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EFFECTIVENESS OF NURSE PRACTITIONERS/PHYSICIAN'S ASSISTANTS IN TRIAGE

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EFFECTIVENESS OF NURSE PRACTITIONERS/PHYSICIAN'S ASSISTANTS IN TRIAGE

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Abstract

As the number of patients seen annually by Emergency Departments (EDs) continues to increase, EDs have implemented a number of strategies to improve throughput efficiency, including placing nurse practitioners and/or physician's assistants in triage. While prior studies have found these strategies to be effective, they have failed to distinguish between whether this intervention truly reduces left without being seen rates or simply encourages elopement, whereby patients who have received a medical screening exam then leave without receiving definitive treatment or disposition. This study reviewed throughput at a site that placed mid-level providers in triage, comparing metrics in the months prior to and after implementation. Wait times were reduced by an average of over 12 minutes, with greater reductions observed in patients who were not admitted. There were no significant effects on overall length of stay. Further, there was a significant shift of 12 percentage points to patients eloping rather than leaving without being seen.

Keywords: Triage, Emergency Service, Nurse Practitioner, Physician's Assistants

I. Introduction

The demand for emergency department (ED) resources is ever-increasing. Between 1996 and 2011, the number of annual visits to the ED in the United States in increased by more than 50%, from 90.3 million to 136.2 million (Centers for Disease Control and Prevention, 2015; Pennsylvania Patient Safety Authority, 2010). Despite this increase, the number of EDs continues to decline, with closures associated with economic and market forces, generally tracking the factors influencing overall hospital closure (Hsia, Kellerman, & Shen, 2011; Wiler et al., 2010). As such, the remaining departments must use their resources more efficiently in order to meet current and future needs of patients and communities. Further, starting in the fourth quarter of 2015, Medicare reimbursement rates have been linked to reported measures of patient throughput (Galarraga & Pines, 2014).

Many "front end" improvements have been proposed, implemented, and studied to reduce patient wait times and increase patient throughput in the ED as part of an overall effort to reduce crowding and mitigate capacity issues (Pennsylvania Patient Safety Authority, 2010; Wiler et al., 2010). One intervention is assigning, in addition to the traditional registered nurse (RN), a provider to triage: The provider performs the legally-required Medical Screening Exam (MSE), definitive care and discharge for minor complaints, and initiates diagnostic testing for more complicated cases when space is not available in the main ED (Pennsylvania Patient Safety Authority, 2010). A recent systematic review has shown that placing a provider in triage decreases time-to-provider, length of stay (LOS), and left without being seen (LWBS) rates (Wiler et al., 2010). In some cases the provider is an emergency physician, but many studies and reports involve nurse practitioners (NPs) and physician's assistants (PAs), collectively referred to as mid-level providers (MLPs), as a more cost-effective solution. The Pennsylvania Patient Safety Authority (2010) notes that most studies most focus on the LWBS rate when reporting on patients who leave without definitive care, which only capture those patients who leave prior to receiving a MSE; those who have been screened but leave without definitive care are categorized differently and are not reported on despite remaining a liability to the hospital should their condition worsen after leaving. The degree to which placing a provider at triage merely substitutes the LWBS rate for other categories of non-definitive disposition, such as *elopement*, whereby patients given MSEs leave from the waiting room, has not been studied and its medicolegal risks remain undefined.

Purpose

This project examined the effectiveness of MLP-in-triage models compared to the traditional sole-RN-in-triage model in reducing standardized metrics of ED throughput, collected in the third and fourth months prior to and third month following the implementation of the MLP-in-triage, with an equal number of visits examined prior and subsequent to the intervention. The four metrics studied - wait time (door to provider), LOS for admitted patients, LOS for discharged patients, and LWBS - are those mandated to be collected and reported to the Centers for Medicare and Medicaid Services (CMS) and are defined in Appendix A (Pennsylvania Patient Safety Authority, 2010). Similar single-site studies have been performed, as described by Wiler et al. (2010); data from this objective was used to establish the validity of the study's findings, in order to support the second objective.

Additionally, this project aimed to determine the extent to which NPs and PAs in triage convert LWBS into elopements as opposed to other disposition types associated with definitive care (discharge, admit, transfer, or AMA), an investigation not previously described in the literature.

This study investigated the impact of the introduction of MLPs in ED triage via three metrics:

1. Mean number of ED dispositions
2. Mean number of LOS, Elopements, and Wait Times
3. Shift between the mean number of Elopements and the mean number of LWBS

Conceptual Model

Iserson and Moskop (2007, p. 275) refer to triage as the "allocation of a scarce medical resource." In the ED, beds and trained staff are resources in short supply during usual operations. Under such conditions, "resources exist to treat every patient, although those less severely ill or injured must wait longer," (Iserson & Moskop, 2007, p. 278). When the number of patients to be seen exceeds the resources available, emergent patients are seen immediately, others wait, and the triage process serves to sort between these two groups (Iserson & Moskop, 2007).

Figure 1 diagrams patient passage through the usual triage process; arrows in the chart indicate patient movement through both time and space. In short, there are two informal levels of triage before a patient makes it to the triage room. The first is the patient's own decision to use the ED for care; the second is the triage or charge nurse's determination of an immediately apparent emergent condition, whereupon the patient is roomed immediately. If no such condition is apparent, the patient is sent to the triage room, where the formal triage process takes place. In the United States, five-level triage systems, such as the Emergency Severity Index or Canadian Triage Acuity Scale are commonly used (Iserson & Moskop, 2007). Once evaluated in triage, some patients are determined to have a hidden emergent or urgent condition and are then immediately roomed or placed at the front of the "line" for the next available room; the rest are sent to the waiting room pending an available treatment space. Patients who leave prior to being seen by a provider are classified as LWBS; while those who have been seen are classified as eloped.

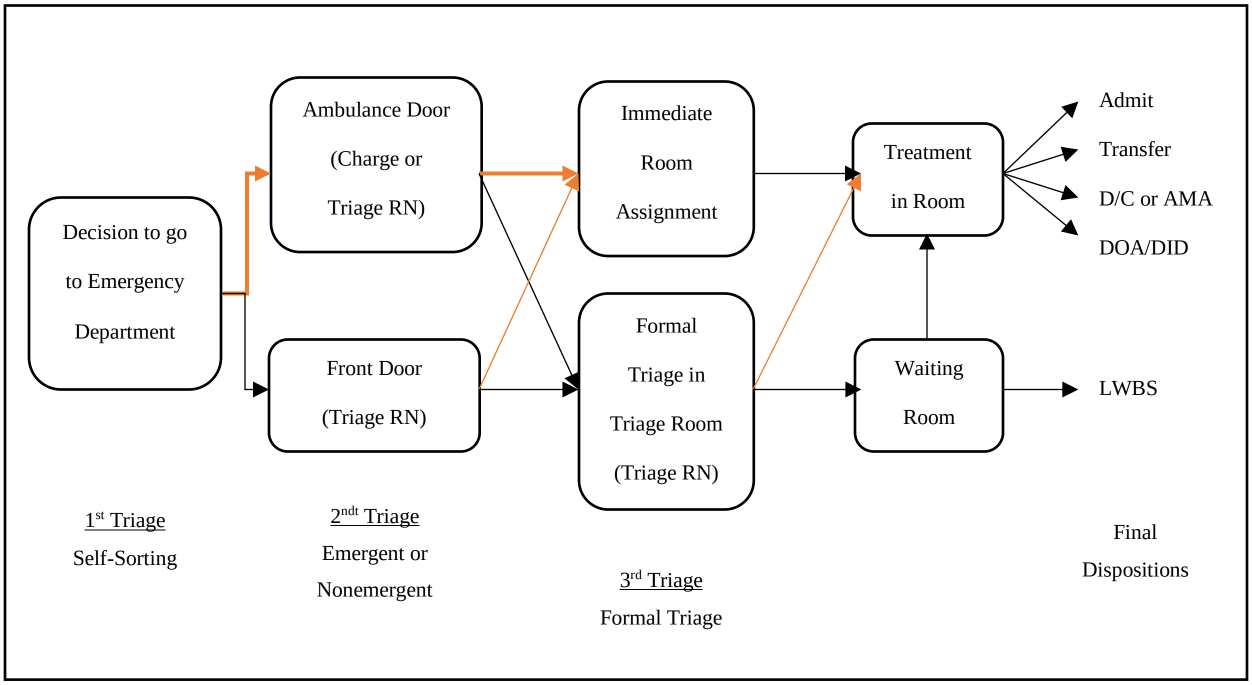

Figure 1. Patient flow through regular ED triage process. Orange lines reflect diversions away from the usual patient flow due to acuity. AMA: Against Medical Advice; D/C: discharge; DID: Died in Department; DOA: Dead on Arrival.

Figure 2 diagrams patient passage through formal triage following the introduction of a MLP who can perform the MSE, enable lab draws and radiologic studies while patients await placement in a treatment room, and speeding time to disposition either by front-loading patient wait times through the aforementioned interventions or by occasionally treating and discharging the patient directly. As predicted by the Circle of Caring Model of advanced practice nursing in Figure 3. (Dunphy, Winland-Brown, Porter, & Thomas, 2015), these changes should reduce wait time (door to provider), time-to-admit, time-to-discharge, and LWBS. The model is a general one, whereby Advanced Practice Nurses (APNs) synthesize subjective and objective data using their own experience and education to apply both medical and nursing interventions for the benefit of the patient. In the context of triage, the MSE is the "Assessment" portion, the tests and interventions are "Advanced practice nursing responses" (third box), and the improvement/decrease in CMS-measured throughput metrics are the "Outcomes" predicted by the model. While PAs differ in their education and licensure, the Circle of Caring model should similarly explain their effect on ED throughput methods (as most EDs treat them as interchangeable with NPs).

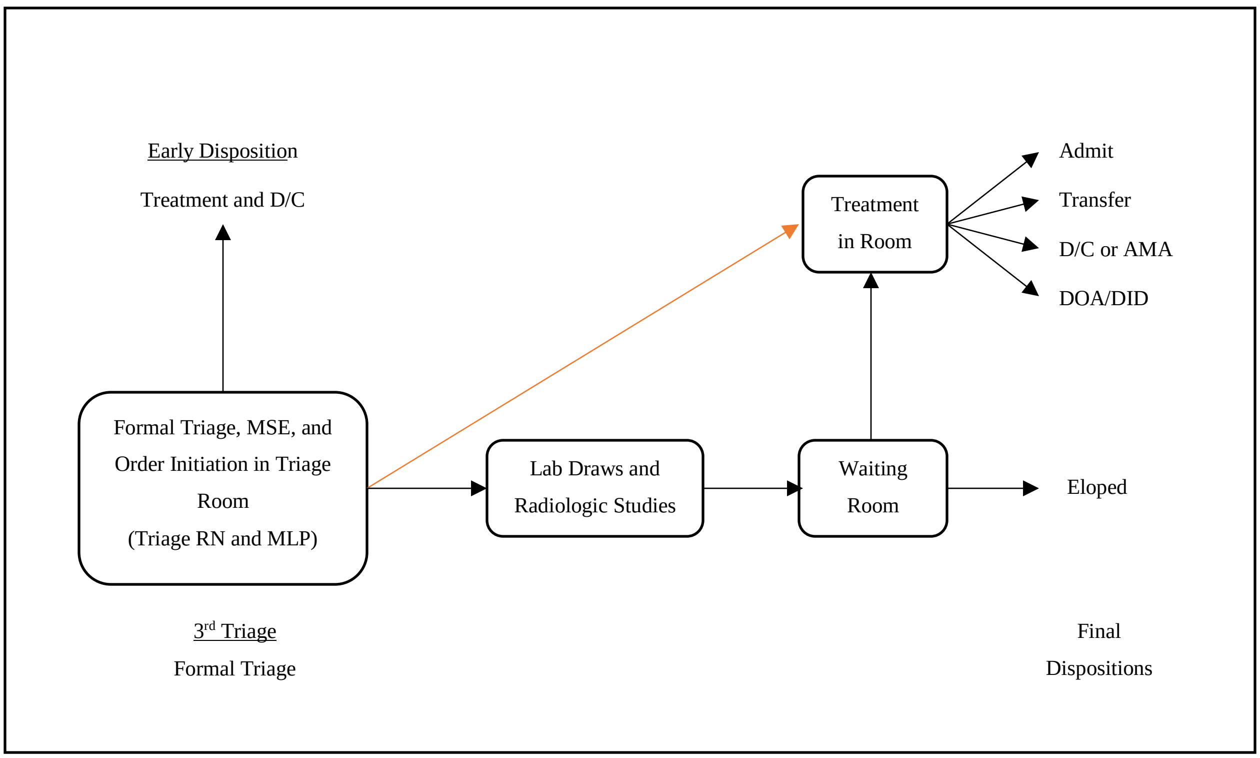

Figure 2. Patient flow after triage following implementation of MLP in triage. The orange line reflects diversion away from the usual patient flow due to acuity. Chart partially adapted from Love, Murphy, Lietz, and Jordan (2012). AMA: Against Medical Advice; D/C: discharge; DID: Died in Department; DOA: Dead on Arrival.

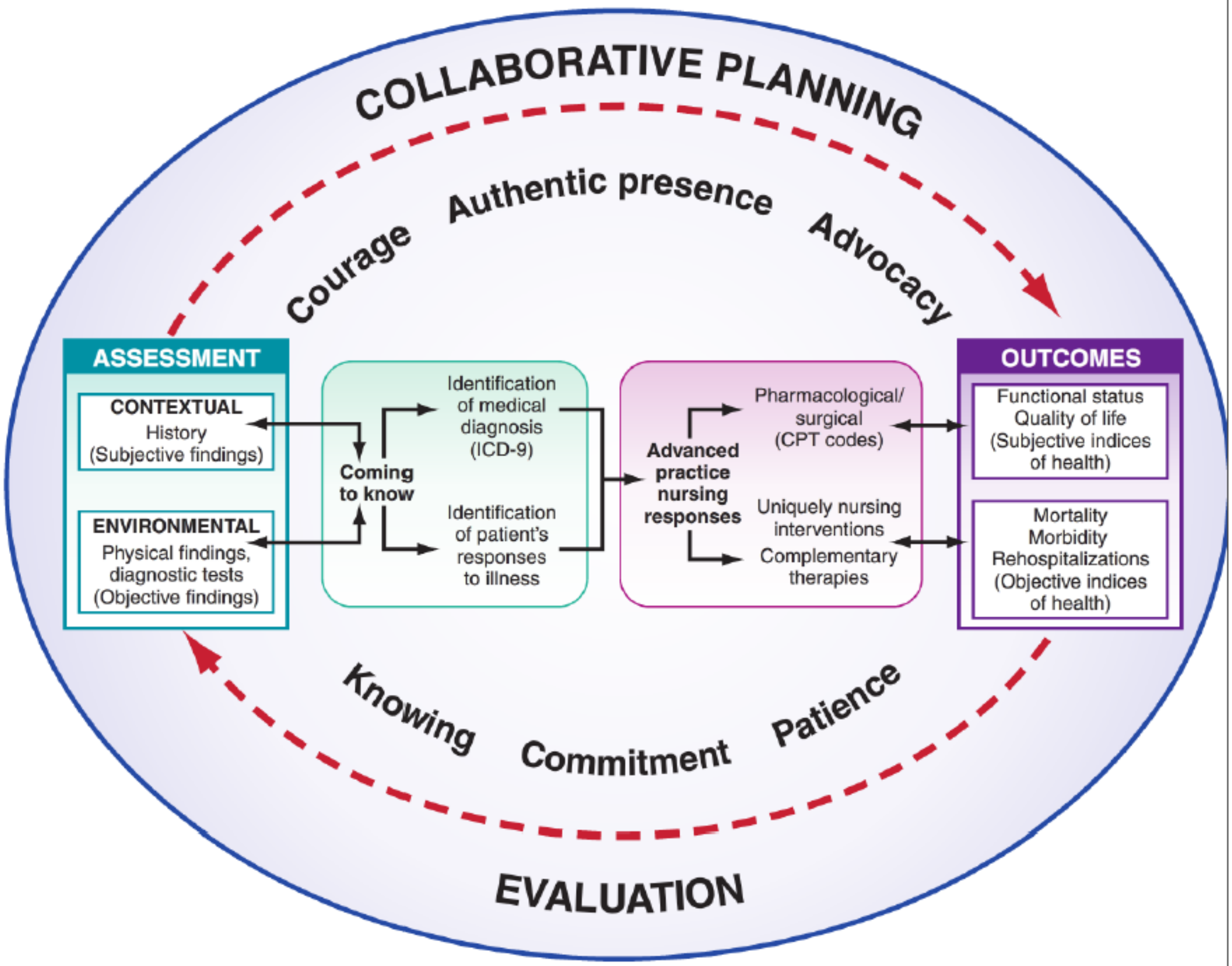

Figure 3. The Circle of Caring model, from Dunphy et al. (2015)

II. Literature Review

Prior to planning research, a systematic search of the literature was performed in April 2015. PubMed was searched using the Medical Subject Heading (MeSH) string: "Emergency Service, Hospital"[Mesh] AND "Patient Care Management"[Mesh] AND ("Nurse Practitioners"[Mesh] OR "Physician Assistants"[Mesh]), which returned 172 results; CINAHL Complete was searched with the string: (MH "Emergency Service") AND (MH "Triage") AND ((MH "Nurse Practitioners") OR (MH "Physician Assistants")), which returned 32 results. Both database searches were performed on all extant entries regardless of date of publication, and all records produced in the search were reviewed. Few articles focused solely on having an NP and/or a PA in triage without also incorporating other interventions to improve patient flow are included below, but were few in number. A "Cited by" search via Google Scholar of one such article - a systematic review by Wiler et al. (2010) – also found a few relevant newer articles. This search process was repeated in September of 2017 after completion of data analysis. The results of both searches are summarized in Appendix B.

Wiler et al. (2010) provide the most recent and systematic review of "front end" improvements to ED throughput, including assigning an MLP to triage. Covering publications up through 2008, they report that placing a provider in triage significantly reduced all relevant CMS benchmark metrics. They note, however, that most of these studies suffered from poor and inconsistent methodology, were all limited to a single site, and that most were nonrandomized. Further, they note that "the medicolegal risk of the triage provider [has not] been quantified" and that "at times when demand outstrips capacity and patients are in queue for an ED bed, it is not clear whether a physician or other provider in triage ameliorates risk in the event of a bad patient outcome" (Wiler et al., 2010, p. 155).

Of those articles cited by Wiler et al. (2010), the work of Holroyd et al. (2007) stands out as it details a controlled trial of adding a Triage Liaison Physician to answer questions from the triage nurse, assess patients and initiate orders, and address administrative issues. While this intervention used physicians instead of MLPs, the roles being filled are similar those filled by MLPs in other studies. Holroyd et al. (2007) found a reduction in LOS of 39 minutes, reducing LOS from 4 hours 57 minutes to 4 hours 21 minutes; they also found a 20% reduction in LWBS (from 7.5% to 6.3%), but after analysis this was found not to be statistically significant (p=0.20).

Burlingame (2009) detailed the implementation of an MLP in Triage at a hospital in South Carolina: LWBS rates were significantly reduced from 10.9% to 5.6% ($p < .001$) as was door-to-disposition ($p < .001$) over the 12 days of the study, but no significant difference in wait times were seen. Burlingame (2009), however, does not discuss the role of the MLP in triage, leaving it uncertain as to whether the NP or PA limited themselves to performing an MSE or if they also submitted orders and/or discharged patients.

Following the work of Wiler et al. (2010), a number of reports on the impact of NPs and PAs in triage were published in 2012, all of which were limited to a single site like the project reported by Burlingame. A report from North Carolina described the use of NPs and PAs triage (Love et al., 2012). At their site, MLPs were present from 1000 to 2300 hours, and performed MSEs, initiated orders, and occasionally discharged patients. Love et al. (2012) reported significant decreases in wait time (from 75 minutes to 25 minutes) and %LWBS (from 3.39% to 0.93%); they also stated that they decreased the idle waiting time of patients before being placed in a treatment space and decreased LOS, but did not present data for those variables.

Nestler et al. (2012) reported on the implementation of a PA in triage at a campus of the Mayo Clinic. Over 8 days at "peak times", the PA performed a MSE and initiated orders in triage without discharging patients (Nestler et al., 2012). This study reported a significant decrease in LOS times (from 270 minutes to 229 minutes, $p<0.001$) and LWBS rates (from 9.7% to 1.4%, $p<0.001$) (Nestler et al., 2012). Additionally, a pediatric ED reported their experience with an MLP in triage (Tsai, Sharieff, Kanegaye, Carlson, & Harley, 2012), comparing the same month of the year before and after implementation. By having the MLP perform the MSE, initiate orders, and discharge low acuity patients, Tsai et al. reported significant reductions in wait time (from 80 minutes to 53 minutes), LOS (from 239 minutes to 181 minutes), and LWBS rates (from 9% to 3%, $p<0.01$).

Additionally, Shea and Hoyt (2012) reported on the implementation of a related concept, "Team Triage." They substituted the traditional triage process using a single RN with a team composed of an MLP, an LVN instead of an RN, and a tech from 1000 to 2200 (Shea & Hoyt, 2012). Using their new process, they were able to significantly reduce LOS (from 187 minutes to 127 minutes) and LWBS rates (from 4.4% to 1.44%) .

More recently, Pierce and Gormley (2016) looked at combining a split-flow model with a provider-in-triage (either a physician, NP, or PA) during busy hours as compared to split flow without a provider-in-triage at the same site, as well as against a separate site with no provider and a blended flow through the entire department. This study only looked at the effects of their intervention on the LOS for patients who were discharged, specifically excluding those patients who LWBS, eloped, or expired; they reported a 16.3 minute reduction in discharge LOS (from 173.8 minutes to 157.5 minutes) with the split-flow model alone, while reporting a discharge

LOS reduction of 28.5 minutes (reduced from 173.8 to 145.3 minutes) when a provider-in-triage was added to the split-flow model.

On a related note, a recent study by Begaz, Elashoff, Grogan, Talan, and Taira (2017) investigated the effects on having NPs as opposed to physicians as Provider-in-Triage on test ordering and LOS. The authors found no meaningful difference between the two provider types on number or type of tests ordered in triage, and also no effect on LOS, demonstrating that NPs do not order excess tests or delay patient disposition.

III. Methods

Design

This project utilized a retrospective study design.

Setting

West Suburban Medical Center (WSMC), in Oak Park, IL, is a Comprehensive Community Hospital owned by Tenet Healthcare that sees between 40,000-60,000 ED visits annually. WSMC's ED used a traditional RN-in-Triage model prior to February 2015, after which it used both PAs and NPs in triage during peak hours. Data from this site is summarized both daily and monthly, although elopement is an administrative designation and is manually compiled by staff.

Inadequacy of Public Data

As of 22 April 2015, CMS posted some of the metrics under study to http://hospitalcompare.hhs.gov/, but only for specified time periods - which differed by metric - and the site did not provide access to historical data. By 3 June 2015, ED data were reported for the same time period, but only for the most recent fiscal year, with access to historical data still lacking; the situation was the same on 27 August 2016. As such, information needed to be collected directly from the institution.

Recruitment Procedure

In order to determine the number of patients to be included, a power analysis was performed based on the data provided by the prior investigations discussed in the literature review, looking at door-to-provider and LOS times, as well as the LWBS rate. Given the low percentages involved, LWBS required the largest number of records: based off the data reported by Holroyd et al. (2007) requires 5,000 data points to be adequately described both prior to and after the intervention (i.e. introducing NPs and PAs into triage) to obtain 80% power.

As WSMC's ED sees 3,000-4,000 patient visits a month, two months of data will be requested prior to and after the intervention in order to ensure adequate power while minimizing administrative burden on the site providing data. Temporary throughput issues during the adjustment phase around the implementation presented a potential confound; thus, in lieu of requesting data for the two months immediately before and after the intervention, data from the third and fourth months prior to and after the intervention were requested instead. All patient visits at WSMC's ED during those times were included, except those who meet the exclusion criterion of having their disposition listed as Dead On Arrival (DOA). DOA patients obviously bypass the normal triage system, and their "length of stay" is determined by forensic, documentation, and other medicolegal concerns rather than actual treatment, and as such they were not of interest to this study. In order to comply with IRB restrictions limiting collection to the first 5,000 records exactly on either side of the intervention, DOA records were removed and the remaining records were counted off starting with the first patient in May 2015 going forwards and the last patient of November 2011 going backwards until 5,000 records were reached. One DOA patient each was removed from the pre- and post-intervention data sets.

Data Collection

Relevant time and disposition data was retrieved from patient charts by WSMC's electronic medical record (EMR) system; this data was already compiled for internal use as well as for reporting to CMS into monthly and daily reports. The categorization of patients as having eloped was performed by nursing staff according to institutional policy. Data was provided by the administrative assistant for WSMC's ED as described below, following approval of DePaul's and Tenet's Institutional Review Boards.

WSMC's EMR system automatically generates a monthly report in a read-only Excel spreadsheet of all patient encounters listing time of arrival, patient name, patient account number, disposition type, door-to-provider time, and door-to-disposition time (the terminology the EMR uses for length-of-stay); these reports are stored on computers within the administrative offices of WSMC's ED. The administrative assistant for the department removed the patient name and account number columns from the relevant reports, copy/pasted the remaining cells into a new spreadsheet, saved this new spreadsheet to a USB flash drive, and provided the thus deidentified data to the researcher. The values from these reports were used to determine the median wait time, median LOS for both admitted and discharged patients, the LWBS rate, and the elopement rate for the relevant time period.

Data Analysis

The study assessed the effectiveness of MLP-in-triage models compared to the traditional sole-RN-in-triage model via retrospectively comparing two 5000-person cohorts of patients seen at WSMC's ED – those seen three months before (late October / November 214) and those seen three months after (May 2015) the introduction of MLPs to the ED. The cohorts were evaluated on three standardized metrics: Disposition, LOS, and wait time.

Disposition. Patients were expected to be broadly disposed into six categories: Discharged, Admitted, Transferred, Eloped, LWBS, and Against Medial Advice (AMA). The disposition distribution of the two cohorts (Before / After introduction of MLPs) was assessed non-parametrically via a chi-square test of independence. The strength of the relationship (if any) between MLP and Disposition was assessed via Cramer's V, an effect size measure bounded between 0 and 1, where a value of 0 means there is no relationship between the two variables and a value 1 means that knowing the values of one variables lets one perfectly predict the values of the other variable. V is a symmetric measure (i.e., the direction of prediction doesn't affect its value). To address the more specific and meaningful question - how well does knowing the provider type predict disposition - V was supplemented via lambda (λ), an asymmetric measure of association (meaning that the direction of prediction matters). Similar to V, λ is bounded between 0 and 1, with 0 indicating that knowing provider type yields no information about disposition and 1 indicating that knowing provider type perfectly predicts disposition.

In addition to comparing disposition distribution between cohorts in general, the analysis was repeated for the more targeted question of interest- whether the presence of MLPs affected the distribution of definitive care (DC; Discharged, Admit, Transferred, AMA) vs non-DC (Eloped, LWBS). Finally, within the category of non-definitive care, the analyses were repeated to assess whether the presence of MLPs affected the distribution of elopement vs LWBS.

Length of Stay. As LOS data were highly positively skewed, LOS was $\log_{10}$ transformed to normalize the distribution (the improvement in fit was confirmed via the box-cox procedure). Prior to model fitting, the LOS data were screened for incorrect entries / outliers.

Log(LOS) was linearly predicted as a function of disposition (admitted or discharged), the presence of a MLP, and their interaction (more complex generalized linear models such as Poisson and negative binomial yielded no benefit in model fit over the GLM). In addition to F tests, unweighted (least square [LS]) mean differences and appropriate post-hoc tests are presented for any significant main effects and interactions.

Wait Time. Log(WT) was investigated among patients as a function of disposition (discharged, admitted, transferred, eloped, LWBS, or AMA), the presence of a MLP, and their interaction. Apart from the greater number of disposition categories, WT was analyzed via the same process as LOS.

Protection of Human Subjects

This project obtained and used data on individual patient encounters collected and supplied by WSMC on patient throughput times and disposition types. The data in question was already collected for regulatory and internal quality improvement purposes, was deidentified as described above, and the investigator had no access to patient-identifiable information. Further, due to the large number of patients seen at the ED at WSMC, as well as being removed from the actual collection of data by a few years, it is impossible to match the encounter time data to actual patients once the data has been deidentified. As such, the data this study posed no additional risks to the patients seen at these institutions. Therefore, this project was exempt from Institutional Review Board oversight at both DePaul and at the IRB covering West Suburban Medical Center, the Tenet Northeast Market IRB at MetroWest. Letters to this effect were obtained from the IRBs at all relevant institutions.

IV. Results

Disposition

Table 1 provides the disposition counts of the first 5000 patients seen three months before (late October / November 214) and after (May 2015) the introduction of MLPs to the ED. Low frequency events (< 5 patients either before or after) - including not being charted by the RN, died in department (DID), entered improperly in the system (Void), left without triage - were excluded from further analyses, yielding an analysis sample of 9969. See Table 2 for the reduced disposition counts. Using the remaining six dispositions, there was a significant difference in patient distribution before and after the introduction of MLPs, $\chi^2(5) = 49.42$, $p < .001$, with a weak association between them, Cramer's V = .07; knowledge of the presence of a MLP, however, did not yield a significant proportional reduction in disposition category prediction error, $\lambda = .02$ (SE = .02), $z = 1.13$, $p = .26$.

Table 1. Disposition Before and After Introduction of MLPs, Ordered by Frequency

	MLP Introduction		
Disposition	Before	After	Total
Discharged	4057	3976	8033
Admit	663	635	1298
Transferred	131	130	261
Eloped	58	154	212
LWBS	34	50	84
AMA	35	46	81
Not RN charted	11	4	15
DID	5	4	9
Void	4	0	4
DOA	2	0	2
Left Without Triage	0	1	1
Total	5000	5000	10000

Note. MLP = Mid-level practitioner; LWBS = Left without being seen; AMA = Against medical advice; DID = Died in Department; DOA = Dead on arrival

Table 2. Disposition Before and After Introduction of MLPs, Ordered by Frequency, Rare Events Excluded

	MLP Introduction		
Disposition	Before	After	Total
Discharged	4057	3976	8033
Admit	663	635	1298
Transferred	131	130	261
Eloped	58	154	212
LWBS	34	50	84
AMA	35	46	81
Overall	4978	4991	9969

Note. MLP = Mid-level practitioner; LWBS = Left without being seen; AMA = Against medical advice

Definitive versus non-definitive care. The more targeted question of interest was whether the presence of MLPs affected the distribution of definitive care (DC; Discharged, Admit, Transferred, AMA) versus non-DC (Eloped, LWBS); see **Error! Reference source not ound.**3 for the counts. There was a significant difference in patient distribution before and after the introduction of MLPs, $\chi^2(1) = 50.97$, $p < .001$, with a weak association between them, Cramer's V = .07 and knowledge of the presence of a MLP yielding a significant proportional reduction in disposition category prediction error, $\lambda = .02$ (SE = .004), $z = 6.51$, $p < .001$. After the introduction of MLPs, patients were 2.35 times (95% CI: [1.85, 3.00]) more likely to receive non-definitive care, with the percent of patients receiving non-definitive care increasing to 4.39% (SE = .19) from 1.86% (SE = .30), a 2.52 point difference (SE = .36), $z = 7.07$, $p < .001$.

Table 3. Definitive Care Before and After MLP Introduction

MLP Introduction	Definitive Care		
	No	Yes	Total
Before	92	4886	4978
After	204	4787	4991
Total	296	9673	9969

Note. MLP = Mid-level practitioner

Elopement versus LWBS. Finally, within the category of non-definitive care, the question of interest was whether the presence of MLPs affected the distribution of elopement versus LWBS; see Table **Error! Reference source not found.**4 for the counts. There was a ignificant difference in patient distribution before and after the introduction of MLPs, $\chi^2(1)$ = 4.83, p = .03, with a weak association between them, Cramer's V = .13 and knowledge of the presence of a MLP yielding a significant proportional reduction in disposition category prediction error, $\lambda = .12$ (SE = .06), $z = 2.12$, $p < .03$. After the introduction of MLPs, patients were 1.20 times (95% CI: [1.00, 1.43]) more likely to elope, with the percent of patients eloping increasing to 75.49% (SE = 3.01) from 63.04% (SE = 5.03), a 12.45 point difference (SE = 5.86), $z = 2.12$, $p < .03$.

Table 4. Eloped versus LWBS Before and After MLP Introduction

MLP Introduction	non-DC Disposition		
	Eloped	LWBS	Total
Before	58	34	92
After	154	50	204
Total	212	84	296

Note. MLP = Mid-level practitioner; LWBS = Left without being seen; DC = Definitive care

Length of Stay

Prior to General Linear Model (GLM) fitting, the LOS data were screened for incorrect entries / outliers: Among, the 9331 records, 6 were eliminated for negative values and 9 for extreme values (LOS > 1000; based on visual inspection of discontinuities in the extreme positive tail). The LOS data were highly positively skewed, so LOS was $\log_{10}$ transformed to normalize the distribution (Feng, Wang, Lu, & Tu, 2013). The improvement in fit was confirmed via the Box-Cox normality plot procedure (Li & De Moor, 2002).

Using the GLM, (Log) LOS was investigated among patients as a function of disposition (admitted or discharged), the presence of a MLP, and their interaction (more complex generalized linear models such as Poisson and negative binomial yielded no benefit). There was no interaction between Disposition and MLP, $F(1,9312) = 2.14$, $p = .14$, nor a main effect of MLP, F((1,9312) = 2.33, $p = .13$. There was a main effect of Disposition, $F(1,9312) = 1213.30$, $p < .0001$, with admitted patients ($M = 315.72$ minutes, SE = 1.02) staying significantly longer ($M_{\text{diff}} = 147.41$, SE 1.02) than discharged patients ($M = 168.31$, SE = 1.00) $t(9312) = 34.83$, $p < .0001$.

Wait Time

Prior to GLM fitting, the wait time (WT) data were screened for incorrect entries / outliers: Among the 9969 records, 3 were eliminated for negative values and 4 for extreme values (WT > 600; based on visual inspection of discontinuities in the extreme positive tail). As with LOS, WT were highly positively skewed, so WT was $\log_{10}$ transformed to normalize the distribution. The improvement in fit was confirmed after the Box-Cox normality plot procedure was performed.

The (Log) WT variable was investigated among patients as a function of disposition (discharged, admitted, transferred, eloped, LWBS, or AMA), the presence of a MLP, and their interaction using the GLM (see Figure 4). More complex generalized linear models such as Poisson and negative binomial were explored but yielded no benefit.

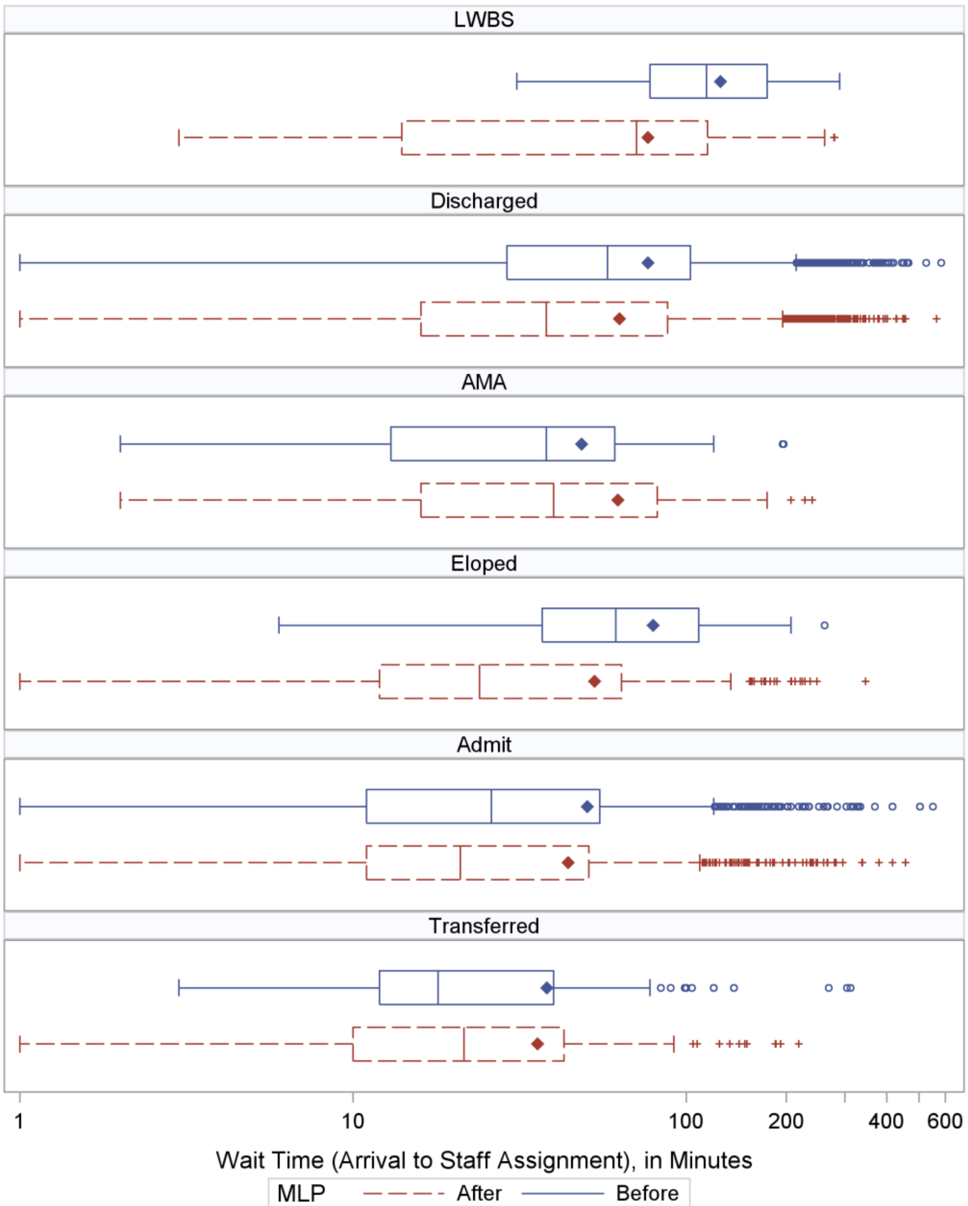

Figure 4. Wait time in minutes (log scale) before (solid line) and after (dashed line) introduction of MLPs, by Disposition (ordered by median wait time).

Interaction. There was a significant interaction between Disposition and MLP, $F(5,9950) = 6.92$, $p < .0001$, which was further explored via a simple effects analysis which compared the MLP and non-MLP cohorts at each disposition type:

- Among the discharged, $F(1,9950) = 239.97$, $p < .0001$, WTs were significantly shorter for the MLP cohort (M = 35.12, SE = 1.02) than for the non-MLP cohort (*M* = 51.92, SE = 1.03), $M_{diff} = -16.80$ minutes (SE = 1.03), $t(9950) = -15.49$, $p < .0001$.
- Among the admitted, $F(1,9950) = 5.99$, p < .01, WTs were significantly shorter for the MLP cohort (M = 22.42, SE = 1.05) than for the non-MLP cohort (*M* = 26.15, SE = 1.04), $M_{diff} = -3.73$ minutes (SE = 1.06), $t(9950) = -2.45$, $p < .01$.
- Among the eloped, $F(1,9950) = 22.11$, $p < .0001$, WTs were significantly shorter for the MLP cohort (*M* = 26.23, SE = 1.10) than for the non-MLP cohort (*M* = 59.50, SE = 1.16), $M_{diff} = -33.27$ minutes (SE = 1.19), $t(9950) = -4.70$, $p < .0001$.
- Among LWBS, $F(1,9950) = 13.61$, $p < .0002$, WTs were significantly shorter for the MLP cohort (*M* = 43.93, SE = 1.17) than for the non-MLP cohort (*M* = 111.05, SE = 1.21), $M_{diff} = -67.11$ minutes (SE = 1.29), $t(9950) = -3.69$, $p < .0002$.

Main effects. There was a main effect of MLP, $F(1,995) = 24.95$, $p < .0001$, with WTs being significantly shorter for the MLP cohort (*M* = 29.96, SE = 1.05) than for the non-MLP cohort (*M* = 42.74, SE = 1.06), $M_{diff} = -12.77$ minutes (SE = 0.70, $t(9950) = -4.99$, $p < .0001$. There was a main effect of Disposition, $F(5,995) = 74.48$, $p < .0001$, but the simple effects analysis of MLP at each Disposition (see Interaction analysis above) should be interpreted instead.

V. Discussion

Consistent with prior literature, this study found that placing MLPs in triage significantly reduced wait times at a single location. This was an expected finding, corroborating prior study reports, supporting the alternative hypothesis that NPs or PAs placement in ER triage will reduce ER wait times, which is an important metric reported to CMS. Interestingly, the hoped-for knock-on effects, including reduction in LWBS and LOS did not materialize: the intervention had no effect on LOS, and actually increased LWBS rates. This differs from the findings of many prior authors, who found that LOS decreased with similar interventions (Burlingame, 2009; Love et al., 2012; Nestler et al., 2012; Tsai et al., 2012; Wiler et al., 2010). It is possible that improvements in LOS and LWBS rates were realized later, when the intervention had more time to become ingrained in the workflow of the department, as Burlingame (2009), Love et al. (2012), and Tsai et al. (2012) all evaluated improvements five to six months after; however, Holroyd et al. (2007) saw improvements in LOS after only two months, so length of time after the intervention may not have a meaningful impact on the data. In any case, evaluating the length of time necessary to see improvements in various measures was outside the scope of this investigation.

The main interest of this project was whether placing an NP or PA in triage significantly shifted LWBS rate onto the Elopement rate, which it did; this was a new finding not previously reported on in the literature. Additionally, an unforeseen effect of adding NPs and PAs in triage was that patients were more likely to Elope or LWBS, i.e. receive non-definitive care, despite the presence of MLPs having minimal effect on the distribution of patients between each disposition category when considered individually. These findings combine to show that patients were more likely to Elope after being seen in triage by an NP or PA; one can only hypothesize that these patients had blood draws and other tests ordered and completed and were sent back out to the waiting room, only to Elope. To date, this is a novel result, which has not been previously reported in the literature. Any attempt to explain this behavior is speculation without access to patient satisfaction survey results or other qualitative investigation; however, one may surmise that these patients, having been seen and 'worked up,' became impatient as they waited without disposition or being brought back to a bed in the ED.

The research in this project had some limitations. This is a retrospective analysis, conceived of to analyze a change already implemented by management. Control of patient presentation was not done randomly, in real-time, but instead across time in the same location, which might have been affected by extraneous variables, such as the severity of various winter disease seasons (URI, influenza, etc.) which are known to change over time. Also, as a retrospective study, cause and effect relationships could not be established between the presence of NPs or PAs in Triage and the outcome variables. This is a single-site study, which, as noted by Wiler et al. (2010), limits the generalizability of its findings. While this study looked at all patient encounters in the relevant time frame, reducing possible sampling bias, the patient population itself is largely urban and low-income, and facilities in different settings and with different patient mixes may note different results from those found here. Additionally, some disposition types (such as "not RN charted") were revealed to the researcher only upon acquiring the data; had a full chart review been performed, the true disposition for these encounters might have been ascertained and the affected encounters included in the data analysis. These encounters, however, account for only 15 of the 10,000 initially obtained from WSMC, so the impact of them would be questionable.

Implications for Research

The results of this project suggest further research in two main directions. First, qualitative follow-up mail or phone surveys or other outreach could be conducted to identify the reasons patients leave without definitive treatment after receiving the MSE in triage and compared to the extant literature on why patients LWBS or Elope from the ED in general, in order to better understand the underlying patient decision process in this instance, as well as indicate possible small changes that could reduce the rate at which patients elope after receiving an MSE in ED triage.

Additionally, a chart review could be conducted, with one of two aims. A more limited review could look at the laboratory, radiologic, and other data already returned for patients who elope after an MSE to determine relative risks, stratifying patients into cohorts that would have been discharged, needed further evaluation, or would likely have been admitted based on findings or tests initiated with the triage MSE. An extensive review would incorporate records from multiple facilities, ideally all facilities in a metropolitan region, to also identify patients who left to be seen at another facility, either that same day or within the next few days or weeks, and the ultimate outcomes of those encounters, compared to patients who engage in the same behavior without having received an MSE in triage.

Further, retrospective studies like this project give rise to research questions for investigation using prospective, longitudinal designs. Future studies are warranted to validate the findings in this retrospective study; given the complexities of current emergent health care delivery systems, strong theoretical underpinnings should guide the conduct of future studies on the effect of MLPs on relevant metrics of ED throughput used for internal quality improvement and reported to CMS.

Implications for Practice

As noted by Wiler et al. (2010), the medicolegal impact of providing an MSE in triage is poorly understood. Although decreased wait times indicate that more patients are being evaluated by a provider sooner, thus alleviating concerns about immediately threatening issues in lower-acuity patients, the increase in patients receiving non-definitive care (i.e. those who LWBS or elope) raises concerns about patients not being properly diagnosed or treated for conditions. If the goal of having a provider in triage is to simply provide better screening than nurse-run triage alone, then it is successful. However, this intervention needs to be paired with other innovative interventions in order to provide meaningful improvements in ED visit-related patient outcomes on standard metrics of receipt of definitive care, reduced elopement and LWBS rates, and reduced wait time.

VI. Conclusion

This project showed a marked improvement on wait times and LWBS after introducing MLPs to the triage process at West Suburban Medical Center; however, a statistically significant recategorization of patients from LWBS to Eloping was found when comparing patient visits three months prior to and three months after the intervention. Further, expected reductions in LOS were not observed. While providing the MSE in triage, thereby shortening wait times and sorting out unexpectedly acute patients, may reassure a facility that serious cases are not being missed, it is no guarantee of improved overall throughput, or an increase in the rate that a department provides definitive care. As such, the findings of this project suggest that measures to clear patients out of beds in the ED, and thus increasing the rate at which patients are seen, treated, and dispositioned, may provide better dividends in reduced LOS and improved rates of definitive care than focusing solely on front-end improvements. Further studies utilizing prospective, longitudinal study design are warranted to validate the findings and test new hypotheses which arise from this retrospective study.

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Appendix A

Relevant ENA and CMS definitions

Term	Definition
Emergency Department	A dedicated location serving an unscheduled patient population requesting emergency assessment.[a]
Emergency Department Arrival Time	The time that the patient first arrives at the institution for the purpose of requesting emergency care should be recorded as the arrival time. This is the first contact not necessarily registration time or the triage time.[a]
Emergency Department Physician/APRN/PA Contact	The time of first contact of the physician, APRN, or PA (defined as an institutionally credentialed provider) with the patient to initiate the medical screening exam. [a]
Emergency Department Departure Time	The time of physical departure of a patient from the emergency department treatment space. The time most closely represented by being out of the department and no longer the emergency department's responsibility. [a]
Emergency Department LOS	Emergency department arrival time to emergency department departure time. [a]
Median LOS for Admitted Patients	Emergency Department LOS for all admitted patients, ED_1b. [b]
Median LOS for Discharged Patients	Emergency Department LOS for all discharged patients, OP-18. [c]
Wait time	Emergency Department Arrival Time to Emergency Department Physician/APRN/PA Contact Time[d], OP-20. [c]
Left Without Being Seen (LWBS)	Total number of patients who left without being evaluated by a physician/NP/PA divided by total number of patients who presented to the ED; OP-22 [c]

Note. [a] From Emergency Nurses Association (2011); [b]Centers for Medicare and Medicaid Services (2015b); [c]Centers for Medicare and Medicaid Services (2015a); [d]American College of Emergency Physicians (2012)

Appendix B

Evidence-Based Research

Authors	Year	Design	Sampling	Study variables	Stats analysis	Study findings
Wiler, Gentle, Halfpenny, Heins, Mehrotra, Mikhail, Fite	2010	Systematic Review	MEDLINE	NA	NA	Found all studies with NP/Provider in triage were single-site studies; most studies of poor/inconsistent methodology
Li, Westbrook, Callen, Georgiou, and Braithwaite	2013	Qualitative, semi-structured interviews, grounded theory	NPs, ED MDs, and senior RNs from 2 hospitals in Australia	NA	NA	NPs/RNs and MDs differ in contributions of NPs; need to reconcile for NP progress to continue
Love, Murphy, Lietz, and Jordan	2012	Quantitative, descriptive, prospective, before-after interventional	Presbyterian Hospital Mathews in NC	Wait time, LWBS %	None – descriptive only	Focused on process implementation; NP/PA, RN, tech, phlebotomist/ekg tech, and registrar in triage; team only present for 12hrs/day
Shea and Hoyt	2012	Quantitative – descriptive; qualitative – "perspective" of stakeholders	All pts while RAPID triage team available at St. Mary's	LWBS, LOS	None – descriptive only	Quantitative data not well presented, focused on process of development and qualitative
Burlingame (Doctoral project)	2009	Quantitative – descriptive	Comparing "standardized" days before/after implementing NP in triage	Door to provider, door to treatment, door to disposition, LWBS, LOS	ANOVA	Doesn't state what the NP in triage does – provide MSE, initiate treatment, definitive care & d/c, etc. No data on LWBS/Elopement substitution
Nestler et al.	2012	Quantitative – descriptive, prospective, before/after interventional	St. Mary's /Mayo Clinic; Urban, academic ED & Level I Trauma	Time in waiting room, time in treatment room, disposition time, LOS, LWBS	Chi-squared, Mann-Whitney U-test, multiple linear regression	
Tsai, Sharieff, Kanegaye, Carlson, and Harley	2012	Quantitative, descriptive, retrospective before/after interventional	Pediatric ED Triage	Door to provider, LOS, LWBS	Chi-squared, t-test	Doesn't specify type of MLP

McGee and Kaplan	2007	Qualitative exploratory study	Convenience sampling of ED managers in SW Washington	Presence/absence of NPs in ED	NA	Didn't really – since ED managers had no direct control over NP presence
Pierce and Gormley	2016	Quantitative, prospective, before-after interventional	Comparison of two "comparable" EDs at same time	Implementation of multiple interventions, Discharge LOS	NA	Decreased LOS with Provider in Triage on top of Split-Flow model
Begaz, Elashoff, Grogan, Talan, and Taira	2017	Quantitative, retrospective analysis of completed prospective RCT (secondary analysis)	Nonpregnant adult pts with abdominal pain at a Los Angeles County ED for 10 months	Physician versus NP as Provider in Triage	*t*-test, chi-squared, negative binomial regression	No significant difference in number of categories of tests ordered or LOS

Note: Search Terms for each database - PubMed: From MeSH terms: "Emergency Service, Hospital"[Mesh] AND "Patient Care Management"[Mesh] AND ("Nurse Practitioners"[Mesh] OR "Physician Assistants"[Mesh]); CINAHL Complete: (MH "Emergency Service") AND (MH "Triage") AND ((MH "Nurse Practitioners") OR (MH "Physician Assistants")); Google Scholar: "nurse practitioner" model emergency; Additional Google Scholar search: "Cited by" search for Wiler et al., 2017