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A Method for Assessing the Risk of Influenza Attributable Rehospitalization

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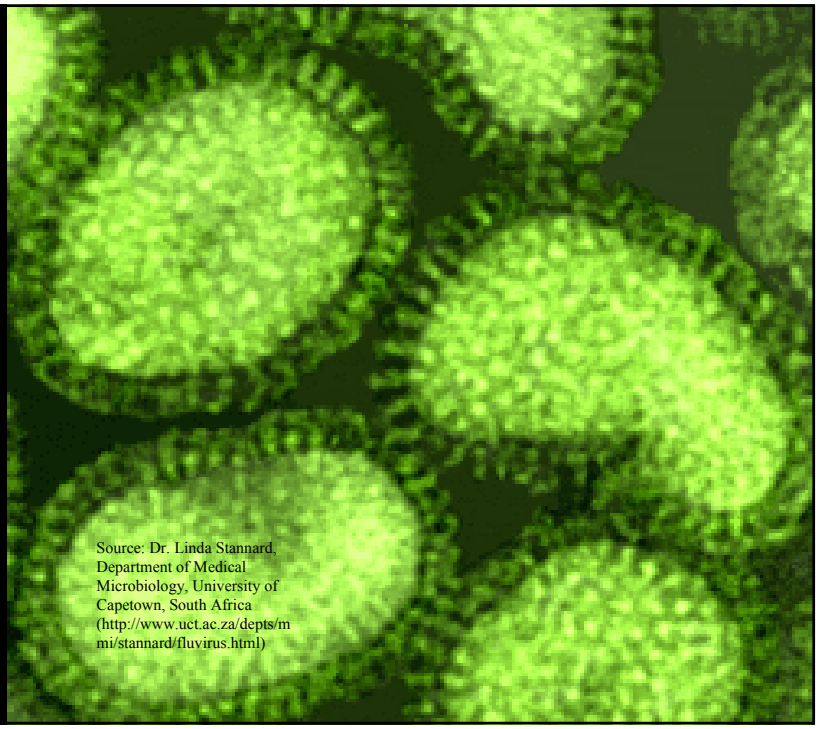
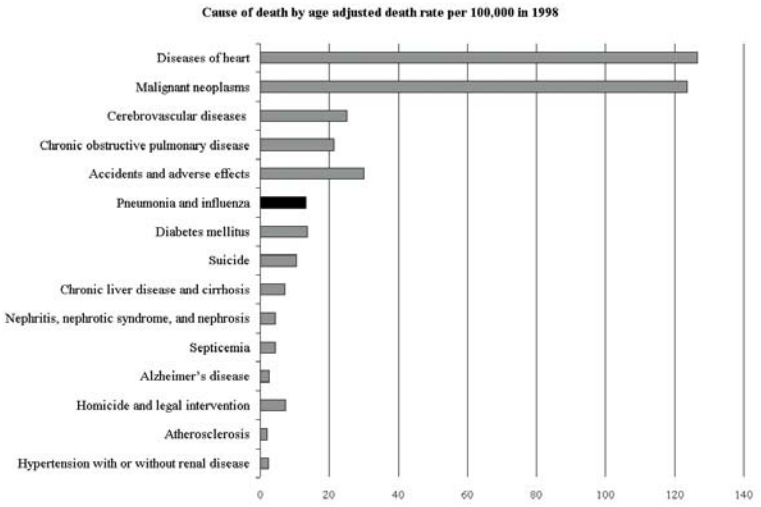


Source: Dr. Linda Stannard, Department of Medical Microbiology, University of Capetown, South Africa (http://www.uct.ac.za/depts/mmi/stannard/fluvirus.html)



Source: Murphy SL. Deaths: Final Data for 1998. National vital statistics reports; vol 48 no. 11. Hyattsville, Maryland: National Center for Health Statistics. 2000.

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The influenza vaccine is effective in reducing the risk of hospitalizations for influenza attributable conditions

Risk adjusted percent reduction in hospitalizations among vaccinated members of a large health maintainance organization who were 65 and older (n = 147,551)

Reason for hospitalization	Total	High risk only
pneumonia and influenza	39 %	29 %
acute and chronic respiratory disease	32 %	19 %
congestive heart failure	27 %	14 %

Note: all comparisons were statistically significant at $p < 0.001$, except for pneumonia and influenza for the high risk only group ($p = 0.002$) and congestive heart failure for the high risk group (0.07)

Note: 'high risk' includes patients with heart or lung disease

Source: Nichol KL, Wuorenma J, von Sternberg T. Benefits of influenza vaccination for low-, intermediate-, and high-risk senior citizens. Archives of Internal Medicine. 1998; 158: 1769-1776

The CDC Advisory Committee on Immunization Practices (ACIP) recommends that :

(1) persons of all ages (including children) with high-risk conditions, and

(2) persons aged > 50 years

who are hospitalized at anytime from September through March should be offered and strongly encouraged to receive influenza vaccine before they are discharged

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Although influenza vaccination coverage rates have improved during the last decade, the majority of individuals at high risk for influenza attributable hospitalizations do not receive the vaccine.

Percent of persons who reported receiving influenza vaccine, National Health Interview Survey, United States, 1995

	%	(95 % C.I.)
high risk persons aged 18-49	20.4	(17.8 - 23.0)
high risk persons aged 50-64	37.7	(33.7 - 41.7)
all persons aged 65 and older	58.2	(56.4 – 60.0)

Note: 'high risk' includes persons with self reported diagnoses of diabetes, asthma, emphysema, chronic bronchitis, tuberculosis, chronic kidney disease, cancer treatment, and heart disease

Source:
Singleton JA, Greby SM, Wooten KG, Walker FJ, Strikas R. Influenza, Pneumococcal, and Tetanus Toxoid Vaccination of Adults – United States, 1993-1997. In: CDC Surveillance Summaries, September 22, 2000. MMWR 2000; 49 (No. SS-9): 39-62.

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The CDC ACIP recommends that hospital based influenza vaccination programs include:

(1) publicity and education,

(2) a plan for identifying persons at high risk,

(3) use of reminder/recall systems, and

(4) remove barriers that prevent persons from receiving the vaccine.

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Research question

Can an improved method be developed to identify hospital patients according to their risk for influenza attributable rehospitalization ?

California hospital discharge abstract data:

- 3.7 hospitalizations annually
- up to 25 diagnoses and 21 procedures
- unique patient IDs (encrypted) allow record linkage
- all dates limited to month and year
- data is of high quality

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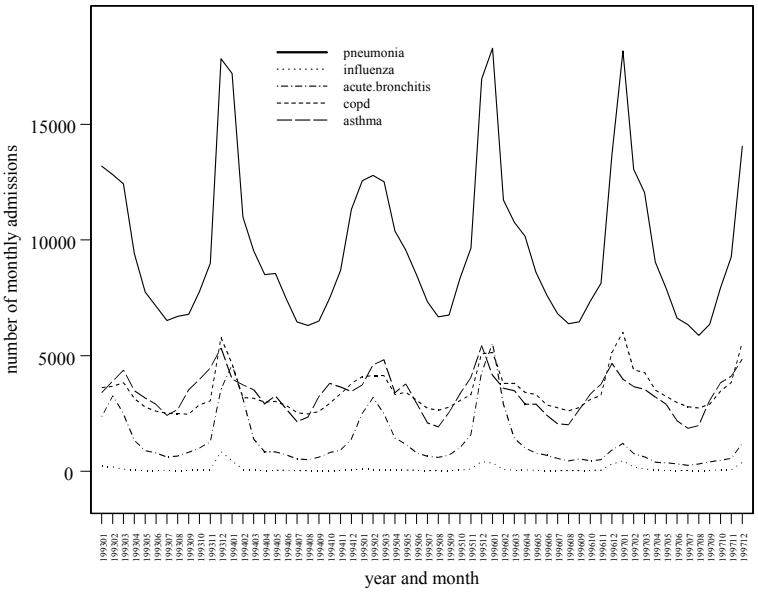

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Study population (n = 160,895)

- persons hospitalized during November 1996
- discharged alive
- over 6 months old

Outcome measure (n = 4,428 (2.75%))

- rehospitalization during December 1996 through April 1997 for influenza, pneumonia, acute bronchitis, COPD, or asthma.

Predictor variables

- age, sex, race, insurer, admitted from and/or discharged to LTC
- 260 diagnosis categories
- 231 procedure categories

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Model development method

Multivariable logistic regression analysis

- 506 degrees of freedom:
- 20 demographic variables (polytomous categories)
- 258 mutually exclusive diagnosis categories
- 229 mutually exclusive procedure categories

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The model's performance in identifying patients with high risk was assessed using the C statistic:

- C statistic = 0.865
- the C statistic is a measure of discrimination
- the C statistic is equivalent to the area under the receiver operating characteristics (ROC) curve
- the C statistic is equivalent to the proportion of all possible pairs of patients who were rehospitalized with patients who were not rehospitalized for whom the model predicted probability of rehospitalization is higher for the patient who was rehospitalized than for the patient who was not rehospitalized

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Validity of the developed model assessed by applying the estimated equation (fixed intercept and parameter coefficients) to a validation population

- all persons over 6 months old who were discharged alive during December 1996 (n = 165,144).
- developed model C statistic = 0.865
- validated model C statistic = 0.842

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Calibration was assessed in the following manner:

- validation population ranked by predicted probability
- divided into 100 equal sized groups (n = 1,651)
- for each group, we calculated the mean number of observed rehospitalizations and the mean predicted probability of readmission
- plotted bivariate relationship between mean observed and predicted for each group
- linear model coefficient=1 when calibration is perfect

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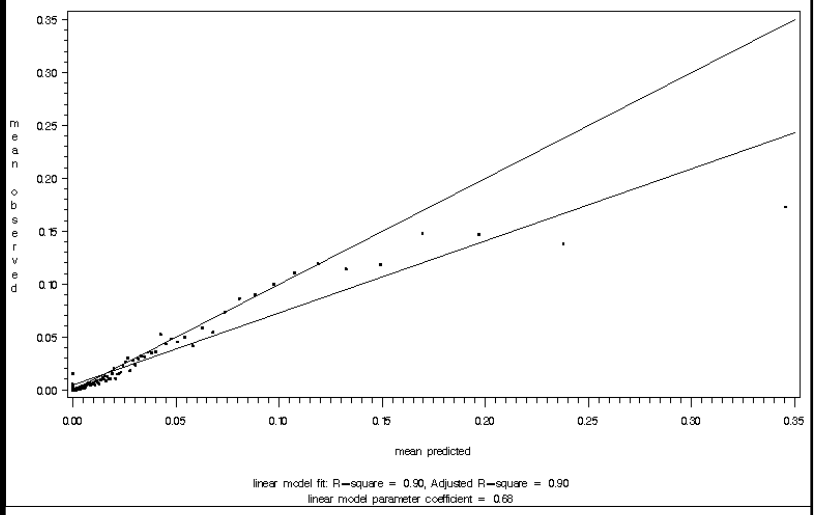

Demographic risk factors

	% Total	Odds Ratio	P value
Age group - 6 months to 24 months	0.57	2.69	<0.0001
Age group - 2 years to 9 years	2.11	1.68	0.0003
Age group - 10 to 19 years	5.30	1.06	0.6929
Age group - 20 to 29 years	15.03		reference group
Age group - 30 to 39 years	16.93	1.21	0.1474
Age group - 40 to 49 years	11.49	1.63	<0.0001
Age group - 50 to 59 years	9.67	2.02	<0.0001
Age group - 60 to 69 years	11.52	2.50	<0.0001
Age group - 70 to 79 years	15.03	2.75	<0.0001
Age group - 80 to 89 years	10.00	3.61	<0.0001
Age group - 90 years and older	2.35	3.95	<0.0001

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Demographic risk factors

	% Total	Odds Ratio	P value
admitted from long term care setting	2.03	1.19	0.0215
discharged to long term care setting	15.71	1.21	<0.0001
male	36.17	1.10	0.0060
racial group - white	75.05		reference group
racial group - black	9.06	1.27	<0.0001
racial group - native american	0.41	1.22	0.4533
racial group - asian	6.67	1.25	0.0010
racial group - hispanic	8.80	1.01	0.9204

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Diagnosis category risk factors

	% Total	Odds Ratio	P value
Asthma	3.92	5.23	<0.0001
Cystic fibrosis	0.05	4.87	<0.0001
COPD and bronchiectasis	8.02	3.88	<0.0001
Multiple myeloma	0.14	2.59	<0.0001
Other congenital anomalies	0.47	2.10	<0.0001
Sickle cell anemia	0.17	2.07	0.0154
Systemic lupus erythematosus (etc)	0.44	2.03	<0.0001
Leukemias	0.34	2.00	<0.0001
HIV infection	0.42	1.75	0.0068
Pneumonia (except caused by TB/STD)	4.81	1.68	<0.0001
Acute bronchitis	0.66	1.62	<0.0001
Other endocrine disorders	0.67	1.57	0.0007

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Problem: method is sensitive but not specific

Hospitalizations for acute respiratory disease can be caused by

- influenza virus
- parainfluenza virus
- respiratory syncytial virus
- other types of viruses
- bacterial infections
- other causes

We applied two existing methods used by the CDC to estimate the number of influenza caused deaths and hospitalizations to estimate the percentage of rehospitalizations attributable to influenza among all rehospitalizations caused by acute respiratory disease in our study:

- linear baseline method (Simonsen L, et al., 2000)
- convex baseline method (Simonsen L, et al., 1997)

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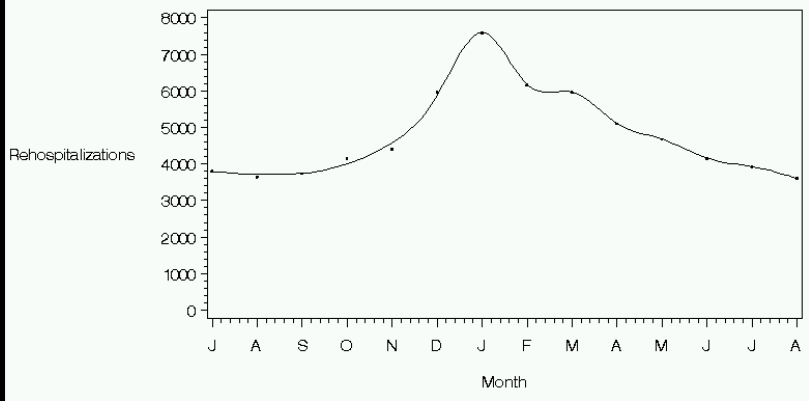

Monthly acute respiratory disease hospitalizations from June 1996 through July 1997 among patients who were also hospitalized during the prior 5 months

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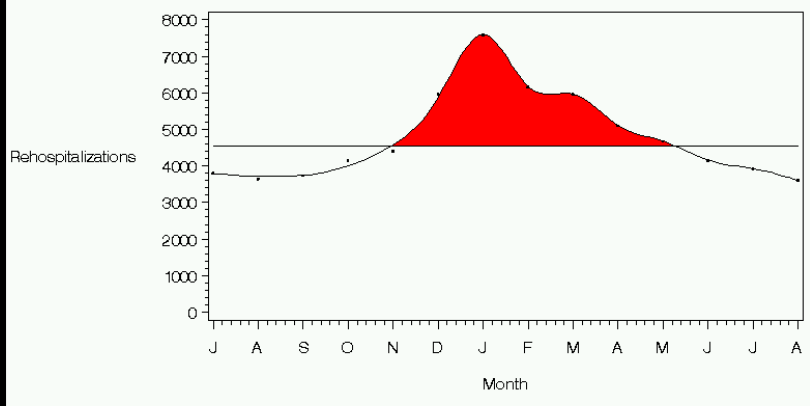

linear baseline method

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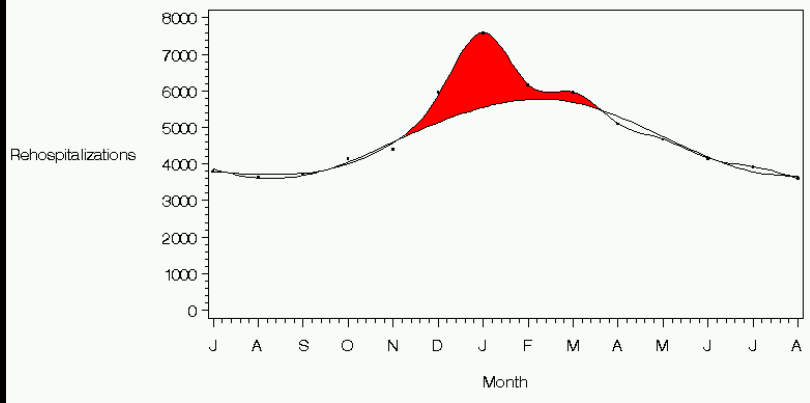

convex baseline method

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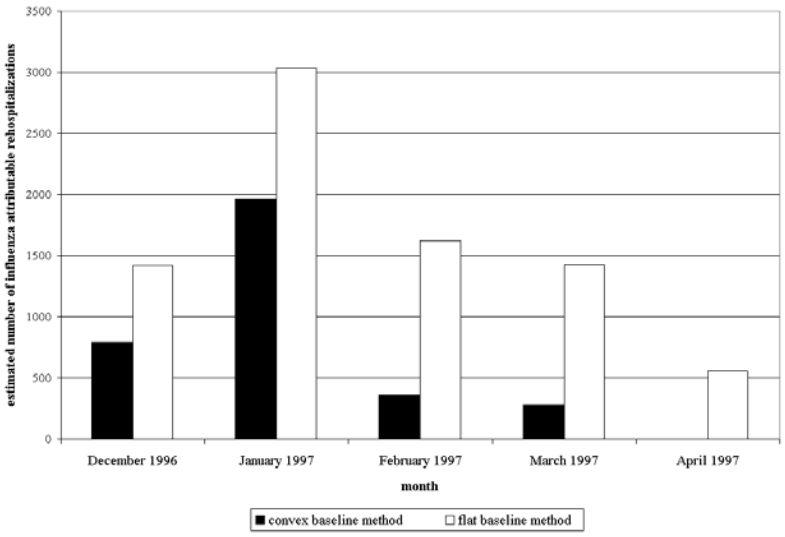

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30,789 rehospitalizations for acute respiratory disease during the period from December 1996 to April 1997

Estimated percentage attributable to influenza

- 26% (n = 8,064) using linear baseline method
- 11% (n = 3,394) using convex baseline method

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Results from developed model

• 53% of patients hospitalized in December 1996 (87,872) were at or over a 1% risk of being rehospitalized

• patient's with a 1% risk or more accounted for 95% of all rehospitalizations (3,966 of 4,167)

Assumptions

• identify all patients with over 1 % risk

• only 50% of model identified patients already vaccinated

• all model identified patients are vaccinated before discharge

• per case of cost of identification and vaccination is $10

• vaccine is 40% effective in preventing rehospitalizations

• average cost of avoided rehospitalizations is $4,000

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Intervention Cost Savings Assessment

Assuming that 11% of rehospitalizations are attributable to influenza	
$698,016	total cost of preventable rehospitalizations
$439,360	total cost of identification and vaccination program
$258,656	net savings
$1.59	rate of return per vaccination program dollar
Assuming that 26% of rehospitalizations are attributable to influenza	
$1,649,856	total cost of preventable rehospitalizations
$439,360	total cost of identification and vaccination program
$1,210,496	net savings
$3.76	rate of return per vaccination program dollar

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Limitations of developed method

- 'noisy' response variable
- vaccination status is an important but unmeasured predictor
- California data may not reflect experience of other states

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Advantages of developed method

- effective discrimination for patients with high risk
- can be implemented as part of automated records
- model could be simplified into score for ease of use
- would allow more efficient vaccination program
- can be used to educate patients about their specific risk
- can reduce health care costs and improve health status

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The influenza vaccine contains three strains representing the influenza virus that the CDC identifies as most likely to circulate in the U.S. during the winter

The 2000-2001 trivalent vaccine strains are

- A/Moscow/10/99 (H3N2)
- A/New Caledonia/20/99 (H1N1)
- B/Beijing/184/93

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Diagnosis category risk factors

	% Total	Odds Ratio	P value
Neoplasms (unspecified)	0.44	1.52	0.0156
Rheumatoid arthritis & related disease	0.78	1.44	0.0048
Disease of bladder and urethra (other)	0.81	1.44	0.0258
Epilepsy, convulsions	2.51	1.32	0.0006
Chronic renal failure	1.01	1.29	0.0338
Other upper respiratory infections	1.27	1.26	0.0288
Cancer of bronchus, lung	0.97	1.25	0.0444
Complication of device, implant or graft	2.76	1.24	0.0218
Pulmonary heart disease	0.80	1.24	0.0434
Pleurisy, pneumothorax, (etc)	2.44	1.21	0.0145
CHF, nonhypertensive	6.65	1.17	0.0012
Lower respiratory disease (other)	2.07	1.17	0.0334
Diabetes mellitus without complication	6.91	1.16	0.0048