The Economic Burden of Non–Influenza-Related Viral Respiratory Tract Infection in the United States

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**Background:** Viral respiratory tract infection (VRTI) is the most common illness in humans. Despite the high incidence, the economic impact of non–influenza-related VRTI has not been rigorously explored. Our objectives were to obtain an updated incidence of non–influenza-related VRTI in the United States and to quantify the health care resource use (direct costs) and productivity losses (indirect costs) associated with these infections.

**Methods:** A nationwide telephone survey of US households (N=4051) was conducted between November 3, 2000, and February 12, 2001 to obtain a representative estimate of the self-reported incidence of non–influenza-related VRTI and related treatment patterns. Direct treatment costs measured included outpatient clinician encounters, use of over-the-counter and prescription drugs, and associated infectious complications of non–influenza-related VRTI. Absenteeism estimates for infected individuals and parents of infected children were extrapolated from National Health Interview Survey data.

**Results:** Of survey respondents, 72% reported a non–influenza-related VRTI within the past year. Respondents who experienced a self-reported non–influenza-related VRTI averaged 2.5 episodes annually. When these rates are extrapolated to the entire US population, approximately 500 million non–influenza-related VRTI episodes occur per year. Similarly, if the treatment patterns reported by the respondents are extended to the population, the total economic impact of non–influenza-related VRTI approaches $40 billion annually (direct costs, $17 billion per year; and indirect costs, $22.5 billion per year).

**Conclusions:** Largely because of the high attack rate, non–influenza-related VRTI imposes a greater economic burden than many other clinical conditions. The pending availability of effective antiviral therapies warrants increased attention be paid to this common and expensive illness.

Arch Intern Med. 2003;163:487-494
Cellulitis and sinusitis are common conditions that can be managed with antibiotics. However, the optimal treatment for viral respiratory tract infections (VRTIs) remains a matter of debate.

The burden of VRTI is significant, with medical care visits for colds, coughs, and flu-like illness accounting for nearly 18 million lost school days and 21 million lost workdays each year in the United States. The Centers for Disease Control and Prevention (CDC) estimate that VRTI causes more than 50 million lost workdays and school days annually.

To quantify the economic burden of VRTI, researchers developed a conceptual model depicting the natural history of VRTI and its associated costs. This model was used to estimate both direct costs (e.g., medical care expenses) and indirect costs (e.g., productivity losses).

The model was based on a comprehensive review of published literature and included data from a wide survey of US households. The survey was conducted between November 3, 2000, and February 12, 2001, using a random digit-dial method to minimize selection bias.

The model was refined by experts in the field, and cost estimates were derived from published sources. The indirect costs were estimated by calculating the loss of productivity due to the time lost from work or school.

The results of this study highlight the importance of managing VRTI effectively to reduce the economic burden on individuals and society as a whole. The model provides a framework for evaluating the effectiveness of different treatment strategies and for designing public health interventions to reduce the impact of VRTI.

To rigorously estimate the economic burden of the common cold, a 3-step process was used. First, a conceptual model was developed to determine which costs (direct and indirect) are potentially attributable to symptomatic episodes. Second, non–influenza-related VRTI incidence and health care use were determined from a comprehensive epidemiological survey of US households. Once incidence and treatment patterns were elicited, unit cost estimates were obtained from a synthesis of published literature and secondary data sources. These same data sources were used to estimate associated indirect costs.

**CONCEPTUAL MODEL OF POTENTIAL COSTS ATTRIBUTABLE TO VRTI**

A conceptual model depicting VRTI natural history and possible management options was constructed to direct the measurement of resources that could be potentially used by a person (or his or her caregiver) with a symptomatic episode (Figure 1). This conceptual model was derived from a comprehensive review of published literature evaluating the pathogenesis, clinical presentation, clinical course, risk factors, and patterns of care. The pathway was reviewed and modified by a 14-member expert panel consisting of 6 respiratory specialists, 3 primary care clinicians (A.M.F. and others), 2 pediatricians, 2 infectious disease specialists, and 1 otolaryngology specialist.

**PRIMARY DATA COLLECTION: NON–INFLUENZA-RELATED VRTI INCIDENCE AND ASSOCIATED HEALTH CARE USE**

To obtain a more recent and representative estimate of the incidence of non–influenza-related VRTI in the United States and to determine patterns of care for those with colds, a nationwide survey of US households was conducted between November 3, 2000, and February 12, 2001. An unrestricted random sampling method (random digit–dial) was used to minimize bias found in systematic sampling procedures. The survey was administered using a computer-assisted telephone interviewing system to optimize accuracy of data collection and entry.

Only adults (defined as persons 18 years or older) who were willing to respond to the survey were included in the sample. Questions focused on the number of colds the respondent (and/or child) experienced during the past 12 months and specific ways in which the respondent treated the illness. Adult respondents were first asked questions about their non–influenza-related VRTI “cold” history, followed by questions regarding the history of the child in the family with the most recent episode (if applicable). A cold was defined in the survey as “having symptoms such as stuffy or runny nose, sore/scratchy throat, sneezing, with little or no fever and usually lasting about 1 week . . . not referring to ‘the flu,’ which is usually characterized by high fever, headache, overall body aches, pains, and weakness.”

Respondents who had experienced a symptomatic VRTI episode were asked specific questions aimed at quantifying health care use and self-care practices. These questions provided data regarding the frequency of use for over-the-counter (OTC) medications, the frequency of telephone calls to a physician, the frequency of outpatient physician visits, and the use of prescrip-

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**Figure 1. Conceptual model of potential costs attributable to viral respiratory tract infection (VRTI).** A complication is defined as a respiratory exacerbation, otitis media, sinusitis, or a lower respiratory tract infection. OTC indicates over-the-counter; PH, telephone contact with a physician; ED, emergency department; and OV, office visit.
tion medications (eg, antibiotics and symptomatic treatments). Respondents were further asked to list the prescription medications received during their most recent episode. Specific OTC medications were not elicited.

SECONDARY DATA SYNTHESIS: COMPLICATIONS OF NON–INFLUENZA-RELATED VRTI AND COST MEASUREMENT

Estimates of the frequency of physician encounters through an emergency department and the occurrence of VRTI-related complications, including acute sinusitis, otitis media, and lower respiratory tract infections, were obtained from the published literature and from pooled data generated from several randomized clinical trials. Estimates of absenteeism (for the person with the cold and the caregiver) were extrapolated using data from the National Health Interview Survey (NHIS) and the Bureau of Labor Statistics.

To quantify the unit costs for each use variable, data from the literature and from publicly available databases, including the US Census, the NHIS, the Medical Expenditure Panel Survey, and the National (Hospital) Ambulatory Medical Care Survey, were used.

Direct Medical Costs

Unit cost data for outpatient physician visits, physician encounters in an emergency department, and the treatment of acute sinusitis, otitis media, and lower respiratory tract infections were obtained from the 1997 Medical Expenditure Panel Survey database. The Medical Expenditure Panel Survey database contains cost estimates composed of physician service costs and diagnostic/laboratory testing costs. The value for each type of physician encounter was calculated using the average insurance payment (not the charged amount). The average cost per complication associated with non–influenza-related VRTI was calculated by weighing the cost of each type of physician encounter by the proportion of patients who use the respective type of encounter. The cost of a telephone physician encounter was assumed to be $0.

No source was identified reporting OTC cost figures specific to non–influenza-related VRTI. As a result, a per-episode cost of $8.31 (range, $5.56–$11.04) was included for individuals who reported purchasing an OTC product for their non–influenza-related VRTI. This estimate was based on the retail costs of a market basket of 10 popular cold and flu medications, including NyQuil, TYLENOL Cold & Flu, Advil Cold & Sinus, Sudafed Cold & Cough, Children’s Dimetapp, Coricidin D, Alleve Cold and Sinus, and Alka-Seltzer Cold & Sinus. The low cost estimate ($5.56, or a 33% reduction) reflects the cost of similar products purchased as generic (instead of brand name) cough and cold remedies.

To estimate the unit cost incurred for prescription medications, the typical dosing regimen for each medication listed by respondents was determined. To this dose, a unit cost per regimen was applied using published average wholesale price lists. A weighted-average cost per prescription was calculated based on the regimen price and relative distribution of medication use across the therapeutic class (antibiotics and symptomatic therapies). All cost estimates were converted to 2001 US dollar values using inflation adjustments from the Bureau of Labor Statistics.

Indirect Costs

Missed Caregiver Workdays. Missed caregiver workdays were defined as absenteeism of a parent or guardian secondary to a child staying home from school or day care because of a non–influenza-related VRTI. The number of missed workdays per cold was calculated using statistics from the NHIS and primary data obtained from the epidemiological survey. The following assumptions were used to extrapolate the number of school days lost by the NHIS child population to the general child population with non–influenza-related VRTI. Assumption 1. Only single-parent families (with the one parent working) and dual-parent families (with both parents working) were considered. In these households, it was assumed that the number of missed school days for children aged 5 to 17 years is equal to the number of missed caregiver workdays. Assumption 2. For the fully employed households previously described, it was assumed that the proportion of missed day care or school days per cold episode for children from birth to the age of 4 years is equal to the proportion of missed school days per cold episode in children aged 5 to 17 years. This is a conservative assumption in that the incidence of non–influenza-related VRTI is higher in the younger population (birth–4 years) and it is reasonable to expect that a caregiver is at least as likely to stay home with a younger child as with an older child (aged 5–12 years). Assumption 3. Productivity cost is based on an average hourly wage of $14.35 from the Bureau of Labor Statistics (2001) and an 8-hour day.

Given these assumptions, the following was estimated ($ indicates cost in US dollars; and p, proportion):

\[
\text{Caregiver Cost} = \left( \frac{\text{No. of Episodes}}{100} \right) \times p \times \text{All-Worker Family}
\]

\[
\text{Missed Workdays (Absenteeism)}
\]

\[
\text{Work Loss} = \left( \frac{\text{No. of Episodes}}{100} \right) \times (\text{Workday}) \times p \times \text{Missed Workday}
\]

SENSITIVITY ANALYSIS

To measure how robust our results were to changes in base case inputs, a sensitivity analysis was performed with 2 methods. First, in a Monte Carlo simulation, inputs were varied simultaneously and randomly for more than 1000 iterations, yielding a range of cost estimates when variables in the model are allowed to take on different distributions. From this simulation, a 95% confidence range was calculated for the total cost estimate and the relative importance of each input variable was determined. Second, univariate sensitivity analyses were performed around a range for each of the inputs evaluated.

The distribution of all input variables used in the model was assumed to be normal across the range of reasonably possible values. For all probabilities or percentage values (ie, use percentages), the SE assumptions used in the sensitivity calculations were derived from the following equation for a binomial variable (where p indicates proportion; and n, number of observations):

\[
SE = \sqrt{p(1-p)/n}
\]

RESULTS

INCIDENCE OF NON–INFLUENZA-RELATED VRTI

A total of 84 239 randomly placed telephone calls were made. Of these calls, 80 161 did not generate a usable response: 57% were not answered, 21% refused to partici-
Survey respondents reported that adults seek medical attention at a physician’s office in 16.1% of the symptomatic episodes, while children visited their physician 31.7% of the time (weighted average, 22.0%). In addition, those with colds or their caregivers contacted their physician by telephone in 4.6% of cases. By applying these use rates to the annual number of episodes previously reported, there are 110 million physician visits and 23.2 million physician telephone calls in the United States yearly. Similarly, an estimated 6 million emergency department visits for the cold occur annually.

Survey respondents reported that more than two thirds (69%) of those with colds self-medicate with an OTC product. Survey respondents experiencing a symptomatic VRTI episode indicated that they receive prescriptions for antibiotics and symptomatic therapies 8.2% and 3.0% of the time, respectively, leading to more than 41 and 15 million prescriptions annually, respectively.

Table 1. Demographic Characteristics of the 4051 Survey Respondents

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*Percentages may not total 100 because of rounding.

When the survey responses and applicable unit cost estimates (Table 1) were extrapolated to the US population, the estimated total cost in the United States approaches $40 billion annually (95% confidence interval, $31.2–$48.0 billion). Direct medical costs represent about 45% ($17 billion) of the total, and indirect costs represent about 55% ($22.5 billion) of the total costs. Indirect costs can be further divided by whether the illness itself or caring for a sick child was the cause of work loss (Figure 2).

Direct Expenditures

Of the $17 billion in direct medical costs for non–influenza-related VRTI episodes, $7.7 billion (45%) is spent on physician services (not including telephone consultations) and $4.8 billion (28%) is spent on individuals whose non–influenza-related VRTI is complicated by acute sinusitis, otitis media, and lower respiratory tract infections (asthma exacerbations were not included). Americans spend $2.9 billion annually on OTC medications and $400 million annually on drugs prescribed for symptomatic relief. In addition, more than $1.1 billion is spent annually on the estimated 41 million unnecessary antibiotic prescriptions for persons experiencing a non–influenza-related VRTI episode.

Indirect Expenditures

An estimated 189 million school days (an average of nearly 1 day per episode) are missed annually as a result of a non–influenza-related VRTI episode.9 Recall that the calculations included only the proportion of those days associated with the children who live in a 2-parent family with both parents fully employed and those living in a single-parent household in which that parent is fully employed (68% of all family households).37 In these families, it was assumed that a day of work is missed for each day of school missed. Based on this estimate, 126 million workdays are missed by parents caring for their child. Thus, the indirect costs associated with these missed workdays were estimated to be $14.5 billion annually.

In addition to missed workdays for caregivers, an additional 70 million workdays are missed annually because of employees experiencing a non–influenza-related VRTI episode (an average of 1 day per 4.4 episodes). This translates into an indirect cost of $8.0 billion annually. This estimate does not include costs incurred by those who do not work outside the home, the value of lost leisure time, and decreased productivity while at work (presenteeism).

Sensitivity Analysis

The effects of varying individual inputs on the total cost of VRTI-related illness were evaluated using a univariate sensitivity analysis (Figure 3). As shown in the fig-
ure, the variables on which the precision of the total cost of VRTI is most dependent include the hourly wage of the caregiver and the number of workdays missed by caregivers and those with a non–influenza-related VRTI. If the hourly wage for lost productivity was reduced from $14.35 to $9.63 and all other inputs remained constant, the total cost of illness estimate would decrease to $34.7 billion. Likewise, if the caregiver wage was assumed to be $19.07 (a 33% increase), the total cost would be $44.2 billion.

### Figure 2. Economic impact of non–influenza-related viral respiratory tract infection, by type of medical cost and type of work loss.

### Figure 3. Univariate sensitivity analysis: impact of individual variables on the cost of viral respiratory tract infection (VRTI). The impact of changing the value of selected variables on the total cost of VRTI is shown. Ranges evaluated for individual variables are shown at the ends of the horizontal bars. LRTI indicates lower respiratory tract infection; OTC, over-the-counter; and ED, emergency department.
There were no circumstances in the Monte Carlo simulation or the univariate sensitivity analysis in which the estimated total economic burden of VRTI decreased below $30 billion per year.

Non–influenza-related VRTI has typically been perceived as a self-limiting condition with little or no economic impact on society and the health care system.\(^\text{31,40}\) However, our findings suggest that the resultant clinical and cost ramifications attributable to this common condition impose a significant clinical and economic burden on society, approaching or surpassing the costs of many common diseases (\textbf{Figure 4}). Our $40 billion estimate places VRTI at or above many significant chronic conditions, including hypertension, chronic obstructive pulmonary disease, congestive heart failure, asthma, and migraine, for total annual cost in the United States (\textbf{Figure 4}). The total cost of VRTI is much greater compared with other acute conditions, such as allergic rhinitis.

Given these findings and that antiviral therapies are forthcoming, this common and expensive disease warrants increased attention from clinicians and policy makers. Based on our results, an innovation that can decrease the number of workdays lost, reduce inappropriate antibiotic use, prevent costly complications, diminish physician visits, or reduce viral transmission will likely have a profound effect on the economic burden.

The burden of non–influenza-related VRTI is highly dependent, not surprisingly, on the incidence. Although the published literature\(^\text{9,40}\) reports a wide variability in the range of VRTI incidence, VRTI due to picornavirus—unlike influenza—remains highly prevalent from one year to the next. The National Institute of Allergy and Infectious Disease estimates that the number of colds exceeds 1 billion annually, while the NCHS estimated in 1996 that almost 62 million cases of non–influenza-related VRTI (more specifically, the common cold) required medical attention and resulted in restricted activity.\(^\text{9,8,5}\) The National Institute of Allergy and Infectious Disease estimate is based on research\(^\text{3,15,50}\) indicating that adults experience 2 to 4 non–influenza-related VRTI cases per year and children experience 6 to 8 cases per year. This estimate may not be representative of the US population because of study sample characteristics. Likewise, the NCHS figure is not representative of the overall incidence because cases were only reported if the respondent sought medical attention or had normal activities restricted, indicating a more severe episode. Our survey-based estimate is intermediate among the published values.

If we were to apply the non–influenza-related VRTI incidence estimate from the NCHS to our conceptual framework and self-reported treatment patterns derived from more than 4000 respondents, the total cost estimate would decrease to roughly $5 billion. Likewise, if we were to assume 1 billion episodes, as cited by the National Institute of Allergy and Infectious Disease, the total annual cost of VRTI would approach $80 billion. Our incidence estimate (500 million annual episodes), derived from a representative national sample, provides a reasonable basis for an estimate of the economic burden of VRTI.

Non–influenza-related VRTI should no longer be viewed as a benign self-limited condition treated exclusively with OTC medications. Primary care office visits (>116 million per year) result in a $7.7 billion cost to the health care system. The survey results indicated that 17% of adults and 33% of children who experience a non–influenza-related VRTI episode seek medical attention through either a physician’s office or an emergency department. These figures are similar to those generated from previously conducted epidemiological research.\(^\text{38}\)

In addition to the cost of these visits, VRTIs often lead to inappropriate treatment with antibiotics. Our respondents reported that 39% of adults and 33% of children seek-
ing medical attention for non–influenza-related VRTI receive an antibiotic prescription. These findings are concordant with published studies\(^5\)\(^3\)\(^,\)\(^3\)\(^2\)\(^,\)\(^2\)\(^,\)\(^3\) reporting that 44% and 60% of children and adults, respectively, diagnosed as having non–influenza-related VRTI receive antibiotics. Not only does this behavior result in unnecessary costs but it contributes to the development of antibiotic resistance, a significant public health concern.\(^5\)

The unclear relationship between colds and attributable complications has implications on aggregate cost estimates. We estimate that $4.8 billion is spent annually treating acute sinusitis, otitis media, and lower respiratory tract infections secondary to non–influenza-related VRTI. This estimate is conservative because data were not available to estimate the incremental cost of an asthma or chronic obstructive pulmonary disease exacerbation precipitated by a VRTI episode, despite the fact that non–influenza-related VRTI has been implicated as a major contributor to asthma exacerbations, especially in children.\(^2\)\(^2\)\(^,\)\(^2\)\(^9\) In fact, an estimated 45% to 85% of exacerbations in children are thought to be related to VRTIs.\(^7\)\(^,\)\(^2\)\(^8\)\(^,\)\(^3\)\(^0\)\(^,\)\(^3\)\(^1\) In adults, between 10% and 36% of exacerbations are thought to involve VRTI, depending on severity.\(^2\)\(^9\)\(^,\)\(^3\)\(^2\) Ongoing research will better establish the link between non–influenza-related VRTI and its bacterial sequelae; from this, a more accurate, and likely higher, cost estimate of attributable complications can be made.

One factor contributing to the lack of attention to VRTI is the lack of effective treatments. Symptomatic remedies of varying effectiveness (available OTC and by prescription), including antihistamines, decongestants, antitussives, analgesics, and alternative or complementary preparations, are available. While these treatment options may reduce the severity of certain symptoms, none treat the underlying cause. There are at least 5 treatments under development that target the most common viruses implicated in non–influenza-related VRTI, including 3 virus capsid–binding agents: pleconaril, pirodavir, and tremacamra. Such treatments may soon offer physicians the first therapeutic alternative to actually diminish viral load.

The methods and inputs used in the estimation of the economic burden of VRTI are subject to some important limitations. First, our survey method is subject to respondent recall bias. To minimize the effect of subject recall, a sensitivity analysis was performed to assess how each input variable affected the final aggregate economic estimates.

Second, while our objective was to capture the complete costs of non–influenza-related VRTI, data limitations prevented the inclusion of several important variables, including costs of telephone calls to physicians, costs attributable to VRTI–associated asthma and acute exacerbations of chronic bronchitis, and reduced productivity at work while ill. It is most likely that inclusion of these inputs would further increase the aggregate cost estimates presented.

Third, the data used to estimate the frequency of lower respiratory complications resulting from a non–influenza-related VRTI episode were obtained from the placebo groups of controlled clinical trials conducted in otherwise healthy individuals. Thus, the base-case model underestimates the frequency of such complications in high-risk groups, such as elderly persons, children, and immunocompromised hosts. This limitation likely generates a conservative cost estimate.

Fourth, the effects of viral illness in the workplace were not fully evaluated. Specifically, the effect of viral illness on productivity while at work and transmission to others is critical in setting employer-based policies, such as implementing educational and disease management initiatives. Because most viral transmission occurs among preschool- and school-aged children and their family members, an intervention that slowed transmission would yield substantial benefits.\(^3\)\(^4\)

Fifth, although we took an analytical approach to exclude symptomatic episodes due to influenza, there remains a possibility—despite these best efforts—that some of these self-reported symptomatic episodes were in fact caused by influenza. This limitation is tempered by the fact that influenza accounts for only 9% of total upper respiratory tract illnesses and 13% of upper respiratory tract illnesses that lead to physician consultation.\(^3\) Thus, even if all influenza episodes (an extremely unlikely event) in a respondent were included, our cost estimates would not be expected to vary by more than 10%. Further diminishing this concern was that the 2000–2001 influenza season was mild in the United States.\(^5\)\(^5\)

Finally, inputs were derived from studies using various methods and were generated in different years and thus may not be expected to vary by more than 10%. Further diminishing this concern was that the 2000–2001 influenza season was mild in the United States.\(^5\)\(^5\)

This study was presented in part at the International Society for Pharmacoeconomics and Outcomes Research Fourth Annual European Congress, Cannes, France, November 12, 2001.
REFERENCES