

# The Time Trend of Callssuspected of Having A Stroke with The Emergency Medical Services and Its Forecasting for The Next 5 Years in Iran

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## Research Article

**Keywords:** Stroke, Trend, Prediction, Iran, Emergency Medical Services, Time Series

**Posted Date:** February 11th, 2022

**DOI:** <https://doi.org/10.21203/rs.3.rs-1148328/v1>

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## Abstract

**Backgrounds:** Stroke is known as the second leading cause of death and the first leading cause of disability in developing and underdeveloped countries and the annual absolute numbers of people with stroke, stroke survivors, stroke-related deaths, and overall stroke burden have shown an increasing trend. This study was aimed to investigate the time trend of calls for suspected stroke received by the Emergency Medical Services and to predict this trend for the next 5 years in Shiraz, Iran.

**Methods:** This was a descriptive-analytical ecological study with time series data. The required data were extracted from Shiraz Emergency Medical Center between 2013 and 2019. ITSM 2000, Excel 2013 and SPSS, version 19.0 were used to analyze and predict the data.

**Results:** During 2013-2019, a total of 844,004 calls were received by EMS call center in Shiraz city, of which 6,620 calls were suspected of strokes. The number of suspected cases of stroke between 2013 and 2016 demonstrated a steady trend in a certain range, while between 2016 and 2017, it has significantly increased and after that the number of stroke cases has reached a relative stability. In a short time period, like monthly or seasonally, the highest incidence of stroke occurs in February, the coldest month of the year in Shiraz city, and the lowest incidence of stroke occurs in July and August, the warm times of the year in Shiraz city, and this trend is repeated every year. Also, the predict of stroke incidence for the next 5 years indicated that the trend is almost constant with a slight decline, that is the total number of stroke cases will diminish by 6% in 2024 compared to 2019.

**Conclusion:** The results of study demonstrated that the long-term trend of reported suspected calls cases of stroke in EMS is currently stable following an increase in Iran, and it is expected to decline in the upcoming years. Besides, in short-term seasonal trend, the number of reported suspected calls cases of stroke in EMS is higher in cold seasons than in warm seasons.

## Introduction

Stroke is the second leading cause of death and disability in developing and underdeveloped countries (1-3). In the United States, stroke is the 7th leading cause of death (4). As the World Health Organization (WHO), 6.1 million deaths occurred due to stroke in 2019 (5). Although, mortality rates globally have dropped over the past two decades, the absolute number of people with stroke each year, stroke survivors, stroke-related deaths, and overall stroke burden (measured by the disability-adjusted life year (DALYs)) have shown an increasing trend. Temporal changes in stroke incidence as well as mortality from cerebrovascular disease have been investigated in several studies in different countries with various climatic conditions, but contradictory findings have obscured the conclusions (6-11). A systematic review of a population-based stroke study on 28 countries showed an increasing trend in stroke incidence in low-income and middle-income countries. However, there has been a 42 percent reduction in high-income countries over the last four decades (12). In a short-term trend review in Finland, in winter season, the trend of acute ischemic and hemorrhagic strokes was shown to increase seasonally (13).

Since the management of acute stroke is time-dependent, early detection of symptoms and quick transportation to hospital can reduce related mortality and disability (5). EMS personnel should be sophisticated enough to be able to diagnose, examine, manage, treat, triage and transport stroke patients in a timely manner (14). In Iran, the system "724", which provide specific services for acute stroke patients seven days a week and 24 hours a day and the code SAMA (Emergent Stroke) aimed at rapid identification and screening of patients suspected of acute stroke, and establish better communication and coordination between the pre-hospital system and stroke centers for faster transmission by either air or land, have been established since July 2015 (15). It seems necessary to assess factors associated with pre-hospital and hospital delay, the quality of provided care and individual factors associated with timely treatment in any society (16). In Iran, there are challenges and potentials for improvement of stroke care that can be improved by increasing public awareness and creating an organized program in the healthcare system (17).

Fars province located in the south of Iran was established in 1316 as the center of Shiraz metropolis. According to 2016 Census data, the population of Shiraz city is 1,565,572 (29).

The short-term and long-term trend of stroke in Iran is not well-known and also due to the important roles of diagnosis, treatment and early transfer of stroke patients by EMS, this work was carried out to investigate the seasonal trend of the number of calls received by EMS call center in Shiraz city during 2013-2019, and forecasting the frequency of calls for the next upcoming months to help officials and authorities to establish training intervention regarding in order to improve awareness of public and the staff towards system 724 instructions.

## Methods

The current study is a descriptive-analytical ecologic using time series analysis. A time series is a set of statistical data that are collected at regular intervals and the statistical methods that use these statistical data is called time series analysis (18). The data of this work were extracted from 2013 to 2019 from the emergency medical call center of Shiraz city, which was registered by the software in this center, by month and year. In this investigation, all contacts that were established with the Shiraz Emergency Medical Service from 2013 to 2019 and were diagnosed with a suspected stroke according to the diagnosis of emergency medical technicians or the physician of the EMS were participated in our study.

ITSM 2000, Excel 2013 and SPSS version 19.0 were used to analyze and predict the data. Initially, the data were extracted in the form of Excel files from the EMS call recording software at the Shiraz EMS calling center. Then, these data were entered into SPSS and the frequency of suspected cases of stroke was evaluated by month and year, and the number of accidents in different months was determined. Then the data trend was examined separately by year and month in different seasons. Data were entered into the ITSM program and static data analysis was performed. The data fitting was performed to best fit different models. Thus, we used self-correlated seasonal Auto Regressive Integrated Moving Average (SARIMA) to predict the data. In this model, S is the seasonal period, which is selected for the trend of call suspected of stroke between 2013 and 2019. The autoregressive (AR) is the self-correlated model with the order P, and MA is the average mobility with the order Q. The final model for SARIMA is as follows:

$$1. SARIMA (p, d, q) \times (P, D, Q) S$$

In the current study, the fitted model is as follows:

$$SARIMA (0, 1, 3) 12$$

Two tests were applied to ensure the accuracy of modeling and prediction in this work; 1) data randomization following model fitting and prediction using Turning Points method, i.e. the p-value was equal to 1 at a significance level of 0.05 in this method, thus the data are random, indicating the good reliability of the model, 2) Using ACF Residual and PACF Residual in the data prediction model.

## Results

According to the findings of this paper, a total of 844004 calls were received by the Shiraz EMS, which were categorized in 15 separate sections, of which 522266 calls led to the ambulance dispatch, and 6620 of these calls were emergency calls for suspected stroke. Detailed data on calls for suspected stroke by month during the 2013 and 2019 are given in Table 1.

Table 1: Calls related to suspected stroke during the years 2013 to 2019 by year and month

Month	April	May	June	July	August	September	October	November	December	January	February	March
Year												
2013	48	32	49	47	51	51	41	58	59	55	53	42
2014	44	49	54	53	37	56	33	56	57	74	48	50
2015	53	43	31	29	39	35	55	53	54	40	53	55
2016	67	67	52	54	37	39	47	41	36	41	86	65
2017	70	78	71	88	82	117	96	114	107	145	137	130
2018	100	112	112	115	153	114	115	116	126	129	164	131
2019	114	137	127	107	106	131	106	121	139	127	172	115

The results of this study suggest that the number of suspected cases of stroke between 2013 and 2016 revealed a steady trend in a certain range, while a significant elevation was observed in this trend from 2016 to 2017, and afterwards the number of reported cases of stroke reached a relatively stable trend. These results are also shown in Figure 1.

To review and analyze the data with time series, the data on calls for suspected stroke received by EMS in Shiraz city were entered into ITSM. Figure 1 shows the Preliminary image of the data, following entering the ITSM software.

For static data as well as eliminating the seasonal trend of data and estimating the trend of these events, the BOX-COX transformation was first set to zero and DIFFERENCE 12 and 1 were used for the next 5 years. Figure 2 shows the data after the mentioned measures.

Then, in order to determine the order of  $q$  and  $p$  in AR, MA and ARMA models, autocorrelation function (ACF) and partial autocorrelation function (PACF) plots were used. Therefore, the appropriate values of  $p$  and  $q$  were equal to 14 and 11, respectively. Figure 3 shows the ACF/PACF plot.

In the next step, different models were fitted to the data and among the evaluated models, MA model (3) based on innovations method and search for the smallest AICC value by ITSM had the lowest value of Akai index and was selected as the best model. Based on this model, the AICC coefficient was calculated as -24.428596.

Finally, two tests were used to evaluate the reliability of the data prediction model. The P-value of this method was equal to 1 and was statistically significant at the level of 0.05. Therefore, the data were random, indicating the good reliability of the model. Using ACF and PACF in the data prediction model. Given that in both cases, the number of lag times outside the zero range is less than 0% of the total number of lag times, it can be concluded that the time series model is best fitted and the predictions are reliable.

Ljung - Box statistic = 41.209 Chi-Square ( 20 ), p-value = .00350

McLeod - Li statistic = 21.469 Chi-Square ( 23 ), p-value = .55247

Turning points = 46.000~AN(46.000,sd = 3.5071), p-value = 1.00000

Diff sign points = 34.000~AN(35.000,sd = 2.4495), p-value = .68309

Rank test statistic = .11870E+04~AN(.12425E+04,sd = .10073E+03), p-value = .58166

Jarque-Bera test statistic (for normality) = 1.1536 Chi-Square (2), p-value = .56168

Order of Min AICC YW Model for Residuals = 0

The final formed model was as follows:

$$X(t) = Z(t) - .5790 Z(t-1) + .2109 Z(t-2) - .2915 Z(t-3)$$

The results of prediction of trend of suspected stroke calls over the next five years on a monthly basis according to Figure 4 and Table 2 with a 95% confidence interval are as follows:

As shown in figure 4, the overall long-term time trend of stroke incidence after a significant increase between 2016 and 2017, has reached a relative stability and continued to be stable for the next upcoming years. These results are also presented in more detail in Table 2.

Table 2: Forecasting of the number of calls for suspected stroke received by the EMS of Shiraz city during 2020-2024

Year	Month	Prediction	Prediction bounds	
			Lower	Upper
2020	April	109	63	189
	May	127	70	231
	June	123	62	245
	July	103	50	211
	August	102	49	214
	September	127	59	271
	October	102	47	224
	November	117	52	261
	December	134	58	307
	January	122	52	286
	February	166	69	395
	March	111	45	269
2021	April	105	33	334
	May	123	36	419
	June	119	31	452
	July	100	25	400
	August	99	23	416
	September	122	27	528
	October	98	21	455
	November	112	23	543
	December	129	25	651
	January	118	22	620
	February	159	29	874
	March	106	18	607
2022	April	101	14	726
	May	118	15	927
	June	114	12	1009
	July	95	10	911
	August	94	9	964
	September	116	10	127
	October	94	8	1095
	November	107	8	1329
	December	123	9	1620
	January	112	8	1569
	February	152	10	2250
	March	101	6	1590
2023	April	96	4	1873
	May	112	5	2421
	June	108	4	2656
	July	91	3	2432
	August	90	3	2613
	September	110	3	3495
	October	89	2	3055
	November	102	2	3760
	December	116	2	4650
	January	106	2	4567
	February	143	3	6639
	March	96	1	4757
2024	April	91	1	5569
	May	106	1	7273
	June	102	1	8040
	July	85	1	7450
	August	84	1	8102
	September	104	1	10969
	October	84	1	9704
	November	95	1	12091
	December	109	1	15135
	January	100	1	15045
	February	135	1	22134
	March	90	1	16054

The results presented in table 2 indicate that the prediction of stroke incidence is almost constant with a slight decrease, so that the total number of stroke cases in 2024 compared to 2019 will decrease by 21 percent. It was also found that in the short-term trend (e.g. monthly or seasonal) the highest incidence of stroke occurred in February, the coldest month of the year in Shiraz city, whereas the lowest incidence of stroke occurred in July and August, the warm seasons of the year.

## Discussion

The results of our study revealed that the time trend of incidents leading to contact with the EMS call center, suspected of stroke after a raise is currently at a steady annual level, while in seasonal and monthly surveys, this prevalence is more in winter, especially in February compared with other seasons. These findings were well-grounded by other studies. As such, Farhang and colleagues investigated the seasonal prevalence of thrombotic stroke in two seasons, winter and summer of 1998-1999 in Loghman Hakim medical training center and demonstrated that 63% of patients with thrombotic stroke in the neurology ward of Loghman hospital occurred in winter and 37% in summer (19). As well as, Jalkorevic and colleagues assessed seasonal variations in the prevalence of stroke in the Finnish adult population between 1982 and 1992, and reported the prevalence of stroke as 12% higher in winter than in summer (20). However, another cross-sectional study aimed at assessing the frequency of stroke patients who referred to the emergency department in summer and winter in 2020 in Tehran indicated that the prevalence of stroke was higher in hot seasons than in cold seasons (21). These contradictory results may be attributed to the classification of types of stroke. Overall, the prevalence of stroke was shown to be higher in winter than in summer, which may be due to the increased prevalence of respiratory infections in winter season. Respiratory infections can also increase plasma fibrinogen and anti-cardiolipin antibodies and reduce protein C levels (22). Cold climate is also associated with high blood pressure, so cold weather, especially in winter, raises blood pressure, especially in the elderly, and increase the risk of stroke (23).

The results of our study proved that the trend of suspected stroke events is currently in an almost constant annual condition and this stability initiated almost from 2017 and continued until 2019 with a slight decline (e.g. 4 percent in Year), which is expected to continue. This finding was consistent with the results of previous studies. A study on stroke incidence and 10-year survival in Sweden from 1975 to 2001 found that stroke rates and short-term mortality followed a stable pattern in Sweden between 1975 and 1990 (24). The results of other studies have also shown that the incidence of stroke in most industrialized countries was stable from the second half of the 1970s to the end of the 1980s (27-25). Another study conducted between 1990 and 2010, indicated that the number of strokes decreased by approximately 10% in developed countries and increased by 10% in developing countries (28). It seems that in Shiraz city as the representative of Iran, the increasing trend of stroke has ended and the decreasing trend has begun, which demonstrates the end of the silent peak of stroke. This change is similar to the change in disease trends in developed countries where the rate of reduction in the incidence of stroke began many years ago, which may be due to the increased public awareness about risk factors for stroke or lifestyle changes in the community.

## Conclusion

The results of our study disclosed that the long-term trend of reported suspected cases of stroke in EMS after an increase, is currently stable and is expected to decline in the next upcoming years in Iran. Besides, we found that in the short-term seasonal trend, the number of suspected cases of stroke in EMS was higher in cold seasons compared to warm seasons.

## Limitations

One of the limitations of this paper include the Lack of demographic information of callers with EMS for suspected cases of stroke. If this information was available, a more efficient prediction with demographic characteristics could be made.

## Recommendations

It is suggested to conduct future studies in other populations with demographic characteristics and compare the results. Also, we recommend to determine the actual number of calls, suspected of stroke between 2020 and 2024 on the study population and compare the results with the projected results in the present study.

## Abbreviations

**EMS:** Emergency Medical Services

**WHO:** World Health Organization

**SAMA:** Stroke Code in Iran

**SARIMA:** Seasonal Autoregressive Integrated Moving Average

**AICC:** Akaike Information Criterion

**ACF:** Auto-Correlation Function

**PACF:** Partial Auto-Correlation Function

**AR:**Auto-Regressive

**MA:** Moving Average

**ITSM:** Interactive Time Series Modelling

## Declarations

### Ethics approval and consent to participate

This study carried out in accordance with relevant guidelines and regulations (declarations of Helsinki). The authors declare that this study does not contain experiments on humans or human tissues. From the call data of Shiraz pre-hospital emergency center, only the time and type of accident (suspected of having a stroke) were extracted and the demographic information of the calls was not extracted. Although this study excluded from receiving informed consent and this issue has been approved by the ethics committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran and the code of ethics approval for this study is (IR.SSU.REC.1399.268). This study has been approved by the ethics committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran (IR.SSU.REC.1399.268).

### Consent for publication:

Not Applicable.

### Availability of data and materials

The data sets generated and analyzed during the current study are available from the Emergency Medical Services Center of Shiraz, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available, but are available at the reasonable request of the corresponding author.

### Competing interests

The authors declare that they have no competing interests.

### Funding

This study was supported by a grant from Shahid Sadoughi University of Medical Sciences, (8389) Yazd, Iran. The grant supported data collection process. The funders had no role in the design of the study and collection, and analysis, interpretation of data or preparation of the manuscript. The report of the study's findings is sent by the authors to funder at the end of the study.

### Authors' Contributions

S.S & KH.N conceptualized and designed the study.

S.S & MJ.M collected the data. S.S & M.S analyzed the data.

S.S, S.M, KH.N wrote the main manuscript text.

All authors reviewed the manuscript.

### Acknowledgements

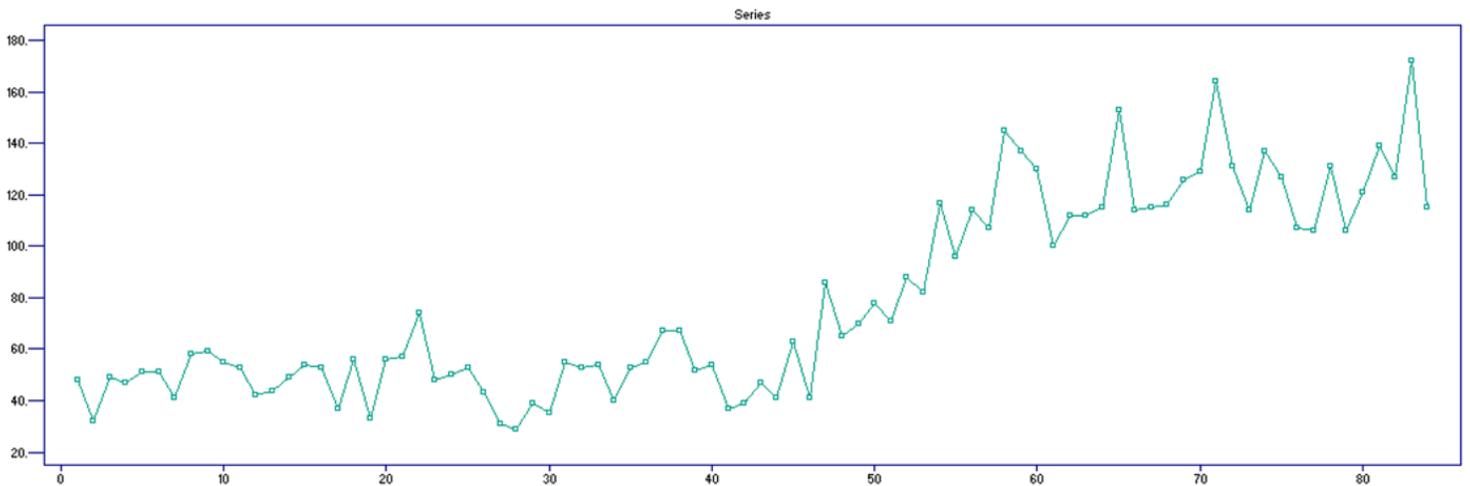
The authors express their gratitude to the Emergency Medical Services Center of Shiraz to make the data available in the study.

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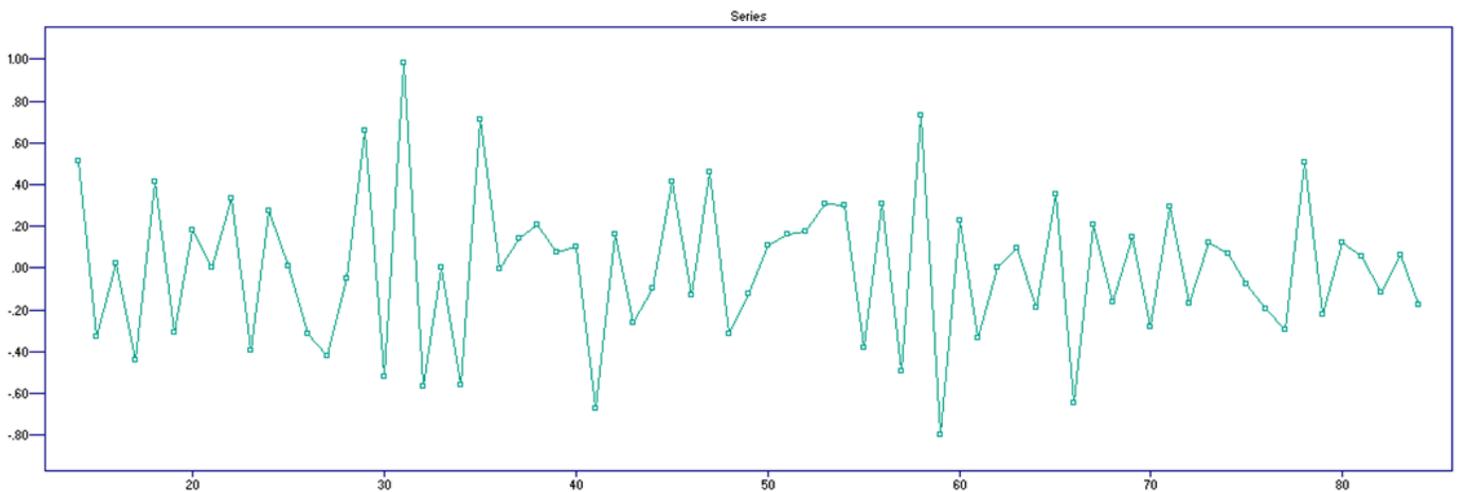
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## Figures



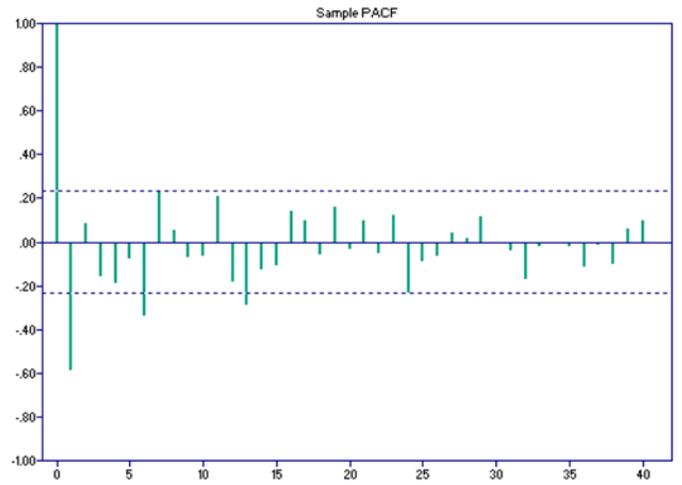
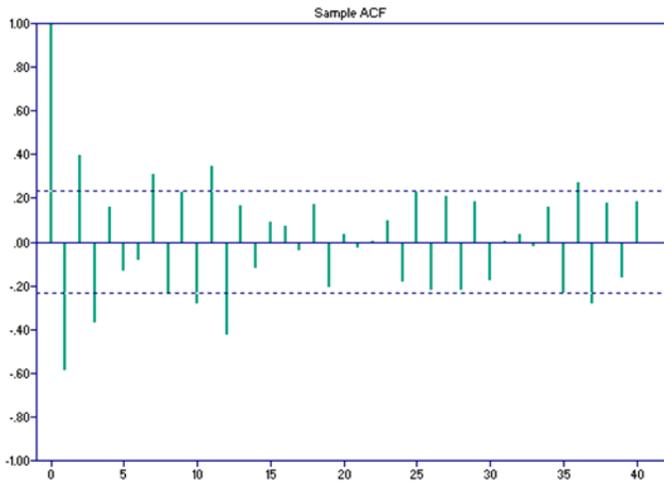
**Figure 1**

Preliminary image of data on suspected cases of stroke between 2013 and 2019, after entering the ITSM software



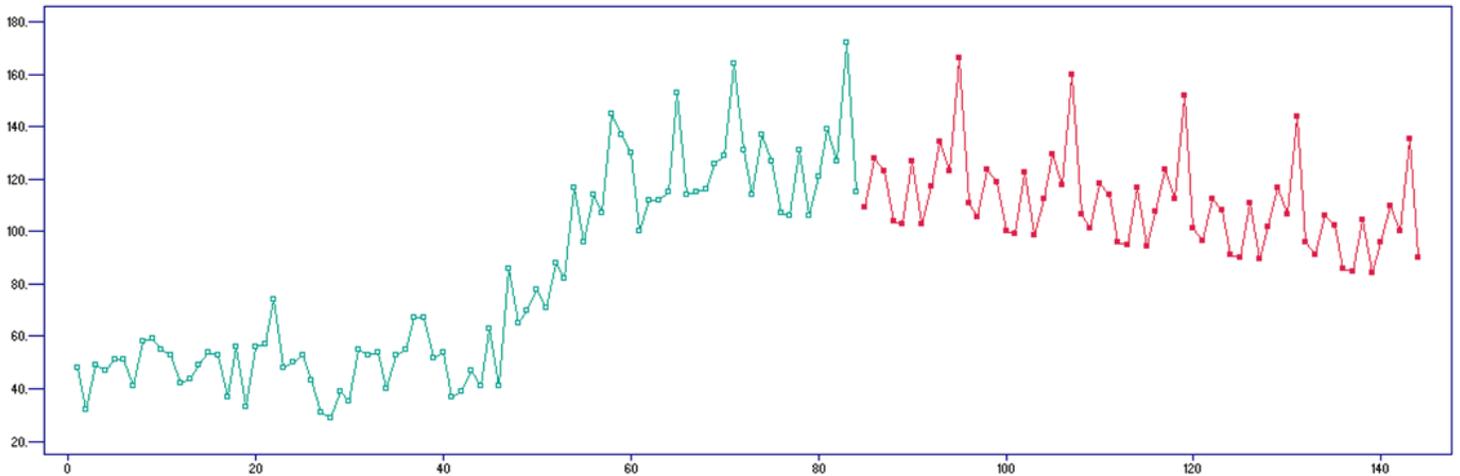
**Figure 2**

Data on suspected cases of stroke during the years 2013 to 2019 after remaining in the ITSM program



**Figure 3**

Image of ACF and PACF data of suspected stroke cases during 2013 and 2019 in ITSM



**Figure 4**

prediction of calls for suspected stroke on a monthly basis over the next 5 years