A study of association of workload with infection of VAP on the Intensive Care Unit (ICU)

Lisha Deng[1], Prof. Peter Diggle[1] and Prof. Andrew Smith[2]

1. School of Health and Medicine, Lancaster University, Lancaster

2. Royal Lancaster Infirmary, Lancaster

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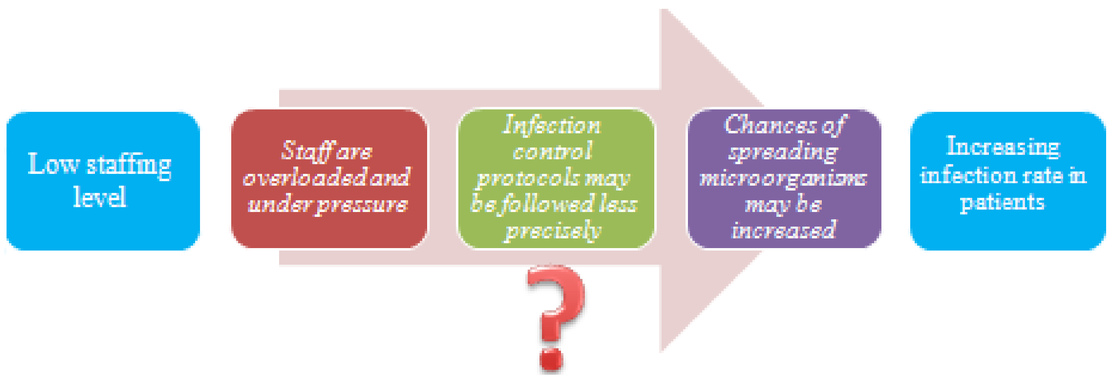
INTRODUCTION & MOTIVATION

VAP(Ventilator-associated Pneumonia):

1. A subtype of hospital acquired pneumonia, only susceptible to patients who are on ventilation byendotracheal or tracheo-stomy tube.
2. Most important symptoms are fever, low body temperature, new purulent sputum and decreasing amounts of oxygen in the blood.
3. Usually caused by Gram-negative bacterial pathogens either acquired endogenously from endogenous bacteria species of internal body or exogenously through intubation.

Motivation:



Is there any evidence to suggest low staffing level will lead to an increase in infection rate?

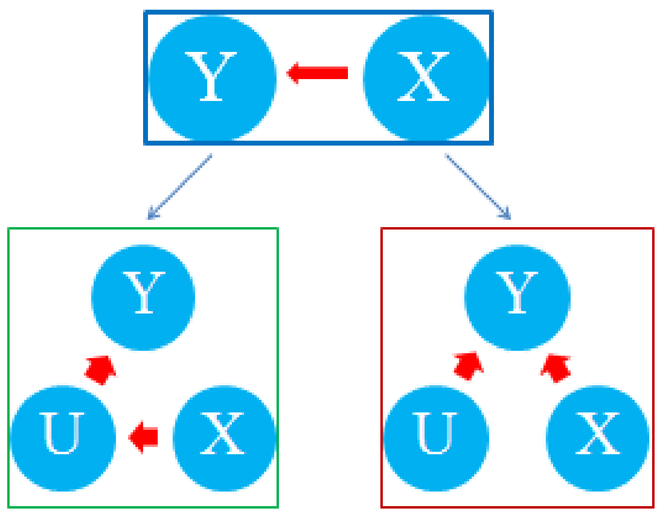
DATA

Specimen are collected every day from the lower respiratory tract of patients in ICU on a ventilator. If Gram-negative bacteria pathogen is found in specimen, we record as on case.

- ***Daily number of VAP infections with Gram-negative bacteria***
  80% of the time has zero counts, max counts in a day is 3.
- ***Daily Exposure to patients***: total hours of each patient staying in ICU
- ***Staff-to-patient ratio***: total working hours of staff divided by total exposure; values from 0.642 to 2.22

CORRELATION ANALYSIS

Let **X be staffing level**, **Y is infection rate**, **U is confounders usually unknown**.
To establish a correlation relationship between X and Y, we need to adjust the effect of confounders.



METHODOLOGY

Step 1: Exploratory regression analysis on Staff-to-patient ratios X_t

Parametric model (green smooth curve):

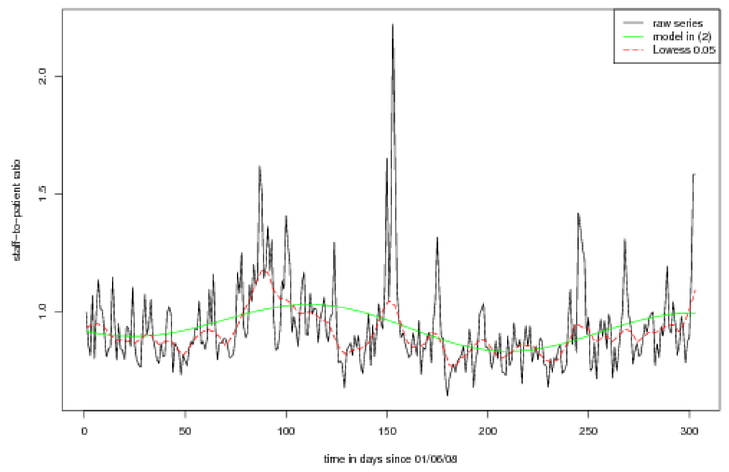
$$E(x_t) = \alpha_k + \beta_1 \sin(\omega_1 t) + \beta_2 \cos(\omega_1 t) + \beta_3 \sin(\omega_2 t) + \beta_4 \cos(\omega_2 t)$$

α_k : days of week effect, $k = 1, 2, ..., 7$

$\sin(\omega t)$ & $\cos(\omega t)$: seasonal effects at 6-month (ω_2)and 12-month (ω_1)

Non-parametric model(red curve):

A ***lowess*** (Cleveland [1979]) method with span 0.05 fits data well.



Step 2: Log-linear regression analysis

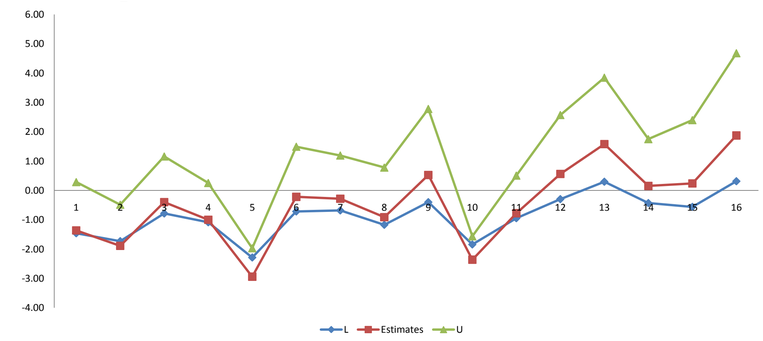
$$Y_t \sim Poisson(\mu_t);\ \mu_t = E_t \rho_t;$$

$$\log \rho_{tk} = \alpha_k + \beta_l r_{t-l};\ k = 1, 2, ...7; l = 1, 2, ...15$$

1. Daily number of infections are mutually independent Poisson counts with time-varying mean.
2. Rate of infection on day t depends on day of week effect and lags of staff-to-patient ratio.
3. Mean depends on the exposure and rate of infection
4. To exclude the possibility of both staff-to-patient ratio and infection rate having common effects, residuals of staff-to-patient ratio after fitting a parametric model are used

RESULTS

- Only staff-to-patient ratio 12 days and 15 days prior to an infection have marginal effects on infection rate with p-value 0.022 for both, the rest are not statistically significant.
- No evidence shows that staff-to-patient ratio is associated with infection rate, since the estimates are oscillating around zero lacking of consistent pattern.



CONCLUSIONS

In our study, there is **NO EVIDENCE** to suggest staffing level is associated with infection rate. This conclusion is limited by the following reasons:

- The data are spare, the study period is 9 month and collected from an ICU with 10 beds only.
- Infections sampled in this study may be associated with patients' underlying health status, masking a staffing -level effect