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Assessment of COVID-19 prevention and protection measures in hospitals

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ABSTRACT

This paper aims to develop an assessment framework for the Covid-19 prevention and protection measures in hospitals. The conceptual model is developed by using fifty-four attributes, fifteen criteria, and three enablers. The multi-grade fuzzy approach is used to develop the assessment framework, and Importance Performance Analysis (IPA) identifies the weaker attributes in the case organization. The case hospital’s preventive and safety measures assessment level is 8.05, which is ‘very highly focused on protection measures,’ and fourteen weaker attributes were identified. The case hospital management should focus on the guidelines of Covid-19 preventive and protection measures, strict protocols, regular audits, education and training of the staff, and active surveillance. Case hospital managers should also focus on staffing and timings, the formulation of policies, and abiding by those policies without any fail. This proposed assessment model is a new initiative in-hospital assessment in preventive and safety measures in the healthcare sector during the Covid-19 era. This framework will enable hospital managers as a continuous assessment tool to improve their Covid-19 prevention operations.

1. Introduction

On December 31, 2019, the WHO National Office in China received the first report of an outbreak of unexplained lower respiratory infections in Wuhan, China’s Hubei Province’s largest urban area (Lu et al., 2020). Covid-19 has spread far more widely in the community than earlier viral outbreaks such as severe acute respiratory syndrome (SARS) in 2003, H1N1 influenza in 2009, and Middle East respiratory syndrome (MERS) in 2012 and 2015. Covid-19’s extremely contagious nature, even throughout the incubation period, favours the gradual and rapid transmission of SARS-CoV-2 (the virus that caused the Covid-19 outbreak) from person to person via respiratory droplets and contact, as asymptomatic people are unaware of their infection (Cheng et al., 2020). Healthcare organization and the staff are the caregivers for treating coronavirus-infected patients. Frontline healthcare workers are at high risk of infection due to direct contact with the infected patients (WHO, 2020b). To reduce the transmission of coronavirus infection and protect the healthcare staff, preventive and protective measures need to be implemented and practiced in hospitals and other healthcare fields. It is required to have safe work conditions for healthcare workers (HCWs) fighting the effects of SARS-CoV-2 on the front lines by conducting extensive risk assessments, evaluating countermeasures, and implementing them sustainably and effectively (Gross et al., 2021). HCWs are at one of the highest risks of developing COVID-19. Independent of the specific exposure connected to healthcare settings, they are also exposed to the same risk and transmission pathways observed in the population outside of working hours. More specifically, risk of contracting SARS-CoV-2 infection due to several factors, including the healthcare setting (not necessarily an at-risk ward requiring strict preventive measures), longer working hours, night shifts that disrupt the normal waking–sleep rhythm, and poor hand hygiene after contact with patients potentially infected with Covid-19, or inadequacy of personal protective equipment (PPE) and training in it (Costantino and Fiacchini, 2020). Shah et al. (2020) discussed on the hospital admission risk of healthcare workers during treating the Covid 19 patients. There is significant past research in the area of Covid-19 protection and prevention in healthcare sectors The Covid-19 preventive and safety measures are extensively discussed by various researchers. Mudatsir et al. (2020) conducted systematic reviews on the Covid 19 severity and the predictors. Izzetti et al. (2020) discussed about the preventive measures. Rajaan et al. (2019) provided an understanding of the covid 19 prevention interventions. Lakshmi Priyadarshini and Suresh (2020) conducted a study to identify the factors which influence the epistemological pandemic characteristics using TISM approach. Lakshmi Priyadarshini et al. (2020) explored the learnings of previous pandemic to decrease the risk of emerging diseases like coronavirus. Rajalakshmi and Sarika (2020)

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explored on the current interventions of Covid 19 and the factors influencing the pandemic. A few authors discussed Covid-19 preventive and safety measures in hospitals. Belingeri et al. (2020) explored on the healthcare professionals’ situation during the covid 19 pandemic. Patrizi et al. (2020) describes the preventive and protection measures adopted in the hospital. Chughtai et al. (2020) investigated on the policies for protecting the health workers in the hospital in covid 19 pandemic. Wang et al. (2020) discussed on the reasons of getting coronavirus infected by the healthcare workers in China. Yang et al. (2020) explored on the safety, control and prevention of coronavirus disease. Barati et al. (2020) focussed on the behaviours of preventive measures in hospitals. Past researchers focussed on the prevention and protection measures of the hospital, how it is practiced and what to be practiced. Still, there is no research subjected to assessing the preventive and protective measures of the hospitals. This research gap is addressed in this study.

The paper’s objective is to develop a conceptual model for assessing the preventive and protection measures in hospitals during the Covid-19 era. The current study identifies the enablers for preventive and protective measures assessment and the criteria and attributes. The formed framework allows the hospital to analyze the present level of preventive and protective measures practiced.

The rest of the paper is organized as follows. Section 2 depicts the literature review, and section 3 shows the research methodology with a multi-grade fuzzy approach and IPA. Section 4 is about the results and discussion with the suggestion for continuous improvement of weaker attributes. Section 5 includes practical implications, and section 6 includes the conclusion.

2. Literature review

The healthcare systems and hospitals should consider general principles which include prompt action, identifying and involving key stakeholders early on, providing accurate information, prioritizing staff safety and mental health, promoting a fully integrated clinical response, developing expansion plans, preparing behavioural issues, and having an emergency plan for pandemic recovery (Orsini et al., 2020). Preventive and protection measures are safety measures for the medical and non-medical staff to reduce infections. Measures include using personal protective equipment (PPE), regular use of hand sanitizers, cleaning the environment, disinfecting the objects, bio-medical waste management, social distancing, personal hygiene, frequent screening of the Covid-19 symptoms, and standard protocols. Preventive and protection measures are implemented and followed in hospitals, but how can we assess whether those measures are practiced. Virus transmission appears to be the most concerning of the workplace concerns associated with SARS-CoV-2. Due to uncertainties about infection pathways, various testing methodologies within and between countries, and diverse illness symptoms, including unknown numbers of asymptomatic patients, reliable data on incidence and prevalence are difficult to obtain. In most studies, assessment referred to HCWs’ contact with Covid-19 patients (Gross et al., 2021). However, it is critical to assess if the healthcare setting or hospital complies with and adheres to preventative and protective measures to reduce the risk.

2.1. Safety practices of caregivers (C1)

The healthcare workers in direct contact with the Covid positive patient care have a higher risk of being positive. Using the mask, face shields/goggles, and regular decontamination of patient surroundings reduces the risk of being positive among healthcare staff. The staff who have re-used the medical gowns has two times more possibility of being tested covid-19 positive. Re-using gowns should be avoided in hospitals, and gowns should be considered a single-use device to ensure healthcare worker safety (Khalil et al., 2020). The usage of masks helps to prevent viral respiratory illnesses like Covid-19 from spreading. This strategy was previously employed to successfully control the SARS pandemic in 2003 (Gutiérrez-Velasco et al., 2021, February). Personal protection levels are categorized as general protection, primary level, secondary level, and the third level of protection based on the severity.

The process of wearing and removing protective clothes and the working environment should be cleaned and disinfected. Equipment disinfection should be strictly followed to reduce the spread of coronavirus (Ding et al., 2020). The challenges faced by the healthcare agencies at the outbreak of the Covid-19 pandemic were less capacity to test patients for coronavirus, shortage of protective equipment, shortage of staff, and treatment of patients (Hossain et al., 2021). Proper treatment equipment for Covid-19 positive patients should be maintained to function effectively (Shang et al., 2020). Since the outbreak of the Covid-19 pandemic, the whole world has been advised to use a face mask and hand sanitizers. The Covid-19 prevention measures have significantly reduced the country’s annual infectious diseases (contact, transmission, and/or droplets) (Galvin et al., 2020). The hospital team should work on area zoning for different levels. The personal protection equipment should vary according to the different contamination levels (Wei et al., 2020). Hand hygiene is recognized as the first step in preventing and controlling infection and the most effective in reducing coronavirus transmission and has also been used in response to SARS, bird flu and plague, etc. Healthcare workers who practiced high hand hygiene were at low risk of developing SARS. The Infection prevention and control behaviour has significantly increased after the Covid-19 outbreak (Lai et al., 2020). Hand hygiene is highly required and following the hand hygiene practice requires proper interpretation and comprehensive practice. Motivation for hand hygiene can be addressed by allocating more staff resources and increasing supervision and education (Zhou et al., 2020). Hand hygiene performance reached a higher level than the typical level in the pandemic period. Media and other sources had communicated the importance of hand hygiene practice, which led to increased personal protective measures. This ensured in reducing the risk of disease transmission (Moore et al., 2020). Practicing good hand hygiene when entering and leaving a healthcare facility will help reduce the risk of transmitting the disease (Knighton et al., 2020). Personal protective equipment and hand hygiene practices introduced for Covid-19 positively affected the public (Wee et al., 2020a). Staffs and employee health play an important role in preventing Covid-19. Prompt and regular staff check-ups are mandatory to initiate the investigation quickly and help reduce referrals. Daily inspections of medical and non-medical staff, followed by immediate isolation and testing, should be performed in hospitals (Kim et al., 2020). Since the coronavirus is extremely infectious and medical staff members are increasingly exposed to viral particles while often not being provided with adequate protective equipment, HCWs are especially vulnerable compared to the general population, as evidenced by the continuous increase in cases (Sommerstein et al., 2020). HCWs can be protected from SARS-CoV-2 infection using surgical masks, hand cleanliness, and other standard procedures (Costantino et al., 2021).

2.2. Standard precautions (C2)

Implementing critical ICPs is the only way to prevent virus spread in the community. Social distancing, wearing face coverings, using hand sanitizer with at least 60% alcohol, and regular cleaning and disinfection of touched surfaces are among the Covid – 19 ICPs recommended by WHO and national health agencies (WHO, 2020a). Infection control measures and safety practices among staff, including temperature checks for every shift staff before their work, asymptomatic testing to enhance case finding should be practiced in the hospital to control the infection. Infected staff should be isolated at home, install physical barriers, and physical distancing and universal masks are mandatory (Hale and Dayot, 2020). The early recognition of exposure risks, outbreak investigation, and implementation of engineering and administrative safety controls are more important in hospitals to reduce
Infection control and prevention reduced respiratory illness rates even during the pandemic where the respiratory infection was prioritized (Wee et al., 2020a). The primary purpose of infection control and prevention is to reduce the risk of disease to healthcare workers. An infected person is an important source of exposure. High exposure is seen in non-patient areas such as nursing stations and staff rooms or break rooms. (Zabarsky et al., 2020). The hospital needs to use disinfection procedures to reduce the risk of hospital infection by direct contact with contaminated areas. Routine effective disinfection procedures are important in hospitals to reduce the risk of Covid-19 transmission via contaminated rooms or surfaces among the medical, non-medical staff, and the patients (Ge et al., 2020). Recent studies show that contact with contaminated areas has a high risk of getting infected. The virus can even be spread through the aerosol-generating processes and re-aerosolization and can be transmitted when the healthcare personnel remove their protective equipment. Efficient and active ventilators help reduce the risk of transmission to patients with the virus in a closed cycle (Lane et al., 2020). Risk assessment of patients and control techniques help reduce the risk and exposure to infection (Ren et al., 2020).

2.3. Management perspective (C3)

Sharing information would help hospitals and health systems plan and reduce staff and patient risk during the Covid – 19 infection (Zaidi and Narasimhan, 2020). Managers should focus on three main key areas: controlling the source of infection, breaking the transmission route, and protecting the vulnerable populations, and drafting management measure plans and real-time rehabilitation based on the disease mutation (Hu et al., 2020). Best practices to control and prevent infection include triage strategies (such as documentation of patient and patient accompanying member and checking the temperature and the Covid-19 symptoms), ensuring that the medical staff is trained and familiarized with the symptoms of Covid-19, guidelines for treatment, and ensuring the staff self-protection. Medical staff should be updated about the current pandemic scenario and the treatment. Strengthening supervision is one of the best practices to control hospital infection (Zhang et al., 2020). Understanding the Covid-19 disease, its vulnerability, and its severity directly impacts the public to follow the guidelines. Understanding the disease and its symptoms helps the public and the healthcare organization to treat the patients. The people who are not aware of the disease and its severity tend not to obey the guidelines and take preventive measures. The policymakers must ensure that the public is aware of the epidemic, its causes, its symptoms, risks, and effectiveness (Prasetyo et al., 2020). If health care workers are unaware of the threat and severity, they will ignore the details and guidelines to protect Covid – 19. The fear among the healthcare workers will help in following the guidelines than the dangerous feeling. Education and training about the Covid-19 should be provided among the medical and non-medical staff to increase and be effective in preventive behaviours. Future training and education programs must consider the level of performance of healthcare workers and increase their awareness of the importance of recommended strategies for developing preventive measures (Barati et al., 2020). Education and proper monitoring are effective tools for improving hand hygiene during the coronavirus epidemic (Zhou et al., 2020). Orientation, training, and continuous education classes for healthcare staff need to be provided in the hospitals, highlighting preventive measures and equipment. Triage and various critical infectious procedures and policies are mandatory in the healthcare organization. The most common reasons for HCW infection were a lack of PPE and a lack of awareness and training in infection control procedures (Gross et al., 2021). Sufficient supplies of the preventive equipment and healthcare work capacity to be provided in the frontline should be planned and prepared at the time of emergency. The health system must provide an integrated guideline document, including an epidemic prevention task and an infection control function (Lu et al., 2020). The planning should focus more on the emergency-enabled doors, ventilation, and air conditioning systems in various areas, such as clean areas, semi-contaminated areas, and contaminated areas in a pandemic situation. It is necessary to form a separate outdoor emergency clinic or cabin to break the chain of infections (Chen et al., 2020). The hospital must have proper risk assessment and management for the Covid-19 pandemic, and it is important to follow appropriate infection prevention and control for pre-operative management. Organizing protocols and standards of the procedure increases the performance efficiency and helps in the smooth functioning of the healthcare organization (Kim et al., 2021). Hospitals should maintain pandemic plans considering the treatment. It is best to perform coronavirus tests, antibody tests, and screening before admitting the patient. There should have a screening of hospital staff to ensure the safety of staff and patients (Dorothesa and Manuela, 2020). Contingency plans should be developed to avoid the spread of infection and collapse of healthcare facilities (Giesen et al., 2020). The Provision of adequate personal protective equipment and surveillance among ancillary healthcare workers should be part of preventing and controlling infection in hospital paws during the epidemic (Wee et al., 2020b).

The research proposes to assess the Covid – 19 prevention and protection measures in hospitals with a case hospital. The multi-grade fuzzy and IPA are applied to develop this assessment framework of prevention and safety measures at the workplace, particularly in hospitals, by the following research question (RQ) s:

RQ1 How to measure the Covid-19 prevention and safety level in hospitals?
RQ2 What are the attributes that influence the Covid-19 prevention and safety level in hospitals?
RQ3 How weaker attributes are addressed in the case hospital?

The prevention and safety level assessment study has been conducted to answer the above research question. This assessment framework will enable healthcare organizations to determine the current Covid-19 preventive and safety measures in their hospitals.

3. Research methodology

The multi grade fuzzy was used to analyze lean, agile, performance, safety practise level, and supply chain management effectiveness in the industrial and service industries. Ganesh and Suresh (2016) conducted a case study of an Indian manufacturing company’s safety practise level assessment utilising a multi-grade fuzzy technique. Vinodh and Chintha (2011) created leanness measurement model using a multi-grade fuzzy technique. Sridharan and Suresh (2016) assessed environmental sustainability by utilising multi-grade fuzzy approach. Vinail et al. (2015) used multi grade fuzzy approach for evaluating the process sustainability. Vinodh (2011) assessed the sustainability by utilising the multi grade fuzzy approach. Almutairi et al. (2019) investigated and assessed the supply chain leanness in a healthcare setting. In this present research the multi grade fuzzy approach is acquired from various researchers.

A review of literature on covid 19 prevention and protection measures is the first step in this study’s methodology. Second, a conceptual model for assessment is developed. Then, a suitable hospital for the case study was identified. To data for this study was gathered through scheduled interviews with a closed ended questionnaire. The questionnaire was designed and validated based on expert opinions. Doctors and managers from various Indian hospitals, having an experience of 3–10 years are among the specialists. The information of the experts is listed in Table 1. 3 enablers, 15 criteria, and 54 attributes were identified as
essential for hospital protection and safety measures. Finally, the interview was conducted with 50 min. The first 10 min were spent discussing the study and the enablers, criteria, attributes, followed by 40 min of data collection from participants. Then, a multi-grade fuzzy logic approach was utilised to assess the prevention and protection measures of Covid 19. A realistic conclusion was drawn after calculating the covid 19 prevention and protection measures index. The attributes that need to be enhanced for a better performance were determined. Fig. 1 shows the proposed structure for a hospital’s prevention and protection measures fuzzy evaluation. There are three stages to it. To uncover ‘enabler’, ‘criteria’, and ‘attributes’ is the first step is to conduct a literature review. The second step is to choose an appropriate hospital for the assessment. The third step entails a continuous examination of assessment and preparing the hospital to investigate the degree of prevention and protection measures practise in order to improve hospital performance.

3.1. Multi-grade fuzzy

The Covid-19 preventive and safety measures are extensively discussed by various researchers. Mudatsir et al. (2020) explored on the predictor factors of coronavirus severity by a systematic review. Izzetti et al. (2020) discussed about the preventive measures in dental care. A few authors discussed Covid-19 preventive and safety measures in hospitals. Belingheri et al. (2020) investigated the situation of healthcare workers during the Covid 19 epidemic. Patrizi et al. (2020) described the hospital’s preventive and protection procedures. Chughtai et al. (2020) looked on policies for protecting healthcare staff during the covid 19 epidemic. Wang et al. (2020) examined the reasons for healthcare professionals in China becoming infected with the coronavirus. Yang et al. (2020) investigated coronavirus disease safety, control, and prevention. Barati et al. (2020) focused on hospital patients’ attitudes about preventive interventions.

This paper develops Covid-19 preventive and safety measures assessment framework using multi-grade fuzzy. This methodology is well known and simple to compute index value, and it’s extensively applied in the service sector (Suresh and Gopakumar, 2021; Ranjitha et al., 2022). Multi Grade Fuzzy approach has been increasingly popular in the field of operations management (Subramanian and Suresh, 2022). To overcome the uncertainty and vagueness inherent with an assessment, researchers developed a fuzzy-logic technique. In the multi-criteria decision-making procedure, there are numerous

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### Table 1

| Designation             | Number of respondents |
|-------------------------|----------------------|
| Administration executives | 5                    |
| Doctors                 | 3                    |
| Staff nurses            | 2                    |

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**Fig. 1.** Development of Covid 19 prevention and protection measures assessment framework for Hospitals using Multi-Grade Fuzzy.
An extensive literature study was undertaken to find the attributes, and attributes are captured from the literature review and expert additional aspects and categorizing it. The questionnaire was used with 54 attributes shown in Table 2. The preventive and safety measures mitigation (Anil and Suresh, 2020).

3.2.1. About the case hospital

The case hospital began in 1998 and has expanded to a NABH-accredited and ISO 2008-certified facility with 600 beds and many consulting departments. It consists of a 24-h pharmacy, laboratory, modern operation theatres, radiology, ambulance services, commercial block with accommodation options for relatives of patients, and cafeteria facility; water and sewage treatment plant are all part of the hospital’s general infrastructure. The hospital runs multi-specialty departments in gynaecology, psychiatry, pulmonology, orthopaedics, ophthalmology, oncology, cardiology, dental care, dermatology, endocrinology, etc. ENT, gastroenterology, and surgery departments.

3.2.2. Calculations

The data was collected using a 10-point Likert scale and a questionnaire. Table 3 lists the linguistics measurements as well as the fuzzy scales for ratings and weightage. For the negative qualities, the opposite corresponds fuzzy scales for ratings and weightage. For the negative qualities, the opposite.

The assessment has been divided into ten grades, and the entire Covid-19 preventive and safety index involves fuzzy determination. \[ C = 10 \times R \] (Vinodh, 2011; Vimal et al., 2015)

The assessment has been divided into ten grades, and the entire Covid-19 preventive and safety index involves fuzzy determination. \[ C = \sum_{i=1}^{10} W_i \times R_i \]

### Table 2

| Enablers | Criteria | Attributes |
|----------|----------|------------|
| Safety practices of caregivers (C1) | Personal protective equipment (C11) | Usage of gloves by medical and non-medical staff (C111) |
| | | Usage of face shield by medical and non-medical staffs (C112) |
| | | Usage of face masks by medical and non-medical staff (C113) |
| | | Goggles/Aprons (C114) |
| | | Protective gowns (C115) |
| | | Shoe covers (C116) |
| | Personal hygiene (C12) | Personal hygiene of medical and non-medical staffs (C121) |
| | | Personal hygiene of canteen staffs (C122) |
| | Preventive measures (C21) | Maintain social distancing among caregivers (C211) |
| | | Use of hand sanitizer regularly (C212) |
| | | Avoid risk age group as patient bystanders (C213) |
| | | Initial assessment units to avoid unnecessary consultation (C214) |
| | | Screening of Covid 19 symptoms in the frontline entrance (C215) |
| | | Disinfect the pen used by the patients in the registration counter (C221) |
| | | Regular cleaning of common washrooms (C222) |
| | | Disinfect the slipper stands (C223) |
| | | Disinfect the diagnostic equipment like ultrasound scanner prob after one patient use (C224) |
| | | Disinfect the OT beds and post-operative wards (C225) |
| | | Disinfect rooms after the discharge of patients (C226) |
| | | Disinfecting the cleaning equipment (C227) |
| | | Cleaning the floors and tables (C228) |
| | | The blankets used in post-operative wards to be sterilized after a single use (C231) |
| | | Sterilization and disinfecting the linen and laundry (C232) |
| | | Disinfecting single-use devices and waste management (C241) |
| | | Separate trash bins for personal protective equipment’s with automatic waste containers (C242) |
| | | Non-touch receptacles for waste disposal (C243) |
| | | Biomedical waste management after disinfecting (C244) |
| | | Control of transport of food items to the ward (C251) |
| | | Limit transport of movements of patients (C252) |
| | | Awareness to the public (C261) |
| | | Use of PPE kits by the visitors in ICU, NICU, and post-operative wards (C262) |
| | | Frequent screening of symptoms of Covid 19 among the caregivers and staff (C263) |
| | | Distance between seats in the waiting area (C271) |
| | | Optimum spacing between beds in wards (C272) |
| | | Reduce the number of bystanders with the patient (C273) |

(continued on next page)
Table 2 (continued)

| Enablers | Criteria | Attributes |
|----------|----------|------------|
| Management perspective (C3) | Top management support (C31) | One-meter distance between the patients in registration counters (C274) |
| | | Purchase of quality and required amount of personal protective equipment (C311) |
| | | Structure for planning and decision making (C312) |
| | | Management decision-making teams (C313) |
| | | Supply of required personal protective equipment daily for caregivers (C314) |
| Visual Control (C32) | | Prepare Covid-19 infection control checklist (C321) |
| | | Maintain token system or call-out names in pharmacy to reduce the overcrowding (C322) |
| Training and guidelines (C33) | | Special training sessions on infection control and prevention to medical and non-medical staffs (C331) |
| | | Staffing guidelines and timings (C332) |
| | | SOP for emergency cases (C333) |
| Standard protocol (C34) | | Formulate infection control policies and audits (C341) |
| | | Development of a written Covid plan (C342) |
| | | Regular audits on infection controls (C343) |
| Information technology integration (C35) | | Documentation of patients’ names and bystanders who visited the hospital (C351) |
| | | Booking facilities with time slot (C352) |
| | | The flow of information internally and externally (C353) |
| Work environment (C36) | | Proper ventilation and light in the rooms (C361) |
| | | Natural light rooms (C362) |
| | | Parking facilities with distance (C363) |

Ratings and weightage scale for Covid-19 preventive and safety measures.

| SL No | Attributes rating | Enabler, Criteria and attributes weight |
|-------|-------------------|----------------------------------------|
|       | Linguistic measure | Rating (Cᵢⱼ) | Weight (Wᵢ/ W/ᵢ) |
| 1     | Worst             | 1            | No Importance      | 1          |
| 2     | Very Very Poor    | 2            | Very Less Important| 2          |
| 3     | Very Poor         | 3            | Less Important     | 3          |
| 4     | Poor              | 4            | Moderate Important | 4          |
| 5     | Fair              | 5            | Important          | 5          |
| 6     | Highly Fair       | 6            | Highly Important   | 6          |
| 7     | Good              | 7            | Very High Important| 7          |
| 8     | Very Good         | 8            | Very Very Important| 8          |
| 9     | Very Very Good    | 9            | Extremely Important| 9          |
| 10    | Outstanding       | 10           | Very Extremely Important| 10          |

‘Personal protective equipment (C11)’ criterion is given below.

Weights concerning “Personal protective equipment” criterion is \( W₁₁ = [0.2, 0.178, 0.213, 0.16, 0.165, 0.165, 0.082] \)

\[
R₁₁ = \begin{bmatrix}
10 & 10 & 10 & 10 & 10 \\
10 & 8 & 9 & 9 & 9 \\
10 & 10 & 10 & 10 & 10 \\
9 & 8 & 7 & 8 & 7 \\
9 & 8 & 6 & 6 & 7 \\
4 & 4 & 4 & 4 & 4 \\
\end{bmatrix}
\]

‘Personal protective equipment’ index \( C₁₁ = W₁₁ \times R₁₁ \) (Suresh et al., 2020)

Using the same computation procedure, the remaining criteria indexes are derived below.

\( C₁₂ = [7.5, 7, 6, 6, 6] \)

\( C₁₃ = [9.2, 8.4, 8.33, 8.36, 8.39] \)

\( C₁₄ = [10, 9, 9, 9, 9] \)

\( C₁₅ = [9.01, 8.76, 8.26, 8.74, 8.5] \)

\( C₁₆ = [7.52, 7.57, 6.52, 5.52, 6.04] \)

\( C₁₇ = [8.33, 7.36, 7.37, 6.04, 8.33] \)

\( C₁₈ = [7.72, 8.02, 7.76, 7.74, 8.02] \)

\( C₁₉ = [8.43, 8.71, 8.5, 8.71, 8.72] \)

\( C₂₀ = [7.61, 8.08, 7.54, 8, 8.08] \)

\( C₂₁ = [9.03, 8.4, 8.4, 8.69, 8.4] \)

\( C₂₂ = [8.31, 8.31, 8.32, 7.98, 8.32] \)

\( C₂₃ = [9.04, 8.73, 8.41, 8.72, 8.41] \)

\( C₂₄ = [7.77, 7.77, 7.77, 8.07, 7.77] \)

3.2.2.2. Second grade computation. The second-grade computation is done for the “Safety practices of caregivers (C1)” enabler is given below.

Weights concerning to “Safety practices of caregivers” enabler is \( W₂ = [0.5, 0.5] \)

\[
R₂ = \begin{bmatrix}
9.18 & 8.85 & 8 & 8.34 & 8.35 \\
7.5 & 7 & 6 & 7 & 6 \\
\end{bmatrix}
\]

‘Safety practices of caregivers’ Index \( C₁ = W₁ \times R₁ \)

\( C₁ = [8.33, 7.93, 7, 7.67, 7.17] \)

Using the same computation procedure, the remaining enabler indexes are derived below.

\( C₂ = [8.74, 8.35, 7.99, 8.08, 8.29] \)

\( C₃ = [8.36, 8.32, 8.15, 8.35, 8.27] \)

3.2.2.3. Third grade computation. The third-grade computation is done for the “Covid-19 Preventive and Safety Index” is given below.

Weights concerning to “Covid-19 Preventive and Safety Index” is \( W = [0.355, 0.34, 0.3] \)

\[
R = \begin{bmatrix}
8.33 & 7.93 & 7 & 7.67 & 7.17 \\
8.74 & 8.35 & 7.99 & 8.08 & 8.29 \\
8.36 & 8.32 & 8.15 & 8.35 & 8.27 \\
\end{bmatrix}
\]

‘Covid-19 Preventive and Safety Index’ \( C = W \times R \)

\( C = [8.48, 8.19, 7.69, 8.02, 7.89] \)

\( C = (8.48 + 8.19 + 7.69 + 8.02 + 7.89)/5 \rightarrow 8.05 \)

\( C = 8.05 \rightarrow ‘very highly focused on protection measures’ \)

The case-hospitals Covid-19 preventive and safety index is 8.05, indicating that hospitals are highly focused on Covid-19 protection measures. Next, the IPA has been conducted to classify the attributes based on their importance and performance.

3.3. Importance-performance analysis (IPA)

Martilla and James (1977) established the Importance-Performance Analysis (IPA). IPA is extensively applied in various areas to classify attributes into four categories (Oh, 2001). This study method has been
used in the past to improve health services and patient satisfaction in the healthcare field. The result of an IPA determines whether or not anything is scientific. The importance and performance of health services are investigated using an IPA (Kinnaer et al., 2020). The IPA is operationalized by subtracting the “importance” values from the “performance” values from the “performance score” to see if disconfirmation exists (Padlee et al., 2020). The IPA model allows both weightage and performance rating to be shown graphically in the same graph (Menon and Suresh, 2020). In the IPA plot, ratings, weights of attributes are represented in the horizontal and vertical axis (Kinnaer et al., 2020). The mean attributes ratings are a central line on the horizontal axis, and the mean of mean attributes weights is a central line on the vertical axis. The ratings mean of means is 8.26, and the weights mean of means is 8.66. Covid-19 preventive and safety attributes are classified based on their importance (weight) and performance (rating) in Figure-2.

Zone I (Attention seeking attributes): The attribute in this zone is needed to pay attention to by the case-hospital manager. The following attributes are present in this zone, Personal hygiene of medical and non-medical staff (C121), Personal hygiene of canteen staff (C122), Disinfect the pen used by the patients in the registration counter (C221), Biomedical waste management after disinfecting (C244), Limit transport of movements of patients (C252), awareness to the public (C261), Use of PPE kits by the visitors in ICU, NICU and post-operative wards (C262), Frequent screening of symptoms of Covid-19 among the caregivers and staffs (C263), the distance between seats in the waiting area (C271), One-meter distance between the patients in registration counters (C274), Staffing guidelines and timings (C332), Formulate infection control policies and audits (C341), Regular audits on infection controls (C343), Booking facilities with time slot (C352).

Zone II (Keep up the good work): This zone’s attributes are needed to maintain the same performance. The following attributes are present in this zone, Usage of gloves by medical and non-medical staffs (C111),

| Table 4 | Covid-19 preventive and safety measures ratings and normalized weights for case-hospital. |
|---------|------------------------------------------------------------------------------------------|
| Enablers | Criteria | Attributes | E1 | E2 | E3 | E4 | E5 | Wij | Wi | W |
| C1      | C11      | C111       | 10 | 10 | 10 | 10 | 10 | 0.2 | 0.5 | 0.3551 |
|         | C112     | 10 | 10 | 8  | 9  | 9  | 0.1782 |
|         | C113     | 10 | 10 | 10 | 10 | 10 | 0.2130 |
|         | C114     | 9  | 8  | 7  | 8  | 7  | 0.1608 |
|         | C115     | 9  | 8  | 6  | 7  | 7  | 0.1652 |
|         | C116     | 4  | 4  | 4  | 4  | 4  | 0.0826 |
|         | C121     | 10 | 9  | 7  | 8  | 7  | 0.5 | 0.5 |
|         | C122     | 5  | 5  | 5  | 6  | 5  | 0.5 |
| C2      | C21      | C211       | 10 | 8  | 7  | 8  | 9  | 0.2184 | 0.1519 | 0.3406 |
|         | C212     | 10 | 9  | 10 | 10 | 10 | 0.2135 |
|         | C213     | 8  | 8  | 7  | 8  | 7  | 0.1747 |
|         | C214     | 9  | 9  | 8  | 8  | 9  | 0.1601 |
|         | C215     | 9  | 9  | 9  | 9  | 9  | 0.233 |
| C22     | C221     | 8  | 8  | 7  | 8  | 7  | 0.1215 | 0.1458 |
|         | C222     | 9  | 9  | 9  | 9  | 9  | 0.1325 |
|         | C223     | 7  | 7  | 6  | 6  | 7  | 0.1022 |
|         | C224     | 9  | 9  | 8  | 9  | 8  | 0.1132 |
|         | C225     | 10 | 10 | 10 | 10 | 10 | 0.1381 |
|         | C226     | 10 | 10 | 10 | 10 | 10 | 0.1381 |
|         | C227     | 10 | 10 | 9  | 10 | 10 | 0.1381 |
|         | C228     | 10 | 9  | 8  | 8  | 9  | 0.1160 |
| C23     | C231     | 10 | 9  | 9  | 9  | 9  | 0.5106 | 0.1428 |
|         | C232     | 10 | 9  | 9  | 9  | 9  | 0.4893 |
| C24     | C241     | 10 | 9  | 8  | 9  | 9  | 0.2470 | 0.1367 |
|         | C242     | 10 | 9  | 9  | 9  | 9  | 0.2588 |
|         | C243     | 8  | 8  | 8  | 9  | 8  | 0.2352 |
|         | C244     | 9  | 8  | 8  | 8  | 8  | 0.2588 |
| C25     | C251     | 9  | 7  | 6  | 6  | 5  | 0.4767 | 0.1337 |
|         | C252     | 8  | 9  | 7  | 6  | 7  | 0.5232 |
| C26     | C261     | 8  | 8  | 8  | 9  | 8  | 0.3571 | 0.1519 |
|         | C262     | 8  | 7  | 6  | 7  | 8  | 0.3142 |
|         | C263     | 9  | 7  | 8  | 8  | 9  | 0.3285 |
| C27     | C271     | 7  | 8  | 7  | 7  | 8  | 0.2634 | 0.1367 |
|         | C272     | 9  | 9  | 9  | 8  | 9  | 0.2473 |
|         | C273     | 8  | 7  | 7  | 8  | 7  | 0.2258 |
|         | C274     | 7  | 8  | 8  | 8  | 8  | 0.2634 |
| C3      | C31      | C311       | 8  | 9  | 8  | 9  | 8  | 0.2795 | 0.1496 | 0.3043 |
|         | C312     | 9  | 9  | 8  | 9  | 9  | 0.2173 |
|         | C313     | 9  | 9  | 9  | 9  | 9  | 0.2173 |
|         | C314     | 8  | 8  | 9  | 8  | 9  | 0.2857 |
|         | C321     | 9  | 9  | 8  | 8  | 9  | 0.5393 | 0.1569 |
|         | C322     | 6  | 7  | 7  | 8  | 7  | 0.4606 |
| C33     | C331     | 10 | 10 | 10 | 10 | 10 | 0.3692 | 0.1715 |
|         | C332     | 8  | 7  | 7  | 7  | 7  | 0.3384 |
|         | C333     | 9  | 8  | 8  | 9  | 8  | 0.2923 |
| C34     | C341     | 9  | 9  | 8  | 8  | 8  | 0.3359 | 0.1824 |
|         | C342     | 9  | 9  | 9  | 9  | 9  | 0.3203 |
|         | C343     | 7  | 7  | 8  | 7  | 8  | 0.3437 |
| C35     | C351     | 10 | 10 | 10 | 10 | 10 | 0.3656 | 0.1605 |
|         | C352     | 8  | 8  | 7  | 7  | 7  | 0.3208 |
|         | C353     | 9  | 8  | 8  | 9  | 8  | 0.3134 |
| C36     | C361     | 9  | 9  | 9  | 9  | 9  | 0.3464 | 0.1788 |
|         | C362     | 9  | 9  | 9  | 9  | 9  | 0.3464 |
|         | C363     | 5  | 5  | 5  | 6  | 5  | 0.3070 |
Usage of face mask by medical and non-medical staffs (C113), Maintain social distancing among caregivers (C211), use of hand sanitizer regularly (C212), Screening of Covid-19 symptoms in the front line entrance (C215), Regular cleaning of common washrooms (C222), Disinfect the OT beds and post-operative wards (C225), Disinfecting the cleaning equipment (C227), The blankets used in post-operative wards to be sterilized after single use (C231), sterilization and disinfecting the linen and laundry (C232), Separate trash bins for personal protective equipment with automatic waste container (C242), Optimum spacing between beds in wards (C272), Purchase of quality and required amount of personal protective equipment (C311), Supply of required personal protective equipment daily for caregivers (C314), Prepare Covid-19 infection control checklist (C321), Special training sessions on infection control and prevention to medical and non-medical staffs (C331), Documentation of patients name and by standers who visited the hospital (C351), Proper ventilation and light in the rooms (C361), Natural light rooms (C362).

Zone III (Possible overkill): The importance of these attributes is low, and performances are more than required. The following attributes are present in this zone, usage of face shield by medical and non-medical staffs (C112), Initial assessment units to avoid unnecessary consultation (C214), Disinfect the diagnostic equipment like ultrasound scanner probe after one patient use (C224), Cleaning the floors and tables (C228), Disinfecting single-use devices and waste management (C241), Structure for planning and decision making (C312), Management decision making teams (C313), SOP for emergency cases (C333), Development of a written Covid plan (C342), Flow of information internally and externally (C353).

Zone IV (Low priority): The importance of the attributes is low, and the performance is also low. The following attributes are present in this zone, Goggles/Apron(C114), Protective gowns (C115), Shoe covers (C116), Avoid risk age group as patient bystanders (C213), Disinfect the slipper stands (C223), Non-touch receptacles for waste disposal (C243), control of the transport of food items to the ward (C251), Reduce the number of bystanders with the patient (C273), Maintain token system or call-out names in pharmacy to reduce the overcrowding (C322), Parking facilities with distance (C363).

4. Results and discussions

The two aspects of analysis that are fundamental in the protection and prevention measures assessment model in a selected case hospital are identifying the current measurement level in case hospital it is 8.05 which is highly focused on preventive and protective measures. Second, identified fourteen weaker attributes that need to be taken for special consideration in the case hospital.

The present study used Importance performance analysis (IPA) to identify the weaker attributes. The study identified fourteen weaker attributes, including personal hygiene of medical and non-medical staffs, personal hygiene of canteen staff, disinfecting the pen used by the patients in the registration counter, disinfection and bio-medical waste management, limited transport of movement of patients, awareness to the public, use of PPE kits by the visitors in ICU, NICU and post-operative wards, frequent screening of symptoms of Covid-19 among the caregivers and staffs, the distance between seats in the waiting area, 1-m distance in the registration counter, staffing guidelines and timings, formulation of infection control and audits, regular audits and booking.

| Importance | Zone I | Zone II |
|------------|--------|---------|
| 10.5       | C122   | C271, C274, C121, C261, C215, C222, C321, C231, C113, C225, C226, C227, C331, C351 |
| 9.5        |        | C263, C314, C272, C232, C361, C362, C242, C212 |
| 9          | C252, C262, C332, C343, C352 | C221, C244, C341, C211, C311, C224, C228, C241, C342 |
| 8.5        | C251   | C322, C273, C353, C224, C228, C241, C342, C112 |
| 8          | C363   | C115, C243, C333 |
| 7.5        |        | C223, C213, C114, C214, C312, C313 |
| 7          |        | |
| 6.5        |        | |
| 6          |        | |
| 5.5        |        | |
| 5          |        | |
| 4.5        | C116   | |
| 4          |        | |
| 3.5        | Zone IV | Zone III |

Fig. 2. IPA plot of Covid-19 preventive and safety attributes for case-hospital.
facilities. The study provides suggestions to the weaker attributes that need to be taken into more consideration for improvement are given in Table 5.

5. Practical/managerial implications

The three major managerial implications of this study are; first, it helps the hospital identify preventive and protective measures. The conceptual model for assessing the measurement level of the hospital used the multi-grade fuzzy approach, and this framework identified the attributes. Second, identifies the attributes which are strong and weaker in the case hospital. Third, the study provides the improvement decisions to enhance the level. This framework provides managers to assess preventive and protective measures. The management should focus on the guidelines of Covid-19 preventive and protection measures, strict protocols, regular audits, education and training of the staff, and active surveillance. Managers should also focus on staffing and timings, the formulation of policies, and abiding by those policies without any fail. This model gives the hospital management a pathway to improve the weaker attributes. It helps the management categorize the attributes based on their importance, such as attributes that hospital managers should pay more attention to, the attributes to maintain the same performance level, the attributes that are practiced more than required, and the attributes with low priority. This Assessment tool can be used continuously to assess and evaluate Covid-19 preventive and protective measures. The management should maintain the stronger attributes and take initiatives to improve the performance of the weaker attributes.

Table 5
Identified improvement required attributes and improvement decisions.

| Improvement required attributes | Suggestions for improvement |
|---------------------------------|----------------------------|
| Personal hygiene of medical and non-medical staff | • Training and education on personal hygiene of medical and non-medical staffs  
• Frequent interval surveillance and supervision |
| Personal hygiene of canteen staffs | • Strict protocols on canteen staff’s hygiene  
• Surprise audits by the management  
• Screening of staffs |
| Disinfect the pen used by the patients in the registration counter | • Remove the common use pen from the registration counter  
• Use of hand sanitizer before entering the registration counter |
| Biomedical waste management after disinfecting | • Revised SOP for waste management.  
• Special units for disinfection  
• Regular audits and supervision |
| Limit transport of movements of patients | • Reduce overcrowding  
• Proper guidelines to the patients and bystanders to avoid unnecessary movement in the hospital. |
| Awareness to the public | • Awareness classes for the public  
• Picturing the risk of the pandemic and the preventive measures as a notice in the hospital’s front entrance.  
• Speakers are announcing the preventive measures to the public who visits the hospital. |
| Use of PPE kits by the visitors in ICU, NICU, and post-operative wards | • Limit the visitors inside the ICU, NICU, and post-operative wards.  
• Provide PPE kits to the visitors in unavoidable cases. |
| Frequent screening of symptoms of Covid-19 among the caregivers and staffs | • Daily screening of Covid-19 symptoms for every shift before and after.  
• Documentation of screening reports  
• Limited the bystanders with the OPD patients |
| Distance between seats in the waiting area | • Set the chairs in 1-m distance  
• Security guards inspect the social distancing among the patients in the waiting area. |
| One-meter distance between the patients in registration counters | • 1 m distance stickers to stand for the patients at the registration counter.  
• Token system to avoid overcrowding near the counter |
| Staffing guidelines and timings | • The management team for charting the staff timings.  
• Co-ordination between the staffs |
| Formulate infection control policies and audits | • Formulate SOP for infection control  
• Regular audits and surveillance  
• Analysis and improvement based on the reports  
• Sharing and updating the information related to Covid-19 |
| Regular audits on infection controls | • Regular audits on infection controls  
• Quick responses for infection controls and preventive measures  
• Active surveillance |
| Booking facilities with time slot | • Online and offline booking facilities with the time slot.  
• Limit the patient consultation slots.  
• Offer prior booking facilities according to the follow-up dates. |

6. Conclusion

The Covid-19 epidemic has spread fast over the last two years. This ailment has garnered global attention and requires an immediate reaction in all sectors of society, both in and out of the hospital, to transform the rural and urban area from this globally affected pandemic. It is critical to be alert and take proactive efforts to prepare for a new infectious illness. When faced with Covid-19, hospitals established a quick and deliberate categorization and triage strategy and several critical infection control procedures. The healthcare workers’ capacity and supplies were listed to provide sufficient protective supplies to frontline employees sustainably and successfully limit the spread of the virus, allowing for more time for adequate preparedness. Frontline healthcare staff must be informed of infection control standard operating procedures and take preventative steps to prevent infectious diseases and to minimize disease outbreaks. When faced with a pandemic threat, healthcare institutions must safeguard their personnel, coordinate with the government, and react swiftly to develop a sustainable joint defence system to tackle the illness. All health system levels should compile a list of the needs for epidemic prevention and infection control activities (Bao et al.) and then implement and evaluate these measures in the hospital to minimize disease outbreaks (Liu et al., 2021).

Assessing the preventive and protective measures in the hospital helps the management to identify its current measures practices. In the present research, a multi-grade fuzzy approach is used to assess the measures in a secondary care hospital. The study focuses on three objectives: first, the conceptual model evaluates the organizations’ preventive and protective measures. Through literature review and expert’s opinion attributes to the measures were identified, these attributes are grouped into criteria and followed the criteria into grouping as enablers. Second, identify the weaker attributes by using importance-performance analysis. Third, the study provides the improvement decisions for the weaker attributes. This model has been conducted in a case secondary care hospital and found fourteen weaker attributes. The case study hospital has 8.05, i.e., very highly focussed on this study. Even though the study shows the case hospital is good in the measures, the case hospital still has fourteen weaker attributes. These fourteen attributes are also important in controlling the transmission of Covid-19 infection and need to be given importance to improve. The study recommends that it is necessary to provide awareness to the public, training and development to the medical and non-medical staff, regular audits, formulation of infection control policies, surveillance, and strict documentation. The current study on the assessment of preventive and protection measures in hospitals has its limitations. This study selected only one secondary care hospital to test the assessment model. In the future, this research study can be extended to other hospitals of different geographical locations.
Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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