TITLE: **Which patients should be transported to ED? – a perpetual prehospital dilemma**

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HT analysed data, drafted the article and takes responsibility for this paper as a whole. AB provided statistical advice. HT, DF, TW, AB, GA, IR, AC, DM, PC, PS, TA and JF were involved in conceiving this study and contributed to the analysis plan, interpretation of results and revision of the article. All have given approval to submit this article.

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**Title**

Which patients should be transported to ED? – a perpetual prehospital dilemma

**Abstract**

Objective: To examine the ability of paramedics to identify patients who could be managed in the community and to identify predictors that could be used to accurately identify patients who should be transported to emergency departments (EDs).

Methods: Lower acuity patients who were assessed by paramedics in the Perth metropolitan area in 2013 were studied. Paramedics prospectively indicated on the patient care record if they considered that the patient could be treated in the community. The paramedic decisions were compared with actual disposition from ED (discharge, admission), and the occurrence of subsequent events (ambulance request, ED visit, admission, death) for discharged patients at the scene was investigated. Decision tree analysis was used to identify predictors that were associated with hospital admission.

Results: In total, 57,183 patients were transported to ED, and 10,204 patients were discharged at the scene by paramedics. Paramedics identified 2,717 patients who could potentially be treated in the community among those who were transported to ED. Of these, 1,455 patients (53.6%) were admitted to hospital. For patients discharged at the scene, those who were indicated as suitable for community care were more likely to experience subsequent events than those who were not. The decision tree found that two predictors (age, aetiology) were associated with hospital admission. Overall discriminative power of the decision tree was poor; the area under the receiver operating characteristic curve was 0.686.

Conclusion: Lower acuity patients who could be treated in the community were not accurately identified by paramedics. This process requires further evaluation.

## Introduction

A new role called an 'extended care paramedic' (ECP) has been introduced in some states in Australia to ameliorate growing demand for emergency health care and reduce potentially unnecessary presentations at emergency departments (ED).[1] ECPs provide lower acuity patients with alternative pathways ('see and treat' at the scene or 'see and refer' to health services in the community) rather than transportation to ED. A study undertaken in New South Wales found that ECPs transported significantly fewer patients to ED than standard paramedics.[2] However, the accuracy of ECPs' decisions of whether a given patient is more suitable for the alternative pathways rather than ED transportation is rarely assessed. Prior to introducing an ECP program, it is important to recognise how paramedics without extended training determine patient disposition. Such assessment is essential for health policy makers to plan the future direction of the emergency health care system and to ensure patient safety.

The aim of this research was to determine which patients should be transported to ED versus being managed in the community as determined by the paramedics. Our specific research questions were (1) Can paramedics accurately identify patients who are suitable for community-based alternative pathways? and (2) Is it possible to identify predictors that could be used to accurately identify patients who should be transported to ED?

## Methods

Study design and data source

This was a prospective cohort study. St John Ambulance Western Australia (SJA-WA) is the sole road-based emergency ambulance provider in the study region. SJA-WA ambulances are staffed by paramedics, who are required to undertake a three year University bachelor degree. All SJA-WA paramedics must take a 2-day refresher education course annually. There was no formal postgraduate clinical supervision or clinical placement at ED for average road paramedics during the study period. Ambulance data collected between 1 January 2013 and 31 December 2013 were used. All lower acuity patients who were attended by SJA-WA paramedics in the Perth metropolitan area were included. A prehospital triage level determined by paramedics was used to select lower acuity patients. The triage level is an ordinal scale ranging from 1 (requiring immediate care) to 5 (to be treated within 120 minutes). Lower acuity patients were defined as those with triage level 3 (to be treated within 30 minutes), 4 or 5.[3] Patients who were transported from a hospital, transported by appointment, or aged younger than 14 years old were excluded. During the study period, there was no guideline regarding patient discharge at the scene in the existing SJA-WA clinical practice guidelines.[4] Paramedics were allowed to discharge a patient when, in their clinical judgement, they felt it was unnecessary to transport the patient to ED. Patients who were transported to ED and those who were discharged at the scene were analysed separately. SJA-WA data were linked with the ED data and WA death registry data using probabilistic matching software (FRIL ver.2.1.5, Emory University and Centers for Disease Control and Prevention, Atlanta, Georgia, U.S.)[5] to identify disposition from ED (discharge, hospital admission, died), subsequent ED visit, hospital admission and deaths within 24 hours after the first paramedic attendance. Cases with missing data in predictor variables (described below) were excluded. The methods for each research question are described separately below.

*Can paramedics accurately identify patients who are suitable for the community-based alternative pathways?*

Prior to this study all SJA-WA paramedics were briefed to explain the research aims and describe the health care resources available in the community, that is, general practitioners (GPs, including after-hours GPs) and in-home health and care services (e.g., Silver Chain home nursing service). During the study period, SJA-WA paramedics were asked to indicate whether a patient was suitable for care in the community on the electronic Patient Care Record (ePCR) during patient transportation based on their standard paramedic experience. Care in the community includes both referral to a health care resource in the community after assessment by the paramedics (see-and-refer) and discharge at the scene after assessment and/or treatment provided by paramedics (see-and-treat). Their decision was entered on the ePCR only when paramedics considered that a patient could be managed in the community. Disposition from ED was the outcome variable for those who were transported to ED. We decided a priori that if a patient was admitted to hospital or died, then this would be assumed (for the purpose of the study) to mean that the patient needed to be transported to the ED. Outcomes for those who were discharged at the scene included subsequent ambulance request, ED attendance, hospitalisation and death within 24 hours after discharge at the scene.

Comparisons were made between those who were and were not indicated as suitable for care in the community. Adjusted odds ratios for the subsequent events (ambulance request, ED attendance, hospitalisation and death) were computed using multivariable logistic regression models that were reduced using backward stepwise variable selection. The models were adjusted for age (14-69 years, 70 years and older),[6] sex, presence of an abnormal vital sign during the prehospital phase, day of week (weekend or not), time of day (night attendance [2300-0700 hours] or not), transportation from a nursing home, and aetiology as determined by paramedics. A patient was considered to have an abnormal vital sign if their systolic blood pressure was < 90mmHg, oxygen saturation < 95%, Glasgow Coma Scale (GCS) < 15 or temperature ≥ 38$^{0}$C during prehospital transportation.[4, 7] These variables were selected empirically and from a similar study.[8] Respiratory rate was not used because it was poorly recorded.

*Is it possible to identify predictors that could be used to accurately identify patients who should be transported to ED?*

To answer this second research question, data on patients who were transported to ED were analysed. A decision tree was derived to identify factors that were associated with hospital admission from ED using classification and regression tree (CART) analysis. A decision tree is a flowchart-like classification model.[9] The tree branches from a root node that contains all of the study population data to child nodes, by splitting the data into subgroups according to a rule based on the values of one of the predictor variables; and it continues to grow in a recursive fashion either until all the nodes contain data with the same outcome or stopping criteria are met. The optimal splitting rule for each parent node is the one that minimizes the Gini impurity index;[9] i.e. the heterogeneity of outcomes is minimized in the child nodes. In this study, terminal nodes, called leaf nodes, were formed when one of the stopping rules listed in Table 1 were applied. The entire dataset was used to both develop and test the decision tree, and 10-fold cross validation was performed to test the tree to avoid over-fitting. The decision tree was built from the same variables used for logistic modelling in the previous section.

The area under the receiver operating characteristic curve (AUROC) was calculated to measure the discriminative ability of the derived tree. The derived decision tree was considered to be useful to identify patients suitable for care in the community if its AUROC was greater than 0.8.[10]

All statistical analyses were performed using IBM SPSS version 21.0 (IBM, Armonk, NY). Chi-square tests were used to compare categorical variables at the 5% significance level. Ethics approval for this study was granted by the Curtin University Human Research Ethics Committee (approval number: HR127/2013). This study was conducted as part of a project supported by the Western Australian Department of Health Targeted Research Fund (reference number: F-AA-00788). The complete study protocol is available as a publication.[11]

## Results

Of the 68,959 lower acuity patients who were attended by SJA-WA paramedics in the Perth metropolitan area in 2013, 1,572 cases (2.3%) were excluded because of missing information. The study cohort therefore comprised 67,387 patients, of whom 57,183 were transported to ED, and 10,204 (15.1%) were discharged at the scene.

*Can paramedics accurately identify patients who are suitable for the community-based alternative pathways?*

Characteristics of the patients who were transported to ED are shown in Table 2. Amongst 57,183 patients who were transported to ED, paramedics identified 2,717 patients (4.8%) within the study cohort as being suitable for the alternative pathways, of whom 261 were suitable for see-and-treat and 2,456 for see-and-refer. From this group of patients identified as being suitable for alternative pathways, 1,455 (53.6%) patients were admitted to hospital after ED assessment including one patient identified as being suitable for an alternative pathway, who died in ED. The majority of the patients identified as being suitable for the alternative pathways had normal vital signs, requested an ambulance on a weekday during daytime hours, and were transported from a place other than a nursing home (Table 2).

Among 10,204 patients discharged at the scene, 1,174 (11.5%) were indicated as being suitable for care in the community. These patients were older, more likely to have abnormal vital signs and be transported from a nursing home and experience subsequent ambulance request, ED attendance, and/or hospitalisation within 24 hours after scene discharge than those who were not indicated as being suitable for care in the community after adjustment for confounders (Table 3).

*Is it possible to identify predictors that could be used to accurately identify patients who should be transported to ED?*

The derived decision tree is shown in Figure 1. The tree contained seven leaf nodes, and splitting rules were based on two predictors (age and aetiology). The most important predictor used to split the root node was age (≥70 or 14-69). After this first split, there were five splits, which all used aetiologies. The patients with the highest probability (80.2%) of hospital admission were those aged 70 years or older and whose aetiology was respiratory, debility or infection (Table 4). The lowest probability of hospital admission (34.6%) was found in the group of patients aged between 14 and 69 years and whose aetiology was intoxication, psychosocial or trauma. The 10-fold cross validation misclassification rate of the tree was 0.349, and the AUROC was 0.686 (95% CI 0.682-0.691).

## Discussion

The potential for prehospital identification of patients suitable for management in the community versus those that needed to be transported to ED was examined using two different approaches. First, the accuracy of paramedic decision making for transportation to ED or community treatment was low. The results showed that more than half of patients who were indicated as being suitable for care in the community by paramedics and were transported to ED were admitted to hospital. Patients who were deemed as being suitable for care in the community and discharged at the scene were found to be more likely to experience subsequent ambulance request, ED visit and hospitalisation within 24 hours.

Other studies have reported that smaller proportions of patients (10.3% to 17.3%) were incorrectly identified as being suitable for care in the community than ours.[12, 13] There may be two reasons for the low accuracy in our study compared to other studies. First, only lower acuity patients were included in this study while the other studies included patients with any triage level.[12, 13] ED disposition of higher acuity patients is easier to predict than that of lower acuity patients because higher acuity patients are more likely to be admitted to a hospital than lower acuity patients. Second, a third of the admissions in our study were hospitalised in short stay units and then mostly discharged directly from the unit.[14] This admission to a short stay unit might inflate the total number of admissions although it is uncertain whether a short stay unit admission could be regarded as equivalent to discharge from ED.

A decision tree was constructed to identify factors associated with hospitalisation after medical care at ED. The discriminative power of the tree measured by AUROC was lower than the acceptable level for use in clinical practice. One of the reasons for the failure is similar to that for a low accuracy of paramedic decisions; i.e., only lower acuity patients were included. Therefore, the proportion of patients with abnormal vital signs, which are strong predictors of critical conditions,[15] was not significantly different between the ED discharge and hospital admission groups in our cohort. More accurate clinical decision tools specific to aetiologies might be created than the tree that included all aetiologies because debility and infection always selected a group of patients with higher probability of hospital admission than other aetiologies, while trauma and intoxication always selected a lower probability of hospital admission than other aetiologies.

*Limitations*

The main limitation of this study is the use of disposition after ED as the reference standard to determine the accuracy of paramedic decisions. The fact that a patient is discharged from ED does not always mean that the patient is manageable in the community. This is because a patient may have been discharged after receiving a treatment which is not readily available in the community (e.g. fracture reduction and immobilization) and/or an extended period of close observation in ED. To a lesser extent, the fact that a patient was admitted also does not always mean community care was unsuitable. Admission may, for example, be for social reasons such as lack of transportation options to discharge an older person at night. Consequently, there is no consensus on the best measure to assess paramedic decisions. Studies have used physician opinions,[16] ED diagnosis,[17] as well as hospital admission[12, 13] for the reference standard, and all have their limitations. Research on the most appropriate measure to determine the accuracy of paramedic decisions is needed.

Another limitation is associated with the fact that the paramedics' decision was not a compulsory entry field of the ePCR. A small proportion of patients (4.8%) were identified as suitable for the alternative pathways by paramedics. This proportion is less than those reported by other studies (12% to 29%).[16, 18] The non-compulsory nature of the research field was used to encourage paramedics to enter their decision only when they felt confident about their judgement. Mandating a response from paramedics may have resulted in the box simply being ticked - without the paramedic necessarily making a considered decision. On reflection, the field would be still made elective – but included a 'no' option (i.e. the patient is not suitable for management in the community); as well as a 'yes' option.

The findings gained from this study may not be generalisable to paramedics who have received extended care training.

## Conclusion

In our study, lower acuity patients who could be treated in the community were not accurately identified by SJA-WA paramedics who did not have extended care training. Our decision tree also failed to achieve an acceptable level of discriminative power for identifying hospital admission. An approach of allowing paramedics without extended care training, to refer or treat patients in the community, may not be without risk and requires further evaluation.

## Author contributions

HT analysed data, drafted the article and takes responsibility for this paper as a whole. AB provided statistical advice. HT, IJ, DF, TW, AB, GA, IR, AC, DM, PC, PS, TA and

JF were involved in conceiving this study and contributed to the analysis plan, interpretation of results and revision of the article. All have given approval to submit this article.

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Professor Ian Jacobs, who was the chief investigator of this project and Clinical Services Director of the St John Ambulance Western Australia died before the final draft of this manuscript was completed. We acknowledge his invaluable support and contribution to this study.

**Competing interests**

Ian Rogers is a member of the Board of Directors and at the time of the study was (Acting) Clinical Director of SJA-WA. Glenn Arendts is a member of the SJA-WA Medical Policy Committee. Tony Ahern is CEO of the SJA-WA. Judith Finn receives research funding from the SJA-WA. The authors alone are responsible for the content and writing of the paper.

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**Figure legend**

Figure 1. A decision tree for hospital admission. The tree flows from left to right, and the seven bolded boxes at the right represent leaf nodes. Each box contains the number of hospital admissions over the total number in the node and the equivalent percentage in brackets.

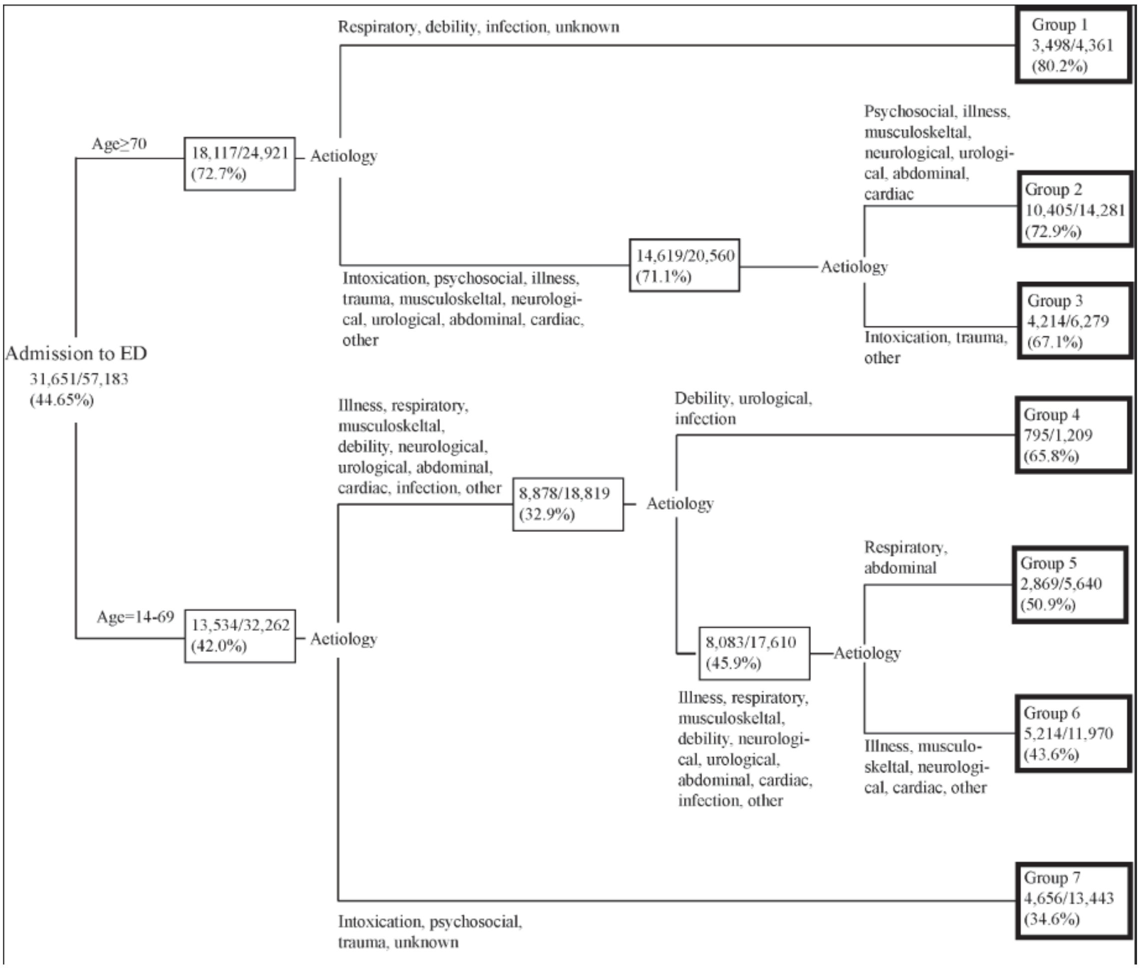

Table 1 Stopping rules for developing a decision tree

| | |
|---|---|
| 1 | A leaf node contained at least 600 cases (approximately 1% of the total subjects) |
| 2 | Each branch had a maximum of five nodes |
| 3 | The Gini improvement measure, which is the difference between Gini impurity measures for a parent node and its child nodes, was less than the specified cut-off value of 0.0005* |

- This optimal cut-off value was determined to minimise misclassification rate (proportion of cases which were incorrectly classified).[19]

Table 2 Comparison of patients who were identified as being suitable for the alternative pathway with those who were not among those who were transported to ED. (N=57,183)

| Characteristics | | No. (%) of patients indicated as being suitable for the alternative pathways (n=2,717) n (%) | No. (%) of patients not indicated as being suitable for the alternative pathways (n=54,466) n (%) | p |
|---|---|---|---|---|
| Discharge from ED | | 1,262 (46.4) | 24,270 (44.6) | 0.05 |
| Admission to hospital | | 1,455 (53.6) | 30,196 (55.4) | |
| Age group (years) | 14-69 | 1,439 (53.0) | 30,823 (56.6) | <0.001 |
| | 70 or older | 1,278 (47.0) | 23,643 (43.4) | |
| Male | | 1,205 (44.4) | 25,162 (46.2) | 0.06 |
| Triage level | | | | <0.001 |
| | 3 | 1,280 (47.1) | 41,539 (76.3) | |
| | 4 | 1,131 (41.6) | 11,371 (20.9) | |
| | 5 | 306 (11.3) | 1,556 (2.9) | |
| Abnormal vital sign | | 641 (23.6) | 11,890 (21.8) | 0.03 |
| Weekend | | 749 (27.6) | 15,968 (29.3) | 0.05 |
| Late night | | 593 (21.8) | 12,323 (22.6) | 0.33 |
| Transport to teaching hospital | | 1,550 (57.1) | 32,806 (60.2) | 0.001 |
| Transport from nursing home | | 2,071 (8.1) | 4,643 (14.7) | <0.001 |
| Etiology | | | | <0.001 |
| | Illness | 616 (22.7) | 10,363 (19.0) | |
| | Abdominal | 407 (15.0) | 6,970 (12.8) | |
| | Trauma | 311 (11.5) | 12,934 (23.8) | |
| | Psychosocial | 227 (8.4) | 2,167 (4.0) | |
| | Respiratory | 203 (7.5) | 3,261 (6.0) | |
| | Musculoskeletal | 195 (7.2) | 3,648 (6.7) | |
| | Neurological | 165 (6.1) | 4,573 (8.4) | |
| | Debility | 155 (5.7) | 1,517 (2.8) | |
| | Intoxication | 142 (5.2) | 3,141 (5.8) | |
| | Infection | 89 (3.3) | 1,027 (1.9) | |
| | Urology | 84 (3.1) | 1,141 (2.1) | |
| | Other | 76 (2.8) | 1,772 (3.3) | |
| | Cardiac | 27 (1.0) | 1,279 (2.4) | |
| | Unknown | 20 (0.7) | 673 (1.2) | |

Table 3. Comparison of patients who were identified as being suitable for alternative care with those who were not for those who were discharged at the scene (N=10,204)

| Characteristics | | No. (%) of patients indicated as being suitable for care in the community (n=1,174) n (%) | No. (%) of patients not indicated as being suitable for care in the community (n=9,030) n (%) | p | Adj OR (95% CI) |
|---|---|---|---|---|---|
| Age group | 14-69 | 596 (50.8) | 5,537 (61.3) | <0.001 | |
| | 70 or older | 578 (49.2) | 3,493 (38.7) | | |
| Male | | 515 (43.9) | 4,275 (47.3) | 0.03 | |
| Triage level | | | | | |
| | 3 | 279 (23.8) | 2,404 (26.6) | <0.001 | |
| | 4 | 457 (38.9) | 2,732 (30.3) | | |
| | 5 | 438 (37.3) | 3,894 (43.1) | | |
| Abnormal vital sign | | 203 (17.3) | 1,280 (14.2) | 0.004 | |
| Weekend | | 327 (27.9) | 2,754 (30.5) | 0.06 | |
| Transport from nursing home | | 125 (10.6) | 569 (6.3) | <0.001 | |
| Etiology | | | | | |
| | Illness | 344 (29.3) | 2,365 (26.2) | <0.001 | |
| | Abdominal | 96 (8.2) | 396 (4.4) | | |
| | Trauma | 282 (0.2) | 2,591 (0.3) | | |
| | Psychosocial | 42 (3.6) | 292 (3.2) | | |
| | Respiratory | 60 (5.1) | 309 (3.4) | | |
| | Musculoskeletal | 60 (5.1) | 179 (2.0) | | |
| | Neurological | 53 (4.5) | 491 (5.4) | | |
| | Debility | 54 (4.6) | 338 (3.7) | | |
| | Intoxication | 38 (3.2) | 565 (6.3) | | |
| | Infection | 16 (1.4) | 63 (0.7) | | |
| | Urology | 23 (2.0) | 53 (0.6) | | |
| | Other | 47 (4.0) | 422 (4.7) | | |
| | Cardiac | 2 (0.2) | 51 (0.6) | | |
| | Unknown | 57 (4.9) | 915 (10.1) | | |
| Subsequent ambulance request within 24 hours | | 122 (10.4) | 620 (6.9) | <0.001 | 1.4 (1.2-1.8) |
| Subsequent ED attendance within 24 hours | | 87 (7.4) | 437 (4.8) | <0.001 | 1.4 (1.1-1.8) |

| | | | | |
|---|---|---|---|---|
| Subsequent hospitalization within 24 hours | 61 (5.2) | 304 (3.4) | 0.001 | 1.4 (1.1-1.9) |
| Death within 24 hours | 2 (0.2) | 17 (0.2) | 0.89 | |

ED: emergency department, Adj OR: adjusted odds ratio

Table 4 Rules derived from the decision tree for hospital admission. .

| Group | Rule | Number of admissions to hospital | Number in node | % admission to hospital |
|---|---|---|---|---|
| 1 | Age≥70, respiratory, debility, infection | 3,498 | 4,361 | 80.2% |
| 2 | Age≥70, psychosocial, illness, musculoskeletal, neurological, urological, abdominal, cardiac | 10,405 | 14,281 | 72.9% |
| 3 | Age≥70, intoxication, trauma, other | 4,214 | 6,279 | 67.1% |
| 4 | Age=14-69, debility, urological, infection | 795 | 1,209 | 65.8% |
| 5 | Age=14-69, respiratory, abdominal | 2,869 | 5,640 | 50.9% |
| 6 | Age=14-69, illness, musculoskeletal, neurological, cardiac, other | 5,214 | 11,970 | 43.6% |
| 7 | Age=14-69, intoxication, psychosocial, trauma | 4,656 | 13,443 | 34.6% |

ED: emergency department