Introduction

At present, relatively comprehensive outpatient emergency systems have been established in various countries. These systems significantly shorten the time for patients to receive treatment and reflect a country’s medical and social management levels (1,2). However, since the establishment of the outpatient emergency system, the demand for related services has increased rapidly, and the types of service problems have also increased significantly, thus promoting continuous improvements in outpatient emergency systems (3). However, the proportion of hospitalized patients experiencing emergencies is considerably higher than the outpatient population. For example, more than half of all deaths occur in hospitals in Canada, approximately 46% of deaths in the UK, and nearly one-third of deaths in the
USA (4). Although the time to treatment in a medical facility is shorter, many patients still die during hospitalization due to a dramatic change in their condition. Therefore, the rapid response system (RRS) in hospitals has been gradually developed (5). The RRS performs an early intervention role based on the patients’ respiratory rate, heart rate, blood pressure, and state of consciousness to identify those in need of emergency treatment in a timely manner and provide multidisciplinary medical care services (6). Numerous studies have shown that using an RRS significantly reduces inpatient mortality (7,8). Moreover, it is also beneficial for assessing the physical condition and medical needs of patients at the end of life (9). The core of the RRS is the start-up criteria and the rapid response team (RRT) (10,11). Furthermore, RRS was also applied in outpatient settings, while related study was few (12). This study adopted a bibliometric method to analyze the research status of emergency RRSs for hospitalized patients.

**Methods**

**Data source**

The data source for this study was the Science Citation Index Expanded (SCI-E) database in the Web of Science Core Collection (WOSCC), a commonly used database for bibliometrics. This database was founded and published by the American Institute for Scientific Information in 1957. The SCI-E database contains papers and their citation information from more than 8,000 journals. It is an important citation retrieval source and an essential database for metrology research and scientific research evaluation.

**Search strategy**

This study adopted the “topic word” retrieval strategy, and the search terms were “emergency” and “rapid response system”. There was no restriction on the publication date of the literature, and all related articles included in SCI-E were retrieved, with the latest retrieval time being 2021-11-07.

**Data collection and bibliometrics analysis**

All the records of the retrieval results and the citations were exported in plain text format as source files for subsequent analysis. This source file was analyzed using CiteSpace software. The content of the analysis included the annual distribution of the literature and the literature citations; the source country of the literature; the distribution of institutions and authors of the literature; the cooperation between countries, institutions, and authors; the distribution of journals that published the literature, and the use of keywords in the literature.

**Statistical analysis**

This study mainly used quantity and percentage to describe the indicators statistically. There was no difference analysis involved, and there was no need to set a test level.

**Results**

**General information**

There were 1,320 research papers, with 29,920 total citations. The average number of citations per paper was 22.67, and the H-index, which reflected the paper’s influence in specific research field, was 79. Among these documents, 1,096 were original articles, 157 were reviews, 51 were editorial materials, 47 were proceedings papers, 11 were online publications, 7 were letters, 6 were conference abstracts, 3 were book chapters, 2 were reprints, and 1 was a presentation (Table 1 shows that 61 papers were classified repeatedly, so the total records in the table are 1,381, but the actual number of papers was 1,320 when calculating the percentage). The statistical results show that the number of documents and citations increased yearly (Figures 1,2).

**Country**

The country visualization map was drawn by CiteSpace V software (Figure 3), where the number of network nodes

| Table 1 Literature types | Records | Percentage (%) |
|--------------------------|---------|----------------|
| Article                  | 1,096   | 83.03          |
| Review                   | 157     | 11.89          |
| Editorial                | 51      | 3.86           |
| Proceedings              | 47      | 3.56           |
| Online                   | 11      | 0.83           |
| Letter                   | 7       | 0.53           |
| Meeting abstract         | 6       | 0.45           |
| Book                     | 3       | 0.23           |
| Re-publication           | 2       | 0.15           |
| Note                     | 1       | 0.08           |
(N) = 105, and one node represents one country; that is, the authors of these documents came from 105 countries. The connection between any two nodes (E) = 711; that is, the number of times any two countries appeared in a document at the same time was 711. The top 5 countries for the number of publications were the United States, Australia, China, the United Kingdom, and Canada (Table 2).

The top 5 countries for centrality, which reflected the status of collaboration of one (individual, institute, countries) with others, were the United States, the United Kingdom, Argentina, the Czech Republic, and Switzerland (Table 3).

**Research institutions**

Similarly, the number of nodes (N) in the institutional visualization map (Figure 4) = 609; that is, 609 research institutions participated in research in this field, and...
the number of times any two institutions appeared in a document at the same time (E) totaled 1,224. The top 10 institutions in terms of number of publications and centrality are shown in Tables 4,5, respectively. The institution with the most publications was Monash University in Australia, and the one with the highest centrality score was Stanford University in the United States. However, we can see (Tables 4,5) that research institutions in the United States and Australia are leading in both the number of publications and the centrality score.
The results show that in this field, there were some researchers who published significantly more literature, notably Associate Professor Daryl Jones from Austin Hospital in Australia (Table 6). However, the centrality score of the researchers was not high; only eight authors reached 0.01, and the highest centrality score was 0.02 from Jones, suggesting that there was relatively little cooperation between authors (Table 7). The results were consistent with the visualization map (Figure 5). The co-citation map shows that the literature cited by the authors had a wide intersection (Figure 6). The most cited author was Dr. Paul Chan from the University of Missouri-Kansas in the United States (Table 8), but the highest cited centrality score was only 0.02, indicating that the cited literature was scattered and lacked classic research literature quality (Table 9).

**Journals**

The 1,320 articles in this study came from 608 journals, of which 17 had more than 10 articles. The top 10 journals by the number of articles published are listed in Table 10. There were 257 journal articles in total, accounting for 19.47% of the total literature (Table 10). These journals were dominated by critical care medicine and emergency medicine, but the more cited journals were either general journals or top critical care medicine journals (Table 11).
Figure 5 Co-author visualization map. Collaborations among authors were scattered and clustered.

Figure 6 Authors co-citation visualization map.
Major journals had higher centrality scores, especially authoritative comprehensive journals (Table 12).

**Keywords**

CiteSpace V software was used to analyze keywords and generate a co-occurrence map (Figure 7). The number of nodes (N) in the graph was 339; that is, in the 1,320 articles included in this study, 339 keywords were used; the total number of times (E) that the keywords appear in the same document in pairs was 2,089. The keyword with the highest frequency was “medical emergency team” (Table 13), and the keyword with the highest centrality score was “emergency” (Table 14). Further burst detection was performed on
keywords with high frequency, and the results showed that the use of popular keywords changed over time (Figure 8).

**Discussion**

This study is the first to conduct a bibliometric analysis of research literature on emergency RRSs. The analysis results showed that, before 2005, the number of research papers had been growing steadily, but after 2006, there was a period of rapid growth with a slight fluctuation in the middle period, followed by an especially significant increase in 2020, which may be related to the COVID-19 pandemic in 2020. The countries studied were mainly developed countries in Europe and the United States. Although China...
has published a large number of studies, it has been less involved in cooperation. The research institutions with more publications and collaboration were predominantly from the United States and Australia. Similarly, the most influential authors were mainly from these countries and institutions. The keyword analysis showed that the hotspots in this research field were “emergency teams” and “rapid response systems”, but the hotspots changed over time.

The results of this study showed that in the field of rapid emergency response, most of the important research comes from developed countries in Europe and America. This is closely related to the country’s economic level and medical facilities. The emergency response system conducts real-time monitoring, early warning, and response to the conditions of hospitalized patients. It provides patients with rapid emergency resources and interventions on the spot, involving administrative management and evaluation (13). At the heart of the RRS is the RRT (14). Unlike the traditional emergency team, the RRT mainly evaluates patients with respiratory, neurological, and cardiac deterioration in advance to prepare for emergencies, allowing the response to adverse events to be more rapid and effective (14). During the COVID-19 pandemic, some hospitals adjusted their RRS to deal with the incoming challenges, most commonly through increasing resources and implementation of protocol changes (15). However, the current research does not have sufficient evidence to draw a clear conclusion on whether the RRS and RRT can bring benefits, and the related research results were inconsistent (16). In a meta-analysis published in 2010, Chan et al. analyzed data from 18 studies and found that the use of an RRT reduced the incidence of cardiopulmonary arrest in adults outside the intensive care unit (ICU) by 33.8% [risk ratio (RR) =0.66; 95% confidence interval (CI): 0.54–0.80], but did not reduce inpatient mortality (RR =0.96; 95% CI: 0.84–1.09); in children, it reduced the incidence of cardiopulmonary arrest outside the ICU by 37.7% (RR =0.62; 95% CI: 0.46–0.84), and also reduced hospital mortality in children by 21.4% (RR =0.79; 95% CI: 0.63–0.98) (17). In a systematic review and meta-analysis, Maharaj et al. found that the use of an RRS reduced the overall mortality of inpatient adults (RR =0.87; 95% CI: 0.81–0.95; P<0.001) and children.

Figure 8 Top 25 keywords with the strongest citation bursts.
funding shortages, which was unrelated to the number of beds in hospitals and pediatric departments (25). In a study by Loisa et al., the authors found that when frequently participated in RRT, the nurses considered their work important and believed it fosters improved critical care skills (26). The authors also found that infrequent RRT participation, feeling overworked and/or undercompensated and conflicts between RRT and ward doctors were barriers for successful RRS among RRT nurses (26).

The results of this study demonstrate the general status of research in emergency RRSs and provide a valuable reference for researchers in this field. As a result of our findings, we hope that relevant literature can be retrieved more accurately. Development and cooperation provide important reference information. This study also has some limitations. Firstly, there were a large number of studies published in languages other than English, including Chinese, Japanese, German, and French, among which there were many high-quality studies. However, because this study only searched the SCI-E database, other studies that were not included in the database may have been overlooked, resulting in some deviation between the research results and the actual situation. Secondly, some studies did not use “rapid response system” as the topic term, but their content was closely related to RRS. These documents may have been missed during the search. Therefore, we suggest that efforts should be made in the future to standardize topic words and keywords to facilitate academic exchanges.

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**Footnote**

**Conflicts of Interest:** All authors have completed the ICMJE uniform disclosure form (available at https://atm.amergroups.com/article/view/10.21037/atm-22-709/coif). The authors have no conflicts of interest to declare.

**Ethical Statement:** The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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