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A novel service robot assignment approach for COVID-19 infected patients: a case of medical data driven decision making

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Abstract
Coronavirus Disease-19 (COVID-19) is a major concern for the entire world in the current era. Coronavirus is a very dangerous infectious virus that spreads rapidly from person to person. It spreads in exponential manner on a global scale. It affects the doctors, nurse and other COVID-19 warriors those who are actively involved for the treatment of COVID-19 infected (CI) patients. So, it is very much essential to focus on automation and artificial intelligence (AI) in different hospitals for the treatment of such infected patients and all should be very much careful to break the chain of spreading this novel virus. In this paper, a novel patient service robots (PSRs) assignment framework and a priority based (PB) method using fuzzy rule based (FRB) approach is proposed for the assignment of PSRs for CI patients in hospitals in order to provide safety to the COVID-19 warriors as well as to the CI infected patients. This novel approach is mainly focused on lowering the active involvement of COVID-19 warriors for the treatment of high asymptotic COVID-19 infected (HACI) patients for handling this tough situation. In this work, we have focused on HACI and low asymptotic COVID-19 infected (LACI) patients. Higher priority is given to HACI patients as compared to LACI patients to handle this critical situation in order to increase the survival probability of these patients. The proposed method deals with situations that practically arise during the assignment of PSRs for the treatment of such patients. The simulation of the work is carried out using MATLAB R2015b.

Keywords COVID-19 · PSRs assignment framework · PB method · FRB approach · HACI · LACI

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1 Introduction

COVID-19 [1, 3, 4, 6, 8, 10, 12, 15–19, 21, 22, 25–28, 30–32, 34–36, 38, 41–44, 46, 50–52, 54, 57] is a very dangerous novel infectious disease in the global scenario. It has been declared as a global pandemic by the World Health Organization (WHO) [47, 48] and WHO also informs that this virus is transmitted through the air. Currently, there are around 1886 lakhs COVID-19 positive cases, 40 lakhs death cases and 1724 lakhs recovered cases reported due to this novel COVID-19 [48] (https://www.worldometers.info/coronavirus/). As this virus spreads rapidly from person to person on a global scale, so each and every individual should focus on the following precautions in order to break the spreading chain of this novel virus in terms of Maintain social distancing, Use suitable masks in the workplace, Staying at home if no emergency work, Cleaning of hand properly at regular intervals, Avoid touching of the face, eyes, mouth and nose, and Avoid mass gatherings etc. However, this virus spreads rapidly and the situation of each and every county gradually very worst in this regard, so it is a very challenging issue to break the spreading chain of this virus. This virus is so dangerous that it grseatly affects the doctors, nurse and other COVID-19 warriors those are actively involved for the treatment of CI patients in several hospitals and some of them also dies due to this virus. It is very much essential for the safety of all the COVID-19 warriors. So, each and every country should focus on automation and AI mechanisms [1, 6, 11, 19, 27, 30, 32, 35, 37, 44, 45] in several hospitals for the treatment of CI patients due to advanced technology so that virus spreading rate can be reduced and the COVID-19 warriors can work safely. Automation refers to the technology by which a procedure or process can be performed automatically with minimal human assistance. AI refers to the simulation of human intelligence in several machines which are programmed to think like humans and mimic their actions. The PSRs can be considered as a solution for autonomous and use of AI mechanisms in several hospitals. The service robots [7, 21, 22, 33, 40, 42, 45, 52, 54–56] are autonomous and operated by the in-built control system. These robots can help human beings by performing useful tasks which is distant, dull, dirty, repetitive, dangerous, etc. including household chores. These robots can be categorized as industrial service robots, domestic service robots, scientific service robots, event service robots, frontline service robots, etc. The domestic service robots that follow a predefined trajectory can typically be used as PSRs which can help CI patients for several activities. The PSRs can be used in hospitals for the treatment of CI patients in different activities such as thermal scanning, supply of medicines, food and water, taking blood for several check-ups, measuring oxygen quantity in the human body, measuring pulse rate, cleaning floors, etc. at regular intervals. Although the cost of service robots are high, the Government of several countries and states should take initiatives to produce the PSRs at lower cast so that these PSRs can be used in several hospitals for the treatment of CI patients for the safety of CI patients as well as COVID-19 warriors and due to which this virus spreading rate can be reduced. In this work, a PSRs assignment framework as well as a PB method [20, 23, 29, 57] using the FRB approach [2, 9, 14, 24, 39] is proposed for the assignment PSRs for HACI patients in hospitals in order to provide safety to the COVID-19 warriors. The proposed novel approach provides a clear view of the assignment of PSRs for the treatment of CI patients in a better way. The PSRs will play an important role in reducing the infection rate which will lead to the safety of COVID-19 warriors as well as the patients. So, the implementation of autonomous mechanisms in several hospitals with the help of PSRs will help in reducing the infection to a greater extent. This approach can able to lower the number of PSRs requirement for the treatment of large number of CI patients.

In this paper, we have categorized all the CI patients as LACI, HACI and severe patients, and we have focused on only LACI and HACI patients. The CI patients those are having no symptoms are considered as LACI patients. The CI patients those are having the symptoms such as fever, dry cough, tiredness, aches and pains, diarrhoea, conjunctivitis, headache, loss of taste and smell, a rash on the skin, discolouration of fingers and toes are considered as HACI patients. The CI patients those are having the symptoms such as difficulty breathing, shortness of breath, chest pain, chest pressure, loss of speech and movement are considered as severe CI patients and some of them require intensive care units (ICUs) and ventilators for their survival. As for the treatment as well as the survival of severe CI patient's active participation of COVID-19 warriors is very much essential so for severe CI patients fully automation and AI mechanism may not be a better option to focus on. The major contributions of this proposed work are stated as follows:

- A PSRs assignment framework and a PB method are proposed for the assignment PSRs for HACI patients in hospitals to provide safety to the COVID-19 warriors and the CI infected patients.
- This method mainly focuses on the FRB approach where HACI patients have been assigned with higher priority as compared to LACI patients in order to increase the survival rate of the CI patients.
- The proposed method deals with situations that will practically arise during the assignment of PSRs for the treatment of such patients.
- The proposed work is carried out using MATLAB R2015b.

The rest of the paper is organized as follows. Section 2 describes related works, Section 3 describes the proposed framework and methodology, Section 4 describes results and discussion and Section 5 describes the conclusion of this work.

2 Related works

Different works have been carried out by different researchers related to COVID-19, service robots, automation as well as AI mechanisms [1, 3, 4, 6–8, 10–12, 15–19, 21, 22, 25–28, 30–38, 40–46, 50–52, 54–56, 57]. Some of the works are described as follows. Zhang et al. [56] focused on the feature design effects of service robot on user perceptions as well as emotional responses. Nishiyama et al. [33] emphasized on the development of user interface for humanoid service robot system. Swangnetr et al. [40] focused on emotional state classification in the case of patient robot interaction with the help of statistics-based feature selection as well as wavelet analysis. Yang et al. [41] emphasized on the role of robotics in managing public health as well as infectious diseases by considering the scenario of fight against the COVID-19 pandemic. Kimming et al. [22] focused on robot assisted surgery during the COVID-19 pandemic for gynaecological cancer. Neri et al. [32] emphasized on the use of CT and AI in suspected or COVID-19 positive patients. Tavakoli et al. [42] focused on the use of robotics, smart wearable technologies as well as autonomous intelligent systems for the health care units during the COVID-19 pandemic. Alimadadi et al. [1] emphasized on the use of AI as well as machine learning mechanisms to fight against COVID-19. Khan et al. [21] focused on the utilization of robotics for healthcare digitization for the management of COVID-19 pandemic. Rahmatizadeh et al. [37] emphasized on the role of AI in the management of critical COVID-19 patients. Javaid et al. [17] focused on the industry 4.0 technologies as well as their applications to fight against the COVID-19 pandemic. Mohamadou et al. [30] emphasized on the review of mathematical modelling, AI as well as datasets used in the study, prediction and management of the COVID-19 pandemic. Ye et al. [52] focused on the feasibility of a 5G based robot assisted remote ultrasound system for cardiopulmonary assessment of COVID-19 patients.

From the above study, by utilizing our knowledge, it is concluded that different works have been carried out related to COVID-19 but the work related to the assignment of PSR to HACI patients have not been carried out yet. So, it is very much essential to carry out the research work in this domain.

3 Proposed framework and methodology

In this section, we have described about the proposed framework for the PSRs assignment and the methodology of the assignment.

3.1 Proposed framework

Currently, the treatment of CI patients is a challenging task on a global scale. Let, there are n number of CI patients and m number of PSRs available in the hospital. The value of m is very less as compared to n i.e. $m < < n$ then it is a difficult task for the assignment of m PSRs to n CI patients for their treatment in an efficient manner. In this work, we have proposed a novel framework and a methodology that acts as a solution for the assignment of m PSRs to the n CI patients in a better way.

The proposed PSRs assignment framework is mentioned in Fig. 1 In this framework, we assume that these PSRs are highly efficient which are having different sensors [5, 53] to carry out several activities in hospitals for the treatment of CI patients and the patients will cooperate with the PSRs in each and every activity performed by the PSRs for their treatment. The PSRs will monitor the CI patients specifically HACI patients in regular intervals. In our work, we have assumed that each PSR will serve maximum of 20 HACI patients in order to reduce the infection as well as the spreading rate of this virus among the HACI patients as the safety of CI patients is an important concern. Communication between

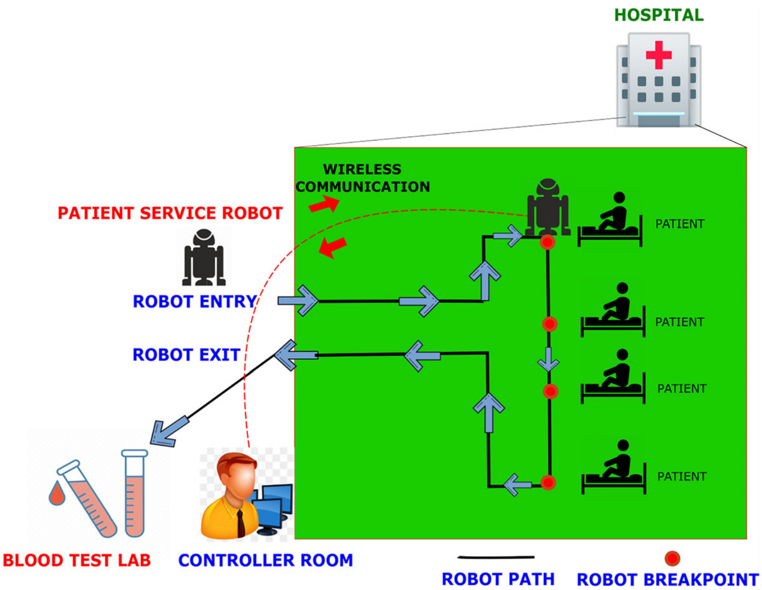

Fig. 1 PSR assignment framework

PSRs and the control room is an important concern. Here, we have focused on wireless communication. The control room will monitor each PSR through wireless communication [5, 53] for the treatment of HACI patients. The control room is associated with trained staff members of the hospital who will monitor the PSRs at regular time intervals. The PSRs are also having the self-monitoring capability using different sensors for the treatment of CI patients. So, the PSRs will manage the situations, if the unavailability of staff members in the control room for a while due to any reason.

The monitoring time period as well as work schedule for each PSRs is predefined and the PSRs will follow it. The PSRs will start the journey from the robot entry point and it will follow the predefined line or path like line following robot. The predefined path will be set in the manner as mentioned in Fig. 1 so that the PSR will reach different CI patients comfortably. So, the predefined path will be set at each PSR so that the PSRs can follow this predefined path with the help of required sensors to reach out at different CI infected patients without facing any problem. The PSRs will stop at breakpoints of respective patients for their treatment at regular intervals. The breakpoints are mentioned in red color. The breakpoint is maintained for each CI patient as mentioned in Fig. 1 so that the PSR will reach the required CI infected patient comfortably with the help of respective breakpoint. So, for this process, the breakpoint information will also be set at each PSR so that the PSR can stop at the destination break point by following the predefined path for the treatment of CI infected patients. The PSRs will be available at the robot exit point after treatment of HACI patients periodically. The PSRs will carry out the activities such as thermal scanning, supply of medicines, food and water, taking blood samples for several check-ups, measuring oxygen quantity in the human body, measuring pulse rate, cleaning floors, etc. at regular intervals for the treatment of CI patients using different PSRs in-built segments. The PSRs will sanitize themselves at regular intervals as safety measures to avoid the spreading of infection. The PSRs will send all the check-ups related information immediately to the control room through wireless communication. The PSRs will be associated with a secondary wireless communication facility along with the primary wireless communication facility for the communication with the control room. So, the PSRs will carry out their treatment with the CI patients by the help of secondary communication facility immediately without facing any problem if an issue such as communication link failure will arise.

The PSRs will take the blood samples of CI patients and keep it inside the in-built storage unit in order to avoid further infection. All the storage units will be properly sanitized at regular intervals. The PSRs will use separate storage container for taking the blood sample of each CI patient and the storage container will be used only once. Each PSR will sanitize its required components after completing the blood sample collection process and then the PSR will start blood sample collection process for the next CI patient. These preventive actions will be followed by the PSRs in order to avoid infection after taking the blood samples from CI patients. The PSRs will submit the blood samples at blood test laboratory for several check-ups. Each PSR will sanitize itself by following COVID-19 guidelines after performing several activities at a CI patient before attempting to another CI patient at regular intervals.

3.2 Proposed methodology

The proposed work mainly focuses on the PB based [20, 23, 29, 57] method that uses FRB approach [2, 9, 14, 24, 39] to assign the PSRs for the treatment of COVID-19 infected patients. The FRB approach is mainly based on the "IF-THEN" rule. When we consider "if T is P then R is Q" then "T is P" is known as premise and "R is Q" is known as consequent. So, the consequent value will be decided by considering the premise value as per his rule. In this work, all the COVID-19 infected patients are categorized as LACI, HACI and severe patients and we have focused only on HACI and LACI patients and we have not considered the cases of severe patients as the PSRs may not be the fully solution for severe patients in hospitals as severe patients are in critical situations. As per the proposed approach, more priority is assigned to HACI cases as compared to LACI. Here, we have mainly focused on priority based FRB mechanism as it will focus on HACI cases to take necessary steps for the treatment in time due to which the survival

Table 1 PB method using FRB approach

Sl. No.	Case	Action
1.	LACI	Home isolation for 1 week with doctor's advice
2.	LACI changed to HACI after 1 week	Assign PSR in hospital for next 1 week
3.	LACI after 2 weeks	Precautions for further days with doctor's advice
4.	HACI	Assign PSR in hospital for 2 weeks
5.	HACI changed to severe after 2 week	Release PSR and assign doctor for emergency treatment

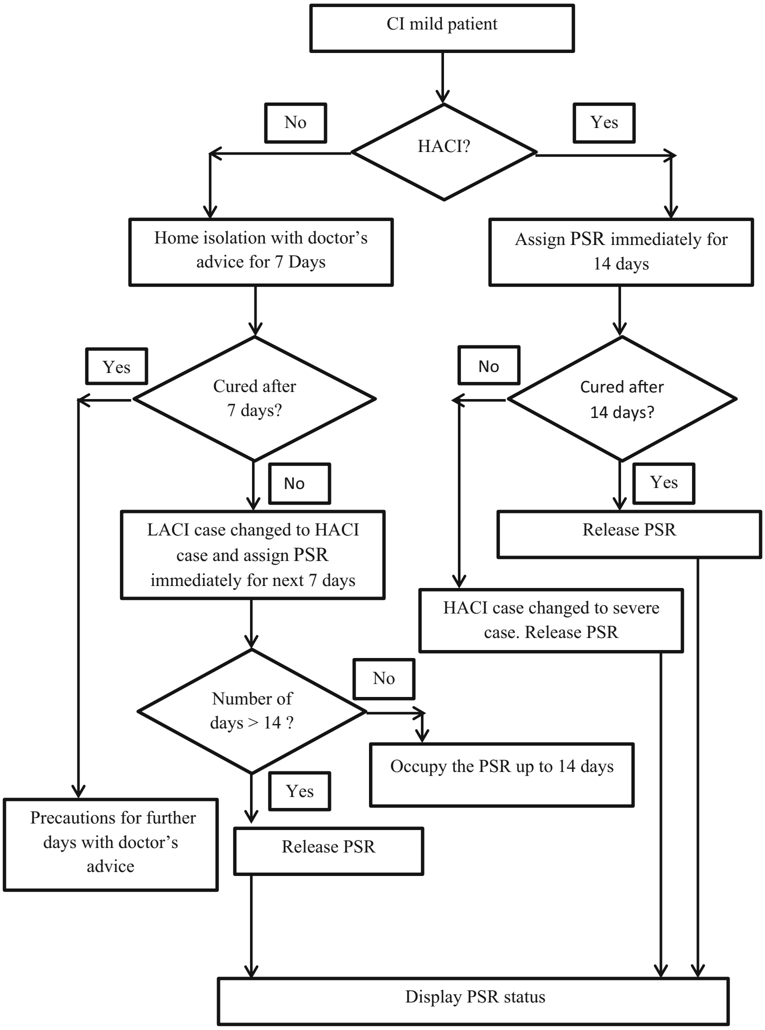

Fig. 2 Proposed Methodology

rate of CI patients will increase as the survivability of CI patients is an important concern. The proposed PB method using FRB approach is represented in Table 1. The proposed Methodology is mentioned in Fig. 2. The proposed algorithm is mentioned in Algorithm 1. So, from the analysis of Table 1, Fig. 2 and Algorithm 1, by applying the FRB approach using PB method, if any patients with the HACI category will arise then they will be immediately assigned with the PSRs in hospitals for 2 weeks (14 days). After 2 weeks, the HACI patients will be cured. After 2 weeks, the patients who will change from HACI to severe cases (hcs: HACI changed to Severe) will be assigned to doctors for emergency treatment. If any patients with LACI cases will arise then they will be kept in home isolation with the doctor's careful advice for one week (7 days) as the survival probability for these patients are high. After one week if the patients with

LACI cases will be cured then they will be careful for further days with the doctor's advice, otherwise, these patients will be moved to HACI cases (lch: LACI changed to HACI) and will be assigned with PSRs in hospitals for next one week. After 1 week, the patients who are converted to HACI cases from LACI (lch: LACI changed to HACI) cases will be cured. In the proposed algorithm 1, the PSR assignment status at different cases is represented using 'psr', and the patient is represented using 'p'.

Algorithm 1: PSR Assignment using the proposed algorithm

Input: Number of CI mild cases

Output: Minimum number of PSRs required in hospital for treatment

```
Initialize psr=0
For i=1 to n CI patients
  If  p_i= = HACI_i       (p:patient)
    then assign a PSR for 14 days
        psr=psr+1
        If no. of days > 14
              If p_i = = hcs_i (hcs: HACI changed to Severe)
                 then release the PSR and assign doctor for treatment
                        psr=psr-1
              End
              If p_i = = cured
                 then release the PSR
                       psr=psr-1
              End
        End
   End
    If p_i= = LACI_i       (p:patient)
      then home isolation for 7 days  with doctor's advice
            If no. of days > 7
                 If  p_i = =cured
                     then careful precautions for further days
                 End
                 If  p_i = =lch_i  ( lch: LACI changed to HACI)
                     then assign a PSR for next 7 days
                        psr=psr+1
                        If no. of days > 14
                               then release the PSR
                                    psr=psr-1
                       End
                 End
            End
      End
End
Display psr (psr: PSR status)
```

From the analysis of report (https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200306-sitrep-46-covid-19.pdf), it is observed that 80% cases are mild and 20% cases are severe and critical (15% requiring Oxygen and 5% requiring ventilators) out of total COVID-19 infected cases in the current scenario. It will take around two weeks to cure the patients with mild cases and around 6 weeks to cure the patients with severe cases. In this work, we have considered that all the mild cases will be categorized as LACI and HACI cases and 10%, 90% of total mild cases will be categorized as HACI and LACI cases respectively. From LACI cases, 10% cases will be changed to HACI cases and from HACI cases 10% cases will be changed to severe cases. So, if T(H), T(L), T(LCH), T(HCS) and T(M) are considered as the total number of HACI, LACI, LACI changed to HACI cases, HACI changed to severe cases and mild cases then this scenario can be represented using Eq. 1.

$$\mathrm{T(H)} + \mathrm{T(L)} + \mathrm{T(LCH)} + \mathrm{T(HCS)} = \mathrm{T(M)} \tag{1}$$

If T(S), T(CI) represents the total number of severe cases and the total number of CI patients then this scenario can be represented using Eq. 2.

$$\mathrm{T(M)} + \mathrm{T(S)} = \mathrm{T(CI)} \tag{2}$$

Out of total severe cases, some cases require ventilators and some cases require ICUs. If T(V), T(I) represents the total number of severe patients requiring ventilators and ICUs respectively, and T (R) represents rest of the severe cases then this scenario can be represented using Eq. 3.

$$\mathrm{T(V)} + \mathrm{T(I)} + \mathrm{T(R)} = \mathrm{T(S)} \tag{3}$$

In our work, we have represented the week wise data of COVID-19 infected patients from 2nd February 2020 to 19th July 2020 in India (https://www.covid19india.org/), (https://www.worldometers.info/coronavirus/) with the help of Tables 2 and 3 to visualize the week wise COVID-19 cases scenario. Graphically, the week wise COVID-19 cases from 2nd February 2020 to 19th July 2020 are represented in Fig. 3.

Similarly, we have represented the month wise data of COVID-19 infected patients from 20th July 2020 to 20th June 2021 in India (https://www.covid19india.org/), (https://www.worldometers.info/coronavirus/) with the help of Table 4 and Fig. 4 to visualize the month wise COVID-19 cases scenario.

Similarly, we have represented the COVID-19 case status in India as on 14th July 2021, 8:48 PM IST (https://www.covid19india.org/, https://www.worldometers.info/coronavirus/) in Table 5 and Fig. 5 and we have analyzed the PSRs assignment to the CI patients by focusing on this data.

As per the report (https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200306-sitrep-46-covid-19.pdf), 80% cases are mild and 20% cases are severe and critical out of total COVID-19 infected cases. Hence, from Table 4 and Fig. 5, the total confirmed cases are 30,981,339 in India as on 14th July 2021 out of which 30,129,597 CI infected patients are recovered, 411,928 are dead and 427,541 are active. So, out of 427,541 active cases, around 85,508 cases are severe and 342,033 cases are mild if we consider 20% severe and critical cases, and 80% mild cases. As per the proposed model, we have assigned the PSRs to only HACI cases.

Table 2 Week wise COVID-19 data in India from Feb. 2, 2020 to May 3, 2020

Patient Status	Feb. 2	Feb. 9	Feb. 16	Feb. 23	Mar. 1	Mar. 8	Mar. 15	Mar. 22	Mar. 29	Apr. 5	Apr. 12	Apr. 19	Apr. 26	May 3
Confirmed	2	3	3	3	3	39	113	403	1139	4293	9211	17,305	27,890	42,779
Recovered	0	0	2	3	3	3	13	23	102	329	1086	2854	6523	11,763
Dead	0	0	0	0	0	0	2	7	27	118	332	560	881	1463
Active	2	3	1	0	0	36	98	373	1010	3843	7790	13,888	20,483	29,549

Table 3 Week wise COVID-19 data in India from May 10, 2020 to July 19, 2020

Patient Status	May 10	May 17	May 24	May 31	June 7	June 14	June 21	June 28	July 5	July 12	July 19
Confirmed	67,177	95,699	138,536	190,648	257,481	333,038	426,901	549,197	697,846	879,467	1,118,107
Recovered	20,970	36,795	57,694	91,862	123,848	169,684	237,258	321,777	424,894	554,429	700,500
Dead	2214	3025	4024	5405	7205	9521	13,703	16,487	19,701	23,182	27,493
Active	43,989	55,875	76,809	93,368	126,412	153,792	175,889	210,877	253,168	301,471	389,707

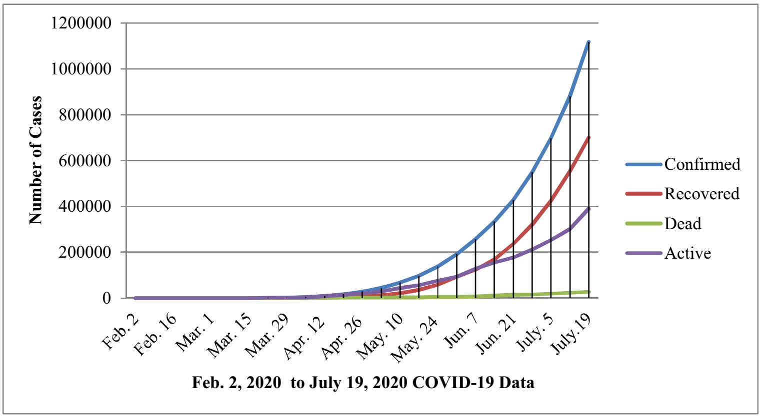

Fig. 3 Confirmed, recovered, dead and active cases in India from Feb. 2, 2020 to July 19, 2020

4 Results and discussion

The simulation of the proposed work is carried out using MATLAB R2015b. If we consider 342,033 mild cases, then 10% cases will be HACI cases and 90% cases will be LACI cases. From HACI cases, 10% cases will be changed to severe cases. From LACI cases, 10% cases will be changed to HACI cases. So, out of 342,033 mild cases, 34,203, 307,830, 3420, 30,783 cases represent the total number of HACI, LACI, HACI changed to severe, LACH changed to HACI cases respectively. In this section, we have analysed the scenario where the mild cases will arrive at hospitals using a uniform distribution mechanism for the first 5 weeks. We have described the maximum number of PSRs requirements by considering the mild CI cases such as 100, 1000, 10,000, 100,000, 1,000,000, 10,000,000, 1,000,000,000, 1,120,000,000 and 342,033. Here, the PSRs are represented as P1, P2, P3, P4, P5,….., and so on. The HACI, LACI, HACI changed to severe, LACI changed to HACI cases are represented as H, L, HCS, LCH respectively. Each PSR will serve maximum of 20 mild CI cases in order to avoid the infection as well as further spreading of this virus. Some of the cases are described by applying algorithm 1 as follows.

The practical scenario of PSRs assignment to mild CI patients using the proposed method is described in case-1.1 to case-1.6 and case-2.1 to case-2.6. The above cases are taken randomly. The PSRs requirement for 100, 1000, 10,000, 100,000, 1,000,000, 10,000,000, 1,000,000,000, 11,120,000,000 and 342,033 mild CI cases using the proposed method are described in Figs. 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 and 27 and Tables 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15. As we have considered the total number of mild CI cases as on 14th July 2021 is 342,033, so the maximum number of PSRs requirement is 3079, 2908, 1540, 1711, 1369 and 1198 with referring to the cases such as (case-1.1, 2.1), (case-1.2, 2.2), (case-1.3, 2.3), (case-1.4, 2.4), (case-1.5, 2.5) and (case-1.6, 2.6) respectively. Hence, from the analysis of results, 111.09, 117.62, 222.10, 199.90, 249.84 and 285.50 times less number of PSRs will be required for the case references (case-1.1, 2.1), (case-1.2, 2.2), (case-1.3, 2.3), (case-1.4, 2.4), (case-1.5, 2.5) and (case-1.6, 2.6) respectively for handling 342,033 mild cases. So, a very less number of PSRs will be required for handling 342,033 mild cases by applying the proposed methodology.

Table 4 Month wise COVID-19 data in India from July 20, 2020 to June 20, 2021

Patient Status	July 20, 2020	Aug. 20, 2020	Sept. 20, 2020	Oct. 20, 2020	Nov. 20, 2020	Dec. 20, 2020	Jan. 20, 2021	Feb. 20, 2021	Mar. 20, 2021	Apr. 20, 2021	May. 20, 2021	June 20, 2021
Confirmed	1,154,917	2,904,329	5,485,612	7,649,158	9,050,613	10,056,248	10,611,719	10,991,091	11,598,710	15,609,004	26,030,674	29,934,361
Recovered	24,303	61,873	92,926	61,933	48,881	25,709	20,071	11,656	22,970	166,643	357,218	78,082
Dead	28,238	55,394	88,539	116,685	133,648	146,829	153,971	157,453	160,927	184,032	301,747	389,572
Active	401,977	690,994	1,004,423	739,923	441,068	304,029	192,585	146,100	309,664	2,155,109	3,023,026	708,260

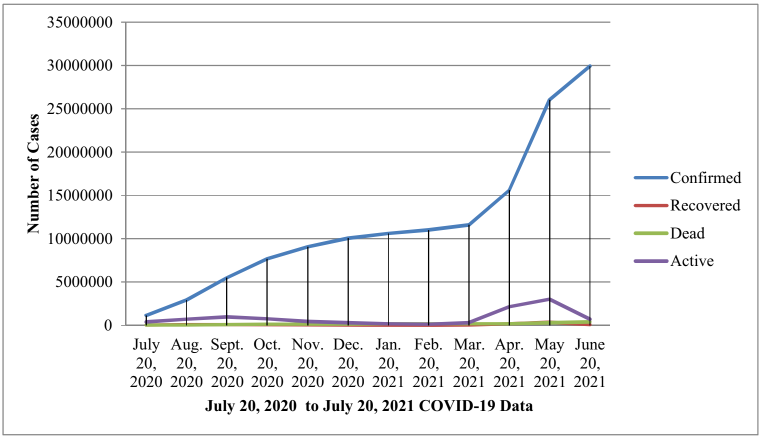

Fig. 4 Confirmed, recovered, dead and active cases in India from July 20, 2020 to June 20, 2021

Table 5 COVID-19 Data in India as on 14th July 2021

Patient Status	14th July 2021
Confirmed	30,981,339
Recovered	30,129,597
Dead	411,928
Active	427,541

Similarly, if we consider 1,400,000,000 (approximately) is the total population of India, then 1,120,000,000 mild cases will be there in the worst case scenario. For 112,000,000 mild cases, the maximum number of PSRs requirement is 10,080,000, 9,520,000, 5,040,000, 5,600,000, 4,480,000 and 3,920,000 with referring to the cases such as (case-1.1, 2.1), (case-1.2, 2.2), (case-1.3, 2.3), (case-1.4, 2.4), (case-1.5, 2.5) and (case-1.6, 2.6) respectively. From the above analysis, it is observed that the proposed framework a well as methodology can handle the PSRs assignment to mild CI cases in hospitals in a better way to lower the infection and to lower the spreading rate of this virus. The proposed method can provide safety

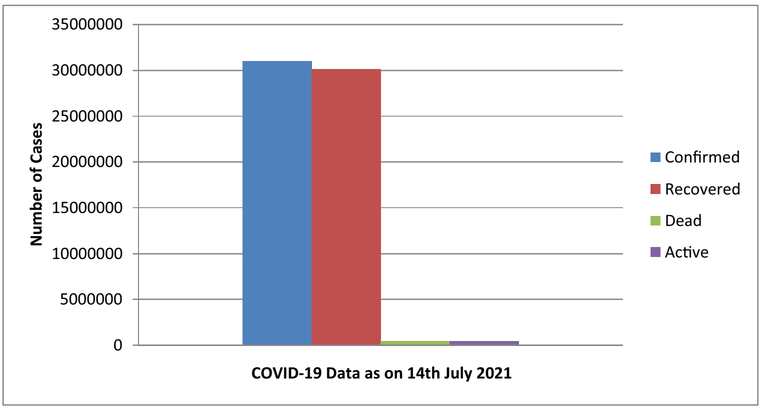

Fig. 5 Statistical Representation of COVID-19 Data in India as on 14th July 2021

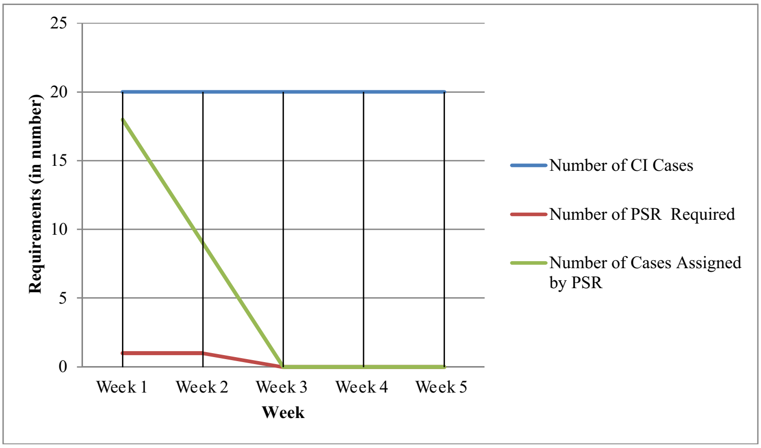

Fig. 6 Week wise PSR status of case 1.1

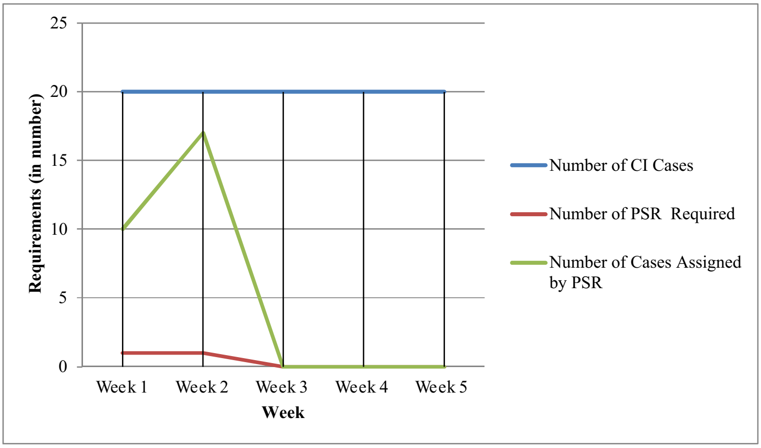

Fig. 7 Week wise PSR status of case 1.2

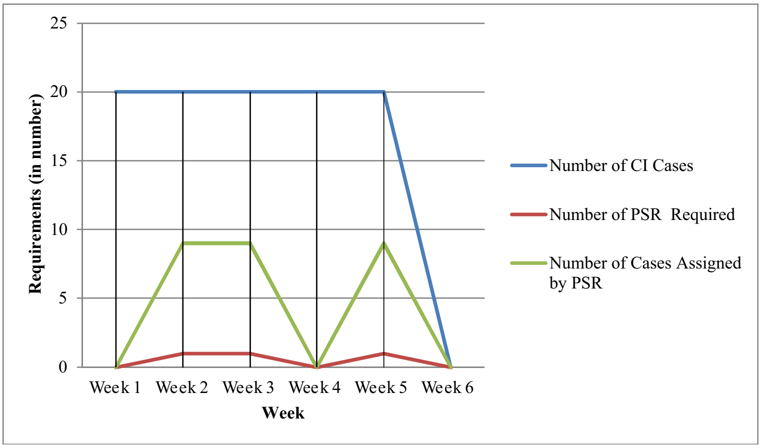

Fig. 8 Week wise PSR status of case 1.3

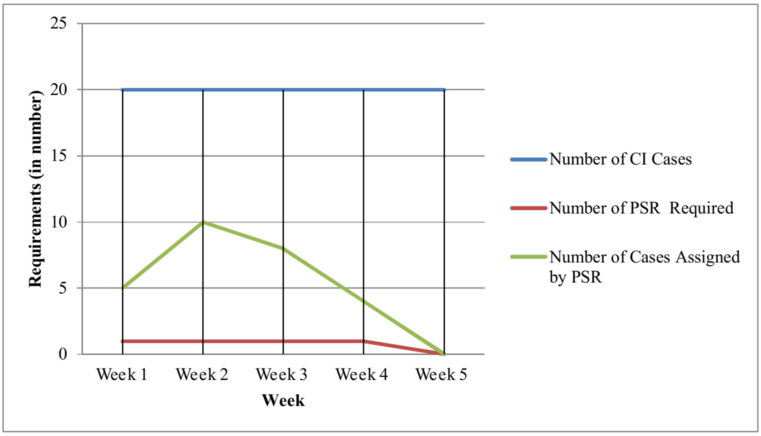

Fig. 9 Week wise PSR status of case 1.4

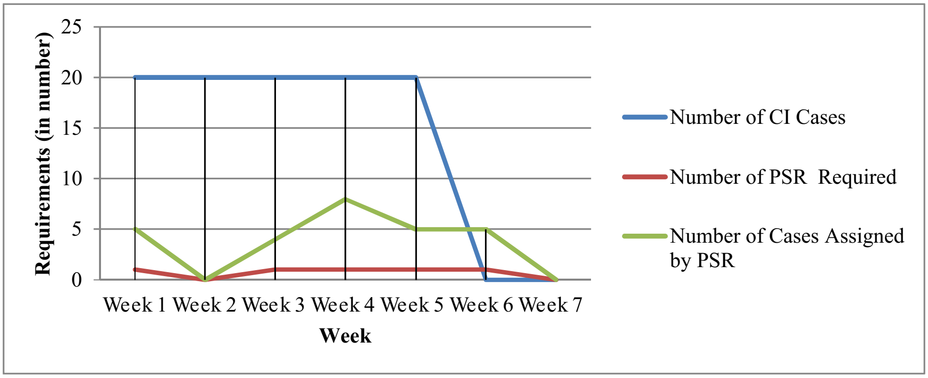

Fig. 10 Week wise PSR status of case 1.5

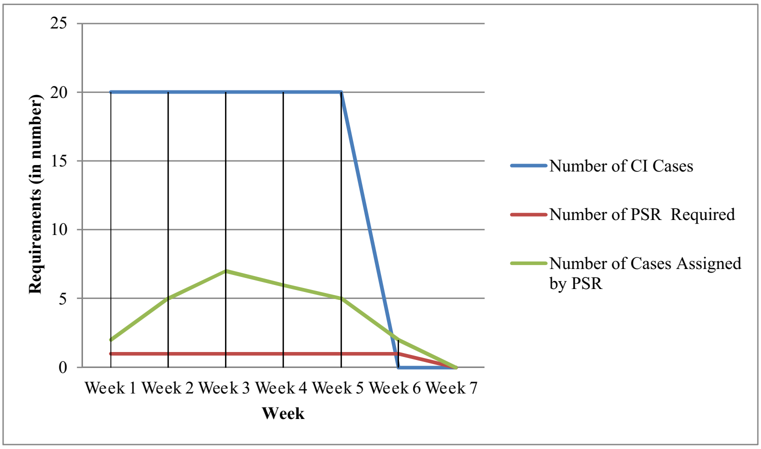

Fig. 11 Week wise PSR status of case 1.6

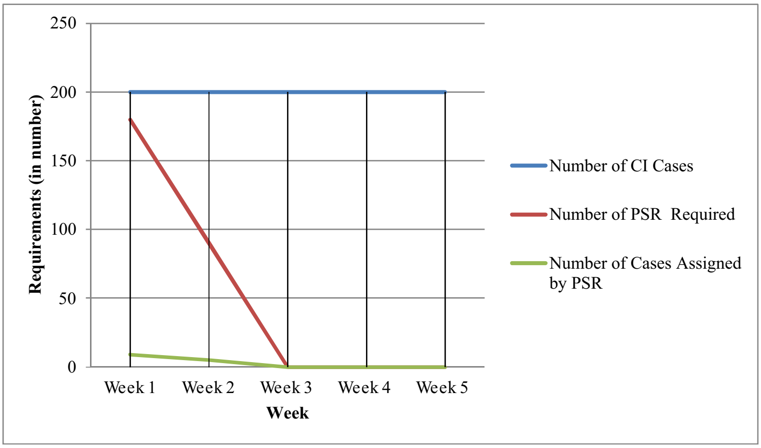

Fig. 12 Week wise PSR status of case 2.1

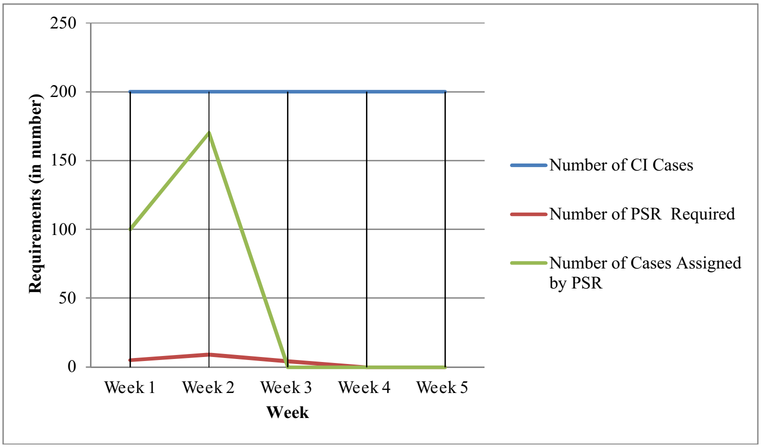

Fig. 13 Week wise PSR status of case 2.2

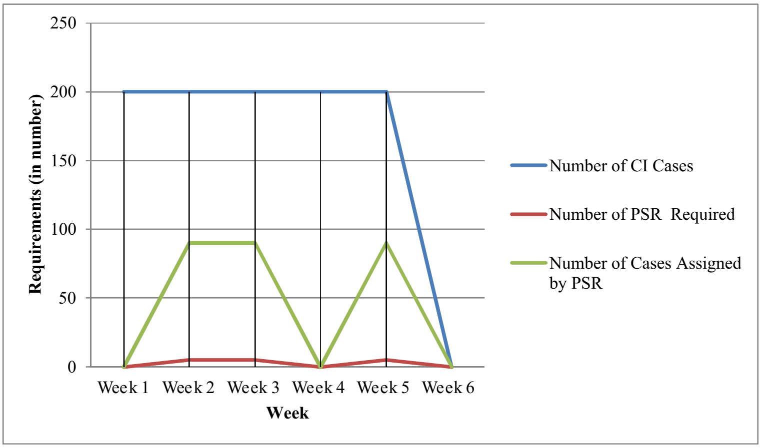

Fig. 14 Week wise PSR status of case 2.3

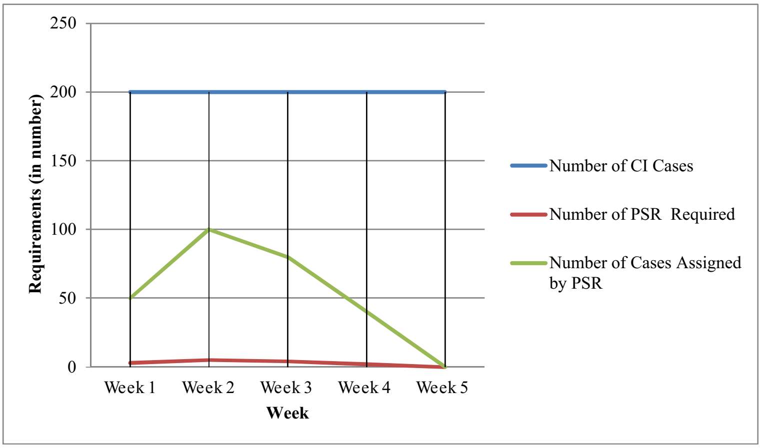

Fig. 15 Week wise PSR status of case 2.4

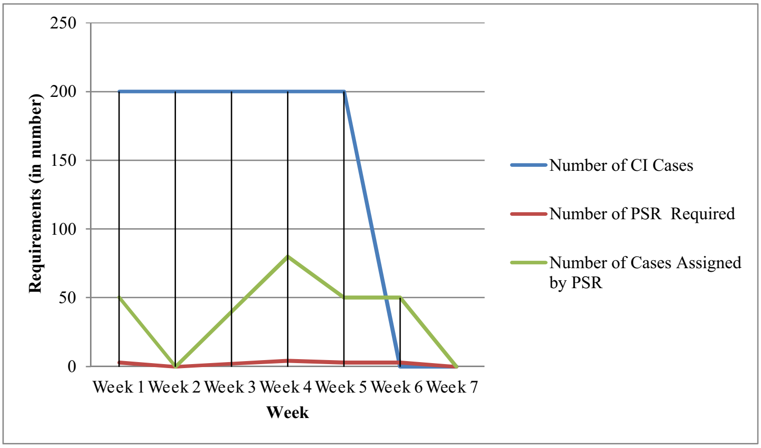

Fig. 16 Week wise PSR status of case 2.5

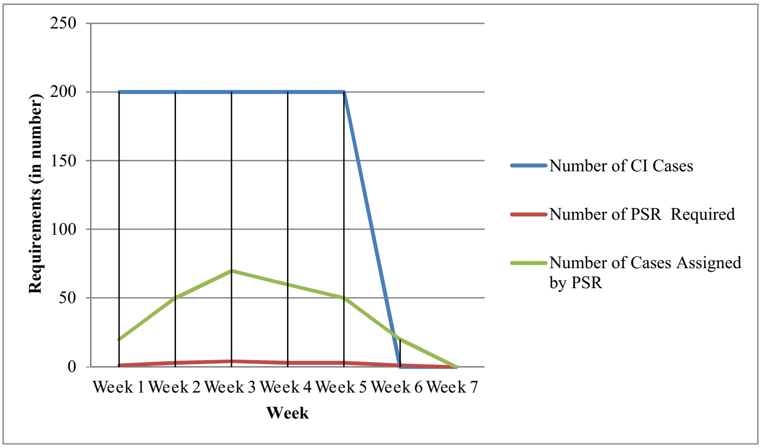

Fig. 17 Week wise PSR status of case 2.6

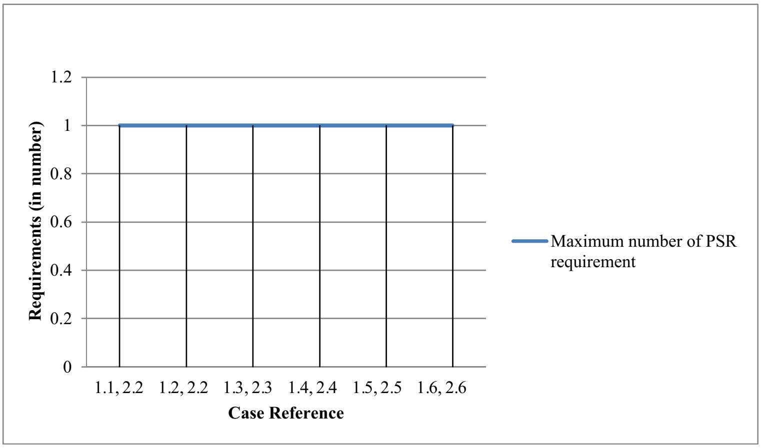

Fig. 18 PSR requirement for 100 CI cases using the proposed method

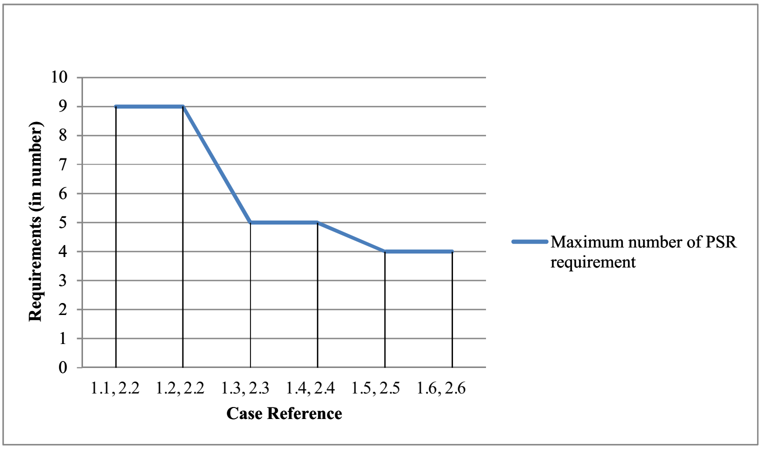

Fig. 19 PSR requirement for 1000 CI cases using the proposed method

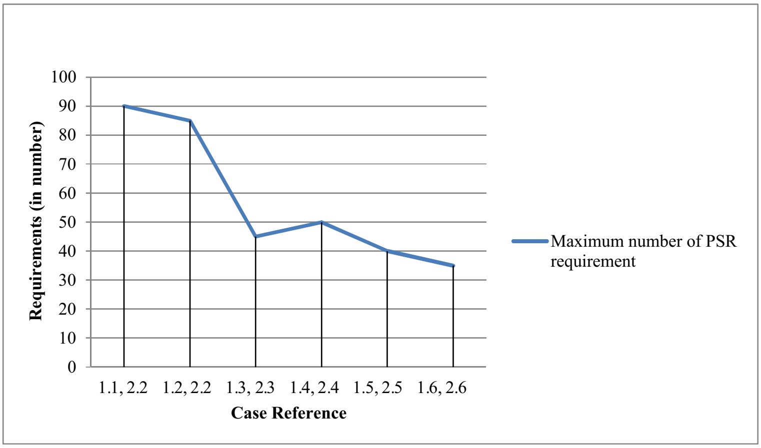

Fig. 20 PSR requirement for 10,000 CI cases using the proposed method

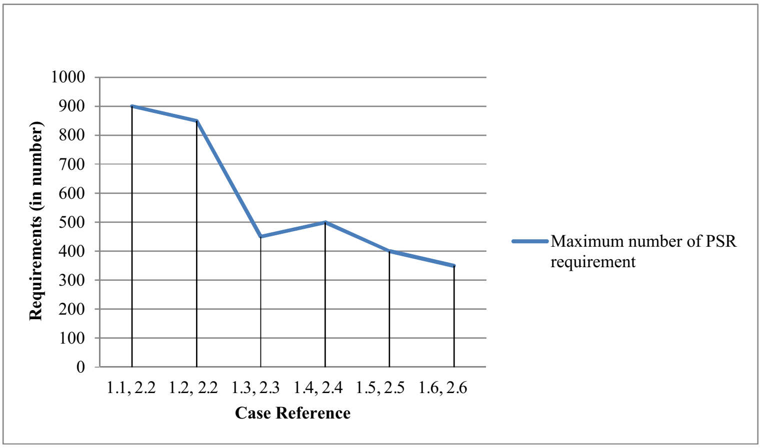

Fig. 21 PSR requirement for 100,000 CI cases using the proposed method

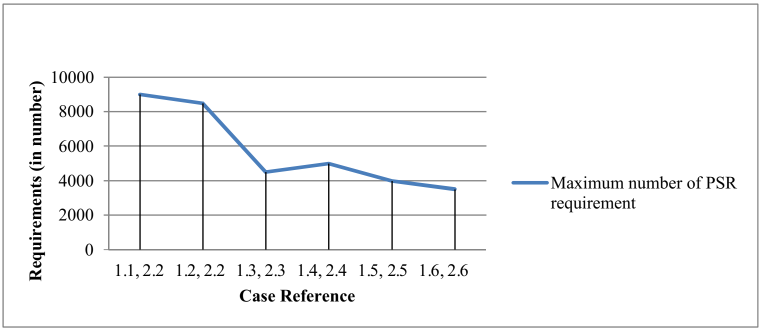

Fig. 22 PSR requirement for 1,000,000 CI cases using the proposed method

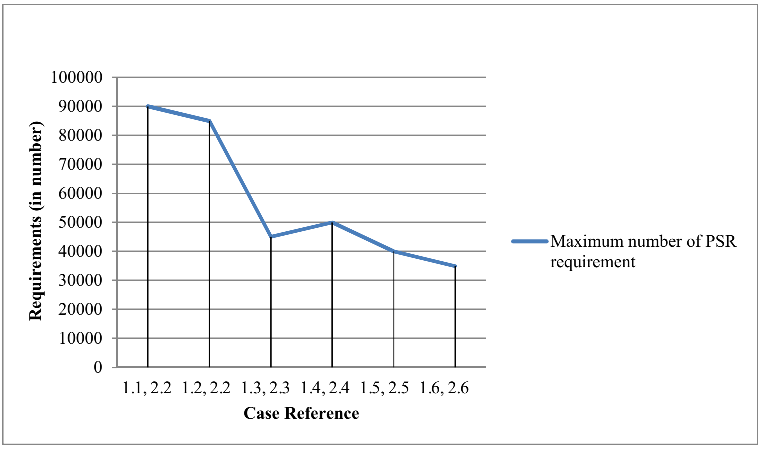

Fig. 23 PSR requirement for 10,000,000 CI cases using the proposed method

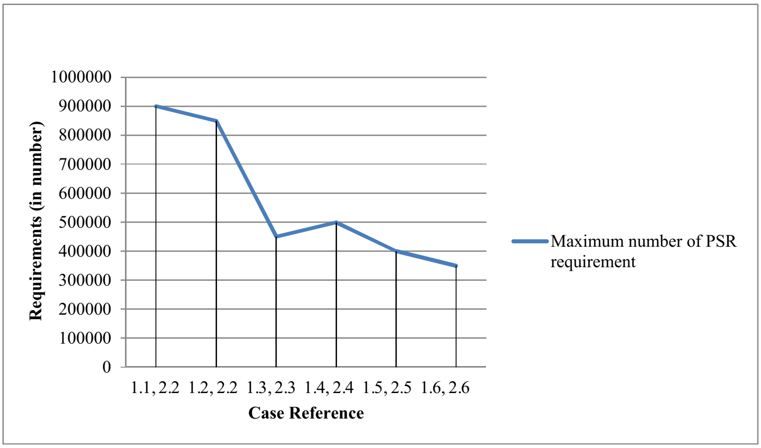

Fig. 24 PSR requirement for 100,000,000 CI cases using the proposed method

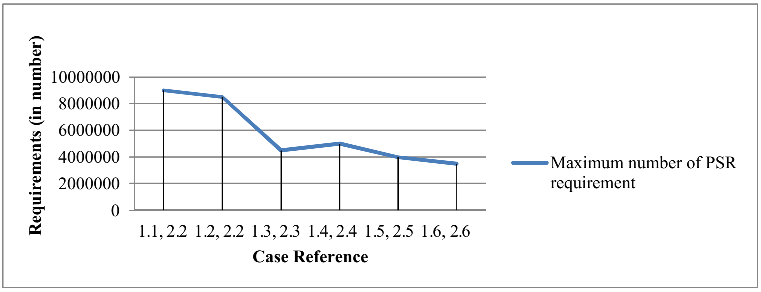

Fig. 25 PSR requirement for 1,000,000,000 CI cases using the proposed method

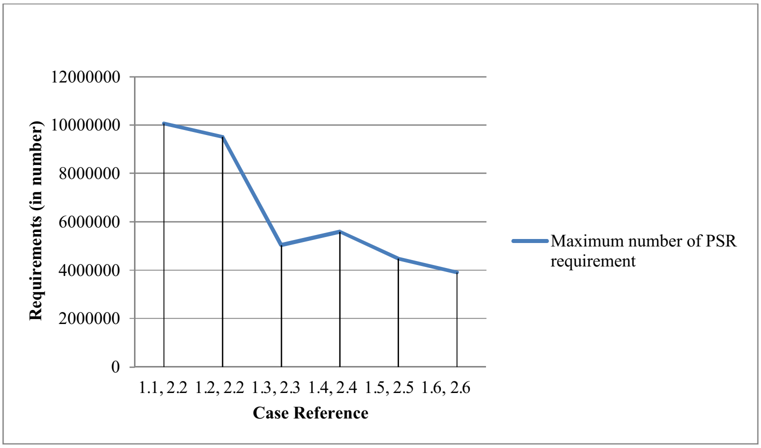

Fig. 26 PSR requirement for 1,120,000,000 CI cases using the proposed method

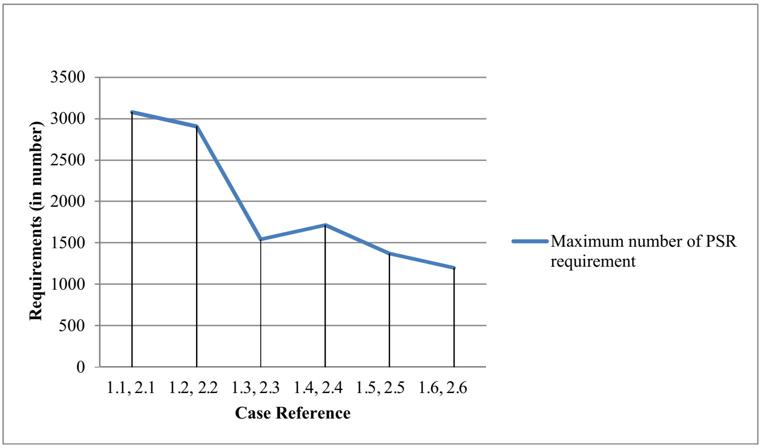

Fig. 27 PSR requirement for 342,033 CI cases using the proposed method

Table 6 PSR requirement for 100 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	1
1.2, 2.2	1
1.3, 2.3	1
1.4, 2.4	1
1.5, 2.5	1
1.6, 2.6	1

Table 7 PSR requirement for 1000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	9
1.2, 2.2	9
1.3, 2.3	5
1.4, 2.4	5
1.5, 2.5	4
1.6, 2.6	4

Table 8 PSR requirement for 10,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	90
1.2, 2.2	85
1.3, 2.3	45
1.4, 2.4	50
1.5, 2.5	40
1.6, 2.6	35

Table 9 PSR requirement for 100,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	900
1.2, 2.2	850
1.3, 2.3	450
1.4, 2.4	500
1.5, 2.5	400
1.6, 2.6	350

Table 10 PSR requirement for 1,000,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	9000
1.2, 2.2	8500
1.3, 2.3	4500
1.4, 2.4	5000
1.5, 2.5	4000
1.6, 2.6	3500

Table 11 PSR requirement for 10,000,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	90,000
1.2, 2.2	85,000
1.3, 2.3	45,000
1.4, 2.4	50,000
1.5, 2.5	40,000
1.6, 2.6	35,000

Table 12 PSR requirement for 100,000,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	900,000
1.2, 2.2	850,000
1.3, 2.3	450,000
1.4, 2.4	500,000
1.5, 2.5	400,000
1.6, 2.6	350,000

Table 13 PSR requirement for 1,000,000,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	9,000,000
1.2, 2.2	8,500,000
1.3, 2.3	4,500,000
1.4, 2.4	5,000,000
1.5, 2.5	4,000,000
1.6, 2.6	3,500,000

Table 14 PSR requirement for 1,120,000,000 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	10,080,000
1.2, 2.2	9,520,000
1.3, 2.3	5,040,000
1.4, 2.4	5,600,000
1.5, 2.5	4,480,000
1.6, 2.6	3,920,000

Table 15 PSR requirement for 342,033 CI cases

Case Reference	Number of PSR required using the proposed method
1.1, 2.1	3079
1.2, 2.2	2908
1.3, 2.3	1540
1.4, 2.4	1711
1.5, 2.5	1369
1.6, 2.6	1198

to COVID-19 warriors as well as CI patients in several hospitals and provide mechanisms that can attempt to save their lives.

5 Conclusion

This paper proposed a novel PSRs assignment framework and a PB method using the FRB approach to assign the PSRs in several hospitals for CI patients in the worst case scenario where the number of PSRs in hospitals is very less as compared to the number of CI patients. The PSRs can be considered as a solution for the treatment of CI patients in the hospitals in the current scenario as the PSRs will help in reducing the spreading of infection, due to which safety can be provided to both COVID-19 warriors and CI patients. This work focuses on lowering the active involvement of COVID-19 warriors for the treatment of HACI patients in this critical situation. From the results, it is concluded that the proposed work can assign the PSRs to the mild CI cases in hospitals in a better way to lower the infection and to break the spreading chain of this virus. The proposed approach can provide safety to COVID-19 warriors as well as to the CI patients in several hospitals and will attempt to save their lives with the help of PSRs. The proposed approach can help the Government of different countries as well as states to take initiatives accordingly, design and assign the PSRs in hospitals to the CI patients in a smooth manner. The proposed method can lower the number of PSRs requirement for the treatment of CI patients as well as can increase the safety of COVID-19 warriors and CI patients in several hospitals. The proposed work provides a clear view of PSRs assignment to the CI patients in a better way in such a crucial situation. This work will be extended to analyze the situations that arise during PSRs assignment to CI patients in several hospitals where the number of mild cases will not arise each and every week in a uniform manner. This work can also be focused on the process of assignment of PSRs to severe CI patients. This work can also be focused on the scheduling of ventilators assignment to the severe CI infected patients.

Declarations

Ethical approval Not Applicable.

Informed consent Not Applicable.

Conflict of interest The authors declare that they have no conflict of interest.

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