	740.42	22.31	9	4680	845.65
16:00-16:59	15.44	741.63	22.10	7	4441	819.85
17:00-17:59	15.20	843.95	15.01	19	4682	876.42
18:00-18:59	8.89	828.54	15.20	1	4726	863.21
19:00-19:59	6.11	870.79	21.79	12	5809	925.94
20:00-20:59	3.85	954.43	25.59	1	5593	941.15
21:00-21:59	1.73	816.04	34.74	7	4357	810.25
22:00-22:59	0.71	824.04	30.77	16	3908	915.96
23:00-23:59	0.60	1021.11	12.12	39	2527	654.95

Table 7.17. Hospital B: Admission requests and boarding time by hour of the day

Season – Statistical significance of each component variable								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	831.8489	64.5981	705.2390	958.4588	165.82	<.0001
Season	Autumn	1	296.3772	60.7649	177.2801	415.4743	23.79	<.0001
Season	Spring	1	100.6707	61.2000	-19.2791	220.6204	2.71	0.1000
Season	Summer	1	635.2201	75.1345	487.9592	782.4810	71.48	<.0001

Table 7.18. Hospital B: General linear model results seasonal segmentation

Month – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	831.8489	64.5981	705.2390	958.4588	165.82	<.0001
Month	April	1	-367.041	77.2589	-518.465	-215.616	22.57	<.0001
Month	August	1	-1102.91	89.3685	-1278.07	-927.753	152.30	<.0001
Month	December	1	-999.070	61.1385	-1118.90	-879.241	267.03	<.0001
Month	February	1	-741.458	48.8410	-837.184	-645.731	230.46	<.0001
Month	July	1	-724.146	89.8569	-900.262	-548.029	64.95	<.0001
Month	June	1	28.8034	76.5641	-121.260	178.8663	0.14	0.7068
Month	March	1	-587.948	52.5843	-691.011	-484.884	125.02	<.0001
Month	May	1	-440.115	77.4758	-591.964	-288.265	32.27	<.0001
Month	November	1	-1147.65	77.8080	-1300.15	-995.144	217.55	<.0001
Month	October	1	-793.370	76.8653	-944.023	-642.717	106.53	<.0001
Month	September	1	-512.834	80.6724	-670.949	-354.719	40.41	<.0001

Table 7.19. Hospital B: General linear model results monthly segmentation

Day of the week – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	-484.338	36.8924	-556.645	-412.030	172.35	<.0001
Day of week	Friday	1	-306.744	38.3081	-381.827	-231.662	64.12	<.0001
Day of week	Saturday	1	-139.340	39.5635	-216.883	-61.7971	12.40	0.0004
Day of week	Sunday	1	-249.853	37.2320	-322.826	-176.879	45.03	<.0001
Day of week	Thursday	1	-17.2909	36.6199	-89.0646	54.4829	0.22	0.6368
Day of week	Tuesday	1	-134.360	36.7651	-206.418	-62.3015	13.36	0.0003
Day of week	Wednesday	1	-484.338	36.8924	-556.645	-412.030	172.35	<.0001

Table 7.20. Hospital B: General linear model results day of the week segmentation

Day of the month – Analysis of maximum likelihood parameter estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Day month	1	5.8002	1.1522	3.5419	8.0584	25.34	<.0001

Table 7.21. Hospital B: General linear model results day of the month segmentation

Time of day – Analysis of maximum likelihood parameter estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Time of day	1	23.9404	2.8977	18.2609	29.6199	68.26	<.0001

Table 7.22. Hospital B: General linear model results hourly segmentation

Overall statistical significance of variable category			
Source	**DF**	**Wald Chi-Square**	**Pr > ChiSQ**
Season	3	79.27	<.0001
Month	11	750.31	<.0001
Day of the week	6	253.75	<.0001
Day the month	1	25.28	<.0001
Time of day	1	67.84	<.0001

Table 7.23. Hospital B: General linear model results global

	Admissions (%)	**Arrivals (%)**	**Discharges (%)**
Monday	14.36	12.37	12.44
Tuesday	15.67	14.58	15.44
Wednesday	15.33	16.09	15.96
Thursday	14.69	15.96	17.37
Friday	15.33	18.76	22.65
Saturday	13.08	12.35	9.50
Sunday	11.55	9.89	6.63

Table 7.24. Hospital B: Admission requests, arrivals and discharges by day of the week

Time of day	**Admissions (%)**	**Arrivals (%)**	**Discharges (%)**
00:00-00:59	0.27	1.94	0.39
01:00-01:59	0.35	2.07	0.23
02:00-02:59	0.15	0.89	0.26
03:00-03:59	0.20	0.40	0.16
04:00-04:59	0.26	0.18	0.33
05:00-05:59	0.07	0.26	0.26
06:00-06:59	0.16	0.25	0.35
07:00-07:59	0.46	0.16	0.30
08:00-08:59	2.44	0.18	0.72
09:00-09:59	2.32	0.93	3.30
10:00-10:59	3.47	1.70	6.93
11:00-11:59	4.54	2.82	9.36
12:00-12:59	6.15	2.28	8.02
13:00-13:59	6.19	4.10	11.27
14:00-14:59	8.43	6.99	14.81
15:00-15:59	12.02	8.69	13.15
16:00-16:59	15.44	6.34	10.24
17:00-17:59	15.20	8.62	7.24
18:00-18:59	8.89	8.81	4.47
19:00-19:59	6.11	7.27	3.49
20:00-20:59	3.85	9.56	2.22
21:00-21:59	1.73	9.46	1.30
22:00-22:59	0.71	8.18	0.74
23:00-23:59	0.60	3.94	0.48

Table 7.25. Hospital B: Admission requests, arrivals and discharges by time of day

Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients	Boarding time (minutes)	% of patients
0-120	11.94	1561-1680	3.74	3121-3240	0.55	4680-4800	0.05
121-240	15.38	1681-1800	2.84	3241-3360	0.24	4801-4920	0.00
241-360	11.40	1801-1920	2.35	3361-3480	0.31	4921-5040	0.00
361-480	6.40	1921-2040	1.42	3481-3600	0.25	5041-5160	0.02
481-600	4.98	2041-2160	1.25	3601-3720	0.20	5161-5280	0.00
601-720	3.04	2161-2280	1.20	3721-3840	0.25	5281-5400	0.00
721-840	2.76	2281-2400	1.24	3841-3960	0.31	5401-5520	0.02
841-960	2.31	2401-2520	1.44	3961-4080	0.15	5521-5640	0.00
961-1080	2.87	2521-2640	1.53	4081-4200	0.15	5641-5760	0.00
1081-1200	3.62	2641-2760	1.44	4201-4320	0.22	5761-5880	0.00
1201-1320	3.25	2761-2880	1.22	4321-4440	0.13	5881-6000	0.00
1321-1440	3.49	2881-3000	1.51	4441-4560	0.09	6001-6120	0.00
1441-1560	3.58	3001-3120	0.80	4561-4680	0.07	6121+	0.02

Table 7.26. Hospital C: Distribution of patients according to boarding time

Season	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Winter	24.29	903.82	12.57	5	4765	876.20
Spring	25.81	1165.97	10.28	5	5488	1040.52
Summer	25.27	737.58	13.81	5	6182	763.60
Autumn	24.63	1159.94	11.00	1	5056	1044.31

Table 7.27. Hospital C: Admission requests and boarding time by season

Month	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
January	8.76	1079.29	11.83	5	4765	956.85
February	7.80	795.29	10.49	17	3919	756.85
March	8.53	968.76	13.65	13	4557	954.34
April	8.38	1569.35	9.54	12	5488	1208.52
May	8.69	1006.38	8.16	12	3967	875.34
June	8.11	749.79	11.43	5	6182	704.44
July	8.20	638.57	13.53	5	4158	641.42
August	8.65	696.68	15.34	7	3614	727.83
September	8.31	917.86	12.91	9	4265	864.05
October	8.25	856.28	12.11	5	3442	802.42
November	8.25	1422.80	10.79	1	4449	1172.30
December	8.07	1197.49	13.06	11	5056	1113.48

Table 7.28. Hospital C: Admission requests and boarding time by month

Day of the week	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
Monday	13.78	1116.44	9.37	7	4765	998.21
Tuesday	14.80	1053.86	10.93	7	4623	976.07
Wednesday	14.40	1004.97	11.74	7	3931	906.60
Thursday	15.62	855.93	14.67	1	4085	773.55
Friday	15.63	769.27	11.51	5	6182	882.99
Saturday	13.40	1017.53	11.80	12	4531	1056.87
Sunday	12.38	1194.37	13.22	12	4659	1043.44

Table 7.29. Hospital C: Admission request and average boarding time by day of the week

Time of day	Admission requests (%)	Average boarding time	Compliance (%)	Minimum boarding time	Maximum boarding time	Standard deviation
00:00-00:59	4.24	1434.73	8.58	14	4226	1012.77
01:00-01:59	3.80	1270.10	11.96	15	3967	919.48
02:00-02:59	1.62	1333.73	8.99	22	3890	930.15
03:00-03:59	0.82	1488.93	11.11	35	5056	1116.85
04:00-04:59	0.80	1303.23	11.36	30	3573	894.01
05:00-05:59	0.91	1236.56	14.00	57	3690	921.39
06:00-06:59	1.36	1279.87	2.67	49	4120	1073.47
07:00-07:59	0.89	1314.39	12.24	14	3523	1010.49
08:00-08:59	2.38	971.31	6.87	5	3772	914.54
09:00-09:59	2.58	1015.71	11.27	15	4765	982.15
10:00-10:59	4.64	839.02	8.63	32	3825	856.09
11:00-11:59	5.33	827.14	10.24	1	4395	865.53
12:00-12:59	5.25	861.08	9.34	5	4637	898.83
13:00-13:59	6.60	813.30	13.50	7	6182	876.68
14:00-14:59	8.71	831.14	16.70	10	4794	932.38
15:00-15:59	6.34	942.33	10.89	9	4623	989.00
16:00-16:59	8.45	886.90	10.11	5	4531	916.50
17:00-17:59	8.60	856.08	9.51	9	4687	842.52
18:00-18:59	6.54	973.72	9.44	13	4486	978.63
19:00-19:59	5.58	919.88	15.64	13	4557	990.01
20:00-20:59	4.45	1024.22	15.51	5	3770	892.54
21:00-21:59	3.67	1174.31	22.28	17	5488	1033.46
22:00-22:59	3.69	1266.16	13.79	11	4393	1016.84
23:00-23:59	2.74	1330.03	13.91	12	4256	1007.07

Table 7.30. Hospital C: Admission requests and boarding time by hour of the day

Season – Statistical significance of each component variable								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1394.702	62.8242	1271.569	1517.835	492.84	<.0001
Season	Autumn	1	509.7073	78.7544	355.3515	664.0632	41.89	<.0001
Season	Spring	1	538.8606	74.8326	392.1914	685.5298	51.85	<.0001
Season	Summer	1	579.4541	89.3964	404.2403	754.6679	42.01	<.0001

Table 7.31. Hospital C: General linear model results seasonal segmentation

Month – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1394.702	62.8242	1271.569	1517.835	492.84	<.0001
Month	April	1	-54.3579	95.0025	-240.559	131.8435	0.33	0.5672
Month	August	1	-946.470	106.5763	-1155.36	-737.585	78.87	<.0001
Month	December	1	-218.921	79.8658	-375.455	-62.3871	7.51	0.0061
Month	February	1	-292.540	59.6327	-409.418	-175.662	24.07	<.0001
Month	July	1	-1023.85	107.0781	-1233.72	-813.978	91.43	<.0001
Month	June	1	-875.441	92.4331	-1056.61	-694.276	89.70	<.0001
Month	March	1	-313.907	65.3231	-441.938	-185.876	23.09	<.0001
Month	May	1	-599.661	94.6194	-785.111	-414.210	40.17	<.0001
Month	November	1	-143.276	98.1918	-335.728	49.1767	2.13	0.1445
Month	October	1	-730.226	98.2180	-922.730	-537.722	55.28	<.0001
Month	September	1	-707.407	97.7146	-898.924	-515.890	52.41	<.0001

Table 7.32. Hospital C: General linear model results monthly segmentation

Day of the week – Analysis of maximum likelihood parameter estimates								
Parameter		**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Intercept		1	1394.702	62.8242	1271.569	1517.835	492.84	<.0001
Day of week	Friday	1	-348.800	44.8738	-436.751	-260.849	60.42	<.0001
Day of week	Saturday	1	-48.5433	46.6928	-140.060	42.9729	1.08	0.2985
Day of week	Sunday	1	101.8638	47.5453	8.6767	195.0508	4.59	0.0322
Day of week	Thursday	1	-248.346	44.8780	-336.306	-160.387	30.62	<.0001
Day of week	Tuesday	1	-21.5674	45.4297	-110.608	67.4732	0.23	0.6350
Day of week	Wednesday	1	-94.7816	45.7894	-184.527	-5.0361	4.28	0.0385

Table 7.33. Hospital C: General linear model results day of the week segmentation

Day of the month – Analysis of maximum likelihood parameter estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Day month	1	-4.7810	1.3782	-7.4822	-2.0799	12.04	0.0005

Table 7.34. Hospital C: General linear model results day of the month segmentation

Time of day – Analysis of maximum likelihood parameter estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald Chi-Square**	**Pr > ChiSQ**
Time of day	1	-9.8010	2.0446	-13.8083	-5.7937	22.98	<.0001

Table 7.35. Hospital C: General linear model results hourly segmentation

Overall statistical significance of variable category			
Source	**DF**	**Wald Chi-Square**	**Pr > ChiSQ**
Season	3	71.20	<.0001
Month	11	345.61	<.0001
Day of the week	6	138.86	<.0001
Day the month	1	12.02	0.0005
Time of day	1	22.93	<.0001

Table 7.36. Hospital C: General linear model results global

	Admissions (%)	**Arrivals (%)**	**Discharges (%)**
Monday	13.78	13.62	14.09
Tuesday	14.80	15.16	14.07
Wednesday	14.40	14.92	15.59
Thursday	15.62	15.87	15.98
Friday	15.63	18.23	19.15
Saturday	13.40	12.42	11.12
Sunday	12.38	9.78	10.00

Table 7.37. Hospital C: Admission requests, arrivals and discharges by day of the week

Time of day	**Admissions (%)**	**Arrivals (%)**	**Discharges (%)**
00:00-00:59	4.24	2.50	0.60
01:00-01:59	3.80	2.36	0.32
02:00-02:59	1.62	0.87	0.31
03:00-03:59	0.82	0.84	0.36
04:00-04:59	0.80	0.40	0.31
05:00-05:59	0.91	0.28	0.32
06:00-06:59	1.36	0.26	0.35
07:00-07:59	0.89	0.21	0.44
08:00-08:59	2.38	0.42	0.89
09:00-09:59	2.58	0.79	3.99
10:00-10:59	4.64	1.47	7.46
11:00-11:59	5.33	2.29	7.70

Time of day	**Admissions (%)**	**Arrivals (%)**	**Discharges (%)**
12:00-12:59	5.25	2.83	7.94
13:00-13:59	6.60	3.66	9.83
14:00-14:59	8.71	6.67	12.87
15:00-15:59	6.34	5.83	8.82
16:00-16:59	8.45	8.64	9.32
17:00-17:59	8.60	6.70	7.73
18:00-18:59	6.54	7.89	6.31
19:00-19:59	5.58	7.35	4.97
20:00-20:59	4.45	7.96	4.04
21:00-21:59	3.67	9.76	2.43
22:00-22:59	3.69	11.33	1.82
23:00-23:59	2.74	4.73	0.88

Table 7.38. Hospital C: Admission requests, arrivals and discharges by time of day

PARTICIPANT INFORMATION

Training : _____ Title : _____

Year occupying this title : _____ Years working at this hospital: _____

THE PROCESS AND THE PARTICIPANT'S ROLE

1. Following an admission request at the ED, what are the next steps in the admission process?

2. What is your role in this process?

3. Who do you collaborate with within this process?

EMERGENCY DEPARTMENT BOARDING: CAUSES

4. What are factors that could explain why a patient would be boarding in the ED (4 major)?

EMERGENCY DEPARTMENT BOARDING: SOLUTIONS

5. What improvements could reduce the importance of these or other issues causing boarding?

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If you check this box, no information concerning your name will be disclosed in the dissemination of the research results. However, the name of your organization will be mentioned. It is therefore possible that someone could obtain your name by cross-referencing. Consequently, you should not expect your anonymity to be protected

- **Consent for audio recording of the interview:**

  - ☐ **I give my consent for the researcher to make an audio recording of this interview.**
  - ☐ **I do not give my consent for the researcher to make an audio recording of this interview.**

You can signify your consent either with your signature, by email or verbally at the beginning of the interview.

PARTICIPANT'S SIGNATURE:

First and last name:

_____

Signature: _____ Date (dd/mm/yyyy): _____

RESEARCHER'S SIGNATURE:

First and last name: Vincent Limoges

Signature: _____ Date (dd/mm/yyyy): _____

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