

## REVIEW

# Application status of the definition of polytrauma in clinical research-A review of the past decade

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**Abstract**

**Background:** The purpose of this study was to investigate the evolution and latest trends in the application of different polytrauma definitions in the past ten years of clinical research, by collecting published polytrauma study data.

**Method:** We conducted Pubmed, Embase and Ovid searches of literature on polytrauma, published between January 2008 and December 2018. The title, author name, definition of polytrauma, publishing date, country, type of article, and the name and impact factor of journal were recorded and analysed.

**Results:** Based on different definition of polytrauma, the selected articles were grouped into four categories: (1) definition of polytrauma based on ISS, (2) definition of polytrauma based on NISS, (3) definition of polytrauma based on AIS, (4) descriptive definition of polytrauma. The 321 selected articles were published in 56 journals, predominantly in European and American medical journals, led by Injury (n = 41), followed by Journal of Trauma and Acute Care Surgery (n = 27) and European Journal of Trauma and Emergency Surgery (n = 17). Germany had the largest number of publications, with 88 articles. All articles were clinical research. There were 88 multi-centre studies and 233 single-centre studies.

**Conclusions:** The definition of polytrauma in clinical research was still mainly based on ISS. The appearance of the "New Berlin Definition" provides a new direction for its development. However, all these varying definitions are inconsistent and a globally recognised definition of polytrauma should be established.

**Keywords**

Polytrauma; Definition; Bibliometric analysis; ISS; NISS; AIS

## 1. Introduction

Polytrauma is a term used to describe injuries that involve multiple parts of the body or body cavity and as a result, other physiological processes or bodily organs may also be compromised, despite not being involved in the initial injuries. Since the 1980s, the treatment of polytrauma has become an integrated treatment model in which multidisciplinary teams are responsible for polytrauma with the rapid development of trauma treatment systems and damage control technologies, such as emergency resuscitation, emergency surgery, Intensive Care Unit (ICU) treatment, and definitive surgery. However, the definition of polytrauma has been debated for a long time, which has led to difficulties in multi-centre research, academic exchanges, treatment systems, and technical level evaluation. Baker [1] proposed that the injury severity score (ISS) can be used to describe the severity of polytrauma in 1974. In 1975, Border *et al.* [2] defined polytrauma as wounds at more than two sites. In 1978, Schweiberer [3] divided polytrauma into three levels: grade I covers moderate injuries which require hospitalisation; grade II covers severe injury with shock and a

loss of 25% of blood volume; and grade III covers emergency and life-threatening injuries with severe shock and loss of about 50% of blood volume. Ertel and Trentz [4] thought that polytrauma could be defined as multiple lesions with ISS  $\geq$  16, coupled with secondary systemic reactions which can cause distant organ dysfunction. In 2002, Osterwalder [5] proposed the basis for the modern definition of polytrauma: two or more sites were injured in six sites of ISS with abbreviated injury scale (AIS)  $\geq$  2. Keel [6] described polytrauma in 2006, as a combination of injuries where ISS > 17 points and SIRS for at least one day. In 2009, Butcher and Balogh [3] pointed out that there was still no consensus on the definition of polytrauma that could be supported by high-level evidence.

To date, there are still many different views on the definition of polytrauma. The purpose of this study is to collect the articles about polytrauma definitions from the past decade, so that the evolution and trends in application of different definitions can be investigated.

## 2. Methods

### 2.1 Search strategy

We performed a Pubmed, Embase, and Ovid search of literature on multiple trauma published between January 2008 and December 2018. We used search terms in combination with ‘polytrauma’, ‘multiple trauma’, or ‘multitrauma’. All electronic searches were performed on a single day (30 October 2019), to avoid changes in citation rates as much as possible.

### 2.2 Research screening

Each article found by the search was reviewed by two independent reviewers (DX and YLS). Preliminary screening was performed by reading the title and abstract. If necessary, the full article was read (with the full texts obtained from Pubmed, Embase or Ovid). Only studies with polytrauma as the main theme were included. Exclusion criteria were (1) articles written in languages other than English; (2) articles focusing on topics other than polytrauma; (3) articles that were reviews, conference contributions or letters; and (4) articles that contained no description of polytrauma definitions. Discussions with a third reviewer (PL) resolved any differences between the two reviewers.

### 2.3 Data collection

The data from the included articles was extracted, in a structured data-collection form, by two authors (DX and YLS) independently. Any dispute was resolved through discussions with a senior investigator (PL). For each article, the following information was sought: (1) the first, second and corresponding authors; (2) the year and language of publication; (3) the study type, (4) the chosen definition of polytrauma, (5) the journal name and impact factor; (6) the article title, (7) the countries of the first and corresponding authors. There was 100% agreement between the two authors.

### 2.4 Included study assessment

Based on the study design, background and objectives, the selected articles were determined to be clinical studies, including observational and randomised controlled trials (RCTs). Prospective, retrospective, and case series are all classified as observational studies. RCTs includes single-blind and double-blind studies.

### 2.5 Statistics

One-way analysis of variance was used to compare numerical data between groups, and  $\chi^2$  test was used for non-numeric data. Data were analysed by using software SPSS 20.0 (SPSS, Chicago, Illinois, USA), and a *P* value of  $< 0.05$  was considered significant.

## 3. Results

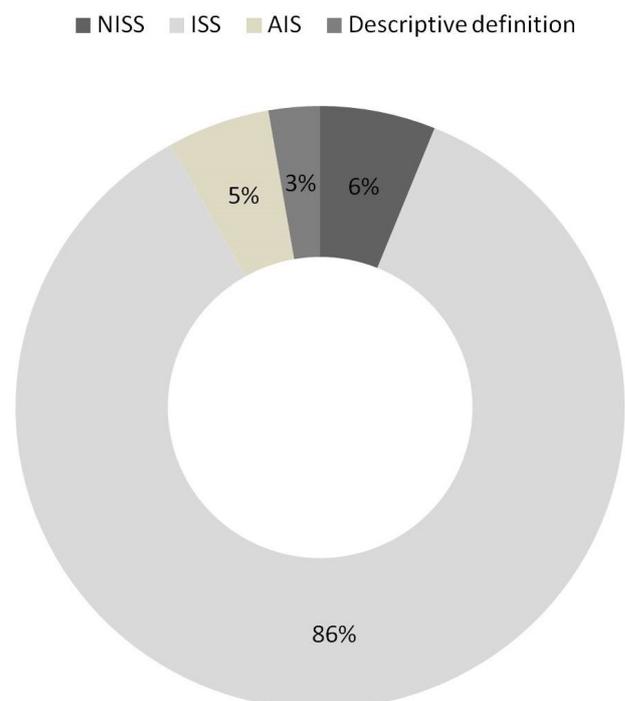
### 3.1 Article collection

After performing a search of literature published between January 2008 and December 2018, a total of 35161 papers were

identified. PubMed retrieved 22633 papers, Embase retrieved 6743 papers, and Ovid retrieved 5,885 papers. Using End-Note X8 (Thomson Reuters, New York, NY), 9828 duplicates were removed, leaving 25333 studies. A review of titles and abstracts eliminated 2367 non-traumatic studies. The full texts of the remaining studies were then reviewed, and 22,673 studies were eliminated. A further 5876 articles were excluded because they were reviews, conference contributions or letters. There was no description of polytrauma definitions in 8765 articles, 865 articles were written in languages other than English, and 6846 articles were focused on topics other than polytrauma. In the end, the analysis included 321 papers, all published in English.

### 3.2 The definition of polytrauma

Based on different definitions of polytrauma, the selected articles were grouped into four categories: (1) definition of polytrauma based on ISS score (277 articles), (2) definition of polytrauma based on the new injury severity score (NISS, 18 articles), (3) definition of polytrauma based on AIS (16 articles), and (4) descriptive definition of polytrauma (10 articles). The ISS definition was the most common, being used in 86% of the articles. Conversely, the descriptive definition of polytrauma was the least common, used in only 3% of the studies (Fig. 1).

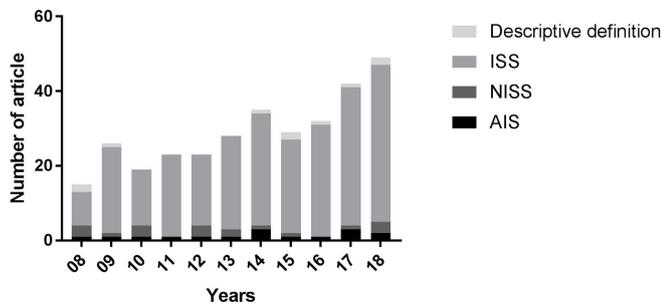


**FIGURE 1.** The number of articles in different groups.

### 3.3 Publication year

The selected 321 articles were published between 2008 and 2018, with more studies published in 2018 than any other year ( $n = 49$ ), whilst the lowest number of studies were published in 2008 ( $n = 15$ ). As time goes on, the number of articles published increased, as shown in Fig. 2. From 2008 to 2012, a

total of 106 articles were published, including 88 in the ISS group, 10 in the NISS group, 5 in the AIS group, and 3 in the descriptive definition group. A total of 215 articles were published between 2013 and 2018, including 189 in the ISS group, 8 in the NISS group, 11 in the AIS group, and 7 in the descriptive definition group (Table 1). The numbers of published articles in the first five years and the second five years were compared between the four groups and there were no statistically significant differences ( $P > 0.05$ ).



**FIGURE 2.** The number of articles is published in different years.

**TABLE 1.** The number of published articles in the first five years and the next five years.

Years	ISS	NISS	AIS	Descriptive definition	Total
2008-2012	88	10	5	3	106
2013-2018	189	8	11	7	215
$\chi^2$	3.497				
$P$	0.321				

### 3.4 Publishing journals

The selected 321 articles were published in 56 different journals, mainly in European and American medical journals. The most common was Injury ( $n = 41$ ), followed by Journal of Trauma and Acute Care Surgery ( $n = 27$ ) and European Journal of Trauma and Emergency Surgery ( $n = 17$ ). A total of 254 articles were indexed by SCI, and the impact factors of 175 articles were from 0 to 3 points. There were 69 articles with impact factors of 3-6 points, 7 articles with impact factors of 6-9 points, 2 articles with impact factors of 12-15 points, and 1 article was published in JAMA which has an impact factor of 44.405 points. The numbers of published articles in two impact factor levels (0-6 points and  $> 6$  points) were compared between the four groups (Table 2). The top five journals with the highest impact factor are JAMA, Intensive care medicine, Annals of surgery, JAMA surgery, BMC Medicine.

### 3.5 Authorship and country

The author who published the most articles is Ladislav Mica who published 7 articles in total, while Helene Lundgaard Soberg authored 5 articles, and Thomas Gross and Steven Ferree published 4 articles. Most of the articles included

**TABLE 2.** The number of published articles with the different impact factor.

Impact factor	ISS	NISS	AIS	Descriptive definition
0-6	213	13	13	5
$> 6$	5	3	2	0

were from European and American countries. Germany had the largest number of publications, with 88 articles. Next was the United States and Switzerland where there were 29 articles from each country. Finally, there were 24 articles in the Netherlands and China.

### 3.6 Publication type

All articles included were clinical research studies. There were 88 multi-centre studies and 233 single-centre studies. The retrospective articles accounted for 231 articles and 90 articles were prospective studies.

## 4. Discussion

The polytrauma definition based on ISS score was still the most widely used in the past decade. However, different articles had different understanding of the ISS definition, which was reflected in the different ISS thresholds (ISS  $> 15$  [7], ISS  $> 16$  [8–10], ISS  $> 18$  [11], ISS  $\geq 18$  [12], or ISS  $> 25$  [13]) and the decision to include anatomical sites or not. The most common definition of ISS-defined polytrauma was based on ISS of  $\geq 16$ . At the same time, there were a small number of ISS definitions that required the injury sites to be greater than or equal to 2. The second largest group was the NISS group, of which the most common definition of polytrauma was when NISS  $> 15$ . The third was the AIS group, and in this case, polytrauma was mostly defined by AIS  $> 2$ , with at least two injury sites. The least common definition was the purely descriptive definition. In general, over the past 10 years, the most widely used definition of polytrauma in clinical research was ISS-based.

In terms of the year publication, the number of articles published in 2018 was the largest, and the number published in 2008 was the least. We found that the number of research articles on the definition of polytrauma has shown an increasing trend in the last ten years. This shows that more and more research and resources are being devoted to polytrauma. It also reflects the importance and urgency of defining the definition of polytrauma. The author compared the number of publications in the first five years and last five years and found that there was no significant difference in the application of the definition of polytrauma with the four groups. This shows there was no significant change in the application of multiple trauma definitions in the past decade, so there is still a long way to go for the application and promotion of a new definition.

The journals that had published articles on polytrauma during the ten years were mainly from Europe and America. Injury as a well-known, authoritative journal in the traumatic world and is the journal that published the highest proportion of the selected articles. From its report on polytrauma, we can find that this is still a very popular research direction. According to

journal impact factor, we divided the journals of the selected articles into two grades: impact factors of 0-6, and impact factors of  $> 6$ . We found that the proportion of articles from the AIS and NISS groups that were published in the high impact factor journals was significantly higher than that of the articles in the ISS group. We suspect that this may be related to the better prediction of mortality and morbidity by the AIS group and the NISS group [3, 14, 15]. Of all the journals where the selected articles were published, JAMA has the highest impact factor, followed by Intensive Care Medicine. This shows that the research into polytrauma has also been recognised by world-leading medical journals.

Similar to the journals, the authors were also largely from Europe and the United States. This shows that the European and American scholars are the mainstay in the field of multi-injury research. Germany, Switzerland, and the United States were the top three countries in terms of the number of articles published. Germany and Switzerland were close to each other, and there was extensive cooperation in their trauma research. The AO organisation was born in Switzerland. Here, there was very in-depth research into pre-hospital emergency care, hospitalisation, and postoperative rehabilitation. It is worth mentioning that there were also quite a number of articles published in China in the past decade. There were two main reasons for this. Firstly, with the development of the economy, the car ownership rate in China increased, which led to a large increase in accidents and injuries [16]. Secondly, the focus on polytrauma research increased, resulting in rising amounts of data being obtained [17].

Large-sample, multi-centred research was largely focused on the European region, particularly Germany and Switzerland. The Trauma Register DGU in Germany, established in 1993, was the most widely used. The aim of this multi-centre database is to anonymise and standardise the documentation of severely injured patients. It is a European multi-centre cooperative organisation, with prospective, standardised, and anonymous documentation of severely injured patients from more than 145 trauma centres. In other parts of the world, especially in Asia, Africa and South America, there was a lack of large sample databases, so their multiple-injury studies were often limited to research in single-centre settings. The authors believe that it is imperative to promote the establishment of a worldwide database of polytrauma, as it is crucial for the advancement of polytrauma research.

The first step for developing a large-scale database is to harmonise the definition of polytrauma. However, there was no significant change in the application of the definitions of polytrauma in the past decade, and the various definitions remain mixed. In 2017, C.S. Rau [18] applied a new definition of multiple trauma in their clinical research. This definition was called the “New Berlin Definition” and was first proposed in 2014 by Pape *et al.* [19]. Using this definition, polytrauma is defined as two injuries that score  $\geq 3$  on the AIS, coupled with and one or more additional diagnoses of hypotension (systolic blood pressure  $\leq 90$  mm Hg), unconsciousness (GCS score  $\leq 8$ ), acidosis (base deficit  $\leq -6.0$ ), coagulopathy (PTT  $\geq 40$  seconds or INR  $\geq 1.4$ ), or age ( $\geq 70$  years). The addition of a relevant physiological condition or pathophysiological change in combination with AIS is reasonable to increase

its predictive power for mortality [20]. The “New Berlin Definition” is a new standard for the definition of polytrauma in recent years. It is evidence-based and derived from a large database, rather than level IV (expert opinion). It covers various physiological and pathological factors and is worthy of promotion in clinical applications. Based on the original definition, and in combination with a number of indicators closely related to vital signs, it makes the new standard more realistic and applicable for polytrauma patients [18]. However, the “New Berlin Definition” has not yet been widely applied, and its predictive capacity and potential to reduce mortality need further research and testing.

This study is the first to identify, rank and characterise the articles from the past decade in the field of the definition of polytrauma. The results of the research show the application status and characteristics of the definition of polytrauma, while providing the necessary information for scholars in related fields to improve the definition of polytrauma. The main limitations of this study are twofold. Firstly, the time span is not long enough. If the study period was 20-30 years, then a more comprehensive analysis of the clinical application of the definition of polytrauma could be performed. Secondly, the selected articles are all in English, therefore, some articles written in other languages could not be included in the study.

## 5. Conclusions

In the past decade, the definition of polytrauma in clinical research has been mainly based on ISS. The appearance of the “New Berlin Definition” provides a new direction for its development. However, there is still much variation between definitions which is unhelpful, and a globally recognised definition of polytrauma established through the WHO consensus meeting would be highly beneficial.

## ABBREVIATIONS

AIS, Abbreviated injury scale; ICU, Intensive Care Unit; ISS, Injury severity score; NISS, New injury severity score; RCTs, Randomized control trials.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

## AUTHOR CONTRIBUTIONS

Ding Xu and Peng Luo designed the study. Ding Xu and Yulong Shi collected the data. Yulong Shi and Peng Luo analyzed the data. Ding Xu and Weijun Guo analyzed the results and drafted the manuscript.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

## AVAILABILITY OF DATA AND MATERIAL

All data generated or analysed during this study are included in this published article.

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