

RESEARCH PAPER

Determining the impact of vitamin C use with the common cold on loss of labour and medical treatment costs for Turkey

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Abstract

Objectives As one of the most common health problems, the common cold may lead to negative consequences such as work or school absenteeism, poor productivity and labour loss. Vitamin C supports immune system defences by supporting the various cellular functions of the immune system, both congenital and adaptive. The purpose of this study is to evaluate the use of vitamin C in white-collar workers and its impact on medical care costs and its impact on the workforce in association with the common cold.

Methods For calculation of the effect of 1000 mg vitamin C daily on the workforce and possible healthcare services costs, a Markov-based model was simulated with 6 cycles consistent with the literature that constituted the model input for the 6-month common cold season. The simulated Markov model included parameters for the number of seasonal flu episodes with or without vitamin C use, the duration of the episodes, productivity loss and daily labour costs. The TreeAge Healthcare Pro 2020 program was used for the Markov model.

Key findings The calculations revealed that the common cold lasted 0.47 days less with vitamin C use. The calculations revealed that the number of days absent from work is 0.38 days more without vitamin C use compared with vitamin C use. The calculations revealed that the medical treatment costs for the common cold is TL 1723.98. According to the analysis conducted based on the Markov model, the total cost of lost productivity and medical treatment that would occur in case of a common cold is TL 3704.97 with vitamin C use and TL 4223.26 without vitamin C use.

Conclusion Based on the results of the analysis, we can suggest that regular vitamin C supplementation may prevent the impact of the common cold on public health and the resulting economic burden.

Keywords: common cold; vitamin C; cost of common cold; productivity loss

Introduction

The common cold is defined as an upper respiratory tract infection caused by different viruses and characterized by symptoms such as coughing or sneezing, sore throat, congested or runny nose, headache, fever, muscle pain or pain in extremities. However, because it is hard to differentiate other upper respiratory tract infections and strains of influenza due to similar symptoms, the description of these diseases is similar.^[1]

The common cold is a heterogeneous group of diseases caused by several viruses that belong to different families. Although it is a disease usually limited to the upper respiratory tract, in some patients, the viral infection spreads to adjacent organs, leading to various clinical consequences and sometimes causes a tendency towards bacterial complications.^[2] The common symptoms are runny nose, sore throat and cough with or without fever.^[3]

The seasonal common cold occurs more frequently in the autumn and winter months. The common cold, a highly contagious disease, spreads rapidly in the community if turns into an outbreak. Although transmission rate varies highly from year to year, it is estimated that 5–20% of the population is infected in an outbreak.^[4] The most important factors responsible for the increasing incidence of the common cold include unhealthy eating habits, high stress levels, poor sleeping habits, sedentary lifestyle, frequent travelling, being in crowded spaces (e.g. commuting by public transportation or working in a crowded office), changes in temperature/climate, exposure to air pollution and smoking.^[5]

In chronic or acute diseases, apart from hazards to the affected person's health, one of the most harmful social and economic consequences of the disease is the restrictions it puts on a person's ability to work and earn their living. Individual and collective results of health problems include decline in job productivity, lost work hours, poor job performance and early withdrawal from the labour market.^[6]

The common cold affects 5–10% of the workforce and causes productivity losses costing billions of dollars.^[7] In the USA, more than 30 000 deaths and 200 000 hospitalizations as well as millions of doctor visits occur due to common cold infections every year.^[8] Additionally, due to the decline in productivity during working hours, the common cold imposes an economic burden on organizations and results in extra costs to health financing sectors. The common cold is a leading cause of acute morbidity and doctor visits and the main reason for school and work absenteeism in high-income countries. The economic burden of the common cold is comparable to that of hypertension or stroke.^[9]

As one of the most common health problems, the common cold may lead to negative consequences such as work or school absenteeism, poor productivity and labour loss.^[10,11] The common cold is among the most frequently encountered conditions in clinical practice. It is the most prevalent cause of work absenteeism and presenteeism. Presenteeism, defined as a decline in performance at work due to the presence of health problems, is usually measured as reduced work output, mistakes on the job, distraction from the work and inability to meet the company's productivity standards.^[12] If the person is obliged to report for their job and work even though they are sick, the frequency of presenteeism increases. Studies show that the majority of adults still go to work when they are sick. Fifty percent of restaurant workers and 60% of healthcare workers say that they still go to work most of the time when they have the common cold or influenza.^[13] Although absenteeism and presenteeism appear to be opposites, managers should consider when sick workers are obliged to come to work in a way that prevents abuse.^[14]

Because the common cold is generally perceived by practitioners as relatively benign with self-limiting conditions that cause minimum effect, it draws less attention than other common clinical conditions. Studies show that the common cold reduces performance in some tasks requiring hand-eye coordination and that these effects may last up to one week after the symptoms have resolved. In general, the negative impacts of the common cold on working life include hindering the learning of new complicated materials, proper functioning of memory, alertness, hedonic tone, daily activities and functional professional performance, as well as delaying mental processing and semantic reaction time.^[15]

The common cold causes a loss of 5–10% of total productivity and billions of liras every year. A study conducted in Turkey in 2013 revealed an annual productivity loss of 2.8 days due to the common cold. The study reported that the labour losses due to the common cold accounted for 92.4% of the total cost.^[8]

Productivity losses due to acute conditions such as the common cold are associated with the number of episodes that occur and the severity of each one. The current data from the studies show that 18.7% of the adults between 25 and 44 years of age and 16.4% of those between 45 and 65 years of age have the common cold in a year.^[6] It is estimated from these data that 20 million working days are lost annually estimated and this is likely an underrepresentation because these estimations involve only cases of common cold that cause one doctor visit and/or limited days of activity. However, estimations based on these data suggest that there may be 70 million working days lost due to the common cold every year with an additional 140 million working days lost due to parents being unable to go to work because they must care for their sick children.^[16]

Many people try to relieve the symptoms of the common cold using prescription or over-the-counter products. These products generally involve high-dose vitamin C (ascorbic acid) supplements. Vitamin C is a potent, water-soluble antioxidant that supports the immune system through increased T lymphocyte activity, phagocyte function, leucocyte mobility and possible antibody and interferon production. Vitamin C is not produced endogenously in humans and is therefore an essential dietary component.^[11]

Vitamin C is a cofactor for various enzymes that play a role in the biosynthesis of collagen, carnitine and neurotransmitters. It is a highly effective antioxidant that protects proteins, lipids, carbohydrates and nucleic acids against exposure to not only free radicals that form during the normal metabolism but also toxins and pollutants (e.g. smoking).^[17] Many experimental studies show that vitamin C affects the immune system. Vitamin C increases proliferative responses of T lymphocytes as well as interferon production and prevents defects in neutrophils.^[18] Vitamin C supports immune system defences by supporting the various cellular functions of the immune system, both congenital and adaptive. Vitamin C supplementation appears to both prevent and treat respiratory and systemic infections.

A meta-analysis study found that vitamin C, when taken regularly during the common cold season, decreased the incidence and the duration of symptoms of the common cold.^[19,20] Vitamin C deficiency causes fatigue, feeling unwell and loss of concentration, while severe vitamin C deficiency leads to scurvy.^[17] A study found that the average duration of the common cold is 6.4 days in those who have vitamin C deficiency and 3.3 days in those who do not and concluded that vitamin C deficiency has a tendency to extend the duration of the common cold.^[21]

The purpose of this study is to evaluate the use of vitamin C in white-collar workers and its impact on medical care costs and its impact on the workforce in association with the common cold.

Method

Data collection

For the study, a general literature review was first conducted on the databases of Google Scholar, Cochrane Library and PubMed for the economic burden of the common cold, its impact on labour loss and the effect of vitamin C on the common cold.

During the literature review, the following keywords were searched in English: 'common cold', 'vitamin C', 'productivity loss' and 'absenteeism'. The review on the treatment costs of the common cold was made in Turkish to calculate the costs in Turkey. No specific time was selected for the literature review, and only studies involving the required data were included in the study.

As a result of a general review in English and Turkish, studies that fit the purpose of this study and that contain the required data were evaluated. The meta-analysis by Ran *et al.* was included in the study because it presents an overall result combining several studies and involves the required data.^[1] The studies included in the meta-analysis were also reviewed, and the data on the number of episodes and the duration of and the number of days absent due to the common cold were obtained from these studies. The data on presenteeism related to productivity loss caused by the common cold were obtained from the study of Dicipinigitis *et al.* because it contains suitable data.^[15] In the review of the treatment costs for the common cold in Turkey, data from Çetin and Ağırbaş's study were included because it provides a detailed presentation of the data and includes

the required information.^[8] The data used in the study are explained in detail in the 'Clinical Data' and 'Economic Data' sections.

In light of the data on possible changes in seasonal common cold events, the duration of common cold episodes, working days lost in common cold episodes, presenteeism and potential productivity loss, which was acquired from the literature review, the effect of vitamin C supplementation at a daily dose of 1000 mg on the workforce and the potential medical care cost savings were calculated.

Clinical data

Number of seasonal common cold episodes

The number of episodes per patient in cases of common cold where vitamin C is used or not used was cited from a study by Anderson *et al.*, which is frequently referenced in a meta-analysis by Ran *et al.*^[1, 22] The study calculated the annual number of common cold episodes as 1.38 with the use of vitamin C and 1.48 without it (Table 1).

Duration of seasonal common cold episodes and number of days absent from work

Data on the duration of common cold episodes (Table 2) with and without vitamin C use and the number of days absent from work in cases of common cold (Table 3) were acquired from the meta-analysis by Ran *et al.*^[1]

For calculation of the duration of seasonal common cold episodes and the total duration of the episodes, the following formulas were used:

$$\text{Duration of the seasonal common cold episodes} = (\text{Study 1} * \text{Sample 1}) + (\text{Study 2} * \text{Sample 2}) + (\text{Study 3} * \text{Sample 3}) + (\text{Study 4} * \text{Sample 4}) + (\text{Study 5} * \text{Sample 5}) / \text{overall sample}$$

Table 1 Number of seasonal common cold episodes^[22]

	Number of patients	Number of episodes	SD
With vitamin C use	561	1.38	0.061
Without vitamin C use	609	1.48	0.056

Table 2 Duration of seasonal common cold episodes^[1]

Studies	With vitamin C use			Without vitamin C use		
	Mean	SD	Sample	Mean	SD	Sample
Lewis 1975a	5.92	3.02	57	7.14	3.12	46
Anderson 1972	5.25	5.99	407	6.02	5.76	411
Anderson 1975b	4.974	6.226	152	5.384	5.087	146
Anderson 1975a	5.047	4.666	150	5.384	5.087	146
Anderson 1974c	5.38	6.54	277	5.4	5.99	285
Overall sample (95% CI)			1043			1034

Table 3 Number of days absent from work in the seasonal common cold^[1]

Studies	With vitamin C use			Without vitamin C use		
	Mean	SD	Sample	Mean	SD	Sample
Anderson 1972	1.3	2.04	407	1.87	2.8	411
Anderson 1975a	1.187	1.739	150	1.61	2.465	146
Anderson 1975b	1.217	1.825	152	1.61	2.465	146
Anderson 1974c	1.7	3.16	277	1.76	2.68	285
Overall sample (95% CI)			986			988

Table 4 Productivity loss in the common cold

	Productivity rate (%)
Without common cold	90
With common cold	64
Productivity loss in the common cold	26.4

Adapted from Dicipinigitis *et al.*^[15]

Total duration of the episodes = Duration of the seasonal common cold episodes * number of episodes

For calculation of the number of days absent from work in the seasonal common cold and the total duration of days absent from work, the following formulas were used:

Number of days absent from work in the seasonal common cold = (Study 1 * Sample 1) + (Study 2 * Sample 2) + (Study 3 * Sample 3) + (Study 4 * Sample 4)/overall sample

Total number of days absent from work = Number of days absent from work in the seasonal common cold * number of episodes

For calculation of the number of days absent from work in the seasonal common cold and the total duration of days absent from work, the following formulas were used:

Number of days absent from work in the seasonal common cold = (Study 1 * Sample 1) + (Study 2 * Sample 2) + (Study 3 * Sample 3) + (Study 4 * Sample 4)/overall sample

Total number of days absent from work = Number of days absent from work in the seasonal common cold * number of episodes

Productivity loss in the seasonal common cold

Data on productivity loss in white-collar workers in cases of the common cold were acquired from the study of Dicipinigitis *et al.*^[15] According to the results of the study, the workers experience a productivity loss of 26.4% in cases where they do not feel well due to the common cold (Table 4).

For calculation of the unproductive workdays for white-collar workers, the following formula was used:

Number of unproductive working days = (Productivity rate without common cold – productivity rate with common cold)/productivity rate without common col.

Economic data

Monthly net income and average employer costs for white-collar personnel

To identify the economic effect of the potential labour loss due to the common cold, the data on the monthly net income of and the percentages of female and male white-collar workers working in Turkey were acquired from the Employee Profile Investigation 2018 conducted by KPMG and the Turkish People Management Association (PERYÖN).^[23] In light of the data obtained from this investigation, the 2020 net income ranges and daily employer costs were calculated for females and males and adjusted for annual inflation based on the net employee incomes for 2018. An annual inflation rate was of 20.30% was used for 2018 and 11.84% for 2019. The calculation was made based on 251 working days for 2020. Table 5 shows the percentage of female and male white-collar workers by net income ranges for 2018.

Table 5 Percentages of females and males by net income ranges for 2018^[23]

Salary ranges	Female (%)	Male (%)
14 999 +	13	18
10 000–14 999	14	10
5000–9999	30	34
3000–4999	24	20
2000–2999	19	18

Table 6 Cost of treating the common cold in 2012^[8]

Nurse salary	15 min	TL 3.44
Family physician salary	15 min.	TL 6.25
Medication costs	Min.	TL 9.22
	Max.	TL 59.63
	Mean	TL 28.73
Cost of pneumonia	(40%) ¹	TL 23.18
Cost of inpatient care	(4.5%) ¹	TL 1541.28
Total		TL 117.04

¹Utilization rate.

For the calculation of average net income for white-collar workers in 2018 and their average inflation-adjusted income for 2019 and 2020, the following formulas were used:

Average net income (2018) = (14,999 * percentage of individuals) + (10,000 + 14,999)/2 * percentage of individuals + (5,000 + 9,999)/2 * percentage of individuals + (3,000 + 4,999) /2 * percentage of individuals + (2,000 + 2,999) /2 * percentage of individuals

Average net income (2019) = Average net income for 2018 * (1 + Inflation rate for 2018 (20.30%))

Average net income (2020) = Average net income for 2019 * (1 + Inflation rate for 2019 (11.84%)).

Cost of treating the seasonal common cold

To identify the cost of the common cold, Çetin and Ağırbaş's study was used.^[8] The difference between the inflation rate in 2012 and that in 2020 was found to be 113.12%. The determined costs were adjusted to 2020 based on the difference in the inflation rate and were included in the analysis. In the analysis, for public hospitals, the cost of a doctor visit for 2020 was taken from the Communiqué on Healthcare Practices (SUT) Supplement 2 – Payment List for Outpatient Presentations and for private hospitals, from Private Health Care Practices 2020 published by the Turkish Medical Association (TTB), and the average coefficient was identified for the 81 provinces to calculate the minimum cost of a doctor visit. The average costs of a doctor visit defined by the SUT and TTB were proportioned to one another, and the difference between them was found.

Çetin and Ağırbaş's study considered medication costs and the charges of the healthcare service providers as direct costs when calculating the cost of the common cold.^[8] When calculating the charges of the service providers, the nurse salary was taken as TL 2200, the average family physician salary as TL 4000, and the time dedicated to each patient was 15 min. The nurses and family physicians were assumed to work an average of 20 days a month and 8 h a day. Table 6 shows the costs taken from Çetin and Ağırbaş's study.^[8]

To adjust the cost of treating the common cold for 2020, the following formulas were used:

Cost of treating the common cold (2012) = Charges of service providers + medication costs + cost of pneumonia * utilization rate + cost of inpatient care * utilization rate

Cost of treating the common cold (2020) = Charges of service providers (2020) + medication costs (2020) + cost of pneumonia (2020) * utilization rate + cost of inpatient care (2020) * utilization rate

Minimum cost of a doctor visit (2020)_{SUT} = Family physician average procedure points * procedure point coefficient

Minimum cost of a doctor visit (2020)_{TTB} = Average coefficient for the 81 provinces * unit

Medication costs (2020) = (medication costs (2012) + (medication costs (2012) * difference in inflation)) * utilization rate

Cost of pneumonia (2020) = (cost of pneumonia (2012) + (cost of pneumonia (2012) * difference in inflation)) * utilization rate

Cost of inpatient care (2020 - public) = (cost of inpatient care (2012) + (cost of inpatient care (2012) * difference in inflation)) * utilization rate

Cost of inpatient care (2020 - private) = (cost of inpatient care (2020 - public) * (minimum cost of a doctor visit_{TTB}/minimum cost of a doctor visit_{SUT})) * utilization rate

Cost of vitamin C

The cost of vitamin C was assumed to be TL 108 for a pack containing 30 tablets at a daily dose 1000 mg. In the analysis, a calculation was made based on 6 packs of vitamin C for 6-month use.

Total cost of seasonal common cold

In light of the information obtained from the literature data, the total cost of the seasonal common cold was calculated considering the labour and medical treatment costs for personnel with or without vitamin C use.

Labor cost = Daily cost of the personnel × (number of episodes × days absent from work per episode + number of episodes × duration of symptoms per episode × productivity loss due to the common cold)

Cost of medical treatment = Number of episodes × average cost of medical treatment per common cold episode

Cost of vitamin C = Cost of vitamin C per Pack × number of use of vitamin C (packs)

Total cost = Cost of labor loss + cost of medical treatment + cost of vitamin C

Economic and workforce effects of seasonal cold

The number of white-collar workers in Turkey was acquired from the workforce statistics published by the Turkish Statistical Institute (TÜİK). Based on the data, there were 14 590 000 white-collar workers in Turkey as of June 2020.^[24]

The economic and workforce effects of the common cold with or without vitamin C use were calculated for 14 590 000 white-collar workers. The average monthly income of the workers was taken as TL 10 000. The daily cost of a worker was accordingly calculated as TL 885.35.

Number of days absent from work due to the common cold = Number of episodes × number of days absent from work per episode × number of white-collar workers

Number of unproductive working days due to the common cold = Number of episodes × duration of symptoms per episode × number of white-collar workers

Total labor loss due to the common cold = Days absent from work due to the common cold + unproductive working days due to the common cold × productivity loss due to common cold

Cost of labor loss = Total working days lost due to the common cold × cost of a worker

Cost of medical treatment = Number of episodes × average cost of medical treatment per common cold episode × number of white-collar workers

Total cost = Cost of labor loss + cost of medical treatment

Model analysis

For calculation of the effect of 1000 mg vitamin C daily on the workforce and possible healthcare services costs, a Markov-based model was simulated with 6 cycles consistent with the literature that constituted the model input for the 6-month common cold season (Figure 1). The simulated Markov model included parameters for the number of seasonal flu episodes with or without vitamin C use, the duration of the episodes, productivity loss and daily labour costs. The values of the data related to the parameters used in the model are specified in the *Findings* section. The TreeAge Healthcare Pro 2020 program was used for the Markov model.

Sensitivity analysis

The sensitivity analysis is conducted to evaluate the effect of the factors in the model on the results of the study.^[25] A tornado analysis was performed as the sensitivity analysis in the simulated Markov model. In economic assessments, tornado diagrams are used to present the result of multiple univariate sensitivity analyses on a single graphic. Tornado diagrams allow the evaluator to assess which parameters have the greatest impact on its results. Typically, horizontal bars are sorted so that those with the greatest propagation (the parameters where the model output is the most sensitive) are on the top of the diagram and those with the least propagation are on the bottom.^[26] In this study, a two-way tornado sensitivity analysis was performed for the Markov model to understand the primary and secondary impact factors of the calculation with a 15% differentiation for use and non-use of vitamin C.

Findings

Duration of seasonal common cold episodes and number of days absent from work

Table 7 shows the duration of seasonal common cold episodes and total duration with and without vitamin C use according to the data from the meta-analysis conducted by Ran *et al.*^[8] The calculations revealed that the common cold lasted 0.47 days less with vitamin C use.

Table 8 shows the number of days absent from work per episode and the total number of days absent from work with and without vitamin C use according to the data from the meta-analysis conducted by Ran *et al.* The calculations revealed that the number of days absent from work is 0.38 days more without vitamin C use compared with vitamin C use.

Productivity loss in the seasonal common cold

According to the data obtained from the study by Dicipinigitis *et al.*, the number of unproductive working days due to productivity loss with the common cold is 0.29 days.^[15]

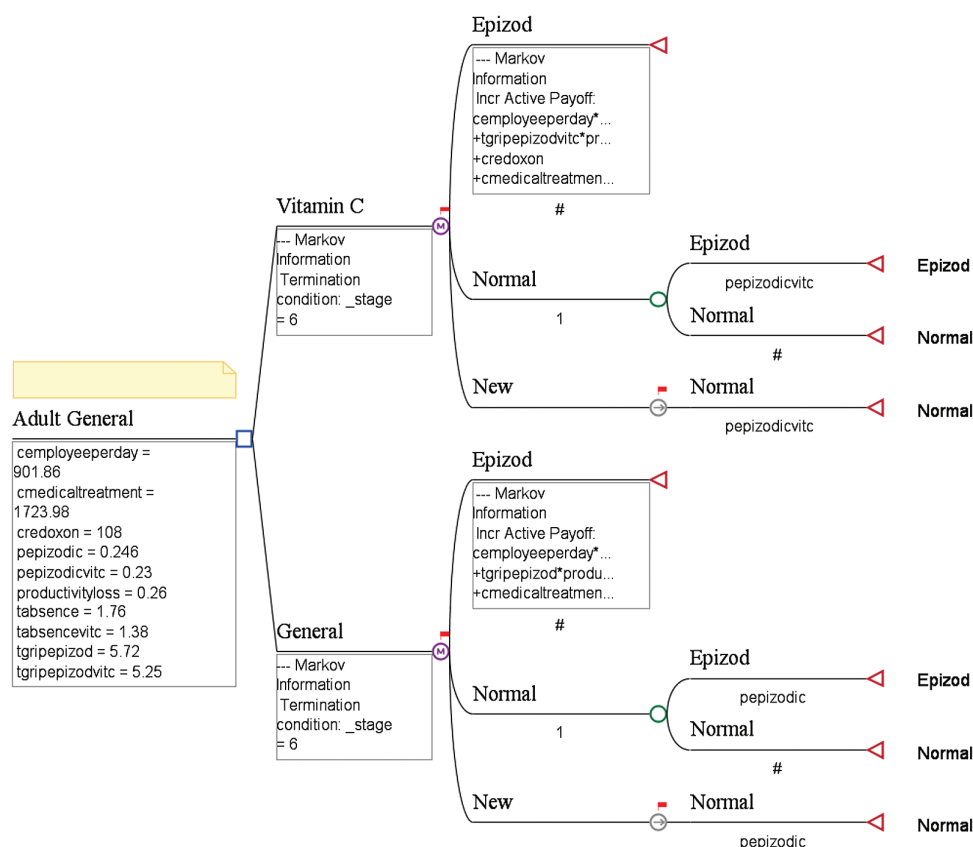


Figure 1 Markov model.

Table 7 Duration of seasonal common cold episodes

	Duration per episode	Total duration
With vitamin C use	5.25	7.25
Without vitamin C use	5.72	8.46
Difference	0.47	1.22

Table 8 Number of days absent from work in the seasonal common cold

	Number of days absent from work per episode	Total number of days absent from work
With vitamin C use	1.38	1.90
Without vitamin C use	1.76	2.61
Difference	0.38	0.70

Table 9 Net income by years

	Female	Male
2018	7422.51	7765.71
2019	8929.28	9342.15
2020	9986.51	10 448.26
2020 Average	10 217.38	

Table 10 Average employer costs for 2020

Average employer costs	2020	Female	Male
Annual		221 055.05	231 677.95
	Mean	226 366.50	
Monthly		18 421.25	19 306.50
	Mean	18 863.88	
Daily		880.70	923.02
	Mean	901.86	

Monthly net income and average employer costs for white-collar personnel

The average net income and employer costs for white-collar workers in 2018, 2019 and 2020 were calculated in light of the data from the PERYÖN study.^[23] The calculations revealed that the net income of an average white-collar worker is TL 10 217.38 for 2020 (Table 9). The daily cost of a white-collar worker to the employer is TL 901.86 (Table 10).

Cost of treating the seasonal common cold

To identify the cost of treating the seasonal common cold, the costs calculated for 2012 were updated with the annual inflation rate and doctor visit charges. The average doctor visit charges were TL 22.68 according to SUT and TL 218.58 according to TTB. The ratio between the average doctor visit charges according to SUT and TTB was calculated as 9.64. While the costs between 2012 and 2020 (public) were updated with the difference in the inflation rate, the inpatient and doctor visit costs for 2020 (private) were calculated according to

Table 11 Cost of treating the seasonal common cold

	Ratio (%)	2012	2020 (public)	2020 (private)
Medication costs	100	TL 28.72	TL 61.21	TL 61.21
Cost of pneumonia	40	TL 23.18	TL 49.40	TL 49.40
Cost of inpatient care	4.50	TL 1541.28	TL 3284.78	TL 31 654.11
Doctor visit	100	TL 9.69	TL 22.68	TL 218.58
Total		TL 117.04	TL 251.47	TL 1723.98

Table 12 Economic and workforce effects of the seasonal common cold for white-collar workers in Turkey

Total absenteeism due to the common cold (days)	38 034 848
Total unproductive working days due to the common cold (days)	123 498 653
Total working days lost due to the common cold (days)	73 712 237
Cost of labour loss	TL 65 260 944 494
Cost of medical treatment	TL 37 226 315 703 ¹
Total	TL 102 487 260 197

¹When calculating the cost of medical treatment, white-collar workers were assumed to receive services from private healthcare service providers.

the ratio between SUT and TTB. The calculations revealed that the medical treatment cost for the common cold is TL 1723.98. Table 11 shows the current cost of treating the common cold.

Economic and workforce effects of seasonal cold

Table 3 evaluates the economic and workforce effects of the seasonal common cold for 14 590 000 white-collar workers. The monthly net income of white-collar workers was TL 10 000 and the daily workforce cost was TL 885.35. According to the results of the analysis for 14 590 000 white-collar workers, the number of days absent from work was 38 034 848, the number of unproductive working days 123 498 653, and the total loss of working days was 73 712 237. A review of the economic effect revealed that the total cost of the common cold was TL 102 487 260 197 (Table 12).

Output of the Markov model analysis

According to the analysis conducted based on the Markov model, the total cost of lost productivity and medical treatment that would occur in case of a common cold is TL 3704.97 with vitamin C use and TL 4223.26 without vitamin C use. The analysis revealed that vitamin C use would save TL 518.28 in terms of workforce and medical care (Table 13).

Sensitivity analysis outputs

A tornado analysis performed to determine the cause of the cost savings with and without vitamin C use revealed that the factor with the greatest impact for cost savings with vitamin C use was the number of episodes due to the common cold. Other impact factors were daily employee cost and medical treatment cost, respectively (Figure 2).

Discussion

Approximately 1 billion cases of the common cold occur in the USA annually. The incidence of the common cold is estimated to increase by 32% particularly in winter. Viruses spread easily, and many patients have the common cold more than once a year. This may cause

Table 13 Results of the Markov model

Cost of productivity loss + treatment of the common cold with vitamin C use	TL 3704.97
Cost of productivity loss + treatment of the common cold without vitamin C use	TL 4223.26
Cost-saving	TL 518.28

frequent doctor visits. The symptoms of the common cold may last for up to 2–3 weeks, which usually translates into lost working days.^[27]

Studies show that the common cold may impose a significant economic burden to individuals, their families, employers and healthcare service providers. The economic burden of the common cold and the flu is estimated to be 10.4 billion dollars annually in the USA. Sick employees and the productivity loss due to mothers who skip work to care for their sick children are estimated to account for 50% of this burden.^[27]

The outbreaks of common cold and flu in Saudi Arabia caused an economic loss of approximately US\$1.1 billion in 2017. Of this loss, 0.4 billion dollars were due to direct costs such as outpatient doctor visits (including the medication and doctor costs) and hospital admissions and 0.7 billion dollars were due to indirect costs (absenteeism and productivity loss). Because the common cold and flu have an immense economic burden on the individuals and the entire community, it is of great importance to adopt treatments that decrease the incidence of infection and/or alleviate the severity of symptoms and/or shorten the duration of disease.^[5]

It is known that the incidence of the common cold and flu may be minimized, the severity of symptoms be alleviated, and the duration of the common cold and flu be shortened by keeping the immune system normal and healthy. Additionally, many studies have established that vitamin C, a basic nutrient found in fresh fruits and vegetables, alleviates the symptoms and shortens the duration of the common cold.^[1, 20]

Cochrane systematic reviews found that vitamin C supplementation shortens the duration of the common cold by 8% in adults and 18% in children.^[20] In addition, data from a double-blind, randomized, placebo-controlled study to evaluate 1000 mg vitamin C plus 10 mg zinc in patients with the common cold showed that there was a decrease of 9–27% in the duration of rhinorrhea.^[3, 17]

As can be seen in the previous studies, common cold puts a notable burden on the economies in different ways, especially through public or private health expenditures and productivity losses. This applies to infectious diseases as well as non-communicable diseases.^[28–30]

In recent years, global economic growth has been driven mostly by developing world economies. The most densely developing countries are BRICS (Brazil, Russia, India, China and South Africa) and N-11 (Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, the Philippines, Turkey and Vietnam).^[31]

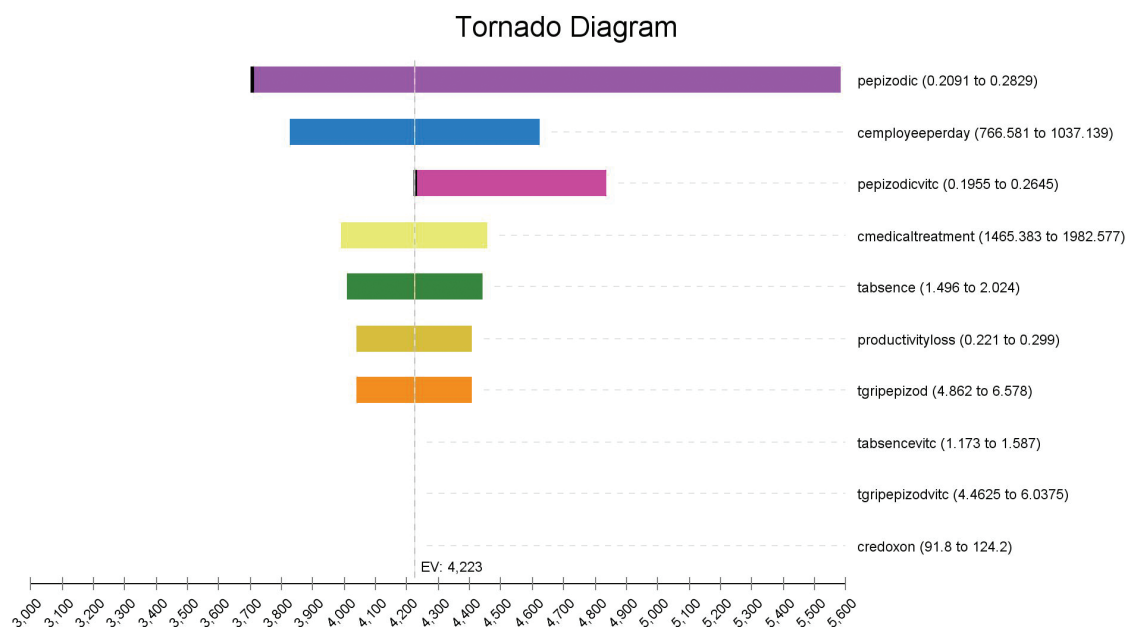


Figure 2 Tornado sensitivity analysis.

The primary goal of the health policies is to protect public health. However, constantly increasing healthcare expenditures have become a significant challenge for the economies of emerging countries to control non-communicable diseases and improve the population's health.^[32, 33]

When examining economic growth on a global scale, Jakovljevic *et al.*, found that since 2017, about half of the economic growth worldwide is attributable to EM7 (China, India, Russia, Brazil, Indonesia, Mexico, Turkey) and only a quarter to the G7 (USA, Japan, Germany, the UK, France, Italy, Canada).^[34] Similarly, another study by Jakovljevic found that per capita health expenditure was almost 4 times higher in G7 countries (4.747 \$PPP) compared with BRICS countries (1.004 \$PPP).^[35] However, when current health expenditures and per capita health expenditures are examined, it is seen that they are quite high in G7 countries compared with EM7 countries. The gross domestic product was found to be higher in EM7 countries compared with G7 countries. This situation is interpreted as giving lower priority to health investments among governments in developing economies and shifting the national budget to other priority areas.^[34]

There is an abundance of studies in the literature on the economic burden incurred by the workforce and the costs of medical treatment due to the common cold. There are also many studies that prove the clinical effects of vitamin C on the common cold. Vitamin C supplementation would alleviate the symptoms and decrease the number of episodes and thus reduce the economic burden. In this study, the results of the Markov and decision tree models demonstrate the economic benefits of 1000 mg/day vitamin C in terms of productivity and healthcare costs. In this regard, the results are similar to other studies in the literature.

Conclusion

According to the World Health Organization, there has been a growing tendency for the common cold and flu to spread around the world in recent years. The seasonal common cold is among the most common diseases in humans and despite great advances in

medicine, it not only has a negative effect on the quality of life, but it also imposes a great economic burden on communities due to work absenteeism.

This study analysed the duration and costs of the common cold with and without vitamin C use in Turkey. According to the results, it was concluded that without vitamin C supplementation, there is an increase in the number of days absent from work per common cold season and the productivity loss experienced even if present at work. A review of the economic results of vitamin C use for 6 months throughout the common cold season, independent of its clinical outcomes, revealed that vitamin C use is cost-saving in terms of both labour loss and medical treatment. Based on the results of the analysis, it is safe to say that regular vitamin C supplementation may prevent the impact of the common cold on public health and the resulting economic burden.

Author Contributions

Data collection: Güvenç Koçkaya. Literature review and writing: Selin Ökçün, Gülpembe Oğuzhan. Data analysis: Mustafa Kurnaz. Idea, interpretation, revision and writing: Selçuk Şen, Burçin Kahveci Kaplan, İsmail Mete Şaylan. All authors contributed to the article and approved the submitted version.

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Conflict of Interest

Mete Şaylan and Burçin Kahveci are employees of Bayer Pharmaceuticals. This study was funded unconditionally by Bayer Pharmaceuticals.

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