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Patient flow management in biological events: a scoping review

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Abstract

Introduction Biological Events affect large populations depending on transmission potential and propagation. A recent example of a biological event spreading globally is the COVID-19 pandemic, which has had severe effects on the economy, society, and even politics,in addition to its broad occurrence and fatalities.

The aim of this scoping review was to look into patient flow management techniques and approaches used globally in biological incidents.

Methods The current investigation was conducted based on PRISMA-ScR: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews. All articles released until March 31, 2023, about research question were examined, regardless of the year of publication. The authors searched in databases including Scopus, Web of Science, PubMed, Google scholar search engine, Grey Literature and did hand searching. Papers with lack of the required information and all non-English language publications including those with only English abstracts were excluded. Data extraction checklist has been developed Based on the consensus of authors.the content of the papers based on data extraction, analyzed using content analysis.

Results A total of 19,231 articles were retrieved in this study and after screening, 36 articles were eventually entered for final analysis. Eighty-four subcategories were identified,To facilitate more precise analysis and understanding, factors were categorised into seven categories: patient flow simulation models, risk communication management, integrated ICT system establishment, collaborative interdisciplinary and intersectoral approach, systematic patient management, promotion of health information technology models, modification of triage strategies, and optimal resource and capacity management.

Conclusion Patient flow management during biological Events plays a crucial role in maintaining the performance of the healthcare system. When public health-threatening biological incidents occur, due to the high number of patients, it is essential to implement a holistic,and integrated approach from rapid identification to treatment and discharge of patients**.**

Keywords Biological events, Patient flow, Pandemic, Disasters

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Introduction

Biological hazards are any type of incident in which one or more biological agents, such as viruses, bacteria, parasites, fungi, toxins, etc., cause harm to humans, animals, plants and the environment [1]. These agents have significant adverse effects on the economy, society,and even politics. They can infect a vast population and cause fatalities and diseases, depending on their capacity for

transmission and proliferation [2–4]. Epidemics of deadly infectious diseases are increasing worldwide [4, 5]. In 2009, according to the estimations, the Hämagglutinin Neuraminidase (H1N1) pandemic caused about 150,000 to 580,000 deaths. Between the years 2002–2003, approximately 8,000 people died as a result of the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV2), which spread to more than 30 nations on five continents [6, 7]. Middle East Respiratory Syndrome Coronavirus (MERS-CoV) was another infectious epidemic discovered in the Middle East in 2012 [6, 7] with a more than 30% mortality rate [7]. The Ebola pandemic is still a public health emergency with international significance. It emerged in Guinea in December 2013, causing 28,616 cases and more than 11,300 deaths, and ended in June 2016. This outbreak has been described as the deadliest recorded Ebola outbreak in history [8, 9].

On December 31, 2019, the spread of viral pneumonia was reported in Wuhan, China, which was caused by a new and genetically modified variant of the coronavirus family SARS-CoV2, named COVID-19 disease [10]. According to the World Health Organization (WHO), as of December 31, 2023, approximately 773,449,299 cases were confirmed and nearly 6,991,842 reported deaths worldwide [11], making it clear once again that the magnitude of the biological threat to human society is more evident than ever before.

In the event of a biological disaster, hospitals and the health system are crucial institutions that manage, treat, and care for the impacted population. The state of the healthcare system's preparedness is crucial in this regard [12]. Managing affected people following epidemics is very difficult. It requires performing a complex and coordinated set of tasks, including implementing a holistic and integrated approach of rapid identification of the infected people locally, real-time monitoring, patient flow management, infection prevention and control services [13], etc. The lack of understanding of how to manage the flow of patients in the COVID-19 pandemic—despite experiences from previous incidents—has caused a great deal of harm to people and health organizations [14]. As COVID-19 spreads and the number of afflicted individuals rises, healthcare systems globally are collapsing [15]. Even in nations previously commended for meeting the gold standard for preparedness, the COVID-19 pandemic revealed severe deficiencies in the public health system [16, 17]. It led to extensive inequalities, uncontrolled costs, unsatisfactory quality of health services, restricted access to services, and marginalization of public health in the United States [14]. These shed light on the current state of global health disability and how to address the urgent and systemic problems brought on by biological occurrences [18].

Traditional healthcare systems' approaches to disaster planning and prevention emphasised ingrained issues such poor patient management, a severe lack of personal protective equipment, difficulty identifying viral outbreaks in advance, and health care personnel' fatigue [15].

On the other hand, the risk management of biological incidents is a national priority of societies. It has been recognized as part of the Sendai Framework and has been considered globally under international health regulations [19]. Therefore, it is essential to comprehend the procedure for controlling patient flow in biological occurrences that pose a signicant risk to public health and safety. The term "patient flow" describes how patients travel through healthcare institutions. The procedure includes providing patients with the medical attention, tangible resources, and internal mechanisms required to manage them from admission to release, guaranteeing their return to their homes and communities while upholding the standard of care. Both the cost of the therapy and its quality are factors that affect patient satisfaction [20, 21]. The impacted society and healthcare systems may bear a heavy financial, social, and psychological cost due to these catastrophes. To control and respond appropriately to the epidemics caused by biological factors, identifying strategies for patient management in Biological Emergencies and disasters in the world in current conditions and similar situations in the future is very important.

Thus, the purpose of this study was to find patterns and strategies for patient management against biological events as well as to examine patient flow management techniques in biological events methodically.

Methods

To learn more about patient flow management techniques and their models and strategies in biological events, a comprehensive scoping review was carried out. The review procedure was monitored and results were reported using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist. This review was conducted based on Arksey and O'Malley's scoping review methodology [22], This Framework conducted in five stages: 1) specify the research question, 2) identify relevant literature, 3) select studies, 4) map out the data, 5) summarize, synthesize, and for reporting the results. used the PRISMA2020 flowchart to show how to reach the final number of articles.

Eligibility criteria

The works on biological events management OR patient flow in biological events that were released until the

end of March 2023 in English-language journals were the main subject of this review. Additionally, papers that satisfied the following requirements were considered for examination. (1). Articles with keywords and subjects about controlling patient flow during Epidemics and pandemics following biological events and also regional biological events. published in English; (3) published through March 2023; (4) full-text articles in English; and (5) Survey, assess and analyze or evaluate related papers analysis of biological events (epidemics, pandemics, infectious diseases, CBRN incidents, and emerging and re-emerging communicable diseases, as well as patient management) and (6) Any primary research articles, including randomized controlled trials, quasi-experimental studies, cohort studies, case–control studies, cross-sectional studies, case reports, qualitative studies and descriptive studies were eligible and all related documents which has been released with trustable organizations, such as WHO, CDC and Ministry of Health of Iran's policies.

Among the exclusion standards were Research that only included an abstract in English and the article's full text is written in a language other than English, Articles that examined deliberate biological incidents, such as bioterrorists, as well as those that dealt with management and policy-making regarding the entire epidemic were disqualified from the analysis.

Information sources and search

A search was conducted using using Scopus, Web of Science, PubMed databases, and Google Scholar search engine.Authors searched Grey Literature and did hand searching in valid websites, CDC, WHO and Ministry of Health of Iran's policies. The search entered studies up to the end of March 2023. The search terms were utilized "Biological", "CBRN", "Biohazard Release," "Mass Casualty Incidents", "Pandemics," "Epidemics," "Communicable Disease," "Outbreak," "Disaster," "Emergencies," "Accidental Release", "Infectious Diseases", "Emerging Communicable Diseases", "Emerging Infectious Disease", "Reemerging Communicable Disease", "Disease Outbreak", "COVID-19", "SARS-CoV-2","Ebola", "SARS","MERS" "patient flow", "patient management", "Patient care management". The National Library of Medicine's MeSH (Medical Subject Headings) was utilized to derive synonyms for these keywords. The method used keyword combinations and Boolean operators based on the restricted text choices available in each database. For further research, references from pertinent excluded publications and included papers were reviewed. For instance, (Table 1) provides the complete

Table 1 Electronic search strategy in Pub Med, Scopus, WOS and google scholar

Pub Med search strategy:	6018
((((("Care Management"[Title/Abstract]) OR ("Patient Care"[Title/Abstract])) OR ("patient flow"[Title/Abstract])) OR ("patient care management"[Title/Abstract])) OR ("patient management"[Title/Abstract])) AND ((((((((((((((((((Biohazard Release[MeSH Terms]) OR ("Biological Accident"[Title/Abstract])) OR ("Biological Incident"[Title/Abstract])) OR ("Accidental Release"[Title/Abstract])) OR ("biological event"[Title/Abstract])) OR ("Biological emergenc*"[Title/Abstract])) OR ("Biological Disaster"[Title/Abstract])) OR (epidemic[MeSH Terms])) OR ((COVID-19[MeSH Terms]) OR (SARS-CoV-2[MeSH Terms]))) OR (disease outbreak[MeSH Terms])) OR (pandemic[MeSH Terms])) OR (communicable disease[MeSH Terms])) OR (Disaster[MeSH Terms])) OR ((((Mass Casualty incident[MeSH Terms]) OR ("Mass Casualty incident"[Title/Abstract])) OR ("Mass Casualties"[Title/Abstract])) OR ("Mass Casualty"[Title/Abstract]))) OR (Mass Casualty incident[MeSH Terms])) OR ("CBRN emergenc*[Title/Abstract])) OR (CBRN Accident[Title/Abstract])) OR ("Biological Disaster"[Title/Abstract])) OR (Communicable Diseases, Emerging[MeSH Terms]))	
Scopus search strategy:	6790
(TITLE-ABS ("care management") OR TITLE-ABS ("patient care") OR TITLE-ABS ("patient flow") OR TITLE-ABS ("patient care management") OR TITLE-ABS ("patient management") AND TITLE-ABS (biohazard AND release) OR TITLE-ABS ("biological accident") OR TITLE-ABS ("biological incident") OR TITLE-ABS ("accidental release") OR TITLE-ABS ("biological event") OR TITLE-ABS ("biological emergenc*") OR TITLE-ABS ("biological disaster") OR TITLE-ABS (epidemic) OR TITLE-ABS (covid-19) OR TITLE-ABS (sars-cov-2) OR TITLE-ABS (disease AND outbreak) OR TITLE-ABS-KEY (pandemic) OR TITLE-ABS-KEY (communicable AND disease) OR TITLE-ABS-KEY (disaster) OR TITLE-ABS (mass AND casualty AND incident) OR TITLE-ABS ("mass casualty incident") OR TITLE-ABS ("mass casualties") OR TITLE-ABS ("mass casualty") OR TITLE-ABS (mass AND casualty AND incident) OR TITLE-ABS ("cbrn emergenc*") OR TITLE-ABS (cbrn AND accident) OR TITLE-ABS ("biological disaster") OR TITLE-ABS (communicable AND diseases, AND emerging))	
WOS search strategy:	10336
((((((TI = (biohazard AND release) OR TI = ("biological accident") OR TI = ("biological incident") OR TI = ("accidental release") OR TI = ("biological event") OR TI = ("biological emergenc*") OR TI = ("biological disaster") OR TI = (epidemic) OR TI = (covid-19) OR TI = (sars-cov-2) OR TI = (disease AND outbreak) OR TI = (pandemic) OR TI = (communicable AND disease) OR TI = (disaster) OR TI = (mass AND casualty AND incident) OR TI = ("mass casualty incident") OR TI = ("mass casualties") OR TI = ("mass casualty") OR TI = (mass AND casualty AND incident) OR TI = ("cbrn emergenc*") OR TI = (cbrn AND accident) OR TI = ("biological disaster") OR TI = (communicable AND diseases, AND emerging))) AND TI = ("care management")) OR TI = ("patient care")) OR TI = ("patient flow")) OR TI = ("patient care management")) OR TI = ("patient management")	
Google Scholar search strategy:	150
"Biological event " + ("patient flow"|"patient management")	

PubMed,Scopus, WOS and google scholar search strategy.

Selection of sources of evidence

Z.H. and M.S., two impartial reviewers, evaluated abstracts and titles to determine their eligibility. Complete copies of the article were retrieved, and both reviewers considered it eligible when they thought the abstract or title may be helpful. By engaging in these activities, we were able to preserve the study's rigor and locate the most pertinent publications. Arbitration was used to resolve differences in opinion on relevance.

Data charting process

Duplicate titles were removed from the search results when loaded into the Mendeley program. A selection of papers was sent for abstract reading and subsequently cross-referenced with the inclusion criteria. Out of these, the most pertinent papers were chosen for independent full-text reading by two researchers (Z. H., SH.A.), an epidemiologist (M.S.), and an expert who confirmed the results (H. R. Kh) and (M.F). Studies were excluded for a variety of reasons such as the paper's themes were not related about patient flow management, were not analysed biological events, Full text were irrelevance, Outcome was not patient flow /lack of the required information and Language was not E/N where the researchers couldn't agree, a third researcher's opinion was sought. In an iterative approach, the two reviewers plotted the data independently, talked about the findings, and updated the data charting form regularly.

Data items

Data on the first author, publication date, kind of biological event, study paradigm, study design/methodology/methods, sample size, and key outcomes were extracted from the selected papers using a checklist. The research team developed a comprehensive checklist that included items covering all aspects of the manuscript, such as the title, abstract, introduction, methods, results, and discussion, Based on the research question and the consensus among the authors, a draft checklist was created to record key information from each source. The authors evaluated 3–5 papers to find the most important components about data extraction's theme. This information included details like the author, reference, and findings relevant to the review questions. The authors selected specific data points, such as the first author, year of publication, origin or country of the study, population and sample size (if applicable), methodology, type of biological event, outcomes, and key findings related to the scoping review questions. all contents of papers has been analyzed using content analysis. Once this form has been completed, the findings reviewed, summarised, and eventually reported.

Synthesis of results

In this study, the Graneheim & Lundman content analysis approach was utilised to analyse the data following data extraction from identified publications [23]. In summary, the principal investigator) evaluated the discussion, conclusion, and results sections multiple times after choosing the final articles. Subsequently, In the second step, the text was divided into semantic units that were summarized and shortened. the primary codes were retrieved from the parts that contained words, terminology, and phrases used to define or explain the concept's features. These sections were classified as semantic units. Subcategories and primary categories were recovered in the next stage by comparing and classifying these codes. the codes that indicated a single topic were placed in a same category and finally main categories and sub categories were formed, And if the data does not match to the concepts, a new concept was generated.

Results

Selection of sources of evidence

The goal of this study was to comprehensively examine patient flow management techniques during biological events, spot trends, and develop patient management plans in the case of a biological event. in the first search using the keywords23297 articles found. All of the found articles were then added to the Mendeley database. for evaluation after duplicate articles were eliminated 19,231 articles were included. then 18,293 articles were eliminated from the study after it was determined from the titles and abstracts that they did not match the inclusion requirements. In total 938 papers were chosen for full-text review After examining the complete texts, the remaining 902 articles were disregarded from the final analysis because of topic disproportion. Eventually, the references were examined and 36 articles were entered into the final analysis (Fig. 1).

Characteristics of sources of evidence

Table 2 displays the data associated with the evaluated studies according to the type of biological event, study paradigm, study design, sample size, primary outcomes, and first author and publication date (Table 2).

Synthesis of results

Among the 36 selected articles, 31 studies investigated the management of the patients flow and infected cases in the COVID-19 pandemic and the focus of the rest of the five articles was on managing patients in other

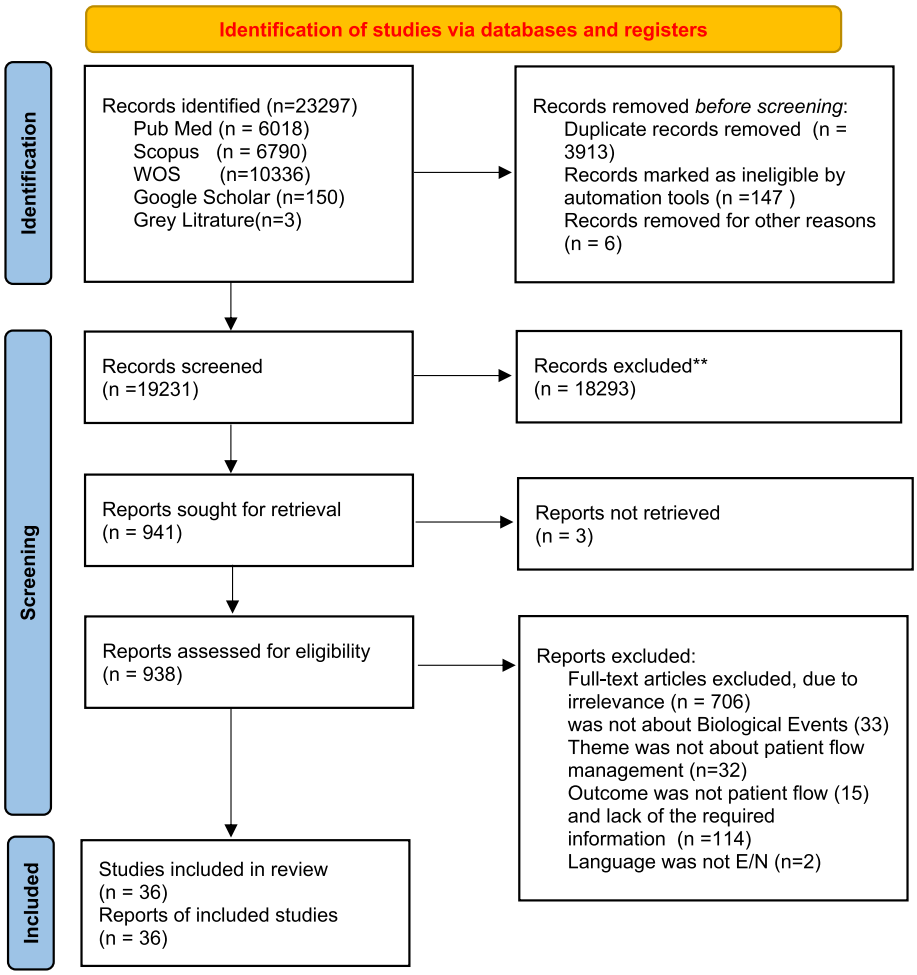

Fig. 1 PRISMA flow diagram of the literature search and study selection process

biological events such as MERS, influenza, measles, Infectious disease.

Of the total studies presented' seven studies (19.4%) were conducted in the United States (Fig. 2). In terms of publication year, 33% of articles were published in 2022. 50% of the articles employed quantitative paradigm, 33.3% qualitative paradigm and 16.7% were conducted by using Mixed Method.

A Graneheim and Landman conceptual data analysis approach (2003) was used to analyse the texts of all 36 collected articles qualitatively. Based on the articles' findings, elements influencing patient flow management in biological accidents were determined. Eighty-four main categories and subcategories were determined by combining pertinent studies. To facilitate a more thorough examination and comprehension, the elements have been divided into seven groups:

Patient flow simulation models, risk communication management, integrated ICT system establishment, promotion of health information technology models, modification of triage strategies, optimal resource and capacity management, and systematic patient management are some examples of collaborative, interdisciplinary, and intersectoral approaches. The parameters that were categorized and taken from literature about patient flow management in biological incidents are displayed in Table 3.

Systematic management of patients

Workers in the health care system are typically the first to diagnose and respond to an outbreak; therefore, emergency department (ED) workers may receive the most common indications of a new and highly infectious disease. Failure to detect index cases and delay in managing an outbreak can pose a global health risk [60] and put the health workers at risk. Thus, in three areas of primary care, hospital, and community level, the following measures are recommended. The COVID-19 pandemic has brought attention to the significance of a holistic and

Table 2 General Characteristics of the studied articles that were eligible for the review

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
1	Tavakoli, M. [21] (2022)	Iran	COVID-19	Using a time-series prediction model, simulate the patient flow process and forecast future patient admissions using a real-case study.	6032 Outpatient 533 emergency cases and 2317 hospitalized patients with 27 hypothetical scenarios	ICU, CCU, and Corona wards accounted for the bulk of patient flow bottlenecks in the simulated system. As tactics for maintaining service continuity and patient management, temporary patient transfers to other facilities, home care activation and patient transfers, and telemedicine services were introduced.
2	Bhandari, S. [24] (2020)	India	COVID-19	retrospective cohort study	We looked at two aspects of hospital discharge and hospital death for 987 hospitalized individuals with COVID-19.	To manage many of patients, the triage technique is modified based on the severity of the disease and how individuals with minor symptoms are managed after convalescence.
3	Bishop, J. A. [25] (2021)	United Kingdom	Infectious disease outbreaks(Influenza)	Retrospective cohort study: Simulation models based on the type of admission and days since hospitalization for the purpose to classify and grade patients' preparedness for discharge within 24 h	A subset of 49,832 admissions from the total number of 225,009 patients with seasonal influenza diagnosis was recorded over a 4-year study period (2013–2017).	All hospital patients are ranked according to their likelihood of being discharged within the next 24 h, and their projected discharge times are calculated using a statistical algorithm. Prioritizing patient discharge under medical supervision increases the effectiveness of hospital bed releases, improving the flow of patients through the hospital as a whole.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
4	Van Der Linden [26], 2023	Netherlands	COVID-19	descriptive mixed mode study that surveyed patient experiences in the subgroup of patients with respiratory problems over 12 weeks utilizing a retrospective chart review	8,589 patients in 2018 9,394 patients in 2019 and 9,274 patients in 2020 were examined. The experiences of 219 patients were surveyed.	As part of the hospital reconstruction and capacity expansion study, more ICU beds were prepared, and the ED was reorganized with compartments isolating suspected COVID-19 non-suspect patients, enlarging treatment rooms and patient reception units, postponing elective surgery and outpatient visits, training personnel from other specialties and retired nurses to augment the ED staff, bringing medical professionals together, and hiring nurse assistants in the ED, ICU, and COVIDIntensive Care Education, General Practitioner Cooperative (GPC) was done as an alternate location for stable patients suspected of COVID-19, six recruiting doctors with abilities, additional CT scan in the ED
5	Greiner, J. [27] 2021	Canada	COVID-19	Lessons Learned	Four different protocols for improving patient flow were compared,and the best protocol was modified and applied. The lessons learned in implementing the modified Traffic Bundling Control (TCB) protocol were reported and shared.	The modified TCB approach, which uses the "red," "yellow," and "green" strategies, was used in this study to identify the hospitalization spaces. Rearranging clinical and operational procedures will lower the risk of infection, enhance patient flow, and lessen the hospital's spread of COVID-19 to patients and healthcare personnel.
6	G Terning, [28] 2022	Norway	COVID-19	simulation modeling: Through progressive elaboration, a conceptual model from the primary stakeholders at the case hospital was extracted and transformed into a computer model	In this investigation, three types of data were employed: (1) data utilised as inputs to execute the simulation model, (2) data utilised to build the simulation model, and (3) data used to verify the results of the simulation.	By simulated patient flow behavior using real-world data (intelligent congestion) actual behavior can be replicated in terms of bed occupancy by the patient which will be effective in managing patient flow in future pandemics.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
7	G Terning [29], 2023	Norway	COVID-19	Using a previously created hybrid simulation model, researchers investigated how adding more treatment rooms and waiting areas would affect patient flow in emergency rooms during a pandemic.	These five scenarios are predicted by this model: (1) patient flow before the pandemic; (2) patient flow with a 20% contamination rate; (3) adding more treatment rooms to the patient flow; (4) adding a waiting zone to the patient flow; and (5) adding additional treatment rooms plus a waiting zone to the patient flow.	Every patient flow parameter is improved when more treatment rooms are taken into account. The waiting area's extension, which doubles as an additional treatment room, has the beneficial consequence of shortening the time it takes for infected patients to get into the treatment area.
8	M Fifolt [30], 2022	USA	Measles Outbreak	The events that led to an infectious disease emergency response and content analysis were described using a case study technique.	A measles case study of a 55-year-old lady is included, along with a content analysis of the interviews conducted with several managers who were involved in the outbreak's containment, including four policymakers.	Among the successful elements in disease control were the early detection of possible threats, the formation of a multidisciplinary working team, and the execution of a pre-incident response plan.
9	Akuamoa-Boateng [31], 2020	Germany	COVID-19	Interventional Implementation of telemedicine and social distancing.	495 patients were surveyed in 2019 and 434 patients in 2020 over 37 working days each year.	Telemedicine implementation, patient visits via video call, reduction of personnel shift fluctuations, observing social distancing and systematic disinfection of wards, prohibition of visiting in inpatient and outpatient wards, etc…... It led to improvement of patient flow in oncology wards.
10	Litvak [32], 2021	North America	COVID-19	The experience at two of the top medical facilities in North America was highlighted as the lesson learned.	Recording lessons and experiences of 2 medical centers in North America	In the event of a pandemic, hospitals can significantly increase patient access to urgent and emergency surgical care, quality of care, and hospital efficiency by organising the time and resources needed by surgical patients and streamlining the flow of surgical admissions on a daily basis.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
11	Fjelltveit [33], E, 2022	Norway	Influenza	Future–oriented cohort	The study included patients who had been admitted to two public hospitals after contracting influenza due to acute respiratory disease. At the start of the point of care, 400 patients underwent rapid testing, and an additional 167 underwent conventional rapid testing.	The emergency department (ED) can shorten patients' length of stay (LOS) and enhance treatment and isolation tactics by quickly using the new Point-of-Care test (POCT) for flu.
12	Foley, M. [13] 2020	Netherlands	COVID-19	Lesson learned emphasizing the experience	emphasizing the experience	In order to effectively manage patients during the COVID-19 pandemic, it is important to adopt a comprehensive and integrated approach that includes responsive microbiological lab based on local capacity, real-time monitoring, active patient flow, and responsive IPC services.
13	Gilbert, A. [34] 2022	Belgium	COVID-19	Interventional: Opening a brand-new, two-tier triage facility outside of the hospital, with separate spaces designated for the evaluation of individuals who are suspected of having COVID-19 and those who are not.	1071 patients in all were assessed. Of the patients, 82% did not exhibit any serious symptoms, while 41.5% exhibited influenza-like symptoms. Of the patients examined, 29.26% were positive for SARS-Cov2. Of the patients, 17% were admitted to the hospital and 83% were discharged.	Establishing specialised triage centres close to the ER is an essential tactic to stop the spread of illness among other patients and medical personnel. Without running the danger of contaminating other non-infectious hospital spaces, patients can be triaged and worked in designated areas outside of traditional emergency rooms and then referred to the appropriate hospital unit.
14	Kassaeian, S. [35] 2022	Iran	COVID-19	case study with a narrative design	Establishing a fangcang hospital was predicated on a field visit, a narrative analysis of two in-depth interviews with four fangcang hospital managers in Iran, and an examination of their policies and procedures.	To stop the disease from spreading further, those with minor symptoms are directed to Fangcang Hospital and, if needed, admitted. Patient flow for screening, treatment, and follow-up is improved as a result.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
15	Ravi, S. [36]2022	USA	COVID-19	Interventional: COVID-19 clinical screening combined with driving-based care pathway triage in place of hospital admission for COVID-19 outpatient testing	2,788 (47%) of the 5,931 patients who were seen could walk. Eleven (11.8%) of these patients underwent screening for possible COVID-19 symptoms; of these, seventy-eight (63.7%) were triaged for care via automobile, and forty-three (36.3%) were triaged in the main emergency department.	Patients were evaluated from their cars during the pandemic in an effort to stop the spread of COVID-19 testing demand to hospitals. This measure decreased length of stay in the emergency department, hospital readmission, and emergency room readmission. In the event of a future respiratory disease outbreak, improving care through driving in conjunction with appropriate screening is secure and effective.
16	Rivera-Sepulveda [37], A. 2023	USA	COVID-19	Cross-sectional study	A total of 67,499 children visits were evaluated in terms of patient management, age of children, length of stay in the hospital and main complaints. Moreover, the effect of establishing a pre-emergency screening tent on the mentioned items was investigated.	Implementing a screening system in triage tents in the hospital parking lot and before reaching the emergency department helped offset the use of resources as well as reduce unnecessary exposure to medical personnel.
17	Arnaud, E. [38] 2022	France	COVID-19	Using an Artificial Intelligence Model for predicting patient management path in emergency department as well as Patient outcomes by prospective method	136,139 patients were admitted to the study center from December 1, 2019 to December 31, 2021, of which 105,457 cases were included.	During the COVID-19 pandemic, the AI model assisted in managing patients in the emergency department by forecasting the maximum and minimum number of beds required. Additionally, it assisted in categorising patients on a quick and conventional ED pathway as suspected COVID-19 patients and non-COVID-19 patients. AI models can be a vital resource in helping to reduce resource waste and streamline ED operations.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
18	Lavina, S. [39] 2021	Philipine	COVID-19	Measuring patient flow process time at the clinic and mapping the process flow were the two main components of the study. Time components, interviews, and narrative explanations of suitable management techniques for issues with patient flow are all included in the data collection process.	Philippine healthcare workers participated in 1514 employee visits during 15 working days.	Appropriate patient flow management techniques included prompt infection control procedures, effective communication, and a suitable degree of task flexibility. The areas of the centres that need more development were the sporadic disinfection procedures, physical distance, and symptom screening.
19	Marsilio, M. [40], 2022	Italy	COVID-19	The primary drivers of shortening the length of stay in the emergency department were identified and operationalized using a qualitative approach in the first phase. The primary causes of ED overcrowding were identified and tested within the quantitative phase in stage 2. Step 3: Qualitative method: aids in the interpretation of quantitative results; in the end, a final focus group of experts evaluated the statistical analysis results to determine solutions for improving patient flow in hospitals.	Key factors in the administration of the ED's operations and patient flow within the hospital were identified by specialists from ten Italian hospitals. Three hours were dedicated to the focus groups. The flow of 1,136,637 patients was examined using three models in the quantitative part to assess five operational areas: ICT, bed and ED personnel management, patient flow operations in the ED, and the process of admitting ED patients to other hospital centres	creating a buffer zone between the emergency room and the hospital by establishing an emergency department or receiving unit. 2) Establishing an office in charge of managing bed management across the hospital, including triage, patient admission, and real-time assessment of bed availability. 3) The goal of streamlining the discharge procedure was to better manage the patients by rearranging ward activities or setting up a discharge room to lessen the issue of a bed scarcity, particularly in the early morning when emergency pressure is at its highest.
20	Brizio, A 2023 [41]	France	COVID-19	Case Study In this study, a case report is presented that details the organisational strategy a private hospital used to employ a telemedicine booth during the COVID-19 outbreak.	The data of 1844 patients referred to the center during one month. The results of the evaluation of the questionnaire completed by emergency personnel were examined, of which 766 patients were evaluated remotely via video communication.	The use of telemedicine-equipped booths for patients before entering triage facilitated the screening process for patients. This led to rapid patient orientation and reduced emergency burden.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
21	Yazdanyar, A. [42] 2022	USA	COVID-19	Cross-sectional Research The flow of patients above the age of eighteen was handled and managed using a modified version of the Early Warning Score (MMEWS). Data from before and after MEWS was put into use were compared.	Of the total 43,892 hospitalized patients, 19,962 (45.5%) before mMEWS and 23,930 (54.5%) in the period after implementing mMEWS were evaluated.	Implementing the admission process with mMEWS was associated with a reduction in ED LOS for hospitalised patients without increasing side effects. The use of the modified MEWS admission process for medical services in hospitals was associated with a significant reduction in the patient's length of stay in the ED without a significant increase in the 24-h activation of the rapid response team.
22	Roberti, J. [43] 2021	Argentina	COVID-19	The semi-structured interviews using content analysis methods were conducted with specialists in 15 general hospitals in Argentina.	15 intensive care professionals interviewed about their experience with barriers and strategies to improve care for COVID-19 patients	The presence of untrained personnel, a lack of resources, poor group and shift communication, and lack of resources were among the obstacles that were noted. Regular feedback and job category communication, sufficient training for inexperienced employees, encouragement, qualitative research, and prompt sharing of experiences and information were all potential facilitators and solutions.
23	Mitchell, R. [44] 2022	Pacific region	COVID-19	Three stages went into designing this qualitative study. Eighty people took part in the online conversation in the first phase. Subsequently, thirteen highly qualified specialists from nine different nations were interviewed in-depth, and the third phase was an online focus group discussion.	There were 116 competitors from the Pacific Island area and more than 14 different countries. Combining deductive and inductive techniques resulted in the adoption of a phenomenological approach.	Among the primary issues were triage and screening capacity in order to evaluate the urgency and risk of transmission. Among the factors that helped with patient treatment were consistent guidelines, prior disaster experience, and support from senior hospital administrators. Implementation tactics that were helpful included the adoption of efficient patient flow processes, checklists, and simulators.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
24	Fanelli, S. [45] 2020	Italy	COVID-19	Three sections were evaluated for a questionnaire with fourteen open-ended questions about managing hospitals and the Italian health system during the COVID-19 epidemic. Part 1: coordinated with the hospital and the local governments, and addressed significant challenges in organisational roles. The relationships between the necessary institutions and the necessary changes to hospital organisation were the key topics of the second section. The final section focused on gathering recommendations to assist hospitals in the process of transition.	Out of 70 health management experts, 30 people answered the questionnaire.	The management of emergency patients depends heavily on reorganising logistics, isolating patients effectively, planning larger spaces to accommodate the high patient flow, and enhancing coordination tools between medical staff, hospital and inter-hospital units, and local departments. It is crucial to have frequent problem analysis meetings, enhance IT, create emergency management plans or standard operating procedures for staff, support medical professionals in times of need, and foster multispecialty and multidisciplinary integration in order to improve patient flow.
25	Chabrol, F. [46] 2023	France	COVID-19	Lessons learnt from level 8 hospitals, focus groups, organised interviews, and direct observations were employed. Interviews were conducted with managers of all ranks and health experts.	There were 44 observational reports, 94 formal interviews, 2 seminars on lessons learned, and 3 focus groups. Data gathering was led by two researchers with training in qualitative methods. Miner MAXQDA was used to encrypt every interview.	Three Setups were identified from the test results: 1) Rearranging areas and services. 2) Controlling the danger of contaminating patients and specialists, and 3) deploying labour that is appropriate for specialised tasks
26	Callagy, P. [47] 2021	USA	COVID-19	Interventional: including the design and implementation of Tele-Garage and assessing its impact on the length of stay in the hospital, the capacity of the hospital to accept patients and the amount of personal protective equipment	5493 patients were monitored and evaluated during 3 periods of telegarage activity.	On average, the duration of stay in the emergency department and the use of personal protective equipment were significantly reduced by setting up a telemedicine equipped garage. The average number of patients visited in Tele-Garage increased and the average length of stay in the emergency department was reduced.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
27	Kwon, J. [48] 2022	USA	COVID-19	Lesson learned emphasizing the experience	Establishing a dedicated outpatient clinic in the pandemic	It was determined that offering COVID-19 patients a separate setting for acute outpatient evaluation and diagnosis as well as starting mobile outpatient clinics appropriate for patient care would be beneficial. Furthermore suggested were special patient scheduling techniques, patient flow procedures, staff education, and personal protective equipment (PPE) guidelines.
28	Kim, W. [49] 2021	Korea	COVID-19	Lesson learned emphasizing the experience	Response systems to the COVID-19 pandemic in South Korea, Singapore and Taipei were reviewed and compared.	Public–private sector collaborations proved beneficial in gathering, presenting, processing, and sharing information for a successful quarantine during the coronavirus epidemic. It was successful to provide the required information in real-time for managing COVID-19-affected individuals under quarantine by using ICT systems.
29	Park, P. [50] 2020	Korea	COVID-19	Korea established the Community Treatment Centre (CTC) as a new facility to treat patients with the illness in an effort to more effectively utilise medical resources.	Thirty-nine patients in all were admitted to CTC. Seven people were admitted to the hospital during the first two weeks owing to worsening symptoms, and 107 individuals were released from the hospital without any problems.	When it comes to controlling major instances of COVID-19 or other newly developing infectious diseases, CTC is an incredibly economical approach that conserves resources.
30	Choe, P. [51] 2020	Korea	COVID-19	Patients with COVID-19 who meet certain criteria such as: alertness, age under 65, absence of underlying disease, etc. were hospitalized in living and treatment centers	113 patients in all were admitted to LTC. Averaging 25 years old, 52.2% of the population was female. Of the 113 patients, 15 (13.3%) did not exhibit any symptoms until the conclusion of their isolation, and 54 (47.8%) were asymptomatic at the time of diagnosis	LTCs can be a safe alternative to health centers and hospitals due to the lack of hospital beds.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
31	Chen, T. Y. [52] 2020	Taiwan	COVID-19	grouping of patients based on symptoms associated with risk. Three risk zones—A, B, and C—were taken into account. Zone A had decent air conditioning and was situated outside the hospital. The emergency room's zones B and C each have their own air conditioning.	Zones A, B, and C were allocated to a total of 214 patients. One patient in zone A was discovered to be infected out of the six. 36 patients were investigated in zone C, while 3 of the 172 patients in zone B tested positive for COVID-19. Positive results were not observed in the samples collected in zone C.	The care of high-risk patients was made easier with the use of graded waiting spaces for patients with varying COVID-19 infection risks. It also lessened the chance that illnesses would spread across the hospital.
32	Cao, Y. [53] 2020	China	COVID-19	The study was designed in 3 stages: In the first stage, the online clinic was set up to facilitate the triage of the patient. In the second stage, triage, temporary visitation and ED area isolation was implemented, and in the last stage the hospital created a powerful command system.	The number of checked fever visits in ED increased during the study period. The proportion of patients with fever visited in EDs increased.	Management strategies such as the online clinic as a temporary emergency plan were able to reduce ED's workload, protect health care personnel and control infections.
33	Sugerman, D. [54] 2011	USA	COVID-19	Online SurveyMonkey was performed. The survey includes 34 questions about managing patients with ED, patient visits and overcrowding, and planning for the flu pandemic (triage, alternative care sites, staff, supplies and equipment)	Conducting an online survey on the management of the influenza epidemic from the managers of 26 related treatment centers	Hospitals can help reduce emergency department overcrowding and increase capacity during pandemics by canceling elective surgeries, discharging low-risk inpatient cases, clearing ED from outpatients, placing patients on inpatient floors, and converting existing empty spaces into beds
34	Kim, K. H. [55] 2017	Korea	MERS	The Korea Centres for Disease Control and Prevention, the Ministry of Health and Welfare, the MERS Policy Committee reports, and the Korean Medical Association provided data for this descriptive cross-sectional study.	Overview, contact information, and infection timeline. 38 fatalities' sex, age, and underlying medical conditions were examined.	The main causes of influenza outbreaks were found to be late detection, unsuccessful quarantines due to strong virus spreaders, visits and family care, patient non-disclosure, poor risk communication from the South Korean government, and inadequate nosocomial infection management.

Table 2 (continued)

No	Author First author/ publication year	Country	Type of Biological Event	Study design	Sample size	Main Results
35	Terrasi, B. [56] 2020	France	COVID-19	establishing a special dispatch, special phone lines, online software to obtain regional ICU bed statistics, and coordination with anesthesiologists and qualified staff to manage ICU beds during the COVID-19 pandemic.	All public and private hospitals received notice of the creation of a special phone number. A special dispatcher was on call seven days a week, twenty-four hours a day. Apart from giving an answer, some suggestions are given for managing the patient and locating an ICU bed in case it's needed. A web application that is responsive was created in this regard.	During the COVID-19 pandemic, launching a centralised expeditionary ICU consultant and bed management software was an effective way to handle the increasing demand for intensive care beds, arrange and streamline the admission of critically ill COVID-19 patients, and avoid or postpone the region's ICU overcapacity.
36	Razu [57] 2021	Bangladesh	Influenza	Snowball sampling was utilised to perform in-depth telephone interviews, which served as data and were recorded, transcribed, and then collected.	Out of 15 interviews, 7 themes were obtained from the study.	All public and private hospitals received notice of the creation of a special phone number. A special dispatcher was on call seven days a week, twenty-four hours a day. Apart from giving an answer, some suggestions are given for managing the patient and locating an ICU bed in case it's needed. A web application that is responsive was created in this regard.

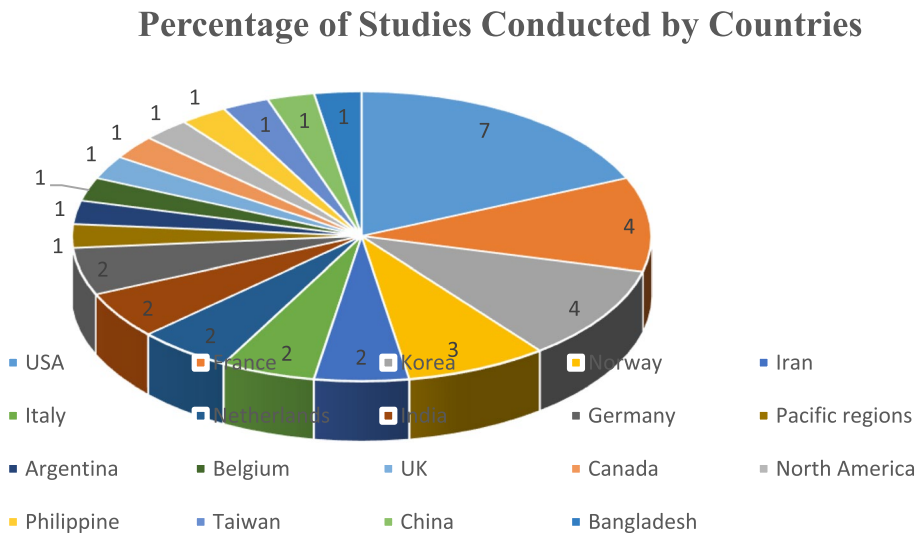

Fig. 2 Distribution of studies by country names

integrated approach, real-time monitoring, and active patient flow [13].

At the primary care system

An Outbreak of infectious diseases is a global security threat [61]. in this regard, for systematic management of the patients, the following steps are recommended: early identification of the threat [30, 55], intelligent screening [35], monitoring patients [49], visiting patients and strengthening home health care to determine the severity of the disease [35, 55] Public–Private Sector participation in quarantine [49]. rapid laboratory diagnosis [13, 33, 49], launching outpatient testing centers [58] and isolation of suspected and infected patients [33].

In regards to hospitality

Using MEWS [42], – Higher EWS scores predict a greater chance of a medical crisis and the need for quicker and more intensive care interventions; lower EWS scores indicate a decreased likelihood of such interventions. Examples of high-risk patients include those who require active patient flow management [13], capable command systems [53], timely monitoring [13], prompt treatment [33, 35], and the establishment of mobile outpatient clinics [48].

The interdisciplinary and intersectoral joint approaches

At the community level

Activation of intermediate care facilities and convalescence centers for hospitalization of patients with mild symptoms [24, 35, 50, 51], follow-up after discharge [35], and not leaving the patient after returning to home and community.

Interdisciplinary and intersectoral joint approach

It can be classified into: revising clinical and multidisciplinary approaches and inter-organizational cooperation and coordination.

Revision of clinical and interdisciplinary approaches

Sustainable intersectoral and interdisciplinary collaboration is beneficial the creation of a new clinical approach and the reorganization of clinical and operational processes [27]. With close interdisciplinary and intersectoral approaches [26, 59] and the development of multidisciplinary teams [30], it is possible to provide practical context for patient flow, resource management and improved communication culture and to manage patient flow and adapt to the challenges of new day-to-day care [58].

Inter-organizational coordination

In emergency management, coordination between medical staff, hospital and inter-hospital units, and local services is essential. The necessity of encouraging multispecialty and multidisciplinary integration is highlighted by the scheduling of regular problem-solving meetings, establishing emergency management plans or routine practice procedures for staff, and strengthening healthcare professionals in emergencies situations [45].

Employing patient flow simulation systems and models

Using simulation and predictive models, a dynamic understanding of patient flow is necessary to enhance the overall performance of hospitals.

Table 3 Categories and subcategories of patient flow management in biological events based on thematic analysis

Main Category	Sub-categories
Systematic management of patients	**At the level of the primary care system:** early threat identification [30, 55], intelligent screening [35], monitoring of patients [49], public–private sector participation in quarantine [49], rapid laboratory diagnosis [13, 33, 49], launching outpatient testing centers [58], strengthening home care centers [55], separating suspected and infected patients [33]. **About hospitals**: active management of patient flow [13], powerful command system [53], timely monitoring [13], use of Modified Early Warning Score (MEWS[a]) [42], rapid treatment [33, 35], launching mobile outpatient clinics [48]. **At the community level:** activation of intermediate care facility [24, 35, 50, 51], Follow-up after discharge [35].
interdisciplinary and intersectoral joint approach	**Revision of clinical and interdisciplinary approaches:** reorganization of operational and clinical processes [27], close interdisciplinary and intersectoral collaboration [26, 59], formation of multidisciplinary working groups [30, 58]. **Promoting interagency cooperation and coordination:** Promoting coordination between hospital and prehospital emergency [45].
Patient flow simulation models	**Simulation models:** using time-series prediction models [21], simulation models based on the nature of the disease and length of hospitalization [25] and simulation models based on patients and spaces [28]. **Predictive Models:** Patient Flow Scenarios [21, 29], utilizing Artificial Intelligence [38].
Risk communications management	**Risk Communication Operations Management**: Improving communication culture, providing transparent information, disclosing information in real time [49]. **Promotion of Information Systems**: The Use of ICT Platforms [49].
Promoting health information technology models	**Data and Information Management:** Integrated Information Technology System [13], Managing the Flow of Information and Data [13, 55]. **Providing Telemedicine Prerequisites**: Supplying Technology Infrastructure [47], Online Triage Clinics [53], Telemedicine Equipped Booths [41], Telegarage [47].
Correcting triage strategy	**Creating special triage centers**: triage in parking lot [37], mobile triage in cars [36], triage tents [37]. **Triage process revision**: Triage Based on Disease Severity [24],Two-tier Triage [34].
Optimal management of capacities and resources	**Processes and Policies:** Considering preventive approaches [44], maintaining a holistic and integrated approach [13] from identification to discharge, using innovative processes [41], cancellation of outpatient visits [26, 53], cancellation of elective surgeries [26, 54], classification of required resources [31, 32], simplification of discharge process of low-risk patients [25, 40, 53], reduced hospitalization time [33, 42, 47]. **Staff:** maintaining mental health of employees [57], reducing burnout [57], training of employees [26, 48], training of skilled workers [26, 43] and flexible [39, 46], giving incentives to effective employees [57], timely monitoring of performance [13], training other categories [26], employing retired forces [13, 26]. **Equipment:** Creating safe work environments [26, 46], adequate and standard personal protective equipment [26, 48], timely infection control measures [13, 39]. **Spaces:** reshaping the emergency department [26, 40, 48], adding graded waiting rooms [29, 52], adding treatment rooms [26, 29], launching dispatch of bed management [24, 40, 56], logistical restructuring [45], standardization of spaces [48], conversion of empty spaces into wards [47, 54], additional CT scan space in emergency room [26], addition of isolation rooms and special beds [13, 33, 56]. Reconstruction of the hospital [26].

[a] Modified Early Warning Score

Simulation models

Simulation is the best tool for identifying and allocating the necessary capacity to satisfy demand quickly and minimize delays to get this understanding. Furthermore, compared to most conventional statistical techniques, simulation is a workable substitute [25] that requires more time and money [62]. Generally speaking, the two primary goals of simulation models employed in several studies to examine healthcare delivery systems are (a) improving patient conditions in various wards and (b) allocating money to enhance services. Improving patient outcomes and reducing waiting times are the first goals of optimising patient hospitalisation. The second goal is to make efficient use of resources and figure out how much human and physical resources are needed to deliver high-quality care.

Predictive models

Predicting future trends and difficulties and making necessary preparations, particularly at the administrative and command levels, are crucial for the second phase [63]. Proposing suitable policies can be aided by

developing several models and precise scenarios for forecasting future infections. By accounting for the number of nurses, doctors, beds, and other resources, anticipating the number of people who may contract an infection in the future might aid in estimating the strain on the healthcare system and making appropriate plans to avoid overload [21, 29]. As a result, agent-based modelling and other computer modelling and simulation can be helpful [28, 64–67].

Additionally, these models can be used to assess scenarios, interventions, operational hazards, and the cost-effectiveness of policies [28]. In this way, by anticipating the maximum and minimum number of beds required, an AI model assisted in managing patients in the emergency room during the COVID-19 epidemic. Additionally, it has aided in placing non-COVID-19 and suspected COVID-19 patients on the quick and conventional ED routes. According to the study's findings, AI models can be a vital resource in helping to reduce resource loss and streamline ED operations [38].

Risk communications management

Responding to biological occurrences and the elements that lead to public health emergencies requires effective risk communication management [68]. It is regarded as essential to guaranteeing a thorough, open, and prompt flow of data and support to hospitals. In fact, prompt action and mitigation of catastrophic effects of disasters aid individuals in making wise decisions and building resilience [69].

Risk communication operations management

Promoting a communication culture [59], providing transparent information [55], and disclosing necessary real-time information [49].

Promotion of information systems

The use of ICT platforms [49] has been introduced as one of the influential factors in the management of structured risk communication.

Promoting health information technology models

Telehealth technologies are crucial in monitoring social distancing, decreasing human contact, and delaying the spread of viruses. They are perfect for managing communicable diseases. Through telemedicine-equipped booths, telehealth technologies provide remote care and evaluation [70].

Data and information management

The development of an integrated information technology system [13] can help to manage the flow of information and data [13, 55].

Providing telemedicine prerequisites

Expanding technology infrastructure [47] provides the possibility for identification and diagnosis of patients and suspicious people through online triage and virtual outpatient clinics. It is also possible to provide care to patients through equipped telemedicine [41] and telegarage [47] in medical centers. For non-infected people who have other diseases and need medical and hospital services, it is also possible to provide required daily care [71]. Providing physical space, technology infrastructure, equipment and workflow of employees are critical to operating the remote care system [47]. Furthermore, the use of telemedicine equipped booths for patients before entering triage as a screening process facilitates the flow of patients. It leads to rapid orientation of patients and reduced emergency burden [41].

Triage strategy modification

Dealing with an epidemic and biological incident is difficult for medical staff and emergency department specialists.

Creating special triage centers

Triage at the emergency room's parking lot [37], mobile triage in cars [36], and triage tents [37], among other locations, is an essential tactic to lower the incidence among other inpatients and medical personnel. SARS-Cov2 patients were hard to diagnose during the COVID-19 pandemic because of the symptoms' lack of specificity and ability to be confused with other bacterial or viral diseases. In addition, because no obvious risk indicators for transmission had been found in the early waves of the COVID-19 pandemic, determining the risk of contracting the virus grew increasingly challenging as the epidemic spread. Triage and working in particular areas outside of the classical emergency rooms allows the patient to be directed to the appropriate hospital unit, without the risk of spreading contamination to other non-infectious hospital areas [34].

Triage revision

A new two-tier triage center outside the hospital with two distinct zones—one for assessing suspected COVID-19 patients and the other for non-suspected patients—was established as one of the reforms that helped improve triage strategy during the COVID-19 pandemic [24, 34].

Optimal management of capacities and resources

Hospital emergency rooms (EDs) become the focus of healthcare personnel after mass casualties due to disasters or emergencies, and they rarely need to function above their intended capacity. Hospitals may lose the quality and safety of patient treatment

during emergencies and disasters due to the large influx of patients, congestion, increased ED admissions, disruption of care flow, and inadequate resources. This is the results from inadequate preparation to boost patient care capacity, quality, and safety during emergencies and disasters [72].

A thorough explanation of capacity enhancement reads as follows: "the ability to acquire adequate staff, equipment, structures, and systems to provide adequate care to meet urgent needs following an influx of patients following a large-scale accident or disaster." A hospital's four areas of improvement are its staff or human resources, equipment and supplies, structure or physical space, and systems that include integrated management policies and processes [72].

Policies and processes

Preventive approaches [44], maintaining a holistic and integrated approach [13] from the time of identification to discharge and the use of innovative processes [41] during screening and triage led to improvements in the classical operational and clinical processes. Furthermore, cancellation of outpatient visits [26, 53], cancellation of elective surgeries [26, 54], classification of required resources [31, 32], simplification of discharge process of low-risk patients [25, 40, 53], reduction of hospitalization duration [33, 42, 47] in biological incidents have been useful in active management of patient flow.

Employees

Increasing staff or human resources is one of the most crucial components of the plan for expanding capacity. The kind of services each employee offers and the significance of realising their part in handling such situations are directly tied to how willing they are to respond to such instances. Transportation issues, the obligation of employees to care for others, ignorance of the risks involved or their part in responding to pandemics, and employees' fear of infecting themselves or their families are some of the obstacles that prevent workers from taking part in pandemic response activities [68, 73, 74].

It has been recommended to provide mental health services for employees [57], reduce occupational burnout [57], train employees [26, 48], train specialised and skilled personnel [26, 43] and provide flexible work schedules [39, 46]. Additionally, it has been suggested to give incentives to effective employees [57], timely monitor their performance [13], train other disciplines [26] and utilise the potential of retired personnel [26].

Supplies and equipment

According to the reviewed studies, creating a safe working environment [26, 46], adequate and standard personal protective equipment [26, 48], timely infection control measures [39] and [13], have been introduced as the effective factors on the improvement of patient flow management.

Spaces

Reshaping the emergency department [26, 40, 48], adding graded waiting rooms [29, 52], adding treatment rooms [26, 29], setting up bed management dispatch [24, 40, 56], logistic restructuring, standardization of spaces [48],conversion of empty spaces into sections [47, 54], additional CT scan space in emergency room [26], addition of isolation rooms and special beds [13, 33, 56], hospital reconstruction [26] and standardization of hospital spaces based on the principles of modern hospital engineering are essential factors about optimal resource management.

Discussion

Based on the analysis of the selected articles, factors affecting patient flow management in biological incidents were identified. From the combination of relevant studies, eighty-four categories and primary sub-categories were extracted. For more detailed analysis and understanding, factors were classified into seven categories: systematic management of the affected patients, interdisciplinary and intersectoral joint approach, patient flow simulation models, risk communication management, establishment of integrated ICT system, promotion of health information technology models, triage strategy modification and optimal management of resources and capacities.

When patients arrive at the emergency department (ED) and cannot be admitted right away for a various reasons, such as a hospital bed shortage, poor patient flow is particularly noticeable [75]. Overcrowding in the ED can have negatively affect on patient satisfaction, critical intervention delays, and patient care delays [20, 76–78].

But in many cases, particularly in biological incidents, there is inadequate management of hospital beds, which leads to a delay in discharge and, ultimately, the release of hospital beds [25]. Poor patient flow has been linked to significant consequences during viral infection episodes, such as the coronavirus pandemic [79] and seasonal flu [80]. Thus, one of the most critical aspects of patient management in biological incidents typically linked to large numbers of victims—is the prediction and enhancement of patient flow.

Numerous investigations have been carried out about patient flow patterns and their handling in biological crises, particularly following the COVID-19 pandemic that caused medical facilities to fail in the majority of the world's nations. This called for the conduct of numerous researches on patient flow and management in hospital

EDs, which constituted the initial care-giving bottleneck for COVID-19 patients. In addition, several studies on infectious diseases like influenza, measles, and SARS have been conducted. Medical centers' emergency departments (EDs) must continue to function as they will continue to be the first to respond to pandemics and other public health emergencies.

Reflecting these problems on the large biological incidents of the COVID-19 pandemic is an opportunity to identify ways to change policy, culture, and systems transformation to improve preparedness in the face of future public health emergencies [81].

Due to an abrupt or gradual inflow of patients, biological events can present difficulties for health centers and the healthcare system, as medical professionals must continue to operate and oversee day-to-day operations in their facilities. However, by efficiently and creatively planning ahead, some of the effects of such catastrophes may be mitigated. The research findings suggest that, in addition to education, the following measures should be considered: increasing resources, demand management, and lean thinking [82]. Corrective strategies include systematic patient management, an interdisciplinary and intersectoral approach, patient flow simulation models, risk communication management, the establishment of an integrated information and communication technology system, the promotion of health information technology models, the modification of triage strategies, and the optimal use of resources and capacities. The patient's flow should be simplified as a process and the path of identification, transfer, acceptance, hospitalization in intensive care units and finally discharging and returning the patient to the community should be clear. Inter-sectoral and external coordination should be facilitated so that when it is necessary to review operational and clinical processes, this can be achieved through interdisciplinary cooperation.

Maximizing the care zone for critical patients can be achieved through creating an alternative care center for the patient, creating flexible plans that can accommodate essential care, and increasing adaptability to transform non-emergency units to emergency care zones to increase capacity [27, 82].

Besides the strategies as mentioned above, strategies, introduction and use of simulation models and machine learning prediction systems can have a statistically significant effect on improving the overall flow of patients [21, 28] This can be attained by presenting different patient flow scenarios and simulation models based on therapeutic spaces and disease type.

During the exceptional COVID-19 outbreak, standards and information were constantly evolving. Under these circumstances, effective and appropriate risk communication should be the main focus. This is especially noticeable during pandemics with high infection rates, serious consequences, little access to treatment, and a sharp increase in the number of cases. Poor risk communication and a lack of awareness of the risk might result in hoarding behavior, which can cause a shortage of medications and personal protective equipment. Maintaining a consistent media presence and using social media and other channels is one possible strategy to guarantee effective risk communication. Involving all parties involved, including community members, in biological occurrences is another crucial step [83].

Telemedicine became widely recognized as a vital tool during the COVID-19 pandemic, helping to enhance patient monitoring, prevent disease outbreaks, identify and treat sick individuals promptly, and, most critically, guarantee ongoing care for frail patients with underlying and chronic illnesses. Even though telemedicine was quite successful during COVID-19 and was adopted more widely in many nations, there were still large gaps in the field. Before telemedicine is widely used, the following important challenges must be resolved: (1) to effectively regulate telemedicine, health care operators must be authorised, patient privacy must be protected, and appropriate policies must be established. Additionally, practical guidelines for the routine clinical use of telemedicine in various contexts must be established and disseminated. Third, telemedicine integration with traditional healthcare services must be increased. Fourth, healthcare professionals and patients must be made more aware of and willing to use telemedicine. Finally, inequalities caused by technological, infrastructure, and economic barriers must be overcome. In the near future, remote patient management will be a vital tool for healthcare systems globally, enhancing both patient care and quality [84] if all these prerequisites are fulfilled.

The capacity of the emergency department automatically doubles when it is located next to other hospital units, when waiting rooms are added, and when the emergency department's capacity is increased. Alternative care facilities, albeit with distinct access and departure doors, can be thought of nearby the EDs to maximize their capacity during these occurrences.

Additional suggestions made for improving capacity in healthcare facilities include the following: 1) creating cohort and dedicated intensive care units for patients who have experienced similar biological incidents; 2) developing suitable procedures for pre triage, diagnosis, and isolation of suspected and confirmed cases of the disease; and 3) providing training to all employees on how to operate in the dedicated intensive care unit, how to use personal protective equipment, and how to manage patients. to work on all the principles of capacity

enhancement, including space definition, supply provision, personnel recruitment, and temporary training of specialized protocols for complete isolation of spaces, staff, and patients to manage resources at the time of biological incidents, hospitals also needed to collaborate across multidisciplinary and intersectoral domains [85]. Healthcare professionals and hospital administrators must participate on multiple levels and in numerous disciplines in order to reconstruct the entire hospital emergency department admissions process and focus all efforts on achieving a single objective. Daily updates and discussions may be necessary for routine processes and procedures.

Strengths and limitations

Broad search and systematic investigation on patient flow management, which is one of the main challenges of the health sector in the face of biological events.

the exclusion of non-English literature may result in the omission of relevant literature, that caused a shortage of resources available during the scoping review and We did not investigate the social and cultural conditions affecting the health system in the management of patient flow in biological events.

Conclusions

The performance of the health care system is crucially dependent on patient flow management during biological incidents, as demonstrated by this review study. Even in a pandemic, health treatment needs to be prompt, effective, safe, and focused on the patient's needs. Managing the flow of patients is difficult when health centers are overcrowded, particularly during epidemics and pandemics. identifying influencing factors of patient flow special in Biological Events, could help healthcare providers to understand and construct targeted interventions. Our review found that patient flow management in biological events is influenced by patient flow simulation models, risk communication management, integrated ICT system establishment, collaborative interdisciplinary and intersectoral approach, systematic patient management, promotion of health information technology models, modification of triage strategies, and optimal resource and capacity management.

Abbreviations

ICT	Information and Communication Technology
CBRN	Chemical, Biological, Radiological, Nuclear
CDC	Centers for Disease Control
MERS	Middle East Respiratory Syndrome
SARS	Severe Acute Respiratory Syndrome
H1N1	Hämagglutinin Neuraminidase
WHO	World Health Organization
MEWS	Modified Early Warning Score
ED	Emergency Department

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Article Summary
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Broad search strategy developed after a preliminary search of the current evidence base and Investigation the management of affected people and patient flow in Biological Events.
Not considering patient flow management in intentional biological incidents such as bioterrorism.
The researcher had limited or lack of access to the full text of some of the articles related to the subject that caused a shortage of resources available during the systematic review.

Authors' contributions
Conceptualisation, data collection, analysis, writing of the manuscript; (Z.H) and (SH.A), confirming analysis, writing of the manuscript;(M.S). conceptualisation, data collection, analysis, writing and editing of the manuscript and revisions the results (H. R. Kh) and (M.F). All authors read and approved the final manuscript.

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Data availability
Data will be provided in supplementary files (physical file from the output of Mendeley software).

Declarations

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