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Original Contribution

Ambulance transport to the emergency department: A patient-selected signal of acuity and its effect on resource provision

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ABSTRACT

Objective: To determine whether ambulance arrival to the emergency department has remained an unidentified signal of perceived medical acuity. Informed by economic signaling theory, does arrival via ambulance affect resource utilization given varying levels of patient acuity?
Methods: The analysis examined a nationally representative sample of de-identified emergency department patient encounters from 2011 to 2015, gathered from the National Hospital Ambulatory Medical Care Survey (NHAMCS). Multivariate logistic regression analysis was employed using regional and time-fixed effects. The provision of twenty diagnostic and imaging services was analyzed. Patient encounters were also categorized into five acuity-levels.
Results: Drawing from the NHAMCS dataset, 98,888 emergency department records were analyzed, weighted to represent 504.5 million estimated emergency department patient encounters. Findings suggest that patients transported to the hospital via ambulance are more likely than those who arrive by other means to receive 19 of the 20 analyzed diagnostic testing and imaging services. Furthermore, when analyzed by acuity-level, the disparity of service provision is the greatest among low-acuity patients, where medical complaints are argued to be the most subjective.
Conclusions: The results are consistent with the notion that emergency department medical providers readily accept ambulance transport as a valid signal of patient acuity, regardless of true acuity level. Consequently, patients transported to the hospital via ambulance may be receiving a disproportionate amount of medical resources in an increasingly cost-conscious environment.

1. Introduction

Upon arrival to a hospital's emergency department, patients must describe highly subjective complaints (e.g.: pain or discomfort) to medical providers. Providers, in turn, must use this information in combination with objective assessment findings (e.g.: vital signs and laboratory testing) to determine an efficacious diagnostic plan. In this case, the *sender* (the patient) must convey information about himself to a *receiver* (the medical provider) through the use of signals. For a large swath of the general public, detailed medical knowledge is rare. Thus, a simple description of one's medical problem is not an efficient means of signaling. Due to the presence of asymmetric information, signaling theory [1] suggests that ambulance transport may be acting as an information mechanism, conveying perceived medical acuity instead of valid acuity.

In an environment that places pressure on the reduction of health care spending, the provision of medical processes and procedures deserves some level of scrutiny. Moreover, an efficient distribution of procedural resources is argued to be of great importance as it relates to efficient medical expenditures. For patients presenting to an emergency department, choices surrounding an initial diagnostic plan must be made quickly. Through self-selection of arrival mode, patients may be helping – or hindering – the decision process by signaling their perceived acuity level to physicians.

Although previous research has explored the issue of medically unnecessary ambulance transport, the act of physical arrival to the ED via ambulance has yet to be considered as a signal. The provision of diagnostic testing was chosen due to its timing in the patient-physician interaction sequence. It is posited that shifts in medical provider behavior, due to patient signals, can be effectively measured through observed disparities in diagnostic provisions between ambulance and non-ambulance patients.

It has been found that, broadly, low-acuity ambulance patients are more likely to receive imaging and laboratory testing services [2,3], and receive more specialist consultations [4] while in the ED. Further stretching ED resources, patients presenting to the hospital via ambulance see a longer length of stay in the ED [5].

Personal perception of one's medical condition is sharply different between ambulance and non-ambulance patients. Ambulance patients have been found to be more likely to call an ambulance for *any* health

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concern and more likely to assert that their illness required care within 1 h of arrival [6]. Of those who have been deemed to have utilized an ambulance inappropriately, 20% of low-acuity patients stated they were "too sick" to travel by means other than emergency ambulance [2]. Given these differences in perception, the purpose of this study is to explore a theoretical basis for disparities in resource provision among ambulance and non-ambulance patients.

2. Methods

Secondary analysis was performed on the National Hospital Ambulatory Medical Care Survey (NHAMCS), Emergency Department Edition for years 2011–2015 (inclusive). Conducted by the Centers for Disease Control and Prevention (CDC), the NHAMCS employs a four-stage national probability sampling design of patient visits to emergency departments of non-institutional general and short-stay hospitals in The United States. The sample excludes federal, military, and Veterans Administration hospitals. Additionally, patient visits expressly made for administrative purposes, such as the payment of a bill or the delivery of a specimen, were excluded from the sample.

Stata (version 13.1) statistical software was utilized and analytic methods followed techniques as described in West et al. [7] for complex multi-stage weighted survey samples. Multivariate logistic regression was utilized to produce adjusted odds ratios and weighted values were used generate national estimates. The NHAMCS assigns statistical weights to certain demographic variables that have been under or oversampled during collection. The NHAMCS provides these weights so that we may calculate population estimates during analysis. West et al. [7] describe this process for use in Stata software. The data were de-identified and publicly available, resulting in an Institutional Review Board decision as exempt for secondary analysis.

Based upon NHAMCS variables, the data were subset based upon the initial triage category assigned to each patient by the receiving hospital. Patients fall into one of five triage categories (*Immediate*, *Emergent*, *Urgent*, *Semi-Urgent*, and *Non-Urgent*). Although there is no nationally mandated protocol for emergency department triage, there has been an increasing trend towards standardization [8]. Development of the Emergency Severity Index (ESI) in 1999 created a standardized and consistent means through which to categorize the severity of a patient's medical condition. The CDC has adapted the ESI system into a five-level time-based categorization system when compiling nationwide data. Each triage category corresponds with an ESI designation, with *Immediate* representing ESI-1 through *Non-Urgent* representing ESI-5.

The primary explanatory variable was arrival by ambulance. This mode of arrival includes patients arriving to the emergency department via air or ground units and includes both Advanced Life Support and Basic Life Support ambulance units. The variable was measured dichotomously. Thus, patients arriving to the ED via means other than ambulance (e.g., personal car, public transit, walk-in) were not distinguished and were categorized as "non-ambulance."

Within the NHAMCS data, twenty diagnostic tests were available for inclusion and were measured dichotomously (Table 1). The provision of seventeen blood tests and three imaging tests were analyzed. Diagnostic tests not included in the final analysis were either uncommon (blood alcohol content, toxicology screening) or overly commonplace (flu test, pregnancy test) resulting in very little variation within the sample. One imaging test (MRI) was analyzed despite its low-frequency use. Its inclusion is due to the test's high financial cost and utilization of highly specialized equipment.

Control variables included patient's age measured in years, age-squared, sex, race, and ethnicity. Age often follows a curvilinear function in regard to health and health care. By including age-squared as a control variable, a second-order relationship with the outcome variable can be identified. In the analysis, age-squared was statistically significant, suggesting non-linearity and thus a valid control mechanism.

Table 1
Dependent variable labels.

Abbreviation	Description
ABG	Arterial blood gas
BAC	Blood alcohol content
BCULTURES	Blood cultures
BGL	Blood glucose level
BNP	B-type natriuretic peptide
BUN	Blood urea nitrogen
CARD MONITOR	Cardiac monitoring (3-lead)
CBC	Complete blood count
DDIMER	D-Dimer
EKG	12-Lead electrocardiogram
ELECTROLYTES	Electrolytes
ENZYMES	Cardiac enzymes
LACTATE	Lactate
LFT	Liver function test
PT/INR	Prothrombin time (international normalized ratio)
TOX SCREEN	Toxicological screening
URINE	Urine analysis
CAT	CAT scan (any body part)
MRI	MRI (any body part)
XRAY	X-ray (any body part)

Adjustments for patient insurance and residential status were also considered. Emergency department wait-time was controlled for and was measured continuously in minutes from arrival to physician contact. Year fixed-effects were included in the analysis in order to adjust for unobserved time-period variation. Each of these variables was collected within the NHAMCS, with race and ethnicity imputed for some observations.

3. Results

Drawing from the NHAMCS dataset, 98,888 emergency department records were analyzed, weighted to represent 504.5 million estimated emergency department patient encounters [7]. The most common triage category was *Urgent*, representing 45% of patients regardless of arrival (Table 2). The proportion of ambulance patients for each triage category followed an expected pattern. The *Immediate* category represented the largest proportion of ambulance patients, and the *Non-Urgent* category saw the smallest proportion of ambulance patients with a consistent gradient between the two categories (Fig. 1). Overall, a plurality of patients was triaged into the *Urgent* category (Table 2).

Findings of multivariate logistic regression indicate that arrival to the ED via emergency ambulance is associated with an increased likelihood of diagnostic testing across all triage groups (Table 3). Analysis revealed an increasing effect of the ambulance signal as the triage category became less acute (Fig. 2). Within the *Immediate* triage group, 11 of the 20 diagnostic services saw statistically significant effects (given a 5% alpha level) while 19 of the 20 diagnostic services were statistically significant in the *Non-Urgent* triage group.

As an example, ambulance patients in the *Immediate* triage category were 3.7 times more likely than non-ambulance patients to receive ABG testing while those arriving by ambulance in the *Non-Urgent* category were over 10 times more likely to receive the test (Table 3). A similar trend was evident with 17 of the 20 diagnostic services. There was no

Table 2
Frequency of triage level by ambulance arrival.

Triage level	Ambulance arrival	Non-ambulance arrival	Total
Immediate	444 (2.7%)	614 (0.7%)	1058 (1.1%)
Emergent	3429 (21.2%)	6871 (8.3%)	10,300 (10.4%)
Urgent	9013 (55.7%)	35,868 (43.4%)	44,881 (45.4%)
Semi-urgent	2863 (17.7%)	32,692 (39.5%)	35,555 (36.0%)
Non-urgent	447 (2.8%)	6647 (8.0%)	7094 (7.2%)
Total	16,196	82,692	98,888

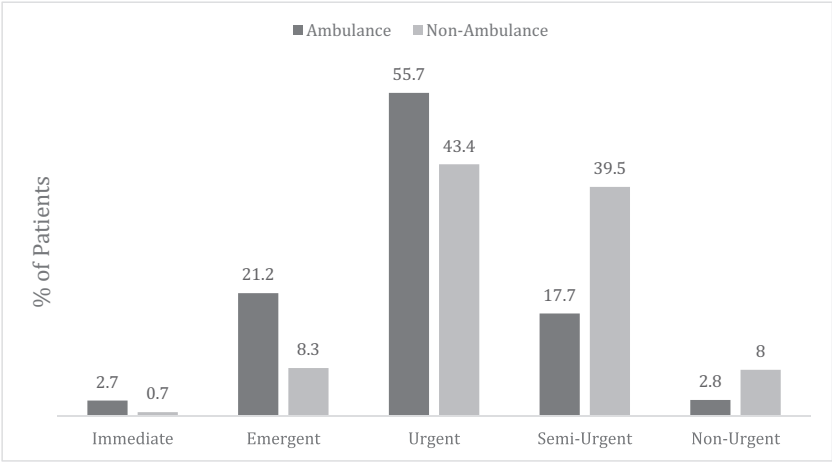

Fig. 1. Proportion of ambulance and non-ambulance patients by triage level.

observed upward trend in the likelihood of ambulance patients receiving MRI services. D-dimer testing was statistically inconclusive.

4. Discussion

Spence's [1] seminal work on signaling theory addresses the issue of asymmetric information between two parties. In his treatise, Spence [1] explores a job-market signaling model. This model posits that potential employees are fully aware of their intrinsic ability while potential employers are unaware of this unobservable characteristic. In light of this asymmetric information, the employer readily accepts one's educational attainment as a valid signal of greater ability.

Spence's work is applicable to numerous disciplines. Within the realm of emergency medicine and emergency services, ambulance utilization can be considered as a signal. In the case of ambulance transport to the ED, the patient acts as a signal *sender*, having subjective information about his perceived condition known to him. The physician acts as a signal *receiver*, obtaining the information through the use of a signaling mechanism.

Due to the very nature of emergency departments, medical providers have a limited timeframe in which to act, contributing to the potential recognition of ambulance patients as medically-serious in nature. The results of this analysis are consistent with the notion that ambulance arrival is accepted as a valid signal of patient acuity, regardless of true medical acuity level.

Various studies have focused on instances of asymmetric information in the health care arena [9-17]. Of the numerous consequences of information asymmetry, increased utilization has been noted to be of unique importance [18-20]. In these models, however, the primary effect of asymmetric information is the emergence of monopoly power for health care providers. In stark contrast, the imbalance of information pertaining to one's unknown medical condition in an emergency setting may instead significantly shift power from the physician to the patient. The physician, acting as a normal risk-averse individual [21-24], may be more inclined to over-utilize medical resources in order to avoid misdiagnosis and subsequent professional liability.

Literature pertaining to ED physician perception of "appropriate use" of ambulance services finds that approximately one-third of ambulance transports are medically unnecessary [2,25-30]. In the case of emergency department presentation, it is argued that patients may not be signaling their true acuity level through the use of an ambulance,

Table 3
Likelihood of diagnostic testing[a] for ambulance patients by triage category – adjusted odds ratios.

Test[a]	Immed.	Emerg.	Urgent	Semi-urgent	Non-urgent
ABG	***3.71***	***1.64***	***1.71***	***3.07***	***10.26***
BAC	***3.46***	***2.28***	***4.05***	***10.24***	***6.74***
BCULTURES	1.96	***1.86***	***1.32***	***2.17***	***3.59***
BGL	1.99	***1.39***	***1.41***	***2.19***	***4.20***
BNP	***7.20***	0.95	1.19	***3.72***	***4.88***
BUN	2.01	***1.31***	***1.28***	***2.14***	***4.72***
CARD MONITOR	2.29	***1.28***	***1.80***	***3.94***	***5.97***
CBC	***2.18***	***1.37***	***1.28***	***2.24***	***3.64***
DDIMER	1.48	***0.68***	1.00	***2.14***	3.65
EKG	1.74	***1.22***	***1.90***	***3.08***	***5.11***
ELECTROLYTES	1.84	***1.29***	***1.37***	***2.24***	***3.80***
ENZYMES	1.22	***1.14***	***1.46***	***2.31***	***5.69***
LACTATE	***13.46***	***3.09***	***1.47***	1.61	***40.81***
LFT	***2.90***	***1.31***	***1.20***	***1.95***	***5.01***
PT/INR	2.09	***1.39***	***1.50***	***2.40***	***5.93***
TOX SCREEN	***3.07***	***1.89***	***3.41***	***4.65***	***5.85***
URINE	***2.10***	***1.33***	1.05	***1.57***	***2.48***
CAT	***3.70***	***1.72***	***1.45***	***2.81***	***4.48***
MRI	***5.52***	***1.45***	***1.67***	***2.52***	0.21
XRAY	***2.82***	***1.20***	***1.49***	***1.49***	***2.70***

Italic bold denotes $p < 0.05$.
[a] Abbreviations for each diagnostic test described in Table 1.

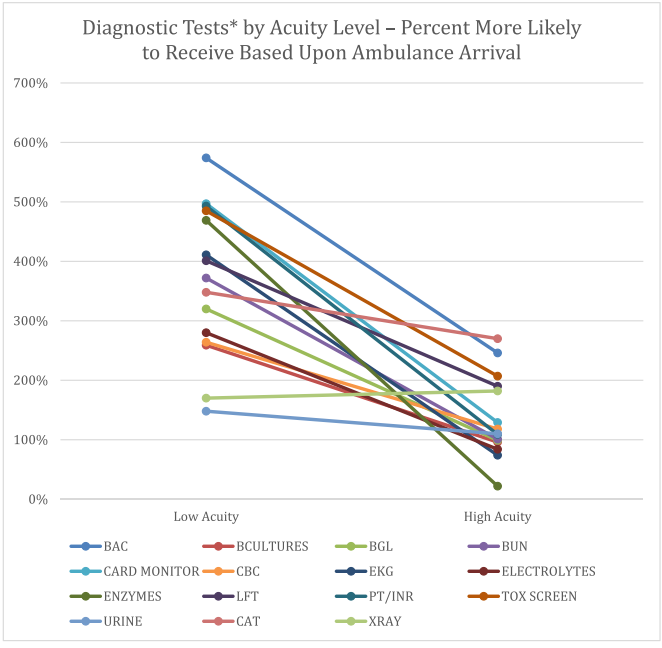

Fig. 2. Likelihood of receiving diagnostic tests* between high and low acuity patients.
*Abbreviations for each diagnostic test described in Table 1.

but instead their perceived acuity level. There still exists an abundance of uncertainty concerning one's personal medical condition when presenting oneself to a health care provider. Without medical training or experience, there is often very limited confidence afforded to a particular set of subjective medical symptoms [27]. This, in turn, may lead a normally risk-averse individual to consider or assume the worst of any given set of symptoms. These dire assumptions must then be conveyed effectively to a health care provider if one believes his condition to be emergent.

Michael Spence's view of signaling in the presence of asymmetric information is directly applicable to the emergency services arena. Patients often present to the emergency department with subjective and vague, or incomplete, personal complaints. Medical terms, such as "nauseous" or "numb," may carry different meanings to separate patients and might not conform to the provider's medical definition [31].

During the initial patient contact, medical providers must use available data to help determine which tests and services will be the most beneficial for symptom diagnosis and treatment. Findings such as patient presentation (skin condition or work-of-breathing) and vital signs can help guide providers. Arrival to the ED by ambulance is now argued to be of importance during this early junction in the medical process.

In an environment that stresses resource management and fiscal prudence, medical providers appear to exhibit a bias towards ambulance patients in regard to diagnostic provisions. This perverse incentive may lead to a strain on the pre-hospital emergency system and the potential excessive use of diagnostic resources within the ED.

5. Limitations

The most obvious limitation of this study is that of health outcomes. While it has been shown that ambulance patients are more likely to receive many diagnostic testing services, it is not known whether this disparity in provision is inefficient. Prospective study may find that an increase in resource provision is beneficial in terms of outcomes. Furthermore, patients self-selected their mode of arrival to the ED. This self-selection removes any chance of randomization in the explanatory variable in addition to the retrospective nature of the data. Nor do the data allow for the consideration of arrival via specialty care such as critical care air transport. Additional qualitative and prospective study is needed to fully examine this issue.

As with any subjective measure, the Emergency Severity Index is an imperfect gauge of patient acuity. Both under and over-triage has been identified [32,33] and interrater reliability has come under question in the triage area [34]. Although a blunt measure of medical necessity, the Index remains an international fixture in the health care setting.

Additionally, some diagnostic services can be completed in the pre-hospital setting. Blood glucose testing, cardiac monitoring, and 12-Lead ECG are the most common of pre-hospital testing. Prior to arrival to the ED, the patient may have already received these services. Once care has been handed over to the ED staff, providers may opt to continue these services in favor of continuity of care.

The National Hospital Ambulatory Medical Care Survey has been widely used in quantitative research for many years. Subsequently, it has been subject to critique as a database compiled by non-medical administrative workers [35,36]. Interrater reliability, however, seems robust [37]. While the survey's limitations exist, its overall utility remains of great import.

6. Conclusions

The results of this study are consistent with the notion that emergency department medical providers readily accept ambulance transport as a valid signal of patient acuity, regardless of true acuity level. Consequently, patients transported to the hospital via ambulance may be receiving a disproportionate amount of medical resources in an increasingly cost-conscious environment.

The findings suggest that medical providers in the ED accept ambulance transport as a signal of potential medical acuity. Just as most ambulance patients perceive their condition as requiring immediate attention [38], providers appear to favor the provision of diagnostic services towards ambulance patients. Prospective study, however, should work to validate these retrospective findings.

This study applies signaling theory to the emergency services setting and provides a theoretical basis explaining why arrival to the ED by ambulance affects the provision of diagnostic testing at a more granular level. Medical providers appear to accept ambulance arrival as a proxy for higher medical acuity, resulting in an increased likelihood of receiving many individual diagnostic testing services.

References

[1] Spence M. Job Market Signaling. Q J Econ 1973;3:355.
[2] Jacob S, Jacoby J, James R, Heller M. Ambulance transport: why ED patients choose as they do. Ann Emerg Med 2006;48(4):S54.
[3] Durant E, Fahimi J. Factors associated with ambulance use among patients with low-acuity conditions. Prehosp Emerg Care 2012;16(3):329–37.
[4] Marinovich A, Afilalo J, Afilalo M, Colacone A, Unger B, Giguère C, et al. Impact of ambulance transportation on resource use in the emergency department. Acad Emerg Med 2004;11(3):312–5.
[5] Ruger JP, Richter CJ, Lewis LM. Clinical and economic factors associated with ambulance use to the emergency department. Acad Emerg Med 2006;13(8):879–85.
[6] Pearson C, Kim D, Mango L, Compton S, Levy P. 124: Factors associated with ambulance use for low acuity conditions in an urban emergency department. Ann Emerg Med 2010;56(3):S42.
[7] West BT, Berglund P, Heeringa SG. A closer examination of subpopulation analysis of complex-sample survey data. Stata J 2008;8(4):520–31.
[8] Gilboy N, Tanabe P, Travers D, Rosenau A. Emergency Severity Index (ESI): a triage tool for emergency department care. Version 4: Implementation Handbook. 2012 ed. MD: Rockville; 2011.
[9] Robinson JC. Hospital quality competition and the economics of imperfect information. Milbank Q 1988(3):465.
[10] Choongsup Lee EM. Optimal medical treatment under asymmetric information. J Health Econ 1995;14(4):419–41.
[11] Schneider U. Asymmetric information and the demand for health care–the case of double moral hazard. Schmollers Jahrbuch J Appl Soc Sci Stud 2004;124(2):233–56.
[12] Jae-Young L. The effect of patient's asymmetric information problem on elderly use of medical care. Appl Econ 2007;39(16):2133–42.
[13] Schneider U, Volker U. The physician-patient relationship revisited: the patient's view. Int J Health Care Finance Econ 2008;8(4):279.
[14] Friehe T. Screening accident victims. Int Rev Law Econ 2009;29(3):272–80.
[15] Lim J-Y, Jo C. The effect of patient's asymmetric information problem on medical care utilization with consideration of a patient's ex-ante health status. Hitotsubashi Journal of Economics 2009;50(2):143–64.
[16] Wang J-Y, Probst JC, Stoskopf CH, Sanders JM, McTigue JF. Information asymmetry and performance tilting in hospitals: a National Empirical Study. Health Econ 2011;20(12):1487–506.
[17] Mascarenhas OAJ, Kellsteadt C, Kesavan R, Bernacchi MD. Information asymmetry in U. S. Healthcare System. Proceedings of the Business, Society & Government Consortium of the Midwest Business Administration Association; 2012. p. 84–112.
[18] Arrow KJ. Uncertainty and the welfare economics of medical care. Am Econ Rev 1963;53:941–73.
[19] Grytten J, Sorensen R. Type of contract and supplier-induced demand for primary physicians in Norway. J Health Econ 2001;20(3):379–93.
[20] Chou S-Y. Asymmetric information, ownership and quality of care: an empirical analysis of nursing homes. J Health Econ 2002;21(2):293–311.
[21] Fiscella K, Franks P, Zwanziger J, Mooney C, Sorbero M, Williams GC. Risk aversion and costs: a comparison of family physicians and general internists. J Fam Pract 2000;49(1):12–7.
[22] Katz DA, Williams GC, Brown RL, Aufderheide TP, Bogner M, Rahko PS, et al. Emergency physicians' fear of malpractice in evaluating patients with possible acute cardiac ischemia. Ann Emerg Med 2005;46(6):525–33.
[23] Tubbs EP, Elrod JAB, Flum DR. Risk taking and tolerance of uncertainty: implications for surgeons. J Surg Res 2006;131(1):1–6.
[24] Coricelli G. The potential role of regret in the physician-patient relationship: insights from Neuroeconomics. Adv Health Econ Health Serv Res 2008;20:85–97.
[25] Gibson G. Measures of emergency ambulance effectiveness: unmet need and inappropriate use. JACEP 1977;6(9):389–92.
[26] Rademaker AW, Powell DG, Read JH. Inappropriate use and unmet need in paramedic and nonparamedic ambulance systems. Ann Emerg Med 1987;16(5):553–6.
[27] Gardner GJ. The use and abuse of the emergency ambulance service: some of the factors affecting the decision whether to call an emergency ambulance. Arch Emerg Med 1990;7(2):81–9.
[28] Billittier AJ, Moscati R, Janicke D, Lerner EB, Seymour J, Olsson D. A multisite survey of factors contributing to medically unnecessary ambulance transports. Acad Emerg Med 1996;3(11):1046–52.

[29] Gratton M, Ellison S, Hunt J, Ma O. Prospective determination of medical necessity for ambulance transport by paramedics. Prehosp Emerg Care 2003;7:466–9.
[30] Patton GG, Thakore S. Reducing inappropriate emergency department attendances–a review of ambulance service attendances at a regional teaching hospital in Scotland. Emerg Med J 2013;30(6):459–61.
[31] Spiro D, Heidrich F. Lay understanding of medical terminology. J Fam Pract 1983;17(2):277–9.
[32] Hinson JS, Martinez DA, Schmitz PS, Toerper M, Radu D, Scheulen J, et al. Accuracy of emergency department triage using the emergency severity index and independent predictors of under-triage and over-triage in Brazil: a retrospective cohort analysis. Int J Emerg Med 2018;11(1):3.
[33] Platts-Mills TF, Travers D, Biese K, McCall B, Kizer S, LaMantia M, et al. Accuracy of the emergency severity index triage instrument for identifying elder emergency department patients receiving an immediate life-saving intervention. Acad Emerg Med 2010;17(3):238–43.
[34] Martin A, Davidson CL, Panik A, Buckenmyer C, Delpais P, Ortiz M. An examination of ESI triage scoring accuracy in relationship to ED nursing attitudes and experience. J Emerg Nurs 2014;40(5):461–8.
[35] Cooper RJ. NHAMCS: does it hold up to scrutiny? Ann Emerg Med 2012;60(6):722–5.
[36] McCaig LF, Burt CW. Understanding and interpreting the National Hospital Ambulatory Medical Care Survey: key questions and answers. Ann Emerg Med 2012;60(6):716–21.
[37] McMullen ME, Pines JM. Assessing severity, immediacy, and ideal setting in ED patients: a pilot study on Interrater reliability. Am J Emerg Med 2016;34(7):1276–80.
[38] Gill JM, Riley AW. Nonurgent use of hospital emergency departments: urgency from the patient's perspective. J Fam Pract 1996;42(5):491–6.