Despite being short and full of noise, **text messages sent between nurses and doctors** regarding patient conditions can augment other visit information to improve performance of **intensive care unit (ICU) transfer prediction**.

# Predicting ICU transfers using text messages between nurses and doctors


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## 1 Introduction

– **Failure to rescue** can be caused by **poor communication** or **lack of situational awareness** in the care team (Brady and Goldenhar 2014).

– Real-time clinical information, especially **communication between nurses and doctors**, may be useful in improving the accuracy of detecting deteriorating patients (Rajkomar et al. 2018).

– **Goal**: Explore the use of **text messages between nurses and doctors** in predicting a patient's **transfer to the intensive care unit (ICU)**.

## 2 Methods

**Data**:

– **38k patients** across **49k visits**, between 2011 and 2017, divided into five different institutional codes.

– Treat each text message as a separate data point –> text message is determined to have the **outcome** if an **ICU transfer occurs within the next 3 days of the message send date**.

– **Visit information**: Patient's age and gender, number of days in hospital, medication and diagnosis (encoded with TFIDF).

**Text messages**:

– Consist of *message headers* (i.e., messages from nurses) and *message replies* (i.e., replies from doctors). We focus our analysis on *message headers* only.

– Challenging to analyze due to **spelling mistakes**, **abbreviations** specific to the medical domain, and **missing punctuation**.

*Examples of message headers (mheader) and message replies (mreply)*

| Examples |
|---|
| **mheader**: 'hb=65, cr=123 & more lab res up from last nights bldwork. Ping if anything you want me to follow up.'<br>**mreply**: 'informed.' |
| **mheader**: 'dc hep drip on epr. Pls see chart order. Thnx.'<br>**mreply**: 'done thanks' |
| **mheader**: 'hey are icu recommends to be cosigned. thx.'<br>**mreply**: 'Ok. Pls run one l of ringers wide & then one more' |

**Text message representations**:

– **TF-IDF**

– Word2vec with **pre-trained PubMed embeddings** (Moen and Ananiadou 2013)

– Word2vec (Mikolov et al. 2013) **trained on text messages**

– **Linguistic features** (e.g., polarity, POS tag counts)

## 3 Results

***Total number of text messages*** *(with % resulting in ICU transfer within 3 days of message send date) and model performance in **Baseline** (i.e., visit information only), **Word2Vec (SMS)** (i.e., Baseline + word2vec trained on text messages), and **TF-IDF** (i.e., Baseline + TF-IDF) features*

| Group | Messages | Baseline | Word2vec (SMS) | TFIDF |
|---|---|---|---|---|
| *A* | 98,468 (16.75%) | 0.47 (0.01) | **0.51 (0.02)** | **0.51 (0.01)** |
| *B* | 91,330 (0.36%) | 0.48 (0.01) | 0.46 (0.07) | **0.50 (0.01)** |
| *C* | 8,159 (35.85%) | 0.44 (0.02) | **0.57 (0.05)** | **0.56 (0.04)** |
| *D* | 821 (22.12%) | 0.44 (0.03) | **0.46 (0.07)** | 0.44 (0.04) |
| *E* | 260 (2.01%) | 0.69 (0.28) | 0.69 (0.28) | 0.69 (0.28) |

– **Input**: Patient demographics, visit information, and text message representations.

– **Model**: **Logistic regression** classifier.

– **F1-macro** averages of 5-fold cross-validation.

*Comparison of word embeddings - Top five similar words for common abbreviated medical terms*

| Word | w2v (SMS) | w2v (PubMed) |
|---|---|---|
| dr | dr., doctor, md, resident, oncologist | 99:1, diastereoselectivities, ee, =98:2, 98:2 |
| bld | blood, bloood, blod, frozen, pt.iv | whi, bldB, EPS-deficient, transposon-generated, A-factor-deficient |
| med | medication, pill, lactulose, risperidone, hypoglycemics | Nicolae, Delores, Dres, habil., CSc. |
| bp | b/p, bp=, bp-, bpm, pulse | nt, bps, nts, bp-long, bp-long |
| icu | msicu, emerg, er, cvicu, gim | bag/mask, Patient-initiated, extrahospital, patient-cycled, airway-management |

## 4 Conclusion

– Best performance in Group C: most ICU transfers, longest text messages and most text messages per visit and per patient.

– *Word2vec* word embeddings trained on our data performs better than the pre-trained ones, since they are able to **capture different spellings and common misspellings**.

**Future work**:

– **Identify key features of the text messages** that are relevant in **predicting ICU transfer**.

– Investigate the utility of **adding the message replies** as features.

– Explore the added value of text messages in a **more complex set of features** (i.e., lab results and vitals).


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