

## FORECASTING DRUG DEMAND USING THE SINGLE MOVING AVERAGE 3 PERIODE AT UGM ACADEMIC HOSPITAL

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### ABSTRACT

Drug management at the Academic Hospital of Gadjah Mada University found that the damaged and expired drugs amounted to 4.71% and the dead stock was 7.89%. One of the influential factors to contribute to the considerable amount of damaged and expired drugs and dead stock is inaccurate planning. Forecasting is one aspect of planning, which helps predict the upcoming event as a way to make planning more effective and efficient. One of the forecasting methods is the 3-period Single Moving Average (SMA). This study aims to forecast drug demand in January 2021 at the Academic Hospital of Gadjah Mada and to see the size of the error using the 3-period SMA method. This is an observational study with the retrospective descriptive analysis. The research population is all drugs used at the Academic Hospital of Gadjah Mada in January 2018-December 2020. The samples are the top 5 most used drugs based on A category resulted from the ABC analysis of consumption in 2020 with certain criteria using purposive sampling technique. The drug demand was forecasted using Eviews 12 software and its error size, particularly the Mean Absolute Percentage Error (MAPE) was calculated using Microsoft Excel. The results showed that the forecast of drug demand in January 2021 was Tutofusin Ops 500ml 496pcs, Hemapo 2000 IU/ml 290pcs, Hemapo 3000 IU/ml 219pcs, Abilify Discmelt 10mg 717pcs, and Otsu-NS Piggyback 3736pcs. The calculated MAPE value was 8-32%, which means that the 3 period SMA forecasting is acceptable and reasonable for further application at the Academic Hospital of Gadjah Mada.

**Keywords:** Forecasting; Single Moving Average; MAPE

## 1. INTRODUCTION

Hospitals need planning to ensure that the stock of drugs accord with the right type, be available on time, be in the right amount, and become efficient. Planning is intended to avoid stockouts using accountable methods and basic planning, such as consumption method, epidemiological method, a combination of consumption and epidemiological methods and in accordance with the existing budget (Kementerian Kesehatan RI, 2016). Previous researches revealed that many hospitals are lacking of appropriate planning and controlling inventory. Consequently, this leads to some problems, including drug vacancies, excessive stock, expired drugs and damaged drugs (Kementerian Kesehatan RI, 2019).

A research at RSU Haji Surabaya found that stagnant and stockout of drugs had an impact on soaring costs, and considerable losses for the hospital (Mellen & Pudjirahardjo, 2013). A number of stagnant drugs will take up space and can increase storage costs (Dewi et al., 2020). One of the planning indicators is the percentage of expired or damaged drugs. The large percentage of expired drug illustrates inaccurate planning and/or poor quality observation in storage, and/or changes in prescribing patterns or existing disease patterns (Satibi, 2016).

A research by [Taufiqurohman et al \(2021\)](#), which was conducted at the Pharmacy Installation of the Academic Hospital of Gadjah Mada University (RSA UGM) on May 1-October 31 2019 found that the percentage of damaged and expired drugs was 4.71% and the percentage of dead stock was 7.89%. In fact, this finding exceeds the acceptable standard percentage of damaged and expired drugs of 0-0.25%, while the standard percentage of dead stock is 0% ([Pudjaningsih, 1996](#)). Dead stock refers to drug supplies in the inventory that is never used or purchased in 3 consecutive months. Dead stock is attributed to some factors, including inaccurate planning, lack of doctor commitment, and lack of officers' understanding on the effect of dead stock ([Akbar, 2016](#)). This situation allows RSA UGM to require an appropriate and effective forecasting methods for planning because according to [Satibi \(2016\)](#), forecasting is an attempt to predict and estimate future conditions, as well as minimize deviations.

Accurate drug supply planning is essential in overcoming problems related to drug availability. The ups and downs of drug demand that occur every year become a separate problem for the warehouse team in planning the procurement based on demand. The occurrence of drug shortages certainly leads to sudden orders, which results in higher purchase prices. In addition, the incidence of drug shortages will put health services at risk (clinical impact) and cause numerous problems for hospitals ([Dewi et al., 2020](#)). Forecasting techniques are needed to help estimate future drug demands ([Akbar, 2016](#)).

There are various forecasting methods, but the most commonly used is the time series method. This method is based on the assumption that the pattern of past demand serve as good indicators for the future ([Zahra, 2020](#)). There are several time series methods, including SMA, single exponential smoothing (SES), BOX-JENKINS and there are other methods ([Lumy, 2012](#)). The SMA method uses actual data from the previous period to generate forecasting scores in the future. This method is characterized by the requirement for historical data for a certain period of time in forecasting the upcoming demand. The longer the period of historical data used, the more visible the smoothing effect in the forecast, resulting in a smoother moving average ([Arsyad, 2009](#)). This study referred to data that did not contain any element of trend or seasonal factors. The advantages of this method are ease of calculation and simplicity ([Irawan et al., 2021](#)). Currently, a number of softwares can be directly used for ease of forecasting, one of which is Eviews 12. The formula for the moving average equation is written as follows:

$$F_t = (Y_{t-1} + Y_{t-2} + \dots + Y_{t-n}) / n \quad (1)$$

Where

- $F_t$  : forecast score in period t  
 $Y_{t-1} + Y_{t-2} + \dots + Y_{t-n}$  : the amount of data for the previous n periods  
n : number of periods in the moving average

The accuracy of the forecasting method is determined by looking at the size of the error. Almost all error measures are resulted from the average of some functions of the difference between the true value and the forecast score. One measure of error that is often used is the Mean Absolute Percentage Error (MAPE).

MAPE is calculated by finding the absolute error of each period, then dividing it by the true value in that particular period, and finally averaging the percentage. MAPE is sometimes considered more useful in calculating forecasting errors when compared to its absolute value ([Lumy, 2012](#)). A smaller error value indicates a better forecasting method.

SMA forecasting aims to eliminate or reduce randomness in the time series ([Arsyad, 2009](#)). In the 3 period SMA forecasting method, the forecast for a month is resulted from the average of the previous 3 months ([Subagyo, 2000](#)). On this basis, this research aimed to conduct a 3-period high school forecasting simulation at the pharmacy installation of RSA UGM. This study resulted in MAPE values as a description resulted from the application of SMA 3 Periods.

## 2. METHOD

This is a retrospective descriptive analysis study, which aims to determine the forecast score for drug demand in January 2021 at the UGM RSA and calculate the error size of the 3 period SMA method. The research population in this quantitative study is all data on drug use at the Pharmacy Installation of RSA UGM in January 2018-December 2020. The research samples referred to data on the use of the top 5 most used types of drugs based on A category, resulted from ABC analysis of consumption in 2020 with inclusion and exclusion criteria. The inclusion criteria were drugs that were included in A category in 2018, 2019, 2020, while the exclusion criteria were drugs with incomplete drug use history for 36 months. The samples were selected using purposive technique derived from retrospective data on drug use in January 2018-December 2020. This study used the Annual Medical Material Sales report file as the research instrument. The report used the 2018-2020 report, which contains the name of the drug, the price of the drug, and the amount of use. The data from instrument were analyzed using Eviews12 and Microsoft Excel.

This research began with determining the research samples. The samples were determined based on the results of the ABC analysis of the annual medical material sales report file (downloaded from the Management Information System of RSA UGM). Reports on sales of medical materials (or drug use data) for 2018, 2019 and 2020, were analyzed by ABC, respectively. Category A drug items in 2020 were then listed in the top 5 most used drugs and according to the inclusion and exclusion criteria were used as research samples. Category A was for drugs which made up 20-30% of the total items and spent 75-80% of funds. Category B referred to drug classification which accounted for 25% of the total item and used 15-20% of funds. Category C was drugs which made up 50% of the total item and spent 5-10% of funds. The five samples were tested for forecasting using the 3 period SMA method using Eviews 12 software. Afterwards, the forecast results and real data were used to calculate the MAPE error size using Excel with formula 4.

Forecasting test was done by opening Eviews 12 and opening a new workfile by clicking create a new Eviews workfile. In this study, Workfile structure type used to determine the data structure was **dated** (determine time series data). The data specification was selected monthly because it used monthly data. Start date was filled with the initial period of data, and end date was filled with the end period of data + period to be predicted, before it was clicked Ok. The drug usage file was entered per item.xls in the workfile by **File>import>import form file>Finish**. Data were presented in Excel form for ease of use rather than manual input. Forecasting tests using 3-period SMA was conducted by selecting **Quick>Generate Series**, and the **Enter Equation** column would appear to write the formula for the SMA method. The formula for the 3-period SMA was  $movav3=@movav(sum,3)$ . @movav (abbreviated from moving average) and it was in brackets, which means that the degenerate variable is a variable with the number and 3 periods. The step was considered successful if a new file appeared in the workfile, namely movav3 as the result of forecasting. movav3 data in the first 2 periods would appear as Not Available (NA), since the value that appeared first was the average result from period 1 to 3 of the actual data and was the forecasting result for period 4. The results of movav3 were then entered into Excel table to calculate its MAPE. In subsequence, MAPE results were interpreted to see the applicability of the forecasting method. MAPE calculation can systematically be formulated as equation (2). The resulted MAPE score was then interpreted according to [Table 1](#).

**Table 1.** Interpretation of MAPE Scores

MAPE (%)	Interpretation
<10	Forecasting is very accurate
10-20	Good fortune telling
20-50	Reasonable forecast
>50	Inaccurate forecast

Source : Lewis (1982) in ([Moreno et al., 2013](#))

$$\text{MAPE} = \left( \sum_{t=1}^n \left| A_t - F_t \right| / A_t \right) \times 100\% \quad (2)$$

### 3. RESULTS AND DISCUSSION

This study used data on drug use at the RSA UGM in January 2018 - December 2020 with movement data 3. The data on drug use were taken from the annual sales report file of medical materials, which contained data on drug names, drug prices, and the amount of drug use taken/downloaded from the Management Information System of RSA UGM. The top five types of category A drugs that were selected as samples were Tutofusin Ops 500ml, Hemapo 2000 IU/ml, Hemapo 3000 IU/ml, Abilify Discmelt 10mg tab, and Otsu-NS Piggyback.

MAPE was calculated by finding the absolute error of each period to be divided by the true value for that period, and finally averaging this absolute percentage. This approach is very useful when the size of the forecasting variable is an important factor in evaluating the accuracy of the forecast. MAPE is more intuitive and easy to interpret than other error measures (Adhikari & Agrawal, 2013).

**Table 2.** Tutofusin Ops 500ml Forecasting Results and Error Size with 3 Period SMA Method

Month	Real Number	Number of Forecasting per Month (pcs)	Deviation (pcs)	Absolute Deviation (pcs)	[Absolute Deviation] <sup>2</sup>	MAPE (%)
Jan-18	696	-	-	-	-	-
Feb-18	413	-	-	-	-	-
Mar-18	605	-	-	-	-	-
Apr-18	540	571	-31	31	982	6
May-18	643	519	124	124	15293	19
Jun-18	446	596	-150	150	22500	34
Jul-18	374	543	-169	169	28561	45
Aug-18	485	488	-3	3	7	1
Sep-18	346	435	-89	89	7921	26
Oct-18	235	402	-167	167	27778	71
Nov-18	362	355	7	7	44	2
Dec-18	674	314	360	360	129360	53
Jan-19	739	424	315	315	99435	43
Feb-19	822	592	230	230	53053	28
Mar-19	543	745	-202	202	40804	37
Apr-19	679	701	-22	22	499	3
May-19	783	681	102	102	10336	13
Jun-19	418	668	-250	250	62667	60
Jul-19	427	627	-200	200	39867	47
Aug-19	423	543	-120	120	14320	28
Sep-19	432	423	9	9	87	2
Oct-19	373	427	-54	54	2952	15
Nov-19	325	409	-84	84	7112	26
Dec-19	394	377	17	17	300	4
Jan-20	637	364	273	273	74529	43
Feb-20	650	452	198	198	39204	30
Mar-20	597	560	37	37	1344	6
Apr-20	548	628	-80	80	6400	15
May-20	779	598	181	181	32640	23
Jun-20	628	641	-13	13	178	2
Jul-20	591	652	-61	61	3680	10
Aug-20	374	666	-292	292	85264	78
Sep-20	403	531	-128	128	16384	32
Oct-20	516	456	60	60	3600	12
Nov-20	477	431	46	46	2116	10
Dec-20	496	465	31	31	940	6
Jan-21		496				

Source: Primary Data

The first three months in [Table 2](#) did not contain the number of forecasting needs because the 3 period SMA method used the data of previous 3 months to predict the next period, in this case was the fourth month. The results of the forecasting were then entered in formula (2) using Excel table to obtain the MAPE score. [Table 2](#) shows that the forecasting score for the demand for Tutofusin Ops 500ml for the 3 period SMA method in January 2021 was 496pcs with an average MAPE score of 25%. The MAPE score in the 20-50% range means that the 3 period SMA forecast for Tutofusin is in the reasonable category. The accuracy value was 75%, resulted from 100% reduced by the MAPE score.

The resulted MAPE score was not in line with the result of forecasting sales of Aknil products (paracetamol + ibuprofen) of PT. Sunthi, which produced an MAPE score of 52.23%. This result indicates that the forecast is inaccurate ([Moreno et al., 2013](#)). Another study that produced a large MAPE score was conducted in Blang Bintang Village using the SMA method, which obtained a forecasting rate of 43.43% and stated that the method was low, reasonable, and acceptable ([Rais et al., 2020](#)).

**Table 3.** Hemapo 2000 IU/ml Forecasting Results and Error Size with 3 Period SMA Method

Month	Real Number	Number of Forecasting per Month (pcs)	Deviation (pcs)	Absolute Deviation (pcs)	[Absolute Deviation] <sup>2</sup>	MAPE (%)
Jan-18	272	-	-	-	-	-
Feb-18	242	-	-	-	-	-
Mar-18	250	-	-	-	-	-
Apr-18	268	255	13	13	178	5
May-18	252	253	-1	1	2	1
Jun-18	234	257	-23	23	514	10
Jul-18	245	251	-6	6	40	3
Aug-18	272	244	28	28	803	10
Sep-18	289	250	39	39	1495	13
Oct-18	286	269	17	17	300	6
Nov-18	298	282	16	16	245	5
Dec-18	285	291	-6	6	36	2
Jan-19	217	290	-73	73	5280	33
Feb-19	241	267	-26	26	659	11
Mar-19	254	248	6	6	40	2
Apr-19	230	237	-7	7	54	3
May-19	274	242	32	32	1045	12
Jun-19	256	253	3	3	11	1
Jul-19	296	253	43	43	1820	14
Aug-19	315	275	40	40	1573	13
Sep-19	265	289	-24	24	576	9
Oct-19	324	292	32	32	1024	10
Nov-19	297	301	-4	4	19	1
Dec-19	322	295	27	27	711	8
Jan-20	272	314	-42	42	1792	16
Feb-20	242	297	-55	55	3025	23
Mar-20	250	279	-29	29	822	11
Apr-20	268	255	13	13	178	5
May-20	252	253	-1	1	2	1
Jun-20	234	257	-23	23	514	10
Jul-20	245	251	-6	6	40	3
Aug-20	272	244	28	28	803	10
Sep-20	289	250	39	39	1495	13
Oct-20	286	269	17	17	300	6
Nov-20	298	282	16	16	245	5
Dec-20	285	291	-6	6	36	2
Jan-21		290				

Source: Primary Data

**Table 3** shows that the results of Hemapo 2000 IU/ml SMA method for 3 periods in January 2021 will require 290pcs. The results of calculations using the formula (2) MAPE an average of 8%. The MAPE value means that the 3-period SMA forecast for Hemapo 2000IU/ml is very accurate with an accuracy of 91%. These results are in line with research that predicts order demand at ACK Fried Chikhen, the results show that the SMA method is very accurate because it has the smallest error rate of MAPE <10% (Hudaningsih et al., 2020). Another suitable research is the Manurung (2020) study which produces a forecast score with a MAPE score of 5.96%.

**Table 4** shows that the Hemapo 3000 IU/ml forecasting for the 3 period SMA method in January 2021 would require 219 pcs with an average MAPE calculation result of 22%. The MAPE score was in the 20-50% range, which means the 3 period SMA forecast for Hemapo 3000 IU/ml category is reasonable or good enough.

**Table 4.** Forecasting Results of Hemapo 3000 IU/ml and Size of Error with 3 Periods SMA Method

Month	Real Number	Number of Forecasting per Month (pcs)	Deviation (pcs)	Absolute Deviation (pcs)	[Absolute Deviation] <sup>2</sup>	MAPE (%)
Jan-18	122	-	-	-	-	-
Feb-18	66	-	-	-	-	-
Mar-18	98	-	-	-	-	-
Apr-18	108	95	13	13	160	12
May-18	104	91	13	13	178	13
Jun-18	90	103	-13	13	178	15
Jul-18	83	101	-18	18	312	21
Aug-18	77	92	-15	15	235	20
Sep-18	79	83	-4	4	19	5
Oct-18	80	80	0	0	0	0
Nov-18	63	79	-16	16	245	25
Dec-18	103	74	29	29	841	28
Jan-19	135	82	53	53	2809	39
Feb-19	79	100	-21	21	455	27
Mar-19	63	106	-43	43	1820	68
Apr-19	62	92	-30	30	920	49
May-19	72	68	4	4	16	6
Jun-19	81	66	15	15	235	19
Jul-19	84	72	12	12	152	15
Aug-19	72	79	-7	7	49	10
Sep-19	45	79	-34	34	1156	76
Oct-19	99	67	32	32	1024	32
Nov-19	94	72	22	22	484	23
Dec-19	129	79	50	50	2467	39
Jan-20	162	107	55	55	2988	34
Feb-20	191	128	63	63	3927	33
Mar-20	198	161	37	37	1394	19
Apr-20	201	184	17	17	300	9
May-20	180	197	-17	17	278	9
Jun-20	187	193	-6	6	36	3
Jul-20	168	189	-21	21	455	13
Aug-20	181	178	3	3	7	1
Sep-20	178	179	-1	1	0	0
Oct-20	215	176	39	39	1547	18
Nov-20	228	191	37	37	1344	16
Dec-20	213	207	6	6	36	3
Jan-21		219				

Source: Primary Data

**Table 5** presents that the forecasting of Abilify Discmelt 10mg tab with the 3 period SMA method in January 2021 would require 717pcs with the resulted MAPE average score of 18%.

This means that the 3 period SMA forecasting for Abilify Discmelt is in good category with an accuracy value 82%.

**Table 5.** Forecasting Results of Abilify Discmelt 10 mg and Size of Error with 3 Periods SMA Method

Month	Real Number	Number of Forecasting per Month (pcs)	Deviation (pcs)	Absolute Deviation (pcs)	[Absolute Deviation] <sup>2</sup>	MAPE (%)
Jan-18	150	-	-	-	-	-
Feb-18	159	-	-	-	-	-
Mar-18	271	-	-	-	-	-
Apr-18	265	193	72	72	5136	27
May-18	327	232	95	95	9088	29
Jun-18	360	288	72	72	5232	20
Jul-18	433	317	116	116	13379	27
Aug-18	406	373	33	33	1067	8
Sep-18	493	400	93	93	8711	19
Oct-18	395	444	-49	49	2401	12
Nov-18	619	431	188	188	35219	30
Dec-18	623	502	121	121	14560	19
Jan-19	472	546	-74	74	5427	16
Feb-19	440	571	-131	131	17248	30
Mar-19	560	512	48	48	2336	9
Apr-19	667	491	176	176	31093	26
May-19	722	556	166	166	27667	23
Jun-19	532	650	-118	118	13845	22
Jul-19	749	640	109	109	11808	15
Aug-19	716	668	48	48	2336	7
Sep-19	674	666	8	8	69	1
Oct-19	875	713	162	162	26244	19
Nov-19	919	755	164	164	26896	18
Dec-19	1007	823	184	184	33979	18
Jan-20	834	934	-100	100	9933	12
Feb-20	811	920	-109	109	11881	13
Mar-20	871	884	-13	13	169	1
Apr-20	708	839	-131	131	17074	18
May-20	523	797	-274	274	74893	52
Jun-20	598	701	-103	103	10540	17
Jul-20	474	610	-136	136	18405	29
Aug-20	638	532	106	106	11307	17
Sep-20	650	570	80	80	6400	12
Oct-20	696	587	109	109	11808	16
Nov-20	734	661	73	73	5280	10
Dec-20	720	693	27	27	711	4
Jan-21		717				

Source: Primary Data

**Table 6** pinpoints that the forecasting of Otsu-NS Piggyback using the 3 period SMA method in January 2021 would require 3736 pcs with an average MAPE score of 17%, which means that the 3 period SMA forecast for Otsu-NS Piggyback is in good category.

From this study, it is obvious that forecasting using the 3 period SMA method makes it easier to determine drug demands in the following period. This result is in accordance with the conclusion of Andriana's research, which stated that the forecasting using SMA made it easier to determine the amount of production of each tea flavor variant, so as to avoid excess or shortage of stock. In addition to using the result of the forecast in the process of determining the number

of products to produce, it is also necessary to pay attention to data on remaining stocks in the warehouse from the previous month (Rusdiana et al., 2020).

Forecasting using the 3 period SMA method for the top 5 most used types of drug A category at RSA UGM for the 2018-2020 period indicates that the MAPE score varies by <50%. Thus, it highlights that the method is reasonable and still acceptable. Various MAPE scores are possible because the 3 period SMA method has several weaknesses, including the need for sufficient historical data, the same weight of the data in each year, and unavailability of random data, which did not result in a good forecast (Irawan et al., 2021).

**Table 6.** Otsu-NS Piggyback Forecasting Results and Error Size with 3 Period SMA Method with 3 Period SMA Method

Month	Real Number	Number of Forecasting per Month (pcs)	Deviation (pcs)	Absolute Deviation (pcs)	[Absolute Deviation] <sup>2</sup>	MAPE (%)
Jan-18	1243	-	-	-	-	-
Feb-18	1192	-	-	-	-	-
Mar-18	1291	-	-	-	-	-
Apr-18	1363	1242	121	121	14641	9
May-18	1223	1282	-59	59	3481	5
Jun-18	959	1292	-333	333	111111	35
Jul-18	1359	1182	177	177	31447	13
Aug-18	1091	1180	-89	89	7980	8
Sep-18	1069	1136	-67	67	4534	6
Oct-18	999	1173	-174	174	30276	17
Nov-18	888	1053	-165	165	27225	19
Dec-18	1200	985	215	215	46082	18
Jan-19	1297	1029	268	268	71824	21
Feb-19	991	1128	-137	137	18860	14
Mar-19	1016	1163	-147	147	21511	14
Apr-19	1168	1101	67	67	4444	6
May-19	1059	1058	1	1	0	0
Jun-19	924	1081	-157	157	24649	17
Jul-19	1305	1050	255	255	64855	20
Aug-19	970	1096	-126	126	15876	13
Sep-19	1136	1066	70	70	4853	6
Oct-19	1225	1137	88	88	7744	7
Nov-19	937	1110	-173	173	30044	18
Dec-19	1379	1099	280	280	78213	20
Jan-20	1852	1180	672	672	451136	36
Feb-20	1749	1389	360	360	129360	21
Mar-20	1682	1660	22	22	484	1
Apr-20	1325	1761	-436	436	190096	33
May-20	1470	1585	-115	115	13302	8
Jun-20	1239	1492	-253	253	64178	20
Jul-20	1813	1345	468	468	219336	26
Aug-20	1504	1507	-3	3	11	0
Sep-20	2490	1519	971	971	943488	39
Oct-20	2905	1936	969	969	939607	33
Nov-20	3199	2300	899	899	808800	28
Dec-20	5103	2865	2238	2238	5010136	44
Jan-21		3736				

Source: Primary Data

#### 4. CONCLUSION

The data collection and processing revealed that the total drug demand for the January 2021 period for the five sample drugs were as follows: Tutofusin Ops 500ml (496pcs), Hemapo 2000 IU/ml (290pcs), Hemapo 3000 IU/ml (219pcs), Abilify Discmelt 10mg tab (717) pcs, and Otsu-NS Piggyback (3736 pcs). The MAPE scores of the five drugs varied by <50%. Thus, it can be concluded that the 3 period SMA method is acceptable and reasonable to assist the planning for



drug demand in the pharmaceutical installation of RSA UGM, especially to help predict drug demand for the next period.

The limitations of this study are the changing patterns of drug prescription and drug use policies in hospitals that affect drug use data, which often contribute to fluctuating data. It is thus advised to forecast on other drug items and to apply forecasting methods into the Hospital Management Information System as a way to help and facilitate the planning team in planning the drug demand of the next period.

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## 6. CONFLICT OF INTEREST

The author declares that there are no competing conflicts of interest.

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