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# Rapid analgesia administration rather than adequate pain relief reduces emergency department length of stay.

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## ABSTRACT

**Objectives:** Evaluate the influence of adequate analgesia and time to analgesic treatment on emergency department (ED) length of stay (LOS).

**Setting and Design:** Post-hoc analysis of real time archived data.

**Participants:** We included all consecutive ED patients ≥18 years with pain intensity >6 (verbal numerical scale from 0 to 10), assigned to an ED bed, and whose pain was re-evaluated less than 1 hour after receiving analgesic treatment.

**Outcome measures:** The main outcome was ED-LOS in patients who had adequate pain relief (AR = ↓50% pain intensity) compared to those who did not have such relief (NR).

**Results:** A total of 2,033 patients (mean age 49.5 years; 51% men) met our inclusion criteria; 58.3% were discharged, and 41.7% were admitted. Among patients discharged or admitted, there was no significant difference in ED-LOS between those with AR (median=9.6 hours, interquartile range: (IQR) 8.5, and 18.2 hours, IQR: 14.1, respectively) and NR (median=9.6 hours, IQR: 9.4, and 17.4 hours, IQR: 15.4, respectively). After controlling for confounding factors, only rapid time to analgesia (and not adequate pain relief) was associated with shorter ED-LOS of both discharged and admitted patients ($p < 0.001$ and $p < 0.05$ respectively). When adjusting for confounding variables, ED-LOS is shortened by 1.2 hour when delay to receive analgesic is <90 min compared to >90 min for discharged and by 1.1 hour for admitted patients.

**Conclusions:** In our study, adequate pain relief was not linked with short ED-LOS. Only rapid administration of analgesia was coupled with short ED-LOS.

## ARTICLE SUMMARY

### Strengths and limitations of this study

-This is a rare study that examines the relationship between pain relief and length of stay controlling for multiple confounding variables in a large cohort of emergency department patients.

-The main limitation of our study is its post hoc design and pre-formed database from a single-centre study in an academic hospital.

## INTRODUCTION

Emergency department (ED) overcrowding has been a concern for many years, and Canada is no exception, with nearly 60% of EDs reporting that problem in 2007.[1] The phenomenon of "boarding" is one of the principal factors identified as its cause.[2,3] "Boarding" (or "access block") refers to situations where bedridden emergency patients wait for the allocation of a bed on the ward for an unreasonably long time period (prolong ED length of stay) with consequent patient overflow in EDs. However, a recent retrospective study revealed that among patients waiting more than 6 hours in the ED, 50% were finally admitted while the other 50% were discharged,[4] indicating that non-boarding patients length of stay (LOS) also contribute to overcrowding. It has been shown to be a strong predictor of low satisfaction among patients[5] and healthcare workers.[1] It is also associated with long hospital LOS,[6,7] and high short- and medium-term mortality rates.[8-10] Furthermore, overcrowding is linked with reduced timeliness and quality of interventions and treatments,[11-13] including delayed analgesic administration, [14,15] particularly when pain is severe,[16] all of which contribute to the snowball effect of cumulating waits.

Pain represents more than 40% of consultations in EDs.[17] In large studies of patients with moderate to severe pain, only 21 to 68%[18-27] received analgesics, and 50 to 74% still had moderate to severe pain at discharge.[17] Severe, persistent pain may also lead to unwanted physiological responses, namely, increased adrenergic tone, augmented oxygen consumption, predisposition to hypercoagulability, decreased immune function, and heightened risk of delirium.[28,29] Moreover, adequate and timely treatment of acute pain could reduce the risk of chronic pain.[17] The relationship between pain management and LOS has not been studied has a primary outcome. However, a study of intermittent injection vs patient-controlled analgesia (PCA) for sickle cell crisis pain in the ED, established that PCA was associated with a significant reduction in length of ED stay, although there was no difference in initial or final pain intensity score [30].

Recent studies have attempted to identify the factors contributing to prolonged ED-LOS. Many of them have already been recognized, namely, number of laboratory examinations required, having to undergo X-ray or scan, the need for more than 3 medications, and number of consultants.[10,31] To the best of our knowledge, the adequacy and effectiveness of pain management have never been investigated in this regard. We sought to evaluate which component of initial pain management was associated with ED-LOS reduction. We hypothesized that ED-LOS would be lessened in patients with significant pain relief.

## MATERIALS AND METHODS

### Study design

We conducted *post hoc* analysis of real time archived data on all consecutive patients presenting with severe pain at our ED between March 2008 and February 2011. The aim of our study was to assess if pain relief was associated with ED-LOS reduction. As a secondary objective, we evaluated if time to receiving analgesic treatment was linked with lessened ED-LOS.

**Setting**

Hôpital du Sacré-Cœur de Montreal is an urban, adult, level I trauma centre with 540 inpatient beds and 60,000 ED visits per year. It sustains 22,000 hospitalizations annually, of which 51% are admitted through the ED. The study was approved by the institutional review board.

**Selection of participants**

Patients 18 years or older were included if they were assigned to an ED treatment bed, had severe pain at triage (defined as >6 on an 11-point verbal numerical scale from 0 to 10),[32-34] received an analgesic, and had their pain intensity re-evaluated in less than 1 hour after such medication.

Patients were excluded if they died during their ED stay, were pregnant or had been transferred from another hospital. We also excluded patients with altered mental status, intoxicated subjects, and anyone with chest pain necessitating emergent PCI, because their LOS could be determined by treatments other than pain management.

**Data collection**

Data were extracted from computerized information and nursing records in our ED (MedUrge™, MediaMed Technologies, Mont-Saint-Hilaire, Québec, Canada). This system is an integrated and mandatory working tool for all physicians, nursing staff, and any employee involved in the ED healthcare process. It contains all demographic data, triage information (including vital signs, purpose of consultation, and pain level when relevant) as well as any pertinent data collected in real time by nurses during their re-evaluation rounds, including medication administration, and pain intensity.

**Data processing**

The cut-off of >6 on 10 was chosen because it was felt that lower pain intensity is less likely to warrant observation in itself. ED-LOS was measured in hours from the time of arrival at the ED to discharge or admission to a ward. We defined adequate pain relief (AR) as reduction of 50% or more of the initial pain level scored on the numerical scale within 1 hour after receiving the first analgesic. The 50% reduction and the 1-hour threshold are based on previous literature suggesting that they represent a meaningful decline[35,36] and acceptable delay in managing severe pain.[34,37,38] Initial pain was the one reported on the triage form. Time between arrival and analgesic administration was dichotomized into ≤90 minutes versus >90 minutes. We selected a 90-minute threshold because it is the median time to analgesia reported in many EDs with a pain scale integrated in their triage assessment.[19,39,40]

Our primary outcome was ED-LOS of patients with and without adequate pain relief. Our secondary outcome was ED-LOS of patients who received their medication in ≤90 minutes compared to those who received it after a longer time period.

**Data analysis**

Median LOS between groups of patients was compared by the Mann-Whitney U test and relationship among LOS and continuous predictors by Spearman rank-order correlations. To examine the relative influence of adequate pain relief and time to analgesia on LOS, multiple linear regression was undertaken for patients discharged from the ED and those admitted to a ward, controlling for age, gender, route of administration (IV vs other), type of arrival at ED (ambulance or alone), triage priority (high vs low), crowding defined as number of patients in ED beds at the time of arrival, time between arrival and physician's first assessment, number of examinations, number of specialty consultations, trauma versus non-trauma, abdominal pain versus other, need for oxygen and for isolation. The Canadian healthcare system being public and free, the presence or absence of insurance was not analyzed. For multivariate analysis, LOS was log-transformed to normalize distribution. Alpha level was set at 0.05 for all statistical tests. All data were analyzed with SPSS version 20 (IBM, Somers, NY).

**RESULTS**

A total of 2,033 patients met our inclusion and exclusion criteria. Of these patients, about 50% were male, 2/3 arrived on foot, 1,186 (58.3%) were finally discharged, and 847 were admitted (Table 1).

Among patients who were discharged from the ED, 45.7% had AR compared to 40.3% of admitted patients. There was no significant difference in ED-LOS between patients with AR compared to those without adequate relief (NR) (p=0.41 for discharged patients and p=0.87 for admitted patients) (Figure 1).

Table 1. Patient characteristics of the whole sample

| Characteristics | Total (N=2,033) |
|---|---|
| Mean age (±SD) | 49.5 (17.0) |
| % male | 51.0 |
| % Triage priority | |
| -high (1-2) | 45.3 |
| -low (3-4-5) | 54.7 |
| % Arrival | |
| -ambulance | 29.2 |
| -standing | 70.8 |
| % -admitted | 41.7 |
| -returning home | 58.3 |
| % -treated with opiates only | 66.7 |
| -treated with non-opiates only | 11.1 |
| -treated with combination | 22.2 |
| % Route of administration | |
| -IV | 62.0 |
| -other | 38.0 |
| Mean (±SD) baseline pain intensity score | 8.8 (1.1) |
| Mean (±SD) final pain intensity score | 5.1 (3.0) |
| Median LOS in hours (IQR) | 12.3 (12.6) |
| Median time between arrival at ED and analgesic treatment in hours (IQR) | 1.8 (2.1) |
| Median time to patient care by physician in hours (IQR) | 0.72 (0.98) |

LOS: length of stay; IQR: interquartile range

Among patients who were discharged from the ED, 533 (45%) received analgesia ≤90 minutes, with ED-LOS reduction of 2.3 hours ($p<0.001$) compared to those with >90 minutes. The same analysis was applied to patients being admitted: only 265 (31%)

received their medication in that interval, and their median ED-LOS reduction was 3.9 hours ($p<0.001$) (Figure 2).

Table 2 and 3 show the bivariate relations between LOS and all confounding variables for discharged and admitted patients respectively. For discharged patients, only type of arrival and crowding were not related to LOS while type of arrival, gender and triage priority were not associated with LOS for admitted patients.

Multivariate analysis showed that when controlling for confounding variables, a brief time period (≤90 minutes) before analgesic administration (and not adequate pain relief) is associated with shortened ED-LOS for both discharged and admitted patients (ß=0.07; 95% confidence interval (95% CI): 0.04-0.10; $p<0.001$ and ß=0.04; 95% CI: 0.006-0.08; $p<0.05$, respectively). When adjusting for confounding variables, ED-LOS is shortened by 1.2 hour when delay to receive analgesic is <90 min compared to >90 min for discharged and by 1.1 hour for admitted patients.

## LIMITATIONS

The main limitation of our study is its post hoc design and pre-formed database. Potential confounding variables, such as ethnicity and linguistic barrier, which are not recorded in demographic charts of our computerized system, could not be taken into consideration. Time from pain onset, component of chronic pain and pharmacological or non-pharmacological analgesia prior to arrival at the ED were also unknown. Case complexity assessment was difficult, although we controlled for number of examinations, number of consultants, need for oxygen and for isolation, which are markers of complexity. Likewise, we do not know if some patients did not receive an analgesic nor

Table 2. Relationship between length of stay and all confounding variables for **discharged** patients.

| Confounding variables | Length of stay in hour (N=1186) | P level |
|---|---|---|
| Categorical confounders: | Median (IQR) | Mann-Whitney U test |
| Gender: -male | 9.0 (7.8) | <0.001 |
| -female | 10.6 (10.2) | |
| Triage priority: -high (1-2) | 9.5 (8.5) | <0.05 |
| -low (3-4-5) | 9.8 (9.2) | |
| Arrival: -ambulance | 9.7 (10.1) | 0.55 |
| -standing | 9.6 (8.4) | |
| Route of administration: -IV | 10.2 (8.6) | <0.001 |
| -other | 8.8 (8.3) | |
| Trauma injury: -Yes | 6.8 (8.5) | <0.001 |
| -No | 9.8 (8.9) | |
| Abdominal pain: -Yes | 11.2 (9.9) | <0.001 |
| -No | 9.1 (7.9) | |
| Blood test: -Yes | 17.5 (12.9) | <0.001 |
| -No | 9.5 (8.7) | |
| Heart-rate monitoring: -Yes | 13.9 (16.6) | <0.001 |
| -No | 9.3 (8.5) | |
| Oxygen support: -Yes | 13.0 (13.4) | <0.001 |
| -No | 9.5 (8.7) | |
| Isolation: -Yes | 22.7 (29.7) | <0.001 |
| -No | 9.5 (8.6) | |
| Continuous confounders: | Spearman rank-order correlation | P level |
| Age: | 0.14 | <0.001 |
| Crowding: | 0.004 | 0.89 |
| Physician taking charge delay: | 0.17 | <0.001 |
| Number of exams: | 0.31 | <0.001 |
| Number of specialist consultation: | 0.43 | <0.001 |

IQR: interquartile range; IV: intravenous

Table 3. Relationship between length of stay and all confounding variables for **admitted** patients.

| Confounding variables | Length of stay in hour (N=847) | P level |
|---|---|---|
| Categorical confounders: | Median (IQR) | Mann-Whitney U test |
| Gender: -male | 17.0 (14.3) | 0.13 |
| -female | 18.6 (15.3) | |
| Triage priority: -high (1-2) | 17.1 (15.1) | 0.07 |
| -low (3-4-5) | 18.2 (14.7) | |
| Arrival: -ambulance | 18.5 (16.1) | 0.47 |
| -standing | 17.3 (14.2) | |
| Route of administration: -IV | 16.7 (13.6) | <0.01 |
| -other | 19.4 (15.4) | |
| Trauma injury: -Yes | 13.7 (15.8) | <0.05 |
| -No | 17.9 (14.6) | |
| Abdominal pain: -Yes | 17.1 (12.8) | <0.05 |
| -No | 18.7 (16.3) | |
| Blood test: -Yes | 21.1 (17.6) | <0.01 |
| -No | 17.2 (14.2) | |
| Heart-rate monitoring: -Yes | 27.1 (26.6) | <0.001 |
| -No | 16.5 (13.2) | |
| Oxygen support: -Yes | 21.9 (21.8) | <0.001 |
| -No | 17.1 (13.9) | |
| Isolation: -Yes | 30.5 (34.8) | <0.001 |
| -No | 17.0 (13.6) | |
| Continuous confounders: | Spearman rank-order correlation | P level |
| Age: | 0.18 | <0.001 |
| Crowding: | 0.08 | <0.05 |
| Physician taking charge delay: | 0.14 | <0.001 |
| Number of exams: | 0.33 | <0.001 |
| Number of specialist consultation: | 0.33 | <0.001 |

IQR: interquartile range; IV: intravenous

had suboptimal pain management because of refusal. However, it is doubtful that any of these confounding variables would cause significant differential bias.

Although we controlled for crowding at the time of visit, we could not track how many nurses were on duty during patient stay. Short-staffing could have been a factor in the prolonged LOS and rate of re-assessment of some patients. However, our rate of pain intensity re-assessment was similar to previously-reported performances (data not shown).[19] Finally, our single-center study in an academic hospital might limit the generalization of our results.

## DISCUSSION

As far as we know, this is the first investigation to evaluate the impact of pain relief on ED-LOS, and our results demonstrated that rapid administration of analgesia, and not adequate pain relief, is associated with shorter ED-LOS. It has been reported that patients expect to receive pain medication 25 to 30 minutes after their arrival,[41] which coincides with the guidelines of our triage system (Canadian Emergency Department Triage and Acuity Scale).[42] Unfortunately, this goal is far from being achieved in many EDs, not only in Canada, but also around the world.[19,27,41] This is a persistent problem that dates back to the late 1980s when Wilson and Pendleton first defined the term "oligoanalgesia".[43]

More recently, the Pain and Emergency Medicine Initiative study demonstrated that patient satisfaction was associated more with the way ED physicians responded to their complaints of pain than to the actual result of pain treatment.[19] Which components of this response to pain were significant was not specified, but a possible part of it was the

promptness with which pain was addressed. Patients with severe pain probably associate receiving pain medication quickly with quality of care and are more inclined to accept a medical treatment plan, even if they do not get relief. This might explain why we observed improved ED-LOS with prompt analgesic administration in patients being discharged or admitted.

In our study, the adjusted ED-LOS was 1.2 hours shorter in discharged patients who received their medication in ≤ 90 minutes than in those treated in > 90 minutes. The rapid administration of analgesia, associated with shorter ED-LOS, could have a significant impact on ED overcrowding. For example, our center received an average of 5,000 patients per year with severe pain on an ED bed. If we extrapolate the proportion of patient who received analgesia >90 minutes after arrival and the time saved if received in less than 90 minutes from our study to this population, a bed could be available during 9.4 hours every day. Such economy of beds would contribute to better throughput of patients and render our EDs more efficient, as espoused by Asplin et al. with their conceptual model of overcrowding in 2003.[2]

A recent consensus of the Canadian Association of Emergency Physicians has ranked "ED-LOS" and "Time to first dose of analgesic" in the top 12 priority indicators of quality care.[44] In the USA, the Joint Commission on Accreditation of Healthcare Organizations mentions "early intervention" as the first goal in the treatment of acute pain.[37] Similarly, the Australian National Institute of Clinical Studies ranked "reduced time to analgesia" as the top priority and is currently working on improving their numbers.[41]

New solutions are being proposed to improve the initial approach to pain management. For example, the simple act of making pain scoring mandatory at triage has been shown to reduce time to analgesia by 45 minutes.[40] Extension of this practice could also integrate pain treatment as early as triage to limit further delays. Such measures have been introduced in Australia where nurse-initiated pain protocols are currently being evaluated. A pediatric ED study has shown 50% reduction of time to analgesia with such a protocol.[39] Early administration of analgesics has been investigated in pre-hospital settings, and appears to be safe and effective, particularly with the use of intranasal Fentanyl.[45,46] Even if no study has yet shown a benefit of this practice in LOS, it certainly has promising advantages, and further investigations should be considered.

In summary, we found that shorter time to analgesia administration is associated with ED-LOS reduction. This observation supports recent interest in analgesia implementation as early as triage or in pre-hospital settings to improve the throughput component of the overcrowding phenomenon seen in EDs around the world.

**Contributors** CS, RD and JMC conceived the study and obtained research funding. JP mined and analyzed the data. CS drafted the manuscript, and all authors contributed substantially to its revision. CS takes responsibility for the paper as a whole. All co-authors have had the opportunity to review the final manuscript and have provided their permission to publish the manuscript.

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**Competing interests** None**.**

**Ethics approval** The study was approved by the institutional review board.

**Provenance and peer review** Not commissioned; externally peer reviewed.

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## FIGURE LEGENDS

**Figure 1:** Median length of stay for subjects with adequate and inadequate pain relief in discharged and admitted patients.

**Figure 2:** Median length of stay for subjects receiving analgesia <90 min versus >=90 min from arrival in discharged and admitted patients.

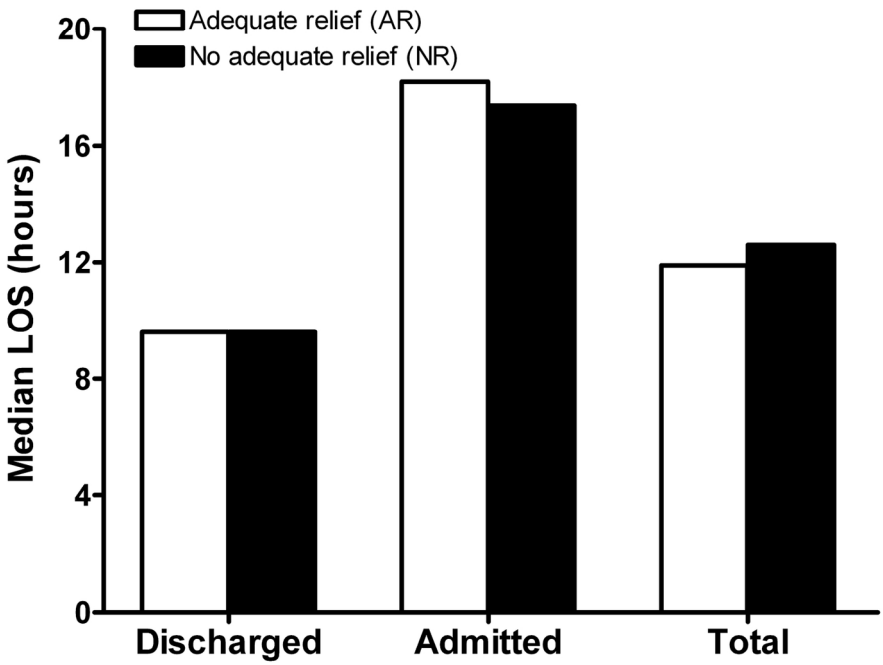


Figure 1: Median length of stay for subjects with adequate and inadequate pain relief in discharged and admitted patients.
152x121mm (300 x 300 DPI)

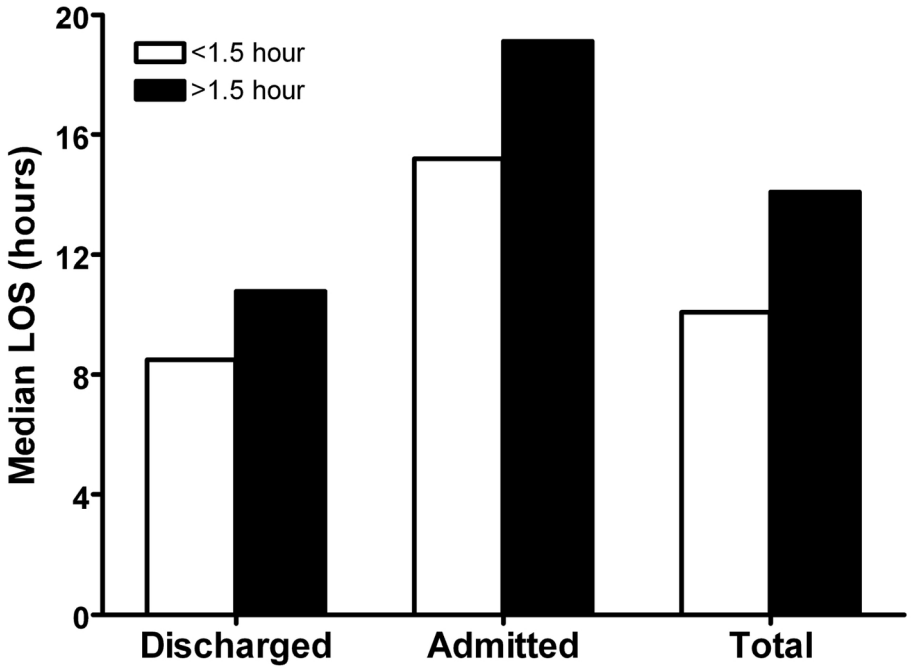


Figure 2: Median length of stay for subjects receiving analgesia <90 min versus >=90 min from arrival in discharged and admitted patients.
148x118mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract **Done** |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Done** |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported **Done** |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses **Done** |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper **Done** |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Done** |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Done** |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Done** |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Done** |
| Bias | 9 | Describe any efforts to address potential sources of bias **Done** |
| Study size | 10 | Explain how the study size was arrived at **Not applicable** |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Done** |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding **Done** |
| | | (*b*) Describe any methods used to examine subgroups and interactions **Not applicable** |
| | | (*c*) Explain how missing data were addressed **Done** |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses **Not applicable** |

Continued on next page

| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Done** |
| | | (b) Give reasons for non-participation at each stage **Done** |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Done** |
| | | (b) Indicate number of participants with missing data for each variable of interest **Done** |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures **Done** |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Done** |
| | | (*b*) Report category boundaries when continuous variables were categorized **Done** |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives **Done** |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Done** |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Done** |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results **Done** |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Done** |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Impact of adequate pain relief on emergency department length of stay.



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# Impact of adequate pain relief on emergency department length of stay.

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## ABSTRACT

**Objectives:** Evaluate the influence of adequate analgesia and time to analgesic treatment on emergency department (ED) length of stay (LOS).

**Setting and Design:** Post-hoc analysis of real time archived data.

**Participants:** We included all consecutive ED patients ≥18 years with pain intensity >6 (verbal numerical scale from 0 to 10), assigned to an ED bed, and whose pain was re-evaluated less than 1 hour after receiving analgesic treatment.

**Outcome measures:** The main outcome was ED-LOS in patients who had adequate pain relief (AR = ↓50% pain intensity) compared to those who did not have such relief (NR).

**Results:** A total of 2,033 patients (mean age 49.5 years; 51% men) met our inclusion criteria; 58.3% were discharged, and 41.7% were admitted. Among patients discharged or admitted, there was no significant difference in ED-LOS between those with AR (median [25th-75th percentile]: 9.6 hours [6.3-14.8] and 18.2 hours [11.6-25.7], respectively) and NR (median [25th-75th percentile]: 9.6 hours [6.6-16.0] and 17.4 hours [11.3-26.5], respectively). After controlling for confounding factors, rapid time to analgesia (and not adequate pain relief) was associated with shorter ED-LOS of both discharged and admitted patients ($p < 0.001$ and $p < 0.05$ respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours when delay to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours for admitted patients.

**Conclusions:** In our study, adequate pain relief was not linked with short ED-LOS. However, rapid administration of analgesia was associated with short ED-LOS.

## ARTICLE SUMMARY

### Strengths and limitations of this study

-This is a rare study that examines the relationship between pain relief and length of stay controlling for multiple confounding variables in a large cohort of emergency department patients.

-The main limitation of our study is its post hoc design and pre-formed database from a single-centre study in an academic hospital.

## INTRODUCTION

Emergency department (ED) overcrowding has been a concern for many years, and Canada is no exception, with nearly 60% of EDs reporting that problem in 2007.[1] The phenomenon of "boarding" is one of the principal factors identified as its cause.[2,3] "Boarding" (or "access block") refers to situations where bedridden emergency patients wait for the allocation of a bed on the ward for an unreasonably long time period (prolong ED length of stay) with consequent patient overflow in EDs. However, a recent retrospective study revealed that among patients waiting more than 6 hours in the ED, 50% were finally admitted while the other 50% were discharged,[4] indicating that non-boarding patients length of stay (LOS) also contribute to overcrowding. It has been shown to be a strong predictor of low satisfaction among patients[5] and healthcare workers.[1] It is also associated with long hospital LOS,[6,7] and high short- and medium-term mortality rates.[8-10] Furthermore, overcrowding is linked with reduced timeliness and quality of interventions and treatments,[11-13] including delayed analgesic administration, [14,15] particularly when pain is severe,[16] all of which contribute to the snowball effect of cumulating waits.

Pain represents more than 40% of consultations in EDs.[17] In large studies of patients with moderate to severe pain, only 21 to 68%[18-27] received analgesics, and 50 to 74% still had moderate to severe pain at discharge.[17] Severe, persistent pain may also lead to unwanted physiological responses, namely, increased adrenergic tone, augmented oxygen consumption, predisposition to hypercoagulability, decreased immune function, and heightened risk of delirium.[28,29] Moreover, adequate and timely treatment of acute

pain could reduce the risk of chronic pain.[17] The relationship between pain management and LOS has not been studied has a primary outcome. However, a study of intermittent injection vs patient-controlled analgesia (PCA) for sickle cell crisis pain in the ED, established that PCA was associated with a significant reduction in length of ED stay, although there was no difference in initial or final pain intensity score [30].

Recent studies have attempted to identify the factors contributing to prolonged ED-LOS. Many of them have already been recognized, namely, number of laboratory examinations required, having to undergo X-ray or scan, the need for more than 3 medications, and number of consultants.[10,31] To the best of our knowledge, the adequacy and effectiveness of pain management have never been investigated in this regard. We sought to evaluate which component of initial pain management was associated with ED-LOS reduction. We hypothesized that ED-LOS would be lessened in patients with significant pain relief.

## MATERIALS AND METHODS

### Study design

We conducted *post hoc* analysis of real time archived data on all consecutive patients presenting with severe pain at our ED between March 2008 and February 2011. The aim of our study was to assess if pain relief was associated with ED-LOS reduction. As a secondary objective, we evaluated if time to receiving analgesic treatment was linked with lessened ED-LOS.

### Setting

Hôpital du Sacré-Cœur de Montreal is an urban, adult, level I trauma center with 540 inpatient beds and 60,000 ED visits per year. It sustains 22,000 hospitalizations annually, of which 51% are admitted through the ED. The study was approved by the institutional review board.

**Selection of participants**

Patients 18 years or older were included if they were assigned to an ED treatment bed, had severe pain at triage (defined as >6 on an 11-point verbal numerical scale from 0 to 10),[32-34] received an analgesic, and had their pain intensity re-evaluated in less than 1 hour after such medication.

Patients were excluded if they died during their ED stay, were pregnant or had been transferred from another hospital. We also excluded patients with altered mental status, intoxicated subjects, and anyone with chest pain necessitating emergent PCI, because their LOS could be determined by treatments other than pain management.

**Data collection**

Data were extracted from computerized information and nursing records in our ED (MedUrge™, MediaMed Technologies, Mont-Saint-Hilaire, Québec, Canada). This system is an integrated and mandatory working tool for all physicians, nursing staff, and any employee involved in the ED healthcare process. It contains all demographic data, triage information (including vital signs, purpose of consultation, and pain level when relevant) as well as any pertinent data collected in real time by nurses during their re-evaluation rounds, including medication administration, and pain intensity.

## Data processing

The cut-off of >6 on 10 was chosen because it was felt that lower pain intensity is less likely to warrant observation in itself. ED-LOS was measured in hours from the time of arrival at the ED to discharge or admission to a ward. We defined adequate pain relief (AR) as reduction of 50% or more of the initial pain level scored on the numerical scale within 1 hour after receiving the first analgesic. The 50% reduction and the 1-hour threshold are based on previous literature suggesting that they represent a meaningful decline[35,36] and acceptable delay in managing severe pain.[34,37,38] Initial pain was the one reported on the triage form. Time between arrival and analgesic administration was dichotomized into ≤90 minutes versus >90 minutes and also analyzed by three category (<1 hour; between 1 and 2 hour; >2 hour). We selected a 90-minute threshold because it is the median time to analgesia reported in many EDs with a pain scale integrated in their triage assessment.[19,39,40]

Our primary outcome was ED-LOS of patients with and without adequate pain relief. Our secondary outcome was ED-LOS of patients who received their medication in ≤90 minutes compared to those who received it after a longer time period.

## Data analysis

Median LOS (25th-75th percentile) between groups of patients was compared by the Mann-Whitney U test and relationship among LOS and continuous predictors by Spearman rank-order correlations. All LOS are presented in hours and separately for patients with intravenous versus patients with other than intravenous route of analgesia

administration. To examine the relative influence of adequate pain relief and time to analgesia on LOS, generalized linear model regressions with Gamma distribution and a log link function were undertaken for patients discharged from the ED and those admitted to a ward, controlling for age, gender, route of analgesia administration (IV vs other), number of dose of analgesia, type of arrival at ED (ambulance or walk in), triage priority (high vs low), crowding defined as number of patients in ED beds at the time of arrival, time of day of arrival with high or low LOS (calculated from a database of 162 000 patients of 18 years or older assigned to a bed between March 2008 and February 2011 from the same ED and selecting hours of arrival with high LOS and hours of arrival with low LOS), time between arrival and physician's first assessment, number of examinations, number of specialty consultations, baseline pain intensity score, trauma versus non-trauma, abdominal pain versus other, need for oxygen and for isolation. Generalized linear model was chosen because LOS is largely skewed and tends to produce less prediction errors than traditional linear regression[41]. Mean LOS difference and Wald 95% CI adjusted at mean covariates were produced from estimated marginal means. The Canadian healthcare system being public and free, the presence or absence of insurance was not analyzed. Alpha level was set at 0.05 for all statistical tests. All data were analyzed with SPSS version 20 (IBM, Somers, NY).

## RESULTS

A total of 2,033 patients met our inclusion and exclusion criteria. Of these patients, about half (51%) were male, more than two third arrived at ED alone, 1,186 (58.3%) were finally discharged and 847 were admitted (Table 1).

Among patients who were discharged from the ED, 45.7% had AR compared to 40.3% of admitted patients. There was no significant difference in ED-LOS between patients with AR compared to those without adequate relief (NR) (p=0.41 for discharged patients and p=0.87 for admitted patients) (Figure 1).

Table 1. Patient characteristics of the whole sample

| Characteristics | Total (N=2,033) |
|---|---|
| Mean age (±SD) | 49.5 (17.0) |
| % male | 51.0 |
| % Triage priority | |
| -high (1-2) | 45.3 |
| -low (3-4-5) | 54.7 |
| % Arrival | |
| -ambulance | 29.2 |
| -walk in | 70.8 |
| % -admitted | 41.7 |
| -discharged | 58.3 |
| % -treated with opiates only | 66.7 |
| -treated with non-opiates only | 11.1 |
| -treated with combination | 22.2 |
| % Route of analgesia administration | |
| -IV | 62.0 |
| -other | 38.0 |
| % with trauma injury | 7.6 |
| % with abdominal pain | 39.5 |
| % with blood test | 6.4 |
| % with heart-rate monitoring | 11.7 |
| % with oxygen support | 9.5 |
| % in isolation | 4.5 |
| Mean (±SD) baseline pain intensity score | 8.8 (1.1) |
| Mean (±SD) final pain intensity score | 5.1 (3.0) |

| | |
|---|---|
| Median LOS in hours (25th-75th percentile) | 12.3 (7.8-20.3) |
| Median time between arrival at ED and analgesic treatment in hours (25th-75th percentile) | 1.8 (1.1-3.2) |
| Median time to patient care by physician in hours (25th-75th percentile) | 0.72 (0.42-1.4) |

LOS: length of stay

Among patients who were discharged from the ED, 533 (45%) received analgesia ≤90 minutes, with ED-LOS reduction of 2.3 hours (p<0.001) compared to those with >90 minutes. The same analysis was applied to patients being admitted: only 265 (31%) received their medication in that interval, and their median ED-LOS reduction was 3.9 hours (p<0.001) (Figure 2). Median ED-LOS for three different times to receive analgesia is displayed in table 2.

Table 2. Median length of stay (25th-75th percentiles) for three different times to receive analgesia controlled for route of analgesia administration for discharged and admitted patients.

| Confounding variables | | IV LOS in hour Median (25th-75th percentile) | Other than IV LOS in hour Median (25th-75th percentile) |
|---|---|---|---|
| Discharged patients: | | (N=698) | (N=481) |
| Time to receive analgesia: | -<1 hour | 8.6 (6.0-11.8) | 6.6 (4.4-9.5) |
| | -from 1 to 2 hour | 10.5 (6.9-15.9) | 8.2 (5.4-12.2) |
| | ->2 hour | 12.9 (8.9-18.0) | 10.1 (6.3-19.2) |
| Admitted patients: | | (N=556) | (N=289) |
| Time to receive analgesia: | -<1 hour | 16.4 (10.8-23.8) | 17.2 (10.7-24.8) |
| | -from 1 to 2 hour | 14.9 (10.4-22.6) | 18.1 (10.0-26.4) |
| | ->2 hour | 18.7 (11.6-27.4) | 19.6 (12.9-28.7) |

LOS: length of stay; IV: intravenous route of analgesia administration; without IV: other than intravenous route of analgesia administration

Table 3 and 4 show the bivariate relations between LOS and all confounding variables controlled for route of analgesia administration for discharged and admitted patients respectively. For discharged patients with IV route of analgesia administration, only type of arrival, crowding and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, type of arrival, triage priority, oxygen support, time of day LOS, crowding and baseline pain intensity score were not associated with LOS. For admitted patients with IV route of analgesia administration, triage priority, type of arrival, blood testing, time of day LOS, crowding, number of dose and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, gender, triage priority, type of arrival, trauma injury, abdominal pain, time of day LOS and physician taking charge delay were not associated with LOS.

Table 3. Relationship between length of stay and all confounding variables for **discharged** patients.

| Confounding variables | IV LOS in hour (N=702) | Other than IV LOS in hour (N=484) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 9.5 (6.7-15.0)** | 8.0 (5.5-12.3)** |
| -female | 11.1 (7.9-16.9) | 9.8 (6.1-18.4) |
| Triage priority: -high (1-2) | 9.7 (6.7-15.3)** | 8.8 (5.8-13.1) |
| -low (3-4-5) | 10.8 (7.9-17.0) | 8.8 (5.8-15.0) |
| Arrival: -ambulance | 10.8 (7.3-16.3) | 8.8 (5.7-15.5) |
| -walk in | 10.0 (7.2-15.7) | 8.7 (5.8-13.5) |
| Trauma injury: -Yes | 7.1 (4.1-13.0)** | 6.4 (4.6-12.7)** |

| | | |
|---|---|---|
| -No | 10.4 (7.3-15.9) | 9.0 (5.9-14.8) |
| Abdominal pain: -Yes | 11.3 (7.8-17.5)** | 10.5 (5.7-13.4)** |
| -No | 9.6 (6.9-14.6) | 8.3 (6.9-14.6) |
| Blood test: -Yes | 16.4 (10.2-23.6)** | 18.5 (11.6-25.0)** |
| -No | 10.0 (7.1-15.5) | 8.6 (5.8-13.8) |
| Heart-rate monitoring: -Yes | 14.6 (10.6-24.4)** | 12.7 (9.2-27.8)** |
| -No | 9.8 (6.9-15.2) | 8.2 (5.7-13.4) |
| Oxygen support: -Yes | 13.5 (8.7-23.0)** | 10.4 (8.7-23.0) |
| -No | 10.0 (7.1-15.4) | 8.6 (5.7-14.0) |
| Isolation: -Yes | 22.7 (11.3-36.7)** | 22.6 (11.7-44.3)** |
| -No | 10.0 (7.1-15.7) | 8.6 (5.8-13.5) |
| Time of day of arrival with: -low LOS | 9.0 (7.1-10.7)** | 8.6 (6.1-10.4) |
| -high LOS | 11.1 (7.2-16.9) | 8.8 (5.7-15.2) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank- order correlation |
| Age: | 0.18** | 0.09* |
| Crowding: | 0.06 | -0.06 |
| Physician taking charge delay: | 0.21** | 0.19** |
| Number of exams (range 0-15): | 0.33** | 0.29** |
| Number of specialist consultation (range 0-8): | 0.41** | 0.44** |
| Number of dose (range 1-7): | -0.13** | -0.10* |
| Baseline pain intensity score: | -0.06 | -0.01 |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Table 4. Relationship between length of stay and all confounding variables for **admitted** patients.

| Confounding variables | IV LOS in hour (N=558) | Other than IV LOS in hour (N=289) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 15.4 (10.5-23.6)* | 18.9 (11.4-27.5) |
| -female | 18.0 (11.7-25.4) | 19.5 (12.7-27.9) |

| | | |
|---|---|---|
| Triage priority: -high (1-2) | 16.4 (10.4-24.5) | 18.4 (11.1-25.8) |
| -low (3-4-5) | 17.2 (11.7-25.0) | 19.5 (12.9-27.6) |
| Arrival: -ambulance | 17.0 (10.7-25.3) | 20.7 (13.5-28.4) |
| -walk in | 16.6 (11.4-24.5) | 18.4 (12.0-26.9) |
| Trauma injury: -Yes | 12.5 (8.7-21.1)* | 15.7 (8.2-27.6) |
| -No | 17.0 (11.4-24.8) | 19.4 (12.6-27.6) |
| Abdominal pain: -Yes | 16.0 (10.9-23.3)* | 19.4 (12.9-26.7) |
| -No | 18.0 (11.5-27.6) | 19.3 (11.6-28.2) |
| Blood test: -Yes | 19.8 (11.8-28.5) | 27.9 (16.4-35.8)** |
| -No | 16.4 (10.9-24.5) | 18.8 (11.6-26.8) |
| Heart-rate monitoring: -Yes | 23.1 (16.2-38.6)** | 30.0 (25.3-45.2)** |
| -No | 15.6 (10.7-23.1) | 17.8 (11.3-25.7) |
| Oxygen support: -Yes | 20.9 (12.3-34.4)** | 26.8 (15.1-45.0)** |
| -No | 15.9 (10.8-24.1) | 18.7 (11.7-26.7) |
| Isolation: -Yes | 30.1 (21.8-54.3)** | 35.5 (22.6-57.8)** |
| -No | 15.9 (10.8-23.8) | 18.5 (11.6-26.7) |
| Time of day of arrival with: -low LOS | 15.7 (9.7-29.1) | 16.2 (10.6-24.2) |
| -high LOS | 17.0 (11.4-24.5) | 19.8 (12.7-27.8) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank-order correlation |
| Age: | 0.15** | 0.22** |
| Crowding: | 0.03 | 0.17** |
| Physician taking charge delay: | 0.16** | 0.06 |
| Number of exams (range 0-15): | 0.34** | 0.36** |
| Number of specialist consultation (range 0-8): | 0.31** | 0.37** |
| Number of dose (range 1-7): | -0.03 | -0.15** |
| Baseline pain intensity score: | 0.003 | -0.12* |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Multivariate analysis showed that when controlling for confounding variables, a brief time period (≤90 minutes) before analgesic administration (and not adequate pain relief) is associated with shortened ED-LOS for both discharged and admitted patients (ß=0.16; 95% confidence interval (95% CI): 0.10-0.22; p<0.001 and ß=0.09; 95% CI:

0.006-0.18; p<0.05, respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours (95%CI: 1.1-2.8; p<0.001) when time to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4; p<0.05) for admitted patients.

## LIMITATIONS

The main limitation of our study is its post hoc design and pre-formed database. Potential confounding variables, such as ethnicity and linguistic barrier, which are not recorded in demographic charts of our computerized system, could not be taken into consideration. Time from pain onset, component of chronic pain and pharmacological or non-pharmacological analgesia prior to arrival at the ED were also unknown. Case complexity assessment was difficult, although we controlled for number of examinations, number of consultants, need for oxygen and for isolation, which are markers of complexity. Likewise, we do not know if some patients did not receive an analgesic nor had suboptimal pain management because of refusal. However, it is doubtful that any of these confounding variables would cause significant differential bias. Finally, our single-center study in an academic hospital might limit the generalization of our results.

## DISCUSSION

As far as we know, this is the first investigation to evaluate the impact of pain relief on ED-LOS, and our results demonstrated that rapid administration of analgesia, and not adequate pain relief, is associated with shorter ED-LOS. It has been reported that patients expect to receive pain medication 25 to 30 minutes after their arrival,[42] which

coincides with the guidelines of our triage system (Canadian Emergency Department Triage and Acuity Scale).[43] Unfortunately, this goal is far from being achieved in many EDs, not only in Canada, but also around the world.[19,27,42] This is a persistent problem that dates back to the late 1980s when Wilson and Pendleton first defined the term "oligoanalgesia".[44]

More recently, the Pain and Emergency Medicine Initiative study demonstrated that patient satisfaction was associated more with the way ED physicians responded to their complaints of pain than to the actual result of pain treatment.[19] Which components of this response to pain were significant was not specified, but a possible part of it was the promptness with which pain was addressed. Patients with severe pain probably associate receiving pain medication quickly with quality of care and are more inclined to accept a medical treatment plan, even if they do not get relief. This might explain why we observed improved ED-LOS with prompt analgesic administration in patients being discharged or admitted.

In our study, the adjusted ED-LOS was 2 hours shorter in discharged patients who received their medication in ≤ 90 minutes than in those treated in > 90 minutes. The rapid administration of analgesia, associated with shorter ED-LOS, could have a significant impact on ED overcrowding. For example, our center received an average of 5,000 patients per year with severe pain on an ED bed. If we extrapolate the proportion of patient who received analgesia >90 minutes after arrival and the time saved if received in less than 90 minutes from our study to this population, a bed could be available during 16 hours every day. Such economy of beds would contribute to better throughput of patients

and render our EDs more efficient, as espoused by Asplin et al. with their conceptual model of overcrowding in 2003.[2]

A recent consensus of the Canadian Association of Emergency Physicians has ranked "ED-LOS" and "Time to first dose of analgesic" in the top 12 priority indicators of quality care.[45] In the USA, the Joint Commission on Accreditation of Healthcare Organizations mentions "early intervention" as the first goal in the treatment of acute pain.[37] Similarly, the Australian National Institute of Clinical Studies ranked "reduced time to analgesia" as the top priority and is currently working on improving their numbers.[42]

New solutions are being proposed to improve the initial approach to pain management. For example, the simple act of making pain scoring mandatory at triage has been shown to reduce time to analgesia by 45 minutes.[40] Extension of this practice could also integrate pain treatment as early as triage to limit further delays. Such measures have been introduced in Australia where nurse-initiated pain protocols are currently being evaluated. A pediatric ED study has shown 50% reduction of time to analgesia with such a protocol.[39] Early administration of analgesics has been investigated in pre-hospital settings, and appears to be safe and effective, particularly with the use of intranasal Fentanyl.[46,47] Even if no study has yet shown a benefit of this practice in LOS, it certainly has promising advantages, and further investigations should be considered.

In summary, we found that shorter time to analgesia administration is associated with ED-LOS reduction. This observation supports recent interest in analgesia implementation as early as triage or in pre-hospital settings to improve the throughput component of the overcrowding phenomenon seen in EDs around the world.

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**Competing interests** None

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## FIGURE LEGENDS

**Figure 1:** Median length of stay for subjects with adequate and inadequate pain relief in discharged and admitted patients.

**Figure 2:** Median length of stay for subjects receiving analgesia <90 min versus >=90 min from arrival in discharged and admitted patients.

# Impact of adequate pain relief on emergency department length of stay.

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## ABSTRACT

**Objectives:** Evaluate the influence of adequate analgesia and time to analgesic treatment on emergency department (ED) length of stay (LOS).

**Setting and Design:** Post-hoc analysis of real time archived data.

**Participants:** We included all consecutive ED patients ≥18 years with pain intensity >6 (verbal numerical scale from 0 to 10), assigned to an ED bed, and whose pain was re-evaluated less than 1 hour after receiving analgesic treatment.

**Outcome measures:** The main outcome was ED-LOS in patients who had adequate pain relief (AR = ↓50% pain intensity) compared to those who did not have such relief (NR).

**Results:** A total of 2,033 patients (mean age 49.5 years; 51% men) met our inclusion criteria; 58.3% were discharged, and 41.7% were admitted. Among patients discharged or admitted, there was no significant difference in ED-LOS between those with AR (median [25th-75th percentile]: 9.6 hours [6.3-14.8] and 18.2 hours [11.6-25.7], respectively) and NR (median [25th-75th percentile]: 9.6 hours [6.6-16.0] and 17.4 hours [11.3-26.5], respectively). After controlling for confounding factors, rapid time to analgesia (and not adequate pain relief) was associated with shorter ED-LOS of both discharged and admitted patients ($p < 0.001$ and $p < 0.05$ respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours when delay to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours for admitted patients.

**Conclusions:** In our study, adequate pain relief was not linked with short ED-LOS. However, rapid administration of analgesia was associated with short ED-LOS.

## ARTICLE SUMMARY

**Strengths and limitations of this study**

-This is a rare study that examines the relationship between pain relief and length of stay controlling for multiple confounding variables in a large cohort of emergency department patients.

-The main limitation of our study is its post hoc design and pre-formed database from a single-centre study in an academic hospital.

## INTRODUCTION

Emergency department (ED) overcrowding has been a concern for many years, and Canada is no exception, with nearly 60% of EDs reporting that problem in 2007.[1] The phenomenon of "boarding" is one of the principal factors identified as its cause.[2,3] "Boarding" (or "access block") refers to situations where bedridden emergency patients wait for the allocation of a bed on the ward for an unreasonably long time period (prolong ED length of stay) with consequent patient overflow in EDs. However, a recent retrospective study revealed that among patients waiting more than 6 hours in the ED, 50% were finally admitted while the other 50% were discharged,[4] indicating that non-boarding patients length of stay (LOS) also contribute to overcrowding. It has been shown to be a strong predictor of low satisfaction among patients[5] and healthcare workers.[1] It is also associated with long hospital LOS,[6,7] and high short- and medium-term mortality rates.[8-10] Furthermore, overcrowding is linked with reduced timeliness and quality of interventions and treatments,[11-13] including delayed analgesic administration, [14,15] particularly when pain is severe,[16] all of which contribute to the snowball effect of cumulating waits.

Pain represents more than 40% of consultations in EDs.[17] In large studies of patients with moderate to severe pain, only 21 to 68%[18-27] received analgesics, and 50 to

74% still had moderate to severe pain at discharge.[17] Severe, persistent pain may also lead to unwanted physiological responses, namely, increased adrenergic tone, augmented oxygen consumption, predisposition to hypercoagulability, decreased immune function, and heightened risk of delirium.[28,29] Moreover, adequate and timely treatment of acute pain could reduce the risk of chronic pain.[17] The relationship between pain management and LOS has not been studied has a primary outcome. However, a study of intermittent injection vs patient-controlled analgesia (PCA) for sickle cell crisis pain in the ED, established that PCA was associated with a significant reduction in length of ED stay, although there was no difference in initial or final pain intensity score [30].

Recent studies have attempted to identify the factors contributing to prolonged ED-LOS. Many of them have already been recognized, namely, number of laboratory examinations required, having to undergo X-ray or scan, the need for more than 3 medications, and number of consultants.[10,31] To the best of our knowledge, the adequacy and effectiveness of pain management have never been investigated in this regard. We sought to evaluate which component of initial pain management was associated with ED-LOS reduction. We hypothesized that ED-LOS would be lessened in patients with significant pain relief.

## MATERIALS AND METHODS

### Study design

We conducted *post hoc* analysis of real time archived data on all consecutive patients presenting with severe pain at our ED between March 2008 and February 2011. The aim of our study was to assess if pain relief was associated with ED-LOS reduction.

As a secondary objective, we evaluated if time to receiving analgesic treatment was linked with lessened ED-LOS.

**Setting**

Hôpital du Sacré-Cœur de Montreal is an urban, adult, level I trauma center with 540 inpatient beds and 60,000 ED visits per year. It sustains 22,000 hospitalizations annually, of which 51% are admitted through the ED. The study was approved by the institutional review board.

**Selection of participants**

Patients 18 years or older were included if they were assigned to an ED treatment bed, had severe pain at triage (defined as >6 on an 11-point verbal numerical scale from 0 to 10),[32-34] received an analgesic, and had their pain intensity re-evaluated in less than 1 hour after such medication.

Patients were excluded if they died during their ED stay, were pregnant or had been transferred from another hospital. We also excluded patients with altered mental status, intoxicated subjects, and anyone with chest pain necessitating emergent PCI, because their LOS could be determined by treatments other than pain management.

**Data collection**

Data were extracted from computerized information and nursing records in our ED (MedUrge™, MediaMed Technologies, Mont-Saint-Hilaire, Québec, Canada). This system is an integrated and mandatory working tool for all physicians, nursing staff, and

any employee involved in the ED healthcare process. It contains all demographic data, triage information (including vital signs, purpose of consultation, and pain level when relevant) as well as any pertinent data collected in real time by nurses during their re-evaluation rounds, including medication administration, and pain intensity.

**Data processing**

The cut-off of >6 on 10 was chosen because it was felt that lower pain intensity is less likely to warrant observation in itself. ED-LOS was measured in hours from the time of arrival at the ED to discharge or admission to a ward. We defined adequate pain relief (AR) as reduction of 50% or more of the initial pain level scored on the numerical scale within 1 hour after receiving the first analgesic. The 50% reduction and the 1-hour threshold are based on previous literature suggesting that they represent a meaningful decline[35,36] and acceptable delay in managing severe pain.[34,37,38] Initial pain was the one reported on the triage form. Time between arrival and analgesic administration was dichotomized into ≤90 minutes versus >90 minutes and also analyzed by three category (<1 hour; between 1 and 2 hour; >2 hour). We selected a 90-minute threshold because it is the median time to analgesia reported in many EDs with a pain scale integrated in their triage assessment.[19,39,40]

Our primary outcome was ED-LOS of patients with and without adequate pain relief. Our secondary outcome was ED-LOS of patients who received their medication in ≤90 minutes compared to those who received it after a longer time period.

**Data analysis**

Median LOS (25th-75th percentile) between groups of patients was compared by the Mann-Whitney U test and relationship among LOS and continuous predictors by Spearman rank-order correlations. All LOS are presented in hours and separately for patients with intravenous versus patients with other than intravenous route of analgesia administration. To examine the relative influence of adequate pain relief and time to analgesia on LOS, generalized linear model regressions with Gamma distribution and a log link function were undertaken for patients discharged from the ED and those admitted to a ward, controlling for age, gender, route of analgesia administration (IV vs other), number of dose of analgesia, type of arrival at ED (ambulance or walk in), triage priority (high vs low), crowding defined as number of patients in ED beds at the time of arrival, time of day of arrival with high or low LOS (calculated from a database of 162 000 patients of 18 years or older assigned to a bed between March 2008 and February 2011 from the same ED and selecting hours of arrival with high LOS and hours of arrival with low LOS), time between arrival and physician's first assessment, number of examinations, number of specialty consultations, baseline pain intensity score, trauma versus non-trauma, abdominal pain versus other, need for oxygen and for isolation. Generalized linear model was chosen because LOS is largely skewed and tends to produce less prediction errors than traditional linear regression[41]. Mean LOS difference and Wald 95% CI adjusted at mean covariates were produced from estimated marginal means. The Canadian healthcare system being public and free, the presence or absence of insurance was not analyzed. Alpha level was set at 0.05 for all statistical tests. All data were analyzed with SPSS version 20 (IBM, Somers, NY).

## RESULTS

A total of 2,033 patients met our inclusion and exclusion criteria. Of these patients, about half (51%) were male, more than two third arrived at ED alone, 1,186 (58.3%) were finally discharged and 847 were admitted (Table 1).

Among patients who were discharged from the ED, 45.7% had AR compared to 40.3% of admitted patients. There was no significant difference in ED-LOS between patients with AR compared to those without adequate relief (NR) (p=0.41 for discharged patients and p=0.87 for admitted patients) (Figure 1).

Table 1. Patient characteristics of the whole sample

| Characteristics | Total (N=2,033) |
|---|---|
| Mean age (±SD) | 49.5 (17.0) |
| % male | 51.0 |
| % Triage priority | |
| -high (1-2) | 45.3 |
| -low (3-4-5) | 54.7 |
| % Arrival | |
| -ambulance | 29.2 |
| -walk in | 70.8 |
| % -admitted | 41.7 |
| -discharged | 58.3 |
| % -treated with opiates only | 66.7 |
| -treated with non-opiates only | 11.1 |
| -treated with combination | 22.2 |
| % Route of analgesia administration | |
| -IV | 62.0 |
| -other | 38.0 |
| % with trauma injury | 7.6 |
| % with abdominal pain | 39.5 |
| % with blood test | 6.4 |

| | |
|---|---|
| % with heart-rate monitoring | 11.7 |
| % with oxygen support | 9.5 |
| % in isolation | 4.5 |
| Mean (±SD) baseline pain intensity score | 8.8 (1.1) |
| Mean (±SD) final pain intensity score | 5.1 (3.0) |
| Median LOS in hours (25th-75th percentile) | 12.3 (7.8-20.3) |
| Median time between arrival at ED and analgesic treatment in hours (25th-75th percentile) | 1.8 (1.1-3.2) |
| Median time to patient care by physician in hours (25th-75th percentile) | 0.72 (0.42-1.4) |

LOS: length of stay

Among patients who were discharged from the ED, 533 (45%) received analgesia ≤90 minutes, with ED-LOS reduction of 2.3 hours (p<0.001) compared to those with >90 minutes. The same analysis was applied to patients being admitted: only 265 (31%) received their medication in that interval, and their median ED-LOS reduction was 3.9 hours (p<0.001) (Figure 2). Median ED-LOS for three different times to receive analgesia is displayed in table 2.

Table 2. Median length of stay (25th-75th percentiles) for three different times to receive analgesia controlled for route of analgesia administration for discharged and admitted patients.

| Confounding variables | IV LOS in hour Median (25th-75th percentile) | Other than IV LOS in hour Median (25th-75th percentile) |
|---|---|---|
| Discharged patients: | (N=698) | (N=481) |
| Time to receive analgesia: -<1 hour | 8.6 (6.0-11.8) | 6.6 (4.4-9.5) |
| -from 1 to 2 hour | 10.5 (6.9-15.9) | 8.2 (5.4-12.2) |

| | | |
|---|---|---|
| ->2 hour | 12.9 (8.9-18.0) | 10.1 (6.3-19.2) |
| Admitted patients: | (N=556) | (N=289) |
| Time to receive analgesia: -<1 hour | 16.4 (10.8-23.8) | 17.2 (10.7-24.8) |
| -from 1 to 2 hour | 14.9 (10.4-22.6) | 18.1 (10.0-26.4) |
| ->2 hour | 18.7 (11.6-27.4) | 19.6 (12.9-28.7) |

LOS: length of stay; IV: intravenous route of analgesia administration; without IV: other than intravenous route of analgesia administration

Table 3 and 4 show the bivariate relations between LOS and all confounding variables controlled for route of analgesia administration for discharged and admitted patients respectively. For discharged patients with IV route of analgesia administration, only type of arrival, crowding and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, type of arrival, triage priority, oxygen support, time of day LOS, crowding and baseline pain intensity score were not associated with LOS. For admitted patients with IV route of analgesia administration, triage priority, type of arrival, blood testing, time of day LOS, crowding, number of dose and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, gender, triage priority, type of arrival, trauma injury, abdominal pain, time of day LOS and physician taking charge delay were not associated with LOS.

Table 3. Relationship between length of stay and all confounding variables for **discharged** patients.

| Confounding variables | IV LOS in hour (N=702) | Other than IV LOS in hour (N=484) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |

| | | |
|---|---|---|
| Gender: -male<br>-female | 9.5 (6.7-15.0)**<br>11.1 (7.9-16.9) | 8.0 (5.5-12.3)**<br>9.8 (6.1-18.4) |
| Triage priority: -high (1-2)<br>-low (3-4-5) | 9.7 (6.7-15.3)**<br>10.8 (7.9-17.0) | 8.8 (5.8-13.1)<br>8.8 (5.8-15.0) |
| Arrival: -ambulance<br>-walk in | 10.8 (7.3-16.3)<br>10.0 (7.2-15.7) | 8.8 (5.7-15.5)<br>8.7 (5.8-13.5) |
| Trauma injury: -Yes<br>-No | 7.1 (4.1-13.0)**<br>10.4 (7.3-15.9) | 6.4 (4.6-12.7)**<br>9.0 (5.9-14.8) |
| Abdominal pain: -Yes<br>-No | 11.3 (7.8-17.5)**<br>9.6 (6.9-14.6) | 10.5 (5.7-13.4)**<br>8.3 (6.9-14.6) |
| Blood test: -Yes<br>-No | 16.4 (10.2-23.6)**<br>10.0 (7.1-15.5) | 18.5 (11.6-25.0)**<br>8.6 (5.8-13.8) |
| Heart-rate monitoring: -Yes<br>-No | 14.6 (10.6-24.4)**<br>9.8 (6.9-15.2) | 12.7 (9.2-27.8)**<br>8.2 (5.7-13.4) |
| Oxygen support: -Yes<br>-No | 13.5 (8.7-23.0)**<br>10.0 (7.1-15.4) | 10.4 (8.7-23.0)<br>8.6 (5.7-14.0) |
| Isolation: -Yes<br>-No | 22.7 (11.3-36.7)**<br>10.0 (7.1-15.7) | 22.6 (11.7-44.3)**<br>8.6 (5.8-13.5) |
| Time of day of arrival with: -low LOS<br>-high LOS | 9.0 (7.1-10.7)**<br>11.1 (7.2-16.9) | 8.6 (6.1-10.4)<br>8.8 (5.7-15.2) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank- order correlation |
| Age: | 0.18** | 0.09* |
| Crowding: | 0.06 | -0.06 |
| Physician taking charge delay: | 0.21** | 0.19** |
| Number of exams (range 0-15): | 0.33** | 0.29** |
| Number of specialist consultation (range 0-8): | 0.41** | 0.44** |
| Number of dose (range 1-7): | -0.13** | -0.10* |
| Baseline pain intensity score: | -0.06 | -0.01 |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Table 4. Relationship between length of stay and all confounding variables for **admitted** patients.

| Confounding variables | IV LOS in hour (N=558) | Other than IV LOS in hour (N=289) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 15.4 (10.5-23.6)* | 18.9 (11.4-27.5) |
| -female | 18.0 (11.7-25.4) | 19.5 (12.7-27.9) |
| Triage priority: -high (1-2) | 16.4 (10.4-24.5) | 18.4 (11.1-25.8) |
| -low (3-4-5) | 17.2 (11.7-25.0) | 19.5 (12.9-27.6) |
| Arrival: -ambulance | 17.0 (10.7-25.3) | 20.7 (13.5-28.4) |
| -walk in | 16.6 (11.4-24.5) | 18.4 (12.0-26.9) |
| Trauma injury: -Yes | 12.5 (8.7-21.1)* | 15.7 (8.2-27.6) |
| -No | 17.0 (11.4-24.8) | 19.4 (12.6-27.6) |
| Abdominal pain: -Yes | 16.0 (10.9-23.3)* | 19.4 (12.9-26.7) |
| -No | 18.0 (11.5-27.6) | 19.3 (11.6-28.2) |
| Blood test: -Yes | 19.8 (11.8-28.5) | 27.9 (16.4-35.8)** |
| -No | 16.4 (10.9-24.5) | 18.8 (11.6-26.8) |
| Heart-rate monitoring: -Yes | 23.1 (16.2-38.6)** | 30.0 (25.3-45.2)** |
| -No | 15.6 (10.7-23.1) | 17.8 (11.3-25.7) |
| Oxygen support: -Yes | 20.9 (12.3-34.4)** | 26.8 (15.1-45.0)** |
| -No | 15.9 (10.8-24.1) | 18.7 (11.7-26.7) |
| Isolation: -Yes | 30.1 (21.8-54.3)** | 35.5 (22.6-57.8)** |
| -No | 15.9 (10.8-23.8) | 18.5 (11.6-26.7) |
| Time of day of arrival with: -low LOS | 15.7 (9.7-29.1) | 16.2 (10.6-24.2) |
| -high LOS | 17.0 (11.4-24.5) | 19.8 (12.7-27.8) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank-order correlation |
| Age: | 0.15** | 0.22** |
| Crowding: | 0.03 | 0.17** |
| Physician taking charge delay: | 0.16** | 0.06 |
| Number of exams (range 0-15): | 0.34** | 0.36** |
| Number of specialist consultation (range 0-8): | 0.31** | 0.37** |
| Number of dose (range 1-7): | -0.03 | -0.15** |
| Baseline pain intensity score: | 0.003 | -0.12* |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Multivariate analysis showed that when controlling for confounding variables, a brief time period (≤90 minutes) before analgesic administration (and not adequate pain relief) is associated with shortened ED-LOS for both discharged and admitted patients (ß=0.16; 95% confidence interval (95% CI): 0.10-0.22; p<0.001 and ß=0.09; 95% CI: 0.006-0.18; p<0.05, respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours (95%CI: 1.1-2.8; p<0.001) when time to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4; p<0.05) for admitted patients.

## LIMITATIONS

The main limitation of our study is its post hoc design and pre-formed database. Potential confounding variables, such as ethnicity and linguistic barrier, which are not recorded in demographic charts of our computerized system, could not be taken into consideration. Time from pain onset, component of chronic pain and pharmacological or non-pharmacological analgesia prior to arrival at the ED were also unknown. Case complexity assessment was difficult, although we controlled for number of examinations, number of consultants, need for oxygen and for isolation, which are markers of complexity. Likewise, we do not know if some patients did not receive an analgesic nor had suboptimal pain management because of refusal. However, it is doubtful that any of these confounding variables would cause significant differential bias. Finally, our single-center study in an academic hospital might limit the generalization of our results.

## DISCUSSION

As far as we know, this is the first investigation to evaluate the impact of pain relief on ED-LOS, and our results demonstrated that rapid administration of analgesia, and not adequate pain relief, is associated with shorter ED-LOS. It has been reported that patients expect to receive pain medication 25 to 30 minutes after their arrival,[42] which coincides with the guidelines of our triage system (Canadian Emergency Department Triage and Acuity Scale).[43] Unfortunately, this goal is far from being achieved in many EDs, not only in Canada, but also around the world.[19,27,42] This is a persistent problem that dates back to the late 1980s when Wilson and Pendleton first defined the term "oligoanalgesia".[44]

More recently, the Pain and Emergency Medicine Initiative study demonstrated that patient satisfaction was associated more with the way ED physicians responded to their complaints of pain than to the actual result of pain treatment.[19] Which components of this response to pain were significant was not specified, but a possible part of it was the promptness with which pain was addressed. Patients with severe pain probably associate receiving pain medication quickly with quality of care and are more inclined to accept a medical treatment plan, even if they do not get relief. This might explain why we observed improved ED-LOS with prompt analgesic administration in patients being discharged or admitted.

In our study, the adjusted ED-LOS was 2 hours shorter in discharged patients who received their medication in ≤ 90 minutes than in those treated in > 90 minutes. The rapid administration of analgesia, associated with shorter ED-LOS, could have a significant impact on ED overcrowding. For example, our center received an average of 5,000 patients per year with severe pain on an ED bed. If we extrapolate the proportion of

patient who received analgesia >90 minutes after arrival and the time saved if received in less than 90 minutes from our study to this population, a bed could be available during 16 hours every day. Such economy of beds would contribute to better throughput of patients and render our EDs more efficient, as espoused by Asplin et al. with their conceptual model of overcrowding in 2003.[2]

A recent consensus of the Canadian Association of Emergency Physicians has ranked "ED-LOS" and "Time to first dose of analgesic" in the top 12 priority indicators of quality care.[45] In the USA, the Joint Commission on Accreditation of Healthcare Organizations mentions "early intervention" as the first goal in the treatment of acute pain.[37] Similarly, the Australian National Institute of Clinical Studies ranked "reduced time to analgesia" as the top priority and is currently working on improving their numbers.[42]

New solutions are being proposed to improve the initial approach to pain management. For example, the simple act of making pain scoring mandatory at triage has been shown to reduce time to analgesia by 45 minutes.[40] Extension of this practice could also integrate pain treatment as early as triage to limit further delays. Such measures have been introduced in Australia where nurse-initiated pain protocols are currently being evaluated. A pediatric ED study has shown 50% reduction of time to analgesia with such a protocol.[39] Early administration of analgesics has been investigated in pre-hospital settings, and appears to be safe and effective, particularly with the use of intranasal Fentanyl.[46,47] Even if no study has yet shown a benefit of this practice in LOS, it certainly has promising advantages, and further investigations should be considered.

In summary, we found that shorter time to analgesia administration is associated with ED-LOS reduction. This observation supports recent interest in analgesia implementation as early as triage or in pre-hospital settings to improve the throughput component of the overcrowding phenomenon seen in EDs around the world.

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**Competing interests** None**.**

**Ethics approval** The study was approved by the institutional review board.

**Provenance and peer review** Not commissioned; externally peer reviewed.

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## FIGURE LEGENDS

**Figure 1:** Median length of stay for subjects with adequate and inadequate pain relief in discharged and admitted patients.

**Figure 2:** Median length of stay for subjects receiving analgesia <90 min versus >=90 min from arrival in discharged and admitted patients.

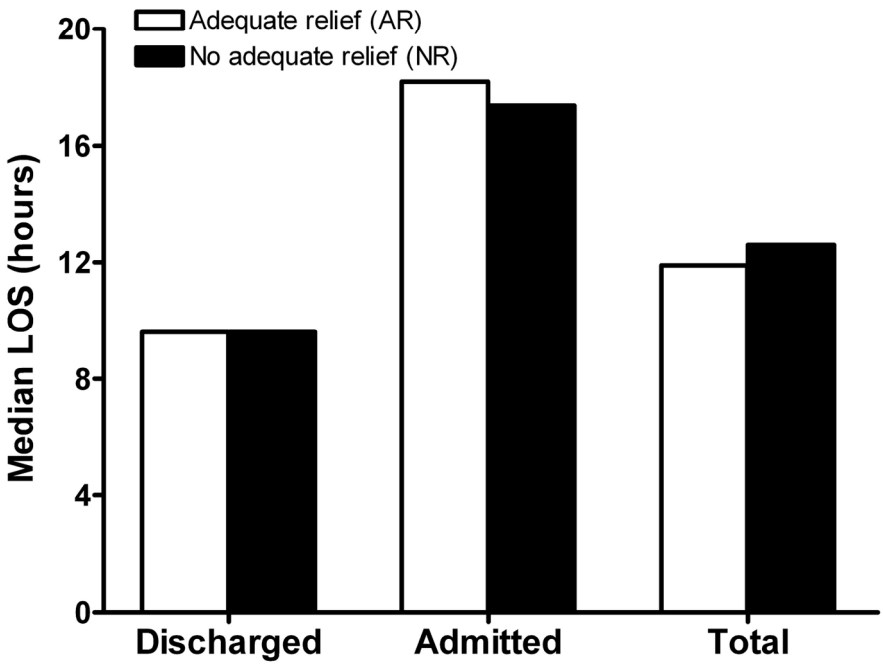


Figure 1: Median length of stay for subjects with adequate and inadequate pain relief in discharged and admitted patients.
152x121mm (300 x 300 DPI)

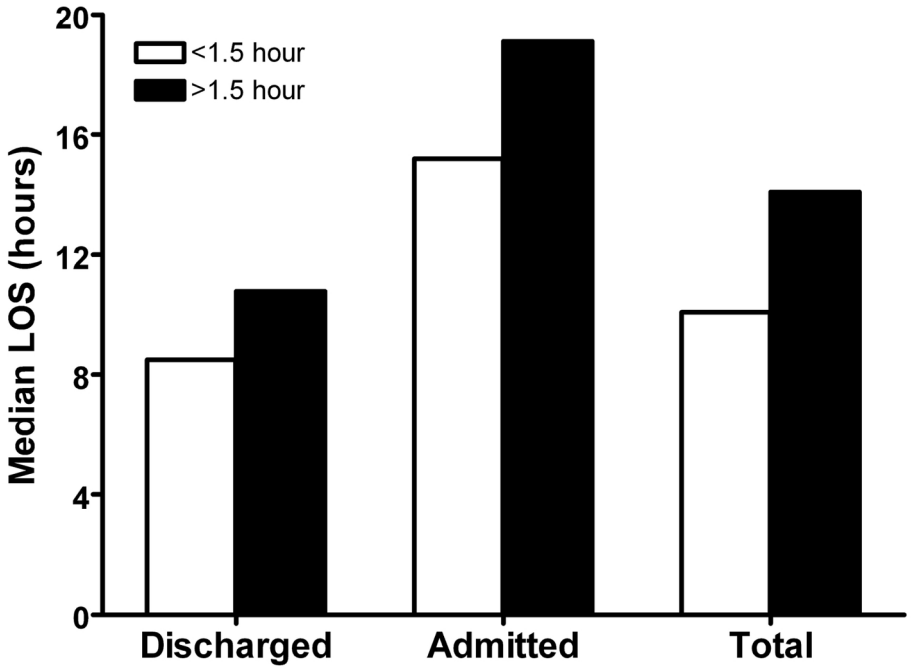


Figure 2: Median length of stay for subjects receiving analgesia <90 min versus >=90 min from arrival in discharged and admitted patients.
148x118mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract **Done** |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Done** |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported **Done** |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses **Done** |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper **Done** |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Done** |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Done** |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Done** |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Done** |
| Bias | 9 | Describe any efforts to address potential sources of bias **Done** |
| Study size | 10 | Explain how the study size was arrived at **Not applicable** |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Done** |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding **Done** |
| | | (*b*) Describe any methods used to examine subgroups and interactions **Not applicable** |
| | | (*c*) Explain how missing data were addressed **Done** |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses **Not applicable** |

Continued on next page

| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Done** |
| | | (b) Give reasons for non-participation at each stage **Done** |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Done** |
| | | (b) Indicate number of participants with missing data for each variable of interest **Done** |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures **Done** |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Done** |
| | | (*b*) Report category boundaries when continuous variables were categorized **Done** |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives **Done** |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Done** |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Done** |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results **Done** |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Done** |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ open

# Is adequate pain relief and time to analgesia associated with emergency department length of stay? A retrospective study.



| | |
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| Keywords: | Pain management < ANAESTHETICS, ACCIDENT & EMERGENCY MEDICINE, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT |
| | |

# Is adequate pain relief and time to analgesia associated with emergency department length of stay? A retrospective study.

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**Keywords :** Analgesia, Length of Stay, Emergency department, Pain relief

**Competing interests:** None Declared

**Word count (excluding abstract):** 2 353

## ABSTRACT

**Objectives:** Evaluate the association of adequate analgesia and time to analgesia with emergency department (ED) length of stay (LOS).

**Setting and Design:** Post-hoc analysis of real time archived data.

**Participants:** We included all consecutive ED patients ≥18 years with pain intensity >6 (verbal numerical scale from 0 to 10), assigned to an ED bed, and whose pain was re-evaluated less than 1 hour after receiving analgesic treatment.

**Outcome measures:** The main outcome was ED-LOS in patients who had adequate pain relief (AR = ↓50% pain intensity) compared to those who did not have such relief (NR).

**Results:** A total of 2,033 patients (mean age 49.5 years; 51% men) met our inclusion criteria; 58.3% were discharged, and 41.7% were admitted. Among patients discharged or admitted, there was no significant difference in ED-LOS between those with AR (median [25th-75th percentile]: 9.6 hours [6.3-14.8] and 18.2 hours [11.6-25.7], respectively) and NR (median [25th-75th percentile]: 9.6 hours [6.6-16.0] and 17.4 hours [11.3-26.5], respectively). After controlling for confounding factors, rapid time to analgesia (and not adequate pain relief) was associated with shorter ED-LOS of both discharged and admitted patients ($p < 0.001$ and $p < 0.05$ respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours (95%CI: 1.1-2.8) when delay to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4) for admitted patients.

**Conclusions:** In our study, adequate pain relief was not linked with short ED-LOS. However, rapid administration of analgesia was associated with short ED-LOS.

## ARTICLE SUMMARY

### Strengths and limitations of this study

-This is a rare study that examines the association between pain relief and length of stay controlling for multiple confounding variables in a large cohort of emergency department patients.

-The main limitation of our study is its post hoc design and pre-formed database from a single-centre study in an academic hospital.

## INTRODUCTION

Emergency department (ED) overcrowding has been a concern for many years, and Canada is no exception, with nearly 60% of EDs reporting that problem in 2007.[1] The phenomenon of "boarding" is one of the principal factors identified as its cause.[2,3] "Boarding" (or "access block") refers to situations where bedridden emergency patients wait for the allocation of a bed on the ward for an unreasonably long time period (prolong ED length of stay) with consequent patient overflow in EDs. However, a recent retrospective study revealed that among patients waiting more than 6 hours in the ED, 50% were finally admitted while the other 50% were discharged,[4] indicating that non-boarding patients length of stay (LOS) also contribute to overcrowding. It has been shown to be a strong predictor of low satisfaction among patients[5] and healthcare workers.[1] It is also associated with long hospital LOS,[6,7] and high short- and medium-term mortality rates.[8-10] Furthermore, overcrowding is linked with reduced timeliness and quality of interventions and treatments,[11-13] including delayed analgesic administration, [14,15] particularly when pain is severe,[16] all of which contribute to the snowball effect of cumulating waits.

Pain represents more than 40% of consultations in EDs.[17] In large studies of patients with moderate to severe pain, only 21 to 68%[18-27] received analgesics, and 50 to 74% still had moderate to severe pain at discharge.[17] Severe, persistent pain may also lead to unwanted physiological responses, namely, increased adrenergic tone, augmented oxygen consumption, predisposition to hypercoagulability, decreased immune function, and heightened risk of delirium.[28,29] Moreover, adequate and timely treatment of acute pain could reduce the risk of chronic pain.[17] The relationship between pain management

and LOS has not been studied has a primary outcome. However, a study of intermittent injection vs patient-controlled analgesia (PCA) for sickle cell crisis pain in the ED, established that PCA was associated with a significant reduction in length of ED stay, although there was no difference in initial or final pain intensity score [30].

Recent studies have attempted to identify the factors contributing to prolonged ED-LOS. Many of them have already been recognized, namely, number of laboratory examinations required, having to undergo X-ray or scan, the need for more than 3 medications, and number of consultants.[10,31] To the best of our knowledge, the adequacy and effectiveness of pain management have never been investigated in this regard. We sought to evaluate which component of initial pain management was associated with ED-LOS reduction. We hypothesized that ED-LOS would be lessened in patients with significant pain relief.

## MATERIALS AND METHODS

### Study design

We conducted *post hoc* analysis of real time archived data on all consecutive patients presenting with severe pain at our ED between March 2008 and February 2011. The aim of our study was to assess if pain relief was associated with ED-LOS reduction. As a secondary objective, we evaluated if time to receiving analgesic treatment was linked with lessened ED-LOS.

### Setting

Hôpital du Sacré-Cœur de Montreal is an urban, adult, level I trauma center with 540 inpatient beds and 60,000 ED visits per year. It sustains 22,000 hospitalizations annually, of which 51% are admitted through the ED. The study was approved by the institutional review board.

**Selection of participants**

Patients 18 years or older were included if they were assigned to an ED treatment bed, had severe pain at triage (defined as >6 on an 11-point verbal numerical scale from 0 to 10),[32-34] received an analgesic, and had their pain intensity re-evaluated in less than 1 hour after such medication.

Patients were excluded if they died during their ED stay, were pregnant or had been transferred from another hospital. We also excluded patients with altered mental status, intoxicated subjects, and anyone with chest pain necessitating emergent PCI, because their LOS could be determined by treatments other than pain management.

**Data collection**

Data were extracted from computerized information and nursing records in our ED (MedUrge™, MediaMed Technologies, Mont-Saint-Hilaire, Québec, Canada). This system is an integrated and mandatory working tool for all physicians, nursing staff, and any employee involved in the ED healthcare process. It contains all demographic data, triage information (including vital signs, purpose of consultation, and pain level when relevant) as well as any pertinent data collected in real time by nurses during their re-evaluation rounds, including medication administration, and pain intensity.

**Data processing**

The cut-off of >6 on 10 was chosen because it was felt that lower pain intensity is less likely to warrant observation in itself. ED-LOS was measured in hours from the time of arrival at the ED to discharge or admission to a ward. We defined adequate pain relief (AR) as reduction of 50% or more of the initial pain level scored on the numerical scale within 1 hour after receiving the first analgesic. The 50% reduction and the 1-hour threshold are based on previous literature suggesting that they represent a meaningful decline[35,36] and acceptable delay in managing severe pain.[34,37,38] Initial pain was the one reported on the triage form. Time between arrival and analgesic administration was dichotomized into ≤90 minutes versus >90 minutes and also analyzed by three category (<1 hour; between 1 and 2 hour; >2 hour). We selected a 90-minute threshold because it is the median time to analgesia reported in many EDs with a pain scale integrated in their triage assessment.[19,39,40]

Our primary outcome was ED-LOS of patients with and without adequate pain relief. Our secondary outcome was ED-LOS of patients who received their medication in ≤90 minutes compared to those who received it after a longer time period.

**Data analysis**

Median LOS (25th-75th percentile) between groups of patients was compared by the Mann-Whitney U test and relationship among LOS and continuous predictors by Spearman rank-order correlations. Median differences and their 95% confidence interval are also reported. All LOS are presented in hours and separately for patients with

intravenous versus patients with other than intravenous route of analgesia administration. To examine the relative influence of adequate pain relief and time to analgesia on LOS, generalized linear model regressions with Gamma distribution and a log link function were undertaken for patients discharged from the ED and those admitted to a ward, controlling for age, gender, route of analgesia administration (IV vs other), number of dose of analgesia, type of arrival at ED (ambulance or walk in), triage priority (high vs low), crowding defined as number of patients in ED beds at the time of arrival, time of day of arrival with high or low LOS (calculated from a database of 162 000 patients of 18 years or older assigned to a bed between March 2008 and February 2011 from the same ED and selecting hours of arrival with high LOS and hours of arrival with low LOS), time between arrival and physician's first assessment, number of examinations, number of specialty consultations, baseline pain intensity score, trauma versus non-trauma, abdominal pain versus other, need for oxygen and for isolation. Generalized linear model was chosen because LOS is largely skewed and tends to produce less prediction errors than traditional linear regression[41]. Mean LOS difference and Wald 95% CI adjusted at mean covariates were produced from estimated marginal means. The Canadian healthcare system being public and free, the presence or absence of insurance was not analyzed. Alpha level was set at 0.05 for all statistical tests. All data were analyzed with SPSS version 20 (IBM, Somers, NY).

## RESULTS

A total of 2,033 patients met our inclusion and exclusion criteria. Of these patients, about half (51%) were male, more than two third arrived at ED alone, 1,186 (58.3%) were finally discharged and 847 were admitted (Table 1).

Among patients who were discharged from the ED, 45.7% had AR compared to 40.3% of admitted patients. There was no significant difference in ED-LOS between patients with AR compared to those without adequate relief (NR) (p=0.41 for discharged patients and p=0.87 for admitted patients) (Table 2).

Table 1. Patient characteristics of the whole sample

| Characteristics | Total (N=2,033) |
|---|---|
| Mean age (±SD) | 49.5 (17.0) |
| % male | 51.0 |
| % Triage priority | |
| -high (1-2) | 45.3 |
| -low (3-4-5) | 54.7 |
| % Arrival | |
| -ambulance | 29.2 |
| -walk in | 70.8 |
| % -admitted | 41.7 |
| -discharged | 58.3 |
| % -treated with opiates only | 66.7 |
| -treated with non-opiates only | 11.1 |
| -treated with combination | 22.2 |
| % Route of analgesia administration | |
| -IV | 62.0 |
| -other | 38.0 |
| % with trauma injury | 7.6 |
| % with abdominal pain | 39.5 |
| % with blood test | 6.4 |
| % with heart-rate monitoring | 11.7 |

| | |
|---|---|
| % with oxygen support | 9.5 |
| % in isolation | 4.5 |
| Mean (±SD) baseline pain intensity score | 8.8 (1.1) |
| Mean (±SD) final pain intensity score | 5.1 (3.0) |
| Median LOS in hours (25th-75th percentile) | 12.3 (7.8-20.3) |
| Median time between arrival at ED and analgesic treatment in hours (25th-75th percentile) | 1.8 (1.1-3.2) |
| Median time to patient care by physician in hours (25th-75th percentile) | 0.72 (0.42-1.4) |

LOS: length of stay

Among patients who were discharged from the ED, 533 (45%) received analgesia ≤90 minutes, with unadjusted ED-LOS reduction of 2.2 hours (95%CI: 1.4-3.0; p<0.001) compared to those with >90 minutes. The same analysis was applied to patients being admitted: only 265 (31%) received their medication in that interval, and their median unadjusted ED-LOS reduction was 3.9 hours (95%CI: 2.0-5.7; p<0.001) (Table 2). Median ED-LOS for three different times to receive analgesia is displayed in table 3.

Table 2. Median unadjusted length of stay differences (25th-75th percentiles) for pain relief groups and time to analgesia groups.

| | **LOS in hour Median (25th-75th percentile)** | **LOS in hour Median (25th-75th percentile)** | **Median difference (±95% CI)** |
|---|---|---|---|
| Disposition after ED | Adequate relief | No adequate relief | |
| Discharged patients: | 9.6 (6.3-14.8) | 9.6 (6.6-16.0) | 0.02 (-0.81-0.86) |

| | | | |
|---|---|---|---|
| Admitted patients: | 18.2 (11.6-25.7) | 17.4 (11.3-26.5) | -0.8 (-2.8-1.1) |
| Total: | 11.9 (7.8-19.6) | 12.6 (7.8-20.6) | -0.7 (-1.6-0.3) |
| Disposition after ED | ≤1.5 hour delay | >1.5 hour delay | |
| Discharged patients: | 8.5 (5.8-12.5) | 10.8 (7.3-17.7) | 2.2* (1.4-3.0) |
| Admitted patients: | 15.2 (10.4-22.6) | 19.1 (11.8-27.6) | 3.9* (2.0-5.7) |
| Total: | 10.1 (6.6-16.3) | 14.1 (9.0-22.7) | 4.0* (2.3-5.6) |

LOS: length of stay; *p<0.001

Table 3. Median length of stay (25th-75th percentiles) for three different times to receive analgesia controlled for route of analgesia administration for discharged and admitted patients.

| Disposition after ED | IV LOS in hour Median (25th-75th percentile) | Other than IV LOS in hour Median (25th-75th percentile) |
|---|---|---|
| Discharged patients: | (N=698) | (N=481) |
| Time to receive analgesia: - <1 hour | 8.6 (6.0-11.8) | 6.6 (4.4-9.5) |
| - from 1 to 2 hour | 10.5 (6.9-15.9) | 8.2 (5.4-12.2) |
| - >2 hour | 12.9 (8.9-18.0) | 10.1 (6.3-19.2) |
| Admitted patients: | (N=556) | (N=289) |
| Time to receive analgesia: - <1 hour | 16.4 (10.8-23.8) | 17.2 (10.7-24.8) |
| - from 1 to 2 hour | 14.9 (10.4-22.6) | 18.1 (10.0-26.4) |
| - >2 hour | 18.7 (11.6-27.4) | 19.6 (12.9-28.7) |

LOS: length of stay; IV: intravenous route of analgesia administration; without IV: other than intravenous route of analgesia administration

Table 4 and 5 show the bivariate relations between LOS and all confounding variables controlled for route of analgesia administration for discharged and admitted patients respectively. For discharged patients with IV route of analgesia administration, only type of arrival, crowding and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, type of arrival, triage priority, oxygen support, time of day LOS, crowding and baseline pain intensity score were not associated with LOS. For admitted patients with IV route of analgesia administration, triage priority, type of arrival, blood testing, time of day LOS, crowding, number of dose and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, gender, triage priority, type of arrival, trauma injury, abdominal pain, time of day LOS and physician taking charge delay were not associated with LOS.

Table 4. Relationship between length of stay and all confounding variables for **discharged** patients.

| Confounding variables | IV LOS in hour (N=702) | Other than IV LOS in hour (N=484) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 9.5 (6.7-15.0)** | 8.0 (5.5-12.3)** |
| -female | 11.1 (7.9-16.9) | 9.8 (6.1-18.4) |
| Triage priority: -high (1-2) | 9.7 (6.7-15.3)** | 8.8 (5.8-13.1) |
| -low (3-4-5) | 10.8 (7.9-17.0) | 8.8 (5.8-15.0) |
| Arrival: -ambulance | 10.8 (7.3-16.3) | 8.8 (5.7-15.5) |
| -walk in | 10.0 (7.2-15.7) | 8.7 (5.8-13.5) |
| Trauma injury: -Yes | 7.1 (4.1-13.0)** | 6.4 (4.6-12.7)** |
| -No | 10.4 (7.3-15.9) | 9.0 (5.9-14.8) |
| Abdominal pain: -Yes | 11.3 (7.8-17.5)** | 10.5 (5.7-13.4)** |

| | | |
|---|---|---|
| -No | 9.6 (6.9-14.6) | 8.3 (6.9-14.6) |
| Blood test: -Yes | 16.4 (10.2-23.6)** | 18.5 (11.6-25.0)** |
| -No | 10.0 (7.1-15.5) | 8.6 (5.8-13.8) |
| Heart-rate monitoring: -Yes | 14.6 (10.6-24.4)** | 12.7 (9.2-27.8)** |
| -No | 9.8 (6.9-15.2) | 8.2 (5.7-13.4) |
| Oxygen support: -Yes | 13.5 (8.7-23.0)** | 10.4 (8.7-23.0) |
| -No | 10.0 (7.1-15.4) | 8.6 (5.7-14.0) |
| Isolation: -Yes | 22.7 (11.3-36.7)** | 22.6 (11.7-44.3)** |
| -No | 10.0 (7.1-15.7) | 8.6 (5.8-13.5) |
| Time of day of arrival with: -low LOS | 9.0 (7.1-10.7)** | 8.6 (6.1-10.4) |
| -high LOS | 11.1 (7.2-16.9) | 8.8 (5.7-15.2) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank- order correlation |
| Age: | 0.18** | 0.09* |
| Crowding: | 0.06 | -0.06 |
| Physician taking charge delay: | 0.21** | 0.19** |
| Number of exams (range 0-15): | 0.33** | 0.29** |
| Number of specialist consultation (range 0-8): | 0.41** | 0.44** |
| Number of dose (range 1-7): | -0.13** | -0.10* |
| Baseline pain intensity score: | -0.06 | -0.01 |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Table 5. Relationship between length of stay and all confounding variables for **admitted** patients.

| Confounding variables | IV LOS in hour (N=558) | Other than IV LOS in hour (N=289) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 15.4 (10.5-23.6)* | 18.9 (11.4-27.5) |
| -female | 18.0 (11.7-25.4) | 19.5 (12.7-27.9) |
| Triage priority: -high (1-2) | 16.4 (10.4-24.5) | 18.4 (11.1-25.8) |
| -low (3-4-5) | 17.2 (11.7-25.0) | 19.5 (12.9-27.6) |

| | | |
|---|---|---|
| Arrival: -ambulance | 17.0 (10.7-25.3) | 20.7 (13.5-28.4) |
| -walk in | 16.6 (11.4-24.5) | 18.4 (12.0-26.9) |
| Trauma injury: -Yes | 12.5 (8.7-21.1)* | 15.7 (8.2-27.6) |
| -No | 17.0 (11.4-24.8) | 19.4 (12.6-27.6) |
| Abdominal pain: -Yes | 16.0 (10.9-23.3)* | 19.4 (12.9-26.7) |
| -No | 18.0 (11.5-27.6) | 19.3 (11.6-28.2) |
| Blood test: -Yes | 19.8 (11.8-28.5) | 27.9 (16.4-35.8)** |
| -No | 16.4 (10.9-24.5) | 18.8 (11.6-26.8) |
| Heart-rate monitoring: -Yes | 23.1 (16.2-38.6)** | 30.0 (25.3-45.2)** |
| -No | 15.6 (10.7-23.1) | 17.8 (11.3-25.7) |
| Oxygen support: -Yes | 20.9 (12.3-34.4)** | 26.8 (15.1-45.0)** |
| -No | 15.9 (10.8-24.1) | 18.7 (11.7-26.7) |
| Isolation: -Yes | 30.1 (21.8-54.3)** | 35.5 (22.6-57.8)** |
| -No | 15.9 (10.8-23.8) | 18.5 (11.6-26.7) |
| Time of day of arrival with: -low LOS | 15.7 (9.7-29.1) | 16.2 (10.6-24.2) |
| -high LOS | 17.0 (11.4-24.5) | 19.8 (12.7-27.8) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank-order correlation |
| Age: | 0.15** | 0.22** |
| Crowding: | 0.03 | 0.17** |
| Physician taking charge delay: | 0.16** | 0.06 |
| Number of exams (range 0-15): | 0.34** | 0.36** |
| Number of specialist consultation (range 0-8): | 0.31** | 0.37** |
| Number of dose (range 1-7): | -0.03 | -0.15** |
| Baseline pain intensity score: | 0.003 | -0.12* |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Multivariate analysis showed that when controlling for confounding variables, a brief time period (≤90 minutes) before analgesic administration (and not adequate pain relief) is associated with shortened ED-LOS for both discharged and admitted patients (ß=0.16; 95% confidence interval (95% CI): 0.10-0.22; p<0.001 and ß=0.09; 95% CI: 0.006-0.18; p<0.05, respectively). When adjusting for confounding variables, ED-LOS is

shortened by 2 hours (95%CI: 1.1-2.8; p<0.001) when time to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4; p<0.05) for admitted patients.

## LIMITATIONS

The main limitation of our study is its post hoc design and pre-formed database. Potential confounding variables, such as ethnicity and linguistic barrier, which are not recorded in demographic charts of our computerized system, could not be taken into consideration. Time from pain onset, component of chronic pain and pharmacological or non-pharmacological analgesia prior to arrival at the ED were also unknown. Case complexity assessment was difficult, although we controlled for number of examinations, number of consultants, need for oxygen and for isolation, which are markers of complexity. Likewise, we do not know if some patients did not receive an analgesic nor had suboptimal pain management because of refusal. However, it is doubtful that any of these confounding variables would cause significant differential bias. Finally, our single-center study in an academic hospital might limit the generalization of our results.

## DISCUSSION

As far as we know, this is the first investigation to evaluate the impact of pain relief on ED-LOS, and our results demonstrated that rapid administration of analgesia, and not adequate pain relief, is associated with shorter ED-LOS. It has been reported that patients expect to receive pain medication 25 to 30 minutes after their arrival,[42] which coincides with the guidelines of our triage system (Canadian Emergency Department

Triage and Acuity Scale).[43] Unfortunately, this goal is far from being achieved in many EDs, not only in Canada, but also around the world.[19,27,42] This is a persistent problem that dates back to the late 1980s when Wilson and Pendleton first defined the term "oligoanalgesia".[44]

More recently, the Pain and Emergency Medicine Initiative study demonstrated that patient satisfaction was associated more with the way ED physicians responded to their complaints of pain than to the actual result of pain treatment.[19] Which components of this response to pain were significant was not specified, but a possible part of it was the promptness with which pain was addressed. Patients with severe pain probably associate receiving pain medication quickly with quality of care and are more inclined to accept a medical treatment plan, even if they do not get relief. This might explain why we observed improved ED-LOS with prompt analgesic administration in patients being discharged or admitted.

In our study, the adjusted ED-LOS was 2 hours shorter in discharged patients who received their medication in ≤ 90 minutes than in those treated in > 90 minutes. The rapid administration of analgesia, associated with shorter ED-LOS, could have a significant impact on ED overcrowding. For example, our center received an average of 5,000 patients per year with severe pain on an ED bed. If we extrapolate the proportion of patient who received analgesia >90 minutes after arrival and the time saved if received in less than 90 minutes from our study to this population, a bed could be available during 16 hours every day. Such economy of beds would contribute to better throughput of patients and render our EDs more efficient, as espoused by Asplin et al. with their conceptual model of overcrowding in 2003.[2]

A recent consensus of the Canadian Association of Emergency Physicians has ranked "ED-LOS" and "Time to first dose of analgesic" in the top 12 priority indicators of quality care.[45] In the USA, the Joint Commission on Accreditation of Healthcare Organizations mentions "early intervention" as the first goal in the treatment of acute pain.[37] Similarly, the Australian National Institute of Clinical Studies ranked "reduced time to analgesia" as the top priority and is currently working on improving their numbers.[42]

New solutions are being proposed to improve the initial approach to pain management. For example, the simple act of making pain scoring mandatory at triage has been shown to reduce time to analgesia by 45 minutes.[40] Extension of this practice could also integrate pain treatment as early as triage to limit further delays. Such measures have been introduced in Australia where nurse-initiated pain protocols are currently being evaluated. A pediatric ED study has shown 50% reduction of time to analgesia with such a protocol.[39] Early administration of analgesics has been investigated in pre-hospital settings, and appears to be safe and effective, particularly with the use of intranasal Fentanyl.[46,47] Even if no study has yet shown a benefit of this practice in LOS, it certainly has promising advantages, and further investigations should be considered.

In summary, we found that shorter time to analgesia administration is associated with ED-LOS reduction. This observation supports recent interest in analgesia implementation as early as triage or in pre-hospital settings to improve the throughput component of the overcrowding phenomenon seen in EDs around the world.

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**Competing interests** None**.**

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# Is adequate pain relief and time to analgesia associated with emergency department length of stay? A retrospective study.

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## ABSTRACT

**Objectives:** Evaluate the association of adequate analgesia and time to analgesia with emergency department (ED) length of stay (LOS).

**Setting and Design:** Post-hoc analysis of real time archived data.

**Participants:** We included all consecutive ED patients ≥18 years with pain intensity >6 (verbal numerical scale from 0 to 10), assigned to an ED bed, and whose pain was re-evaluated less than 1 hour after receiving analgesic treatment.

**Outcome measures:** The main outcome was ED-LOS in patients who had adequate pain relief (AR = ↓50% pain intensity) compared to those who did not have such relief (NR).

**Results:** A total of 2,033 patients (mean age 49.5 years; 51% men) met our inclusion criteria; 58.3% were discharged, and 41.7% were admitted. Among patients discharged or admitted, there was no significant difference in ED-LOS between those with AR (median [25th-75th percentile]: 9.6 hours [6.3-14.8] and 18.2 hours [11.6-25.7], respectively) and NR (median [25th-75th percentile]: 9.6 hours [6.6-16.0] and 17.4 hours [11.3-26.5], respectively). After controlling for confounding factors, rapid time to analgesia (and not adequate pain relief) was associated with shorter ED-LOS of both discharged and admitted patients ($p < 0.001$ and $p < 0.05$ respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours (95%CI: 1.1-2.8) when delay to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4) for admitted patients.

**Conclusions:** In our study, adequate pain relief was not linked with short ED-LOS. However, rapid administration of analgesia was associated with short ED-LOS.

## ARTICLE SUMMARY

### Strengths and limitations of this study

-This is a rare study that examines the association between pain relief and length of stay controlling for multiple confounding variables in a large cohort of emergency department patients.

-The main limitation of our study is its post hoc design and pre-formed database from a single-centre study in an academic hospital.

## INTRODUCTION

Emergency department (ED) overcrowding has been a concern for many years, and Canada is no exception, with nearly 60% of EDs reporting that problem in 2007.[1] The phenomenon of "boarding" is one of the principal factors identified as its cause.[2,3] "Boarding" (or "access block") refers to situations where bedridden emergency patients wait for the allocation of a bed on the ward for an unreasonably long time period (prolong ED length of stay) with consequent patient overflow in EDs. However, a recent retrospective study revealed that among patients waiting more than 6 hours in the ED, 50% were finally admitted while the other 50% were discharged,[4] indicating that non-boarding patients length of stay (LOS) also contribute to overcrowding. It has been shown to be a strong predictor of low satisfaction among patients[5] and healthcare workers.[1] It is also associated with long hospital LOS,[6,7] and high short- and medium-term mortality rates.[8-10] Furthermore, overcrowding is linked with reduced timeliness and quality of interventions and treatments,[11-13] including delayed analgesic administration,[14,15] particularly when pain is severe,[16] all of which contribute to the snowball effect of cumulating waits.

Pain represents more than 40% of consultations in EDs.[17] In large studies of patients with moderate to severe pain, only 21 to 68%[18-27] received analgesics, and 50 to 74% still had moderate to severe pain at discharge.[17] Severe, persistent pain may also lead to unwanted physiological responses, namely, increased adrenergic tone, augmented oxygen consumption, predisposition to hypercoagulability, decreased immune function, and heightened risk of delirium.[28,29] Moreover, adequate and timely treatment of acute pain could reduce the risk of chronic pain.[17] The relationship between pain management and LOS has not been studied has a primary outcome. However, a study of intermittent injection vs patient-controlled analgesia (PCA) for sickle cell crisis pain in the ED, established that PCA was associated with a significant reduction in length of ED stay, although there was no difference in initial or final pain intensity score [30].

Recent studies have attempted to identify the factors contributing to prolonged ED-LOS. Many of them have already been recognized, namely, number of laboratory examinations required, having to undergo X-ray or scan, the need for more than 3 medications, and number of consultants.[10,31] To the best of our knowledge, the adequacy and effectiveness of pain management have never been investigated in this regard. We sought to evaluate which component of initial pain management was associated with ED-LOS reduction. We hypothesized that ED-LOS would be lessened in patients with significant pain relief.

## MATERIALS AND METHODS

### Study design

We conducted *post hoc* analysis of real time archived data on all consecutive patients presenting with severe pain at our ED between March 2008 and February 2011. The aim of our study was to assess if pain relief was associated with ED-LOS reduction. As a secondary objective, we evaluated if time to receiving analgesic treatment was linked with lessened ED-LOS.

**Setting**

Hôpital du Sacré-Cœur de Montreal is an urban, adult, level I trauma center with 540 inpatient beds and 60,000 ED visits per year. It sustains 22,000 hospitalizations annually, of which 51% are admitted through the ED. The study was approved by the institutional review board.

**Selection of participants**

Patients 18 years or older were included if they were assigned to an ED treatment bed, had severe pain at triage (defined as >6 on an 11-point verbal numerical scale from 0 to 10),[32-34] received an analgesic, and had their pain intensity re-evaluated in less than 1 hour after such medication.

Patients were excluded if they died during their ED stay, were pregnant or had been transferred from another hospital. We also excluded patients with altered mental status, intoxicated subjects, and anyone with chest pain necessitating emergent PCI, because their LOS could be determined by treatments other than pain management.

**Data collection**

Data were extracted from computerized information and nursing records in our ED (MedUrge™, MediaMed Technologies, Mont-Saint-Hilaire, Québec, Canada). This system is an integrated and mandatory working tool for all physicians, nursing staff, and any employee involved in the ED healthcare process. It contains all demographic data, triage information (including vital signs, purpose of consultation, and pain level when relevant) as well as any pertinent data collected in real time by nurses during their re-evaluation rounds, including medication administration, and pain intensity.

**Data processing**

The cut-off of >6 on 10 was chosen because it was felt that lower pain intensity is less likely to warrant observation in itself. ED-LOS was measured in hours from the time of arrival at the ED to discharge or admission to a ward. We defined adequate pain relief (AR) as reduction of 50% or more of the initial pain level scored on the numerical scale within 1 hour after receiving the first analgesic. The 50% reduction and the 1-hour threshold are based on previous literature suggesting that they represent a meaningful decline[35,36] and acceptable delay in managing severe pain.[34,37,38] Initial pain was the one reported on the triage form. Time between arrival and analgesic administration was dichotomized into ≤90 minutes versus >90 minutes and also analyzed by three category (<1 hour; between 1 and 2 hour; >2 hour). We selected a 90-minute threshold because it is the median time to analgesia reported in many EDs with a pain scale integrated in their triage assessment.[19,39,40]

Our primary outcome was ED-LOS of patients with and without adequate pain relief. Our secondary outcome was ED-LOS of patients who received their medication in ≤90 minutes compared to those who received it after a longer time period.

**Data analysis**

Median LOS (25th-75th percentile) between groups of patients was compared by the Mann-Whitney U test and relationship among LOS and continuous predictors by Spearman rank-order correlations. Median differences and their 95% confidence interval are also reported. All LOS are presented in hours and separately for patients with intravenous versus patients with other than intravenous route of analgesia administration. To examine the relative influence of adequate pain relief and time to analgesia on LOS, generalized linear model regressions with Gamma distribution and a log link function were undertaken for patients discharged from the ED and those admitted to a ward, controlling for age, gender, route of analgesia administration (IV vs other), number of dose of analgesia, type of arrival at ED (ambulance or walk in), triage priority (high vs low), crowding defined as number of patients in ED beds at the time of arrival, time of day of arrival with high or low LOS (calculated from a database of 162 000 patients of 18 years or older assigned to a bed between March 2008 and February 2011 from the same ED and selecting hours of arrival with high LOS and hours of arrival with low LOS), time between arrival and physician's first assessment, number of examinations, number of specialty consultations, baseline pain intensity score, trauma versus non-trauma, abdominal pain versus other, need for oxygen and for isolation. Generalized linear model was chosen because LOS is largely skewed and tends to produce less prediction errors

than traditional linear regression[41]. Mean LOS difference and Wald 95% CI adjusted at mean covariates were produced from estimated marginal means. The Canadian healthcare system being public and free, the presence or absence of insurance was not analyzed. Alpha level was set at 0.05 for all statistical tests. All data were analyzed with SPSS version 20 (IBM, Somers, NY).

## RESULTS

A total of 2,033 patients met our inclusion and exclusion criteria. Of these patients, about half (51%) were male, more than two third arrived at ED alone, 1,186 (58.3%) were finally discharged and 847 were admitted (Table 1).

Among patients who were discharged from the ED, 45.7% had AR compared to 40.3% of admitted patients. There was no significant difference in ED-LOS between patients with AR compared to those without adequate relief (NR) (p=0.41 for discharged patients and p=0.87 for admitted patients) (Table 2).

Table 1. Patient characteristics of the whole sample

| Characteristics | Total (N=2,033) |
|---|---|
| Mean age (±SD) | 49.5 (17.0) |
| % male | 51.0 |
| % Triage priority | |
| -high (1-2) | 45.3 |
| -low (3-4-5) | 54.7 |
| % Arrival | |
| -ambulance | 29.2 |
| -walk in | 70.8 |
| % -admitted | 41.7 |
| | 58.3 |

| | |
|---|---|
| -discharged | |
| % -treated with opiates only | 66.7 |
| -treated with non-opiates only | 11.1 |
| -treated with combination | 22.2 |
| % Route of analgesia administration | |
| -IV | 62.0 |
| -other | 38.0 |
| % with trauma injury | 7.6 |
| % with abdominal pain | 39.5 |
| % with blood test | 6.4 |
| % with heart-rate monitoring | 11.7 |
| % with oxygen support | 9.5 |
| % in isolation | 4.5 |
| Mean (±SD) baseline pain intensity score | 8.8 (1.1) |
| Mean (±SD) final pain intensity score | 5.1 (3.0) |
| Median LOS in hours (25th-75th percentile) | 12.3 (7.8-20.3) |
| Median time between arrival at ED and analgesic treatment in hours (25th-75th percentile) | 1.8 (1.1-3.2) |
| Median time to patient care by physician in hours (25th-75th percentile) | 0.72 (0.42-1.4) |

LOS: length of stay

Among patients who were discharged from the ED, 533 (45%) received analgesia ≤90 minutes, with unadjusted ED-LOS reduction of 2.2 hours (95%CI: 1.4-3.0; p<0.001) compared to those with >90 minutes. The same analysis was applied to patients being admitted: only 265 (31%) received their medication in that interval, and their median unadjusted ED-LOS reduction was 3.9 hours (95%CI: 2.0-5.7; p<0.001) (Table 2).

Median ED-LOS for three different times to receive analgesia is displayed in table 3.

Table 2. Median unadjusted length of stay differences (25th-75th percentiles) for pain relief groups and time to analgesia groups.

| | **LOS in hour Median (25th-75th percentile)** | **LOS in hour Median (25th-75th percentile)** | **Median difference (±95% CI)** |
|---|---|---|---|
| Disposition after ED | Adequate relief | No adequate relief | |
| Discharged patients: | 9.6 (6.3-14.8) | 9.6 (6.6-16.0) | 0.02 (-0.81-0.86) |
| Admitted patients: | 18.2 (11.6-25.7) | 17.4 (11.3-26.5) | -0.8 (-2.8-1.1) |
| Total: | 11.9 (7.8-19.6) | 12.6 (7.8-20.6) | -0.7 (-1.6-0.3) |
| Disposition after ED | ≤1.5 hour delay | >1.5 hour delay | |
| Discharged patients: | 8.5 (5.8-12.5) | 10.8 (7.3-17.7) | 2.2* (1.4-3.0) |
| Admitted patients: | 15.2 (10.4-22.6) | 19.1 (11.8-27.6) | 3.9* (2.0-5.7) |
| Total: | 10.1 (6.6-16.3) | 14.1 (9.0-22.7) | 4.0* (2.3-5.6) |

LOS: length of stay; *p<0.001

Table 3. Median length of stay (25th-75th percentiles) for three different times to receive analgesia controlled for route of analgesia administration for discharged and admitted patients.

| Disposition after ED | IV LOS in hour Median (25th-75th percentile) | Other than IV LOS in hour Median (25th-75th percentile) |
|---|---|---|
| Discharged patients: | (N=698) | (N=481) |
| Time to receive analgesia: - <1 hour | 8.6 (6.0-11.8) | 6.6 (4.4-9.5) |
| - from 1 to 2 hour | 10.5 (6.9-15.9) | 8.2 (5.4-12.2) |

| | | |
|---|---|---|
| - >2 hour | 12.9 (8.9-18.0) | 10.1 (6.3-19.2) |
| Admitted patients: | (N=556) | (N=289) |
| Time to receive analgesia: - <1 hour | 16.4 (10.8-23.8) | 17.2 (10.7-24.8) |
| - from 1 to 2 hour | 14.9 (10.4-22.6) | 18.1 (10.0-26.4) |
| - >2 hour | 18.7 (11.6-27.4) | 19.6 (12.9-28.7) |

LOS: length of stay; IV: intravenous route of analgesia administration; without IV: other than intravenous route of analgesia administration

Table 4 and 5 show the bivariate relations between LOS and all confounding variables controlled for route of analgesia administration for discharged and admitted patients respectively. For discharged patients with IV route of analgesia administration, only type of arrival, crowding and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, type of arrival, triage priority, oxygen support, time of day LOS, crowding and baseline pain intensity score were not associated with LOS. For admitted patients with IV route of analgesia administration, triage priority, type of arrival, blood testing, time of day LOS, crowding, number of dose and baseline pain intensity score were not related to LOS while for other than IV route of analgesia administration, gender, triage priority, type of arrival, trauma injury, abdominal pain, time of day LOS and physician taking charge delay were not associated with LOS.

Table 4. Relationship between length of stay and all confounding variables for **discharged** patients.

| Confounding variables | IV LOS in hour (N=702) | Other than IV LOS in hour (N=484) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |

| | | |
|---|---|---|
| Gender: -male | 9.5 (6.7-15.0)** | 8.0 (5.5-12.3)** |
| -female | 11.1 (7.9-16.9) | 9.8 (6.1-18.4) |
| Triage priority: -high (1-2) | 9.7 (6.7-15.3)** | 8.8 (5.8-13.1) |
| -low (3-4-5) | 10.8 (7.9-17.0) | 8.8 (5.8-15.0) |
| Arrival: -ambulance | 10.8 (7.3-16.3) | 8.8 (5.7-15.5) |
| -walk in | 10.0 (7.2-15.7) | 8.7 (5.8-13.5) |
| Trauma injury: -Yes | 7.1 (4.1-13.0)** | 6.4 (4.6-12.7)** |
| -No | 10.4 (7.3-15.9) | 9.0 (5.9-14.8) |
| Abdominal pain: -Yes | 11.3 (7.8-17.5)** | 10.5 (5.7-13.4)** |
| -No | 9.6 (6.9-14.6) | 8.3 (6.9-14.6) |
| Blood test: -Yes | 16.4 (10.2-23.6)** | 18.5 (11.6-25.0)** |
| -No | 10.0 (7.1-15.5) | 8.6 (5.8-13.8) |
| Heart-rate monitoring: -Yes | 14.6 (10.6-24.4)** | 12.7 (9.2-27.8)** |
| -No | 9.8 (6.9-15.2) | 8.2 (5.7-13.4) |
| Oxygen support: -Yes | 13.5 (8.7-23.0)** | 10.4 (8.7-23.0) |
| -No | 10.0 (7.1-15.4) | 8.6 (5.7-14.0) |
| Isolation: -Yes | 22.7 (11.3-36.7)** | 22.6 (11.7-44.3)** |
| -No | 10.0 (7.1-15.7) | 8.6 (5.8-13.5) |
| Time of day of arrival with: -low LOS | 9.0 (7.1-10.7)** | 8.6 (6.1-10.4) |
| -high LOS | 11.1 (7.2-16.9) | 8.8 (5.7-15.2) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank- order correlation |
| Age: | 0.18** | 0.09* |
| Crowding: | 0.06 | -0.06 |
| Physician taking charge delay: | 0.21** | 0.19** |
| Number of exams (range 0-15): | 0.33** | 0.29** |
| Number of specialist consultation (range 0-8): | 0.41** | 0.44** |
| Number of dose (range 1-7): | -0.13** | -0.10* |
| Baseline pain intensity score: | -0.06 | -0.01 |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Table 5. Relationship between length of stay and all confounding variables for **admitted** patients.

| Confounding variables | IV LOS in hour (N=558) | Other than IV LOS in hour (N=289) |
|---|---|---|
| Categorical confounders: | Median (25th-75th percentile) | Median (25th-75th percentile) |
| Gender: -male | 15.4 (10.5-23.6)* | 18.9 (11.4-27.5) |
| -female | 18.0 (11.7-25.4) | 19.5 (12.7-27.9) |
| Triage priority: -high (1-2) | 16.4 (10.4-24.5) | 18.4 (11.1-25.8) |
| -low (3-4-5) | 17.2 (11.7-25.0) | 19.5 (12.9-27.6) |
| Arrival: -ambulance | 17.0 (10.7-25.3) | 20.7 (13.5-28.4) |
| -walk in | 16.6 (11.4-24.5) | 18.4 (12.0-26.9) |
| Trauma injury: -Yes | 12.5 (8.7-21.1)* | 15.7 (8.2-27.6) |
| -No | 17.0 (11.4-24.8) | 19.4 (12.6-27.6) |
| Abdominal pain: -Yes | 16.0 (10.9-23.3)* | 19.4 (12.9-26.7) |
| -No | 18.0 (11.5-27.6) | 19.3 (11.6-28.2) |
| Blood test: -Yes | 19.8 (11.8-28.5) | 27.9 (16.4-35.8)** |
| -No | 16.4 (10.9-24.5) | 18.8 (11.6-26.8) |
| Heart-rate monitoring: -Yes | 23.1 (16.2-38.6)** | 30.0 (25.3-45.2)** |
| -No | 15.6 (10.7-23.1) | 17.8 (11.3-25.7) |
| Oxygen support: -Yes | 20.9 (12.3-34.4)** | 26.8 (15.1-45.0)** |
| -No | 15.9 (10.8-24.1) | 18.7 (11.7-26.7) |
| Isolation: -Yes | 30.1 (21.8-54.3)** | 35.5 (22.6-57.8)** |
| -No | 15.9 (10.8-23.8) | 18.5 (11.6-26.7) |
| Time of day of arrival with: -low LOS | 15.7 (9.7-29.1) | 16.2 (10.6-24.2) |
| -high LOS | 17.0 (11.4-24.5) | 19.8 (12.7-27.8) |
| Continuous confounders: | Spearman rank-order correlation | Spearman rank-order correlation |
| Age: | 0.15** | 0.22** |
| Crowding: | 0.03 | 0.17** |
| Physician taking charge delay: | 0.16** | 0.06 |
| Number of exams (range 0-15): | 0.34** | 0.36** |
| Number of specialist consultation (range 0-8): | 0.31** | 0.37** |
| Number of dose (range 1-7): | -0.03 | -0.15** |
| Baseline pain intensity score: | 0.003 | -0.12* |

LOS : length of stay; IV: intravenous route of analgesia administration; other than IV: other than intravenous route of analgesia administration; *p<0.05; **p<0.01

Multivariate analysis showed that when controlling for confounding variables, a brief time period (≤90 minutes) before analgesic administration (and not adequate pain relief) is associated with shortened ED-LOS for both discharged and admitted patients (ß=0.16; 95% confidence interval (95% CI): 0.10-0.22; p<0.001 and ß=0.09; 95% CI: 0.006-0.18; p<0.05, respectively). When adjusting for confounding variables, ED-LOS is shortened by 2 hours (95%CI: 1.1-2.8; p<0.001) when time to receive analgesic is <90 min compared to >90 min for discharged and by 2.3 hours (95%CI: 0.17-4.4; p<0.05) for admitted patients.

## LIMITATIONS

The main limitation of our study is its post hoc design and pre-formed database. Potential confounding variables, such as ethnicity and linguistic barrier, which are not recorded in demographic charts of our computerized system, could not be taken into consideration. Time from pain onset, component of chronic pain and pharmacological or non-pharmacological analgesia prior to arrival at the ED were also unknown. Case complexity assessment was difficult, although we controlled for number of examinations, number of consultants, need for oxygen and for isolation, which are markers of complexity. Likewise, we do not know if some patients did not receive an analgesic nor had suboptimal pain management because of refusal. However, it is doubtful that any of these confounding variables would cause significant differential bias. Finally, our single-center study in an academic hospital might limit the generalization of our results.

## DISCUSSION

As far as we know, this is the first investigation to evaluate the impact of pain relief on ED-LOS, and our results demonstrated that rapid administration of analgesia, and not adequate pain relief, is associated with shorter ED-LOS. It has been reported that patients expect to receive pain medication 25 to 30 minutes after their arrival,[42] which coincides with the guidelines of our triage system (Canadian Emergency Department Triage and Acuity Scale).[43] Unfortunately, this goal is far from being achieved in many EDs, not only in Canada, but also around the world.[19,27,42] This is a persistent problem that dates back to the late 1980s when Wilson and Pendleton first defined the term "oligoanalgesia".[44]

More recently, the Pain and Emergency Medicine Initiative study demonstrated that patient satisfaction was associated more with the way ED physicians responded to their complaints of pain than to the actual result of pain treatment.[19] Which components of this response to pain were significant was not specified, but a possible part of it was the promptness with which pain was addressed. Patients with severe pain probably associate receiving pain medication quickly with quality of care and are more inclined to accept a medical treatment plan, even if they do not get relief. This might explain why we observed improved ED-LOS with prompt analgesic administration in patients being discharged or admitted.

In our study, the adjusted ED-LOS was 2 hours shorter in discharged patients who received their medication in ≤ 90 minutes than in those treated in > 90 minutes. The rapid administration of analgesia, associated with shorter ED-LOS, could have a significant impact on ED overcrowding. For example, our center received an average of 5,000 patients per year with severe pain on an ED bed. If we extrapolate the proportion of

patient who received analgesia >90 minutes after arrival and the time saved if received in less than 90 minutes from our study to this population, a bed could be available during 16 hours every day. Such economy of beds would contribute to better throughput of patients and render our EDs more efficient, as espoused by Asplin et al. with their conceptual model of overcrowding in 2003.[2]

A recent consensus of the Canadian Association of Emergency Physicians has ranked "ED-LOS" and "Time to first dose of analgesic" in the top 12 priority indicators of quality care.[45] In the USA, the Joint Commission on Accreditation of Healthcare Organizations mentions "early intervention" as the first goal in the treatment of acute pain.[37] Similarly, the Australian National Institute of Clinical Studies ranked "reduced time to analgesia" as the top priority and is currently working on improving their numbers.[42]

New solutions are being proposed to improve the initial approach to pain management. For example, the simple act of making pain scoring mandatory at triage has been shown to reduce time to analgesia by 45 minutes.[40] Extension of this practice could also integrate pain treatment as early as triage to limit further delays. Such measures have been introduced in Australia where nurse-initiated pain protocols are currently being evaluated. A pediatric ED study has shown 50% reduction of time to analgesia with such a protocol.[39] Early administration of analgesics has been investigated in pre-hospital settings, and appears to be safe and effective, particularly with the use of intranasal Fentanyl.[46,47] Even if no study has yet shown a benefit of this practice in LOS, it certainly has promising advantages, and further investigations should be considered.

In summary, we found that shorter time to analgesia administration is associated with ED-LOS reduction. This observation supports recent interest in analgesia implementation as early as triage or in pre-hospital settings to improve the throughput component of the overcrowding phenomenon seen in EDs around the world.

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**Competing interests** None**.**

**Ethics approval** The study was approved by the institutional review board.

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STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract **Done** |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Done** |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported **Done** |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses **Done** |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper **Done** |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Done** |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Done** |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Done** |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Done** |
| Bias | 9 | Describe any efforts to address potential sources of bias **Done** |
| Study size | 10 | Explain how the study size was arrived at **Not applicable** |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Done** |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding **Done** |
| | | (*b*) Describe any methods used to examine subgroups and interactions **Not applicable** |
| | | (*c*) Explain how missing data were addressed **Done** |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses **Not applicable** |

Continued on next page

| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Done** |
| | | (b) Give reasons for non-participation at each stage **Done** |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Done** |
| | | (b) Indicate number of participants with missing data for each variable of interest **Done** |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures **Done** |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Done** |
| | | (*b*) Report category boundaries when continuous variables were categorized **Done** |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives **Done** |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Done** |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Done** |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results **Done** |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Done** |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.