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FORECASTING MODEL FOR HOSPITAL ATTENDANCE MANAGEMENT

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Abstract

This paper discusses the use of the method of Centered Moving Average as a forecasting model for Hospital Management. The study demonstrated how Medical Directors can make future plans on hospital attendance and exercise control over their hospitals using Operations Research/Management Science (OR/MS) approach. The study recommendations encouraged hospitals, especially, private and government hospitals that have a sense of prompt and effective medical services to engage the services of Operations Research Professionals whose responsibility will be that of helping medical directors to manage hospital attendance using forecasting models. The study concluded with a note that, close monitoring in attendance can help the management of a hospital in planning and exercising control over the running of the hospital; particularly that, the management can use forecasts to make effective decisions affecting whether or not to employ more staff, provide more bed spaces and facilities or to order more drugs in advance.

Introduction

A major objective of OR/MS study is to enable the decision maker to make a better decision by identifying critical elements in the decision making process and providing courses of actions to be taken on those critical elements. A critical element in Hospital management is the ability of a Medical Director to make future plans (Forecasts) operationally, can greatly improve the performance/output of a hospital. Stevenson (2002) pointed out that, for a good forecast, the forecasting technique should be simple to understand and use. Stevenson further argued that, users often lack confidence in forecasts based on sophisticated techniques. They may not understand either the circumstances in which the techniques are appropriate or the limitations of the technique. Not surprisingly, fairly crude forecasting techniques such as intuitive forecasting enjoy widespread popularity because users are more comfortable working with them. However, this study presents a modest forecasting model with detailed explanation which Medical Directors can have confidence in and find it simple to use.

The Problem Situation

In 2009, Gal-Bose, a 32 Bed Capacity Private Hospital in Yola had Monthly Average Attendance of 609 Patients. It is on retainer-ship with over 16 private and corporate organizations and at least 2,000 enrollees from National Health Insurance Scheme (NHIS) apart from individuals and families who take

their treatment with the Hospital. How to device future plans, therefore, become a critical question for Hospital Management. Hospitals, especially private hospitals like Gal-Bose and may be some Government hospitals which have a sense of Standard Health-Care Service Delivery; need OR/MS methods for planning well ahead of time. This will enable Medical Directors to make forecasts of the demand placed on their hospital and to exercise control over these hospitals which they manage. Thus, the problems tacked in this study were:

1 Development of a forecasting model that can make daily/weekly/monthly/quarterly forecasts possible.
2 Identify patterns in the hospital attendance.
3 Provide means for scanning the environment.
4 Alleviation of the stress (emotional, mental and physical) suffered by the Director and Pharmacist every time there is drug shortage or out of stock.

The Model

According to Stevenson (2002), A Moving Average forecast uses a number of the most recent actual data values in generating a forecast. The Moving Average forecast can be computed using the following equation:

$$F_t = MA_n = \frac{\sum_{i=1}^{n} Ai}{n}$$

Where

i = An index that corresponds to periods

n = Number of periods (data points) in the moving average

A_i = Actual value in period i

MA = Moving Average

F_t = Forecast for time period

Data Collected for the Study

Table 1 Weekly Hospital Attendance in 2007

Week	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec.-07
1	68	109	96	91	75	82	131	75	85	102	106	136
2	104	74	103	102	105	76	96	91	104	104	93	118
3	72	124	106	57	85	68	111	91	117	118	85	112
4	108	94	86	122	102	88	66	83	94	107	138	108
5	77	62	81	86	68	119	100	90	67	114	124	100

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2	104	74	103	102	105	76	96	91	104	104	93	118
3	72	124	106	57	85	68	111	91	117	118	85	112
4	108	94	86	122	102	88	66	83	94	107	138	108
5	77	62	81	86	68	119	100	90	67	114	124	100

Table 2 Weekly Hospital Attendance in 2008

We96+ek	Jan-08	Feb-09	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-09	Oct-08	Nov-08	Dec-08
1	159	123	123	87	115	140	141	111	127	114	109	107
2	135	110	101	89	101	107	118	106	135	134	124	91
3	129	120	107	117	100	110	132	128	99	147	101	131
4	139	116	96	91	95	138	125	115	99	139	98	69
5	94	132	101	78	125	92	116	114	81	155	101	79

Table3 Weekly Hospital Attendance in 2009

Week	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec 09
1	110	137	166	90	100	121	151	138	114	98	126	123
2	135	118	120	94	84	114	138	121	129	132	118	128
3	114	118	135	115	128	153	104	96	124	131	121	138
4	136	116	134	98	135	120	133	105	92	107	95	93
5	159	155	155	94	106	89	191	160	183	156	78	31

Table 4. Weekly Hospital Attendance in Jan 2010

week	Jan - 2010
1	95
2	85
3	84
4	103
5	80

Note: Generally speaking, there are 4 weeks in a month. However, most times a month starts or ends some where in the middle of the week; making 5 week-lines on the calendar. In cases where we had 6 week-lines on the calendar, we added the days either of the first line to the second week-line, or of the last line to the fifth week-line depending on which line had fewer days; which were mostly 1 or 2 days. This had no consequence on our calculations since our interest was monthly forecasts; it still gave us the same monthly totals.

Table 5. Monthly Attendance for the Years 2007, 2008 and 2009

Month	2007	2008	2009	2010
Jan	429	656	654	447
Feb	463	601	644	xxx
Mar	472	528	710	xxx
Apr	458	462	491	xxx
May	435	536	553	xxx
Jun	433	587	597	xxx
Jul	504	632	717	xxx
Aug	430	574	620	xxx
Sep	467	541	642	xxx
Oct	545	689	624	xxx
Nov	546	533	538	xxx
Dec	574	477	513	xxx

Table 6. Quarterly Attendance in 2007, 2008, 2009 and Jan. 2010

Quarter	2007	2008	2009
1st Quarter	1364	1785	2008
2nd Quarter	1326	1585	1641
3rd Quarter	1401	1747	1979
4th Quarter	1665	1699	1675

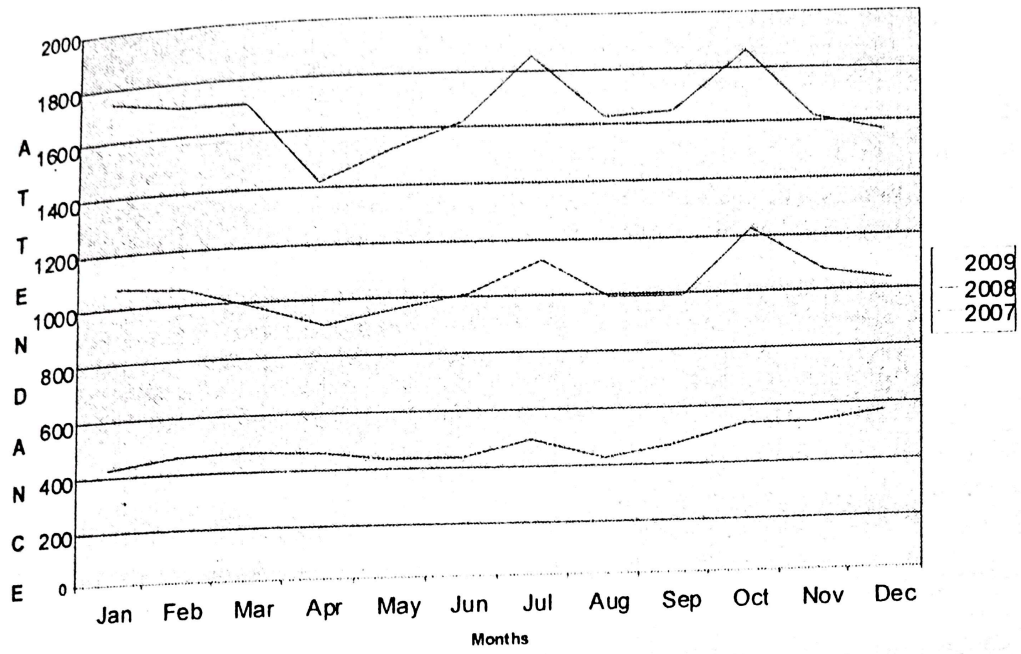
Historical Data

These historical data, Tables 1 to 6, gives much insight about the number of patients that come to the Hospital. It also gives information about the pattern of attendance.

Seasonality

Seasonal Variations in time series data are regularly repeating movements in series values that can be tied to recurring events (Stevenson, 2002). Stevenson further argues that, seasonal variation is also applied to daily, weekly, monthly and other regularly recurring patterns in data. From Figure 1, Seasonality might be observed in the Monthly Attendance for 2007, 2008 and 2009. There is a rise in attendance for the months of February, July and October. However, in the Months of April, August and December, a decrease in attendance is observed.

FIGURE1: ACTUAL ATTENDANCE IN 2007, 2008 AND 2009



Model Application

The seasonality in our data (See Figure 1) leads us to the choice of the Method of Centered Moving Average as a more appropriate technique for analysis. Other models such as Weighted Moving Average and Exponential Smoothing can also handle such Time Series analysis; however, Centered Moving Average is preferred by the researchers.

Advantages of Centered Moving Average

1) Centered Moving Average is useful in obtaining representative values because, by virtue of its centered position – it looks forward and looks backward - it is able to closely follow data movement whether they involve trends, cycles or random variability alone (Stevenson, 2002)
2) Centered Moving Average is most representative of the corresponding time point in the series (Stevenson 2002).
3) The resulting values in Centered Moving Average are associated with a time point rather than the mid-point of the interval between two successive time points (http://itl.nist.gov: engineering stat handbook)
4) Centered Moving Average is useful in measuring the seasonal variations (Robert, 1990)
5) Centered Moving Average smooth out short-term fluctuations in data (Robert, 1990)

6) Centered Moving Average employs the most recent observations to calculate an average, using the result as the forecast for the next period (Stevenson, 2002)

Disadvantages of Centered Moving Average

1) The trend does not have figures for all period because we lose 6 points at each end. According to Freund and Williams (1992), the missing values at the beginning and at the end of artificial series are characteristic of moving averages of this sort; we lose one value at each end for a three-year moving average, two for a five-year moving average, three for a seven-year moving average and so on. This is often of no consequence. Thus, the 6 months lost, as in our case (see Table 11), has no consequence.
2) Each trend figure is calculated over a limited number of periods and all earlier data is ignored (hppt://www.mathsyards.com)
3) The method requires that we choose a suitable period as a basis for calculation, which is not always self-evident (http://www.mathyards.com).

In spite of the above disadvantages, Centered Moving Average is still preferred because of its dominating advantages. Since the number of periods needed in a Centered Moving Average must be equal to the number of "seasons" involved, a 12-period moving average is needed with monthly data as in our case (See Table 11).

Table 11 12-Point Moving Average and Seasonal Relatives.

Year	Months	Actual Attendance	MA_{12}	CMA_{12}	Seasonal Relatives
2007	Jan-07	429			
	Feb-07	463			
	Mar-07	472			
	Apr-07	458			
	May-07	435			
	Jun-07	433			
	Jul-07	504	479.6667		
	Aug-07	430	498.5833	489.1250	1.030411
			510.0833	504.3333	0.852611

	Sep-07	467		512.4167	0.911368
			514.7500		
	Oct-07	545		514.9167	1.058424
			515.0833		
	Nov-07	546		519.2917	1.051432
			523.5000		
	Dec-07	574		529.9167	1.083189
			536.3333		
Year	**Month**	**Actual Attendance**	**MA_{12}**	**CMA_{12}**	**Seasonal Relatives**
2008	Jan-08	656		541.6667	1.211077
			547.0000		
	Feb-08	601		553.0000	1.086799
			559.0000		
	Mar-08	528		562.0833	0.939362
			565.1667		
	Apr-08	462		571.1667	0.808871
			577.1667		
	May-08	536		576.6250	0.929547
			576.0833		
	Jun-08	587		572.0417	1.026149
			568.0000		
	Jul-08	632		567.9167	1.112839
			567.8333		
	Aug-08	574		569.6250	1.00768
			571.4167		
	Sep-08	541		579.0000	0.93437
			586.5833		
	Oct-08	689		587.7917	1.172184
			589.0000		
	Nov-08	533		589.7083	0.903837
			590.4167		
	Dec-08	477		590.8333	0.807334
			591.2500		
2009	Jan-09	654		594.7917	1.099545
			598.3333		
	Feb-09	644		600.2500	1.072886
Year	**Month**	**Actual Attendance**	**MA_{12}**	**CMA_{12}**	**Seasonal Relatives**
			602.1667		
	Mar-09	710		606.3750	1.170893
			610.5833		
	Apr-09	491		607.0189	0.808871

		603.4545	604.5189	0.914777
May-09	553	605.5833	605.5833	0.985826
Jun-09	597	605.5833		
Jul-09	717			
Aug-09	620			
Sep-09	642			
Oct-09	624			
Nov-09	538			
Dec-09	513			

Note

$\mathbf{MA_{12}}$ =12-Point Moving Average of the Attendance

$\mathbf{CMA_{12}}$ = Centered Moving Average of 12: Whenever an even-numbered moving average is used as a Centered Moving Average (e.g. MA_4, MA_6, MA_8, ...), the center is not obvious; hence, a second Moving Average – a two-point Moving Average is used to achieve **correspondence** with period. This procedure is not needed when the number of periods in the Centered Moving Average is odd (e.g. MA_3, MA_5, MA_7 ...) (Aczel, 1999; Andre, 2004; Kress, 1994; Stevenson, 2002)

Seasonal Relatives = Monthly Attendance ÷ $\mathbf{CMA_{12}}$**:** "This is percentage of Average. The Seasonal percentages in the multiplicative model are referred to as Seasonal Relatives or Seasonal Indexes" (Stevenson, 2002). According to Freund and Williams (1992), Seasonal Relatives is the measure of movements in a time series which recur more or less regularly in the same months of successive year. For example, In Table 4.10, the Seasonal Relative for July 2007 is 1.03 approximately. This indicates that, Hospital Attendance for July 2007 was 3 percent above the monthly average. A seasonal Relative of 0.85 as in August 2007 indicates that, the Hospital Attendance in August 2007 was 85 percent of the monthly average or 15 percent below the monthly average.

Deseasonality

To deseasonalise data is to remove the seasonal component from the data in order to get a clearer picture of the non-seasonal (e.g. Trend) component (Armstrong, 2001; Brooks, 1974; Nicholas, 1998; Stevenson, 2002). This is done as follows:

First: Standardize the seasonal relatives of each month (see Table 12). The Standardized Seasonal Relatives (S.R), also known as Adjusted S.R, is obtained by multiplying each of the month's average by 12/ (total of average S.R.). The standardized seasonal relatives must be adjusted so that they equal to 12 (12 months, the number of periods).

Table 12 Average and Standardized Seasonal Relatives

Months	Monthly S.R.	Total	Ave S.R.	Standardized S.R.
Jan	1.2111+1.0995 =	2.3106	1.1553	1.15625
Feb	1.0868+1.0729 =	2.1597	1.0799	1.08074
Mar	0.9394+1.1709 =	2.1103	1.0551	1.05602
Apr	0.8089+0.8089=	1.6178	0.8089	0.80957
May	0.9295+0.9148 =	1.8443	0.9222	0.92291
Jun	1.0261+0.9858 =	2.0119	1.0060	1.00683
Jul	1.1128+1.0304=	2.1432	1.0716	1.07248
Aug	1.0077+0.8526 =	1.8603	0.9302	0.93091
Sep	0.9344+0.9114 =	1.8458	0.9229	0.92366
Oct	1.1722+1.0584 =	2.2306	1.1153	1.11622
Nov	0.9038+1.0514 =	1.9552	0.9776	0.97840
Dec	0.8073+1.0832 =	1.8905	0.9453	0.94603
Total			**11.9902**	**12**

Note

Standardized Seasonal Relatives = (Average Seasonal Relative × 12 Months) ÷ (Total Average Seasonal Relatives). The Standardized Seasonal Relative provides an estimate of the true seasonal relative for each month (http://www.mathyards.com)

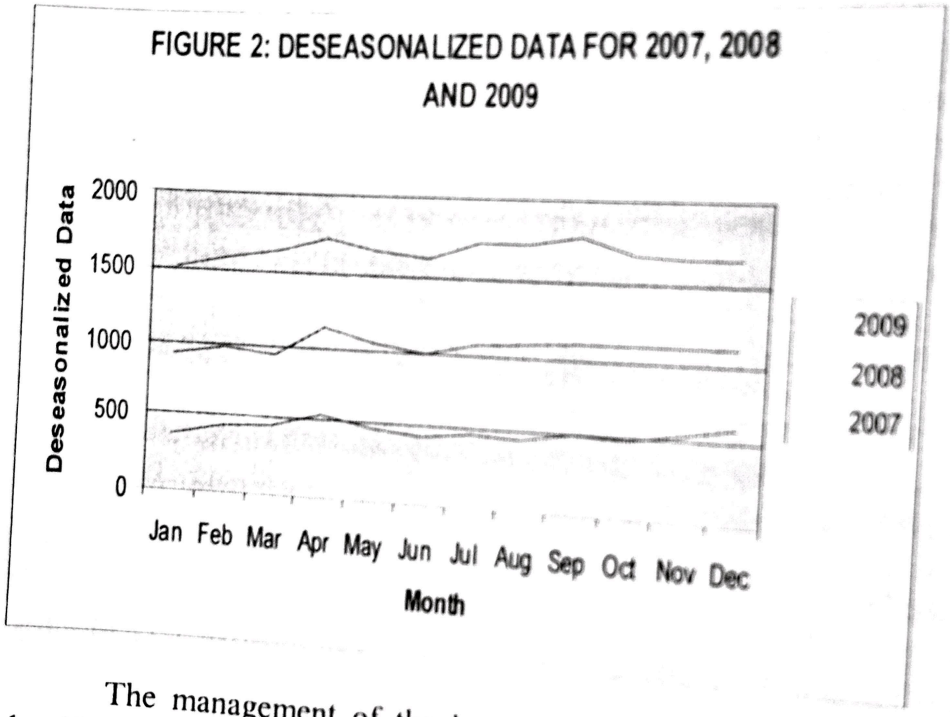
Second: Deseasonalize the data by dividing actual data (attendance) for each month by its standardized S.R. that is, Actual Data ÷ Standardized Seasonal Relatives. (See Table 13).

Table 13. Deseasonalised Data in 2007, 2008 and 2009

	Actual Attendance (X)				Deseasonalized Data (X/T)		
Months	2007	2008	2009	Standardized S.R (T)	2007	2008	2009
Jan	429	656	654	1.15625	371.0273	567.3518	565.6221
Feb	463	601	644	1.08074	428.4113	556.1019	595.8896
Mar	472	528	710	1.05602	446.9626	499.9920	672.3378

Apr	458	462	491	0.80957	565.7363	570.6772	606.4989
May	435	536	553	0.92291	471.3365	580.7732	599.1933
Jun	433	587	597	1.00683	430.0642	583.0201	592.9522
Jul	504	632	717	1.07248	469.9387	589.2882	668.5437
Aug	430	574	620	0.93091	461.9116	616.5982	666.0120
Sep	467	541	642	0.92366	505.5983	585.7145	695.0623
Oct	545	689	624	1.11622	488.2567	617.2639	559.0315
Nov	546	533	538	0.97840	558.0522	544.7652	549.8756
Dec	574	477	513	0.94603	606.7483	504.2142	542.2681

FIGURE 2: DESEASONALIZED DATA FOR 2007, 2008 AND 2009



The management of the hospital can study the Trend in Figure 2 to identify the underlining factors to see whether they can consistently achieve an upward movement in the Hospital Attendance

Forecasting

Develop a 12-month forecast (based on the number of periods) for 2010 using a 12-Month Moving Average based upon the centered moving average attendance series (CMA_{12}). First, you will have to "fill in" the data for the months of July – December 2009 in Table 11. Just make each of these months the average of the previous 12 months (see Table 14).

Continue this method to make your forecasts for the months of January through December, 2010 (see Table 15). Note that you will be using some of your early forecasts as the basis for your later forecasts. (http://www.mathyards.com/ise/mm).

Table 14. Filling the Lost Points at the end of Table 11

Year	Month	Actual Data	CMA12
2008	Jul-08	632	567.9167
	Aug-08	574	569.6250
	Sep-08	541	579.0000
	Oct-08	689	587.7917
	Nov-08	533	589.7083
	Dec-08	477	590.8333
2009	Jan-09	654	594.7917
	Feb-09	644	600.2500
	Mar-09	710	606.375
	Apr-09	491	607.0189
	May-09	553	604.5189
	Jun-09	597	605.5833
	Jul-09	717	591.9511
	Aug-09	620	593.9539
	Sep-09	642	595.9813
	Oct-09	624	597.3965
	Nov-09	538	598.1968
	Dec-09	513	598.9042

Note: The CMA_{12} for July 2009 is the average of the previous 12 months from July 2008 to June 2009. That of August 2009 is the average of the previous 12 months from August 2008 to July 2009, and so on.

Table 15 Monthly Forecasts for 2010

Month	CMA12 (C)	Standardized S.R (S)	2010 Forecast (C*S)	2010 Actual Attendance (T)	Forecast Accuracy (T - (C*S))
Jan	603.0896	1.1562	697	447	-250
Feb	603.8440	1.0807	653		
Mar	604.2034	1.0560	638		
Apr	603.9621	0.8096	489		
May	603.5800	0.9229	557		
Jun	603.4459	1.0068	608		
Jul	603.0896	1.0725	647		
Aug	603.0896	0.9309	561		
Sep	603.0896	0.9237	557		
Oct	603.0896	1.1162	673		
Nov	603.0896	0.9784	590		
Dec	603.0896	0.9460	571		

Note: The CMA_{12} for January 2010 is the average of the 12 months from January to December 2009, in Table 14. That of February 2010 is the average of the 12 months from February 2009 to January 2010, and so on.

Interpretation of Model Application

The forecast for a particular period (month) is obtained by multiplying the Centered Moving Average for the particular period (month) by the Standardized Seasonal Relative for the period (month). See Table 15. the reason for this is to re-seasonalize the forecast so as to become more real. In other words, 2010 forecast in Table 15 is a re-seasonalized data which has already been deseasonazed to some extent by reason of centered moving averages. Centered moving averages reduce seasonal fluctuations, thus, they are called Trend Values in some literatures. Once seasonal fluctuations are removed from data, what remains is the trend. According to Stevenson (2002), Trend is a long-term upward or downward movement in data.

A forecast for the next year (e.g. 2011) will be made once actual data for a particular year (e.g. 2010) is obtained at the end of the year. In actual terms, the more number of Monthly Seasonal Relatives we have, the better our forecast will be. We hope for a much better forecast when more data is added to the available three year data.

An example, the actual attendance in January for the 3 years is as follows:

January 2007 429

January 2008 656

January 2009 654.

Our model made a forecast of 697 people in attendance for January 2010. The actual attendance recorded for the month (January 2010) was 447. A forecast error of -250 was recorded. This has nothing to do with the trust-worthiness of our model. The reason for the massive disparity between our forecast and the actual attendance is likely because the Principal Doctor, Dr. Jalal Saleh has been away from December 2009 till date (8th February 2010). Attendance generally decline once the Principal Doctor is not available for consultations.

Conclusion

Close monitoring in attendance can help the management of a hospital in planning and exercising control in the running of the Hospital. The management can use forecasts to make decisions affecting whether or not the hospital should do the following and much more:

1. Employ more staff to cope with the expected increased attendance
2. Provide more bed spaces
3. Provide more facilities
4. Order for more drugs
5. Expand or relocate if the space cannot accommodate the hospital in the near future
6. Know how well or bad the hospital is performing.

Recommendations

Based on the findings from the study, we recommended that, Gal-Bose hospital should

1 Work with the Forecast of 2010 that is made in this study.

2 Investigate the unusual decrease in attendance in January 2010 and treat it accordingly

3 Study the Monthly performance of the Hospital Attendances for 2007, 2008 and 2009 (See Table 5), to discuss how best to improve the performance of the hospital. New graphs can be created on other indices such as number of Births, Deaths, Admissions and so on to ensure proper management and control of the hospital.

4 Employ an Operations Research graduate who will be saddled with the responsibility of handling database issues which include forecasting, and helping other hospital staff to up-date their information while they are trying to become proficient in the use of the new computerized system.

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