

TB CNR Prediction Using H-WEMA

A Five Years Reflection

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Abstract

Based on the Global Tuberculosis Report 2019, Indonesia was ranked as number three of the highest TB-burden countries. Tuberculosis (TB) itself is one of the top five leading causes of Disability-Adjusted Life Years (DALYs) in Indonesia. One health indicator that can be used to measure TB outbreak in a region is the Case Notification Rate (CNR). There two goals of this study firstly, is to give a holistic reflection of TB disease in Indonesia by using the TB notification rate of each province and secondly, is to predict future TB outbreak in Indonesia by using the province's TB notification rate. The prediction method being used in this study is the Holt's Weighted Exponential Moving Average (H-WEMA) method. The prediction results show that Sulawesi Selatan, DKI Jakarta, Gorontalo, and Papua are the four provinces predicted to have the highest CNR in the near future.

Keywords: *CNR, DALYs, H-WEMA, Indonesia, Prediction, Tuberculosis.*

1 Introduction

Tuberculosis (TB), as an infectious disease, remains as one of the big ten diseases leading to global death [1]. In Indonesia, TB is included in the big five leading causes of DALYs [2]. DALYs is an abbreviation for Disability-Adjusted Life Years, which is a measure that can indicate the overall disease burden [3]. It can be seen as the sum of potential-productive life years lost because of premature mortality or disability [4].

Based on the Global Tuberculosis Report 2019 from the World Health Organization (WHO), Indonesia was ranked three as the highest TB-burden countries right after

India and China [5]. Joko Widodo, the President of the Republic of Indonesia, even has proclaimed and supported the action called ‘Gerakan Maju Bersama Menuju Eliminasi Tuberkulosis’ in early 2020 [6]. It shows the commitment of the Government to enhance the human resource quality, which has become one of the main focuses of his second period of governing. The infographics of TB situation in Indonesia based on the data record in 2018 can be seen in [7].

Case Notification Rate (CNR) is a standard health indicator to measure the current condition of a disease in a country based on the reported notification. In specific, the number of new and relapse notified TB cases in a given year per 100,000 population is known as the TB notification rate [8]. There are much research had been done regarding the usage of CNR of TB disease, as can be seen in Gashu *et al.* [9], Kanyerere *et al.* [10], Takarinda *et al.* [11], and Gebreegziabher *et al.* [12]. Moreover, CNR prediction of TB disease also had been studied by many researchers, such as Wang *et al.* [13] who used SARIMA-GRNN to characterize monthly TB notification rate in China, Liu *et al.* [14] who tried to perform validation research by comparing ARIMA and BPNN model in forecasting seasonality and trend of PTB in Jiangsu Province, China, and Halim *et al.* [15] who applied the fuzzy linear regression algorithm in prediction of TB case in Surabaya city.

Holt’s Weighted Exponential Moving Average (H-WEMA) was first introduced in 2016 [16]. It combines two popular methods in Moving Average family, namely, the Weighted Moving Average (WMA) and the Holt’s Double Exponential Smoothing (H-DES). H-WEMA is relatively easy to understand and to implement compared to other prediction methods, especially the ones included in the stochastic models. It also excels in its two-building block methods, i.e., the WMA and H-DES, in terms of prediction accuracy, as can be seen in [17], [18], and [19].

There two goals of this study firstly, is to give a holistic reflection of TB disease in Indonesia by using the TB notification rate of each province and secondly is to predict future TB outbreak in Indonesia by using the province’s TB notification rate. The prediction method being incorporated in this study is the H-WEMA method, which will be further discussed in Section 2. Moreover, the prediction results and analysis can be seen in the following section, and lastly, some concluding remarks are included in Section 4.

2 Materials and Method

In this section, the dataset being used in the study will be described first, immediately followed by the prediction method highlighted in the study, i.e., H-WEMA method.

2.1 Dataset

The source for TB notification rate in each province in Indonesia was collected from PUSDATIN Kementerian Kesehatan Republik Indonesia [20]. It publishes the Health Profile for Indonesia in a yearly report which can be accessed freely by the visitor. The last report is the health profile report in 2018, which was published in 2019. Table 1 shows the sources used for experiments.

Table 1: Data source

No	Data Source
1	“Profil Kesehatan Indonesia 2014”
2	“Profil Kesehatan Indonesia 2015”
3	“Profil Kesehatan Indonesia 2016”
4	“Profil Kesehatan Indonesia 2017”
5	“Profil Kesehatan Indonesia 2018”

2.2 H-WEMA Method

Holt’s Weighted Exponential Moving Average, abbreviated as H-WEMA, was proposed by Hansun and Subanar in 2016 [16]. It combines the conventional Weighted Moving Average method and Holt’s Double Exponential Smoothing, which excels both the building block methods. H-WEMA procedure, as described in [18], is as follows.

- (a) Find B_t using Eq.(1)

$$B_t = \frac{\sum_{t=k-n+1}^k w_t A_t}{\sum_{t=k-n+1}^k w_t} \quad (1)$$

- (b) Find the predicted value using Eq.(2) – Eq.(4)

$$L_t = \alpha Y_t + (1 - \alpha)(L_{t-1} + T_{t-1}) \quad (2)$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} \quad (3)$$

$$F_{t+k} = L_t + kT_t \quad (4)$$

where

$$L_{t-1} = B_{t-1} \quad (5)$$

$$T_{t-1} = B_t - B_{t-1} \quad (6)$$

(c) Back to (a) until each data point has been visited.

Here,

Y_t is the observed value in time t

α is the smoothing constant ranged from 0 to 1

β is the trend smoothing constant ranged from 0 to 1

L_t is the smoothed constant process value

T_t is the smoothed trend value

F_{t+k} is the forecast value for period $t + k$, where $k > 0$

3 Results and Discussion

3.1 A Five Years Data Reflection

As briefly stated in Section 2, the TB notification rate for each province in Indonesia was collected from PUSDATIN. The data were collected from 2014-2018 from its respective annual report. Table 2 depicts the recapitulation of the TB notification rate in Indonesia.

Table 2: 2014-2018 TB notification rate

No	Regions	2014	2015	2016	2017	2018
1	“Aceh”	110	119	114	139	151
2	“Sumatera Utara”	141	165	161	182	238
3	“Sumatera Barat”	134	134	140	175	201
4	“Riau”	75	91	95	152	197
5	“Jambi”	90	114	96	110	140
6	“Sumatera Selatan”	99	116	114	182	234
7	“Bengkulu”	100	100	98	127	191
8	“Lampung”	84	105	110	122	191
9	“Kep. Bangka Belitung”	108	111	110	131	150
10	“Kepulauan Riau”	132	149	175	198	247
11	“DKI Jakarta”	168	222	269	366	410
12	“Jawa Barat”	134	140	149	173	221
13	“Jawa Tengah”	83	111	105	135	197
14	“DI Yogyakarta”	71	73	83	93	99
15	“Jawa Timur”	107	113	125	131	187
16	“Banten”	61	116	121	134	240
17	“Bali”	70	70	73	83	89
18	“Nusa Tenggara Barat”	135	125	122	137	129
19	“Nusa Tenggara Timur”	92	111	119	132	138
20	“Kalimantan Barat”	119	105	107	120	147

21	“Kalimantan Tengah”	101	100	115	131	139
22	“Kalimantan Selatan”	121	128	139	162	223
23	“Kalimantan Timur”	89	118	134	174	176
24	“Kalimantan Utara”	107	109	183	250	216
25	“Sulawesi Utara”	243	238	219	252	273
26	“Sulawesi Tengah”	118	136	137	174	237
27	“Sulawesi Selatan”	133	153	154	197	357
28	“Sulawesi Tenggara”	178	142	148	149	176
29	“Gorontalo”	143	124	145	165	310
30	“Sulawesi Barat”	111	117	128	145	162
31	“Maluku”	218	213	223	249	250
32	“Maluku Utara”	120	150	150	159	130
33	“Papua Barat”	174	235	210	228	245
34	“Papua”	115	216	260	312	347
	Indonesia	113	130	136	162	214

In Table 2, the highlighted cells are the four highest CNR for TB disease in their respective years. Four provinces with the highest CNR in 2014 are Sulawesi Utara (243), Maluku (218), Sulawesi Tenggara (178), and Papua Barat (174); in 2015 are Sulawesi Utara (238), Papua Barat (235), DKI Jakarta (222), and Papua (216); in 2016 are DKI Jakarta (269), Papua (260), Maluku (223), and Sulawesi Utara (219); in 2017 are DKI Jakarta (366), Papua (312), Sulawesi Utara (252), and Kalimantan Utara (250); and lastly in 2018 are DKI Jakarta (410), Sulawesi Selatan (357), Papua (347), and Gorontalo (310).

There are three provinces that are happened to be included in the highest CNR of TB disease province in Indonesia, namely, DKI Jakarta, Papua, and Sulawesi Utara, as shown in Fig. 1. Especially DKI Jakarta has an unshakeable position as the number one province with the highest CNR of TB disease since 2016. Since CNR could represent the TB epidemic condition in a region, DKI Jakarta, which has almost twice CNR compare to Indonesia or national CNR arguably takes the most attention and need further analysis and proper actions by all related stakeholders, especially the provincial or regional Government.

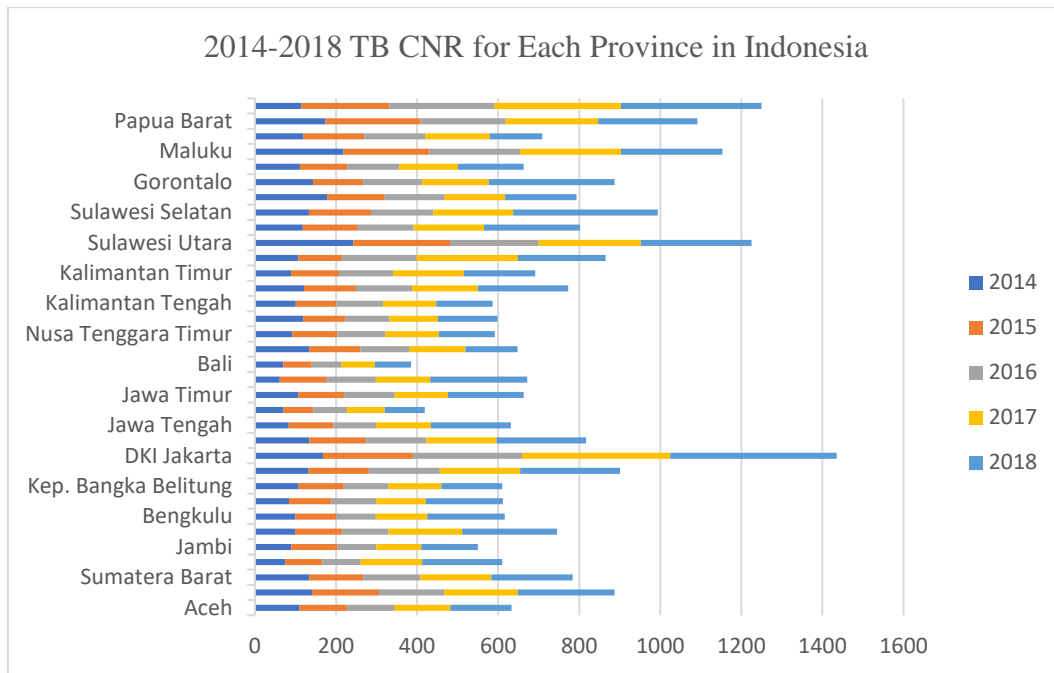


Fig. 1: Five years TB CNR in Indonesia

3.2 Prediction Results

Table 3 shows the prediction results for one period ahead using the dataset and the H-WEMA method. Since the number of historical data is quite small, we used initial data of 4 and spanned data of 3. The percentage difference of CNR increment or decrement for each province is also shown in Table 3.

Table 3: Prediction and difference percentage

No	Regions	Prediction Result	Difference Percentage				
			14-15	15-16	16-17	17-18	18-Pred
1	“Aceh”	167	8.18	-4.20	21.93	8.63	10.60
2	“Sumatera Utara”	294	17.02	-2.42	13.04	30.77	23.53
3	“Sumatera Barat”	229	0.00	4.48	25.00	14.86	13.93
4	“Riau”	244	21.33	4.40	60.00	29.61	23.86
5	“Jambi”	170	26.67	-15.79	14.58	27.27	21.43
6	“Sumatera Selatan”	291	17.17	-1.72	59.65	28.57	24.36
7	“Bengkulu”	255	0.00	-2.00	29.59	50.39	33.51
8	“Lampung”	260	25.00	4.76	10.91	56.56	36.13
9	“Kep. Bangka Belitung”	170	2.78	-0.90	19.09	14.50	13.33
10	“Kepulauan Riau”	296	12.88	17.45	13.14	24.75	19.84
11	“DKI Jakarta”	479	32.14	21.17	36.06	12.02	16.83
12	“Jawa Barat”	269	4.48	6.43	16.11	27.75	21.72
13	“Jawa Tengah”	259	33.73	-5.41	28.57	45.93	31.47
14	“DI Yogyakarta”	109	2.82	13.70	12.05	6.45	10.10

15	“Jawa Timur”	243	5.61	10.62	4.80	42.75	29.95
16	“Banten”	346	90.16	4.31	10.74	79.10	44.17
17	“Bali”	97	0.00	4.29	13.70	7.23	8.99
18	“Nusa Tenggara Barat”	138	-7.41	-2.40	12.30	-5.84	6.98
19	“Nusa Tenggara Timur”	150	20.65	7.21	10.92	4.55	8.70
20	“Kalimantan Barat”	174	-11.76	1.90	12.15	22.50	18.37
21	“Kalimantan Tengah”	151	-0.99	15.00	13.91	6.11	8.63
22	“Kalimantan Selatan”	284	5.79	8.59	16.55	37.65	27.35
23	“Kalimantan Timur”	203	32.58	13.56	29.85	1.15	15.34
24	“Kalimantan Utara”	298	1.87	67.89	36.61	13.60	37.96
25	“Sulawesi Utara”	294	-2.06	-7.98	15.07	8.33	7.69
26	“Sulawesi Tengah”	300	15.25	0.74	27.01	36.21	26.58
27	“Sulawesi Selatan”	517	15.04	0.65	27.92	81.22	44.82
28	“Sulawesi Tenggara”	203	-20.22	4.23	0.68	18.12	15.34
29	“Gorontalo”	455	-13.29	16.94	13.79	87.88	46.77
30	“Sulawesi Barat”	181	5.41	9.40	13.28	11.72	11.73
31	“Maluku”	264	-2.29	4.69	11.66	0.40	5.60
32	“Maluku Utara”	172	25.00	0.00	6.00	18.24	32.31
33	“Papua Barat”	262	35.06	-10.64	8.57	7.46	6.94
34	“Papua”	405	87.83	20.37	20.00	11.22	16.71

As can be inferred from the prediction results, four provinces with the highest CNR are Sulawesi Selatan (517), DKI Jakarta (479), Gorontalo (455), and Papua (405). Sulawesi Selatan has surpassed DKI Jakarta because it has a higher increment of percentage difference in recent years. Moreover, from the difference percentage increment between 2018 actual data and prediction results, there are three provinces with the highest percentage, namely Gorontalo (46.77%), Sulawesi Selatan (44.82%), and Banten (44.17%). Therefore, in future years all stakeholders, especially the related regional governments, should pay more attention to the TB disease cases and put strategic measurements to handle the predicted results.

4 Conclusion

Two goals of this study, i.e., to give a five years reflection of TB disease condition in Indonesia and to make a future prediction of the TB outbreak in Indonesia, have been conducted. There are three provinces that have the highest CNR of TB disease, namely, DKI Jakarta, Papua, and Sulawesi Utara. Moreover, from the prediction results using H-WEMA method, there are four provinces that will have the highest CNR, i.e., Sulawesi Selatan, DKI Jakarta, Gorontalo, and Papua. Thus, those provinces should get more attention from all related stakeholders to handle the

current situation of TB disease conditions in Indonesia and to prevent any outbreaks in the future. Related to the experimental results, future studies could implement and compare other prediction methods in the MA family, especially Brown's Weighted Exponential Moving Average.

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