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Spine surgical-site infection Definition and Diagnosis Criteria – A Scoping Review of the literature

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Spine surgical-site infection Definition and Diagnosis Criteria – A Scoping Review of the literature

Artigo de revisão sistemática

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Resumo

Introdução

A infeção do local cirúrgico (ILC) é uma complicação prevalente da cirurgia da coluna que pode resultar em complicações, tais como pseudoartrose, lesão neurológica, paralisia, sépsis e morte. A incidência da ILC varia amplamente, entre menos de 1% e mais de 10%, influenciada por fatores como os critérios de diagnóstico usados. A variabilidade na definição e diagnóstico de ILCs complica a gestão eficaz do doente e a comparabilidade entre estudos. Além disso, a implementação de uma definição padronizada irá melhorar a vigilância, garantir a coerência entre os estudos e elevar a qualidade dos cuidados aos doentes.

Métodos

Uma revisão sistemática da literatura (*scoping review*) foi realizada seguindo as Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines. Os critérios de inclusão abrangeram estudos que envolveram adultos com doenças degenerativas da coluna torácica e/ou lombar, submetidos a intervenções cirúrgicas com abordagens posteriores. Os estudos foram identificados em pesquisas na PubMed e da EMBASE.

O objetivo principal foi estudar doentes com ILC da coluna vertebral e determinar e comparar as definições e os critérios de diagnóstico utilizados na literatura.

Resultados

A revisão incluiu 64 estudos de 5655 citações identificadas. Os critérios de diagnóstico para ILC variaram de forma significativa: 22 estudos (34,4%) não especificaram critérios, enquanto 27 estudos (42,2%) seguiram as diretrizes dos Centros de Controlo e Prevenção de Doenças (CDC), porém com modificações. Critérios clínicos, laboratoriais, de imagem e intraoperatórios foram descritos, sendo que os de laboratório representaram a maioria (n=30, 93,7%). O exsudado da ferida cirúrgica e a dor foram frequentemente mencionados como critérios clínicos, enquanto os exames microbiológicos foram os critérios de diagnóstico mais referidos. Os critérios de imagem e intraoperatórios foram pouco descritos. As definições de infeção aguda e/ou tardia apenas foram mencionadas em 8 estudos.

Discussão

A revisão destaca a falta de homogeneidade no diagnóstico da ILC em cirurgias da coluna. Vários estudos mencionaram as diretrizes do CDC, mas frequentemente incluíram modificações que

refletem a variabilidade nas práticas clínicas. Esta inconsistência enfatiza a necessidade de definições e critérios uniformes para melhorar a precisão dos diagnósticos, a consistência nos estudos e a qualidade dos cuidados aos pacientes.

Conclusão

Esta revisão demonstra que, independentemente dos avanços nas normas e orientações de saúde, continua a haver bastantes variações na forma como as ILC são definidas e diagnosticadas entre os estudos. Esta revisão destaca a importância de futuras investigações se concentrarem no desenvolvimento de definições e critérios diagnósticos para a ILC da coluna vertebral.

Palavras-chave: Infeção do local cirúrgico na coluna vertebral, Definição de infeção do local cirúrgico na coluna vertebral, Diagnóstico de infeção do local cirúrgico na coluna vertebral

Abstract

Introduction

Surgical site infection (SSI) is a prevalent spinal surgery complication that can result in severe outcomes such as pseudoarthrosis, neurological injury, paralysis, sepsis and death. The incidence of SSI varies extensively, reported within less than 1% to over 10%, affected by factors such as the definitions used. The variability in defining and diagnosing SSIs complicates effective management and comparison across studies. Furthermore, implementing a standardized definition will enhance surveillance, ensure consistency across studies, and elevate the quality of patient care.

Methods

A scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines. The inclusion criteria focused on studies involving adults with thoracic and/or lumbar degenerative spine diseases undergoing specific posterior surgical interventions. Studies were sourced from PubMed and EMBASE. The primary aim was to study patients with postoperative surgical site infection of the spine and to determine and compare definitions and diagnostic criteria used in the literature.

Results

The review included 64 studies from 5655 identified citations. Diagnostic criteria for SSIs varied significantly: 22 (34.4%) studies did not specify criteria, whereas 27 studies (42.2%) followed Centers for Disease Control and Prevention (CDC) guidelines. Clinical, laboratory, imaging, and intraoperative criteria were all used, with laboratory criteria accounting for the majority (n=30, 93.7%). Surgical site discharge and pain were frequently cited as clinical criteria, while microbiological examinations were the most common criteria. Imaging and intraoperative criteria were less well defined and standardized. Definitions of acute and/or late SSI were only mentioned in 8 studies.

Discussion

The review emphasizes the lack of standardization in diagnosing SSIs in spinal surgery. Many studies mentioned CDC guidelines, but they frequently included modifications that reflected variability in clinical practices. The inconsistency of diagnostic criteria emphasizes the need for standardized definitions and criteria to enhance diagnostic accuracy, reporting consistency, and quality of care for patients.

Conclusion

This scoping review reveals that regardless of advances in healthcare standards and guidelines, there remains substantial variation in how SSIs are defined and diagnosed among studies. This review highlights the necessity for future research to focus on developing and establishing definitions and diagnostic criteria for spine SSIs.

Keywords: Spine surgical-site infection, Spine surgical-site infection Definition, Spine surgical-site infection Diagnosis

List of Abbreviations

CDC: Centers for Disease Control and Prevention

CRP: C-reactive protein

ESR: erythrocyte sedimentation rate

ICM: International Consensus Meeting

MRI: Magnetic Resonance Imaging

NHSN: National Health Safety Network

PRISMA-ScR: Preferred Reporting Items for Systematic reviews and Meta-analysis extension for Scoping

SII: surgical-site infection

WBC: white blood cells

Index

List of Tables

List of Figures

Introduction

Surgical-site infection (SSI) is a relatively frequent complication associated with spinal surgery, carrying the potential for severe outcomes like pseudoarthrosis, neurological injury, paralysis, sepsis and death. Managing SSI is challenging due to its different types of presentation. The preventive measures should be our primary focus including preoperative risk assessment and strict surgical protocols in order to reduce the incidence of SSI. [1]

SSI rates have been reported to vary from less than 1% to over 10%, depending on the diagnosis, type of surgery, and patient factors. This variability is also attributed, in part, to small sample sizes, inconsistencies in the definition of an SSI and temporal parameters.[2]

Incurring SSIs following spinal surgery not only escalates patient morbidity and mortality rates but also amplifies healthcare expenditures, constituting a significant burden for both patients and surgeons.[3]

The main risk factors for infection depend on the patient (obesity, diabetes, smoking, corticosteroid therapy, previous hospital stay), the surgical procedure (instrumentation, implants, number of levels operated, site of surgery, duration of the intervention, dural tear, revision surgery, need for transfusion) and the postoperative period (days of drainage, incontinence, prolonged bed rest).[4] Implants represent a critical factor that substantially elevates the risk of SSI. Cases involving instrumentation have yielded infection rates 28% higher compared to cases without implants. Implants offer a non-vascular surface where bacteria can establish a biofilm, serving as a focal point for microbial growth, thus evading antibiotic effects and the host immune system.[5]

SSIs can be defined based on their anatomic relationship to the fascia (superficial or deep), whether the infection is limited to the disc and based on the timing with which they present (early or late).[6]

Physicians may encounter diagnostic challenges when it comes to identifying SSI, primarily because of several factors. These include limited physical examination findings, similarities with non-infectious conditions, the presence of mild symptoms that discourage patients from seeking medical care, suboptimal follow-up procedures and a historical reliance on plain X-rays, which lack the sensitivity required for SSI diagnosis.[5]

There is also a lack of agreement regarding which criteria are both adequate and essential for diagnosing SSI in clinical settings and the interpretation of these criteria can vary inconsistently depending on the person applying them.[7] Nonetheless, the use of a well-defined systematic approach would facilitate the prompt establishment of a conclusive diagnosis. [5]

A delay in diagnosis often occurs due to vague symptoms, such as back and neck pain. Furthermore, patients might not seek early medical attention because an infection can initially manifest as mild back pain as the only clinical finding. The absence of immediate medical follow-up after the procedure can exacerbate this issue. Consequently, there is an ongoing need for extensive multi-center clinical studies to determine the most effective diagnostic approach for SSI. [5,8]

It is crucial to establish a comprehensive and consistent definition for SSI, as research has demonstrated that the incidence of SSI after spinal surgery fluctuates depending on the definition applied.[9] Furthermore, implementing a standardized definition will enhance surveillance, ensure consistency across studies and elevate the quality of patient care.[8]

The International Consensus Meeting (ICM) recommended using the Centers for Disease Control and Prevention (CDC) definition of SSI from the National Health Safety Network (NHSN) Patient Safety Component Manual, Chapter 9: SSI, however, these are not specific for spinal SSI. The CDC definition is the result of multiple years of planning and modifications based on yearly assessments and input from experts worldwide. [8] The more recent (2024) CDC guidelines [10] include criteria for the subclassifications of a superficial incisional SSI, deep incisional SSI, and organ/space SSI and they are detailed in Table I.

The aim of this systematic review is to identify in the literature the definitions and diagnostic criteria for SSI.

Methods

A scoping review was conducted due to the exploratory nature of the research question. The scoping review is reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-analysis extension for Scoping reviews known as the PRISMA-ScR. [11]

Eligibility Criteria

The inclusion criteria for the scoping review were guided by PICO (population, intervention, comparison, outcome) as recommended for scoping reviews[11]: studies including people aged 18 years or older with thoracic and/or lumbar degenerative diseases, such as spinal canal stenosis, disc herniation, spondylolisthesis, and/or degenerative scoliosis. Studies including participants with other concurrent injuries or medical conditions, like inflammatory diseases, neuromuscular disorders, cerebral palsy, early onset/primary/congenital/neuromuscular scoliosis, osteomyelitis, Scheuermann's disease, ankylosing spondylitis, tuberculosis, fractures even in the context of osteoporosis, osteogenesis imperfecta, hemivertebra or Kummel's disease were excluded. These exclusions were done to create a more uniform population of patients with degenerative spine disease.

Patients included underwent the following interventions: posterior approaches such as transforaminal lumbar interbody fusion or posterior lumbar interbody fusion, posterolateral fusion and surgery without instrumentation through a posterior approach (including discectomies, laminectomies, and recalibrations). Only thoracolumbosacral levels were included. Anterior, lateral, oblique, axial and combined approaches were excluded.

The primary aim was to study patients with SSI of the spine and to determine and compare the definitions and diagnostic criteria used in the literature.

Reviewed articles included all types of experimental and observational studies [single- or multi-arm, randomized (parallel, crossover, cluster, other) or nonrandomized], including case series and case studies. Articles which fell into any of the following categories were excluded from this new synthesis: 1) those not in the English language and 2) those not related to spine surgical-site infection as a primary outcome.

Search Strategy

The search was carried out using a uniform search strategy across databases: PubMed and EMBASE. To identify all relevant documents, databases were searched on November 18, 2023. Unpublished studies, reviews or reports were not considered for inclusion. No exclusion was applied based on publication dates; however, considerable emphasis was focused on the most relevant and up-to-date information available at the time of this review.

The bibliographic databases were searched using the following combination ((((spine OR thoracolumbar OR lumbar OR thoracic OR lumbosacral OR "low back" OR "lower back") AND (infection)) AND (posterior))) NOT (trauma[Title/Abstract] OR cervical[Title/Abstract] OR tumor[Title/Abstract] OR neoplasia[Title/Abstract] OR pediatric[Title/Abstract] OR children[Title/Abstract] OR adolescent*[Title/Abstract] OR Spondylodiscitis[Title/Abstract]).

Study Selection

Duplicate identification and removal were performed automatically using the *EndNote* software and the *Rayyan qrci* website manually. Titles and abstracts were then screened by one reviewer for assessment against the inclusion criteria for the review. The results of the search were reported in accordance with the PRISMA-ScR.[11]

The PRISMA flowchart was used to guide the selection and screening process. Filtering process of studies retrieved from the database was performed in three phases: (i) identification phase, where search queries were applied to the databases followed by the removal of duplicates; (ii) screening phase, where titles and abstracts of articles were screened to exclude irrelevant articles; (iii) eligibility phase, where the full texts of articles were read to assess their relevance to this study.

Data Extraction

A standardized data-charting form, based on the scoping review objectives, was developed in *Excel* (Microsoft, Redmond, Washington, 16.85 version). One reviewer independently extracted data on the following categories: author, year of publication, study design, time-based criteria to differentiate an acute versus late spine SSI (days or weeks) and classification used to diagnose spine SSI (predefined, arbitrary or none).

Results

Selection of Sources of Evidence

After duplicates were removed, a total of 5655 citations were identified. Based on the title 5270 citations were excluded and 236 based on the abstract. One-hundred forty-nine full text articles were retrieved and assessed for eligibility. Of these, 49 were excluded for the following reasons: 2 included <18 years old patients, 8 included an anterior approach, 15 included interventions in the cervical spine, 11 included patients with a diagnosis of trauma, 8 included patients with a pre-diagnosis of tumor, 1 included patients with idiopathic scoliosis, 1 included patients with neuromuscular scoliosis, 1 included patients with tuberculosis, 1 included patients with congenital pathologies and 1 included patients with osteoporotic vertebral fracture. Thirty-six studies were excluded because they couldn´t be retrieved, even after sending an email requesting access to the authors. The remaining 64 studies were considered eligible for this review. The complete process of study selection is detailed in Figure 1.

Publication Date and Study Design

The 64 studies were published between 1996 and 2023. From 1996 to 2012, there were sporadic studies conducted, with only one or two studies per year. Until 2019, 57.8% [12–46] of the studies were published, meaning that almost half of the research was performed in the last four years[47–74]. The years 2019, 2021, and 2022 stand out with a relatively high number of studies compared to previous years (Figure 2).

Most studies were non-randomized multi-arm or multi-condition (n=43, 67,2%)[13,15,16,20,21,23,24,26,29–33,37–39,41–47,49–51,53–57,62,63,65,66,68–75] followed by non-randomized single-arm/condition studies (n=19, 29,7 %)[12,14,17–19,22,25,27,28,34,36,40,48,52,58–61,64] and a minority of randomized (n=2, 3,1%)[35,67] (Figure 3).

Diagnostic Approaches

Among the studies included in this review, 22 (34,4%)[12–14,20,21,28,30–35,39,40,46,47,51,57–59,66,67] did not explicitly outline diagnostic criteria for identifying spine SSI. A subset of 15 (23,4%)[16,18,19,24,26,29,41,43,53,55,56,62,69,70,72] studies established their own diagnostic criteria for spine SSI.

The largest proportion of studies in our review, 27 (42,2%)[15,17,22,23,25,27,36–38,42,44,45,48–50,52,54,60,61,63–65,68,71,73–75] in total, adhered to the guidelines provided by the CDC for diagnosing SSI (Figure 4).

In the literature, while researchers generally adhered to established CDC guidelines, they also demonstrated a tendency to incorporate modifications and adaptations. Eight studies (29,6%)[38,49,60,63,65,68,71,73] demonstrated a preference for the recommendations, relying on the 2017 CDC guidelines for infection prevention[76]. Thirteen studies (48,1%)[15,17,22,23,25,36,42,44,48,50,54,74,75] used the established framework outlined in the 1999 CDC definition for diagnosing SSIs[77]. Three studies (11,1%)[27,45,61] incorporated the CDC guidelines from 1992[78]. One study (3,7%)[64] used the surveillance definitions provided by the CDC in collaboration with the NHSN[79]. A single study (3,7%)[52] referred to the CDC without specifying a particular year of the guideline. Finally, in one study more than one CDC definition was integrated. This study (3,7%)[37] mentioned the CDC definitions from 1992 and the 1999 CDC definition[77,78] (Figure 5).

Diagnostic Criteria

Within the diagnostic criteria outlined in the studies, a subdivision was made into clinical, laboratory, imaging, and intraoperative criteria, the final aspect being conducted by the surgeon during direct examination in the operating room, either for revision or debridement purposes.

These diagnostic criteria were identified in studies defined by the authors themselves, as well as in studies that relied on CDC guidelines, but where authors emphasized specific criteria. Of these, 32 studies were included. Laboratory criteria were the most frequently used (n=30, 93,7%)[16,18,19,24–26,29,36–38,41–45,48–50,53–56,61–64,69,70,72,73], followed by clinical criteria (n=22, 68,7%)[18,24–26,36,41–43,48–50,53,54,56,62–65,69–73]. Imaging criteria were utilized in 17 (53,1%)[19,36,41–43,48–50,53,54,62,63,69–73] studies. In 3 publications (9,4%)[36,48,53], intraoperative criteria were employed for diagnosis (Figure 6).

Clinical criteria

A total of 22 studies (68,7%) [18,24–26,36,41–43,48–50,53,54,56,62–65,69–73] were included, each evaluated based on specific clinical criteria. Among the observed studies, 4 (12.5%)[62,70–72] used clinical symptoms that weren´t specified by the authors. Localized symptoms were prevalent and manifested at the surgical sites. The most common localized symptom that was reported as diagnostic criteria was surgical site discharge, noted in 15 (46.9%)[18,24,36,41–43,48–50,53,56,63,64,69,73] studies. Additionally, incisional inflammatory signs that weren´t specified were reported in 1 study (3.1%)[56]. Pain, a prevalent localized symptom, was mentioned in 13 studies (40.6%)[24,25,36,43,48–50,53,54,63–65,69].

Redness[25,49,50,53,54,63–65,73] and tenderness[25,36,42,48,49,53,63,65,73] were also frequently reported, each observed in 9 studies (28.1%). Swelling, heat, and abscess formation were observed in 7 (21.9%)[25,49,53,54,63,64,73], 4 (12.5%)[49,54,63,65] and 5 studies (15.6%)[42,49,54,63,73], respectively. Induration, a less common localized symptom, was mentioned in 1 publication (3.1%)[69].

Several systemic signs were observed in the study sample. Fever with no specific value was reported in 9 studies (28.1%)[24–26,41,43,50,53,64,69]. Fever exceeding 38ºC was noted in 4 studies (12.5%)[36,42,48,49]. A febrile state, characterized by the study as a temperature of 37.2°C, was reported once (3.1%)[56]. Chills were also reported once (3.1%)[56] (Table II).

Laboratorial Criteria

Thirty studies (93,77%)[16,18,19,24–26,29,36–38,41–45,48–50,53–56,61–64,69,70,72,73] employed laboratory criteria as their diagnostic criteria. Microbiological examinations that weren´t specified were mentioned in 2 studies (6.2%)[49,64]. Culture tests that weren´t specified were noted in 7 studies (21.9%)[36,42–45,49,56], while drainage cultures were mentioned in 10 studies (31.3%)[24,37,53–55,61,63,70,72,73]. Additionally, wound discharge cultures were reported in 9 studies (28.1%)[18,29,38,50,53,54,62,69,70] and blood cultures were conducted in 1 publication (3.1%)[38]. In 2 studies (6.2%)[50,62], blood tests without markers specification were noted.

Blood markers included C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), white blood cells (WBC) count and procalcitonin. In 7 studies (21.9%)[19,25,26,41,43,54,69], CRP was reported without a particular value and in 1 study (3.1%)[56] it was used as a diagnostic criteria when the concentration exceeded 5mg/ml. Regarding ESR, it has been referenced in 4 studies (12.5%)[19,25,41,43] without a precise value and once (3.1%)[56] with a value of more than 25mm/hour. In 4 studies (12.5%)[19,26,41,69], the WBC count was reported but without a cut-off value, while in 1 publication (3.1%)[56], the WBC count exceeded 11,000/µl. Procalcitonin was mentioned once (3.1%)[54] and the value was not reported. Finally, histological examination was indicated in 6 studies (18.7%)[16,36,48,49,63,69] (Table III).

Imagology Criteria

Imagology criteria were applied in a total of 17 studies (53,1%)[19,36,41–43,48–50,53,54,62,63,69–73]. Among these studies, 5 (15.6%)[41,42,49,70,71] were found to have imaging findings that weren´t specified by the authors as the diagnostic criteria. Additionally, in 4 studies (12.5%)[19,50,54,69], Magnetic Resonance Imaging (MRI) scans didn´t specify the findings in their criteria. Seven studies (21.9%)[36,48,53,62,63,72,73] were classified as applying radiologic findings without detailing the findings.

One study (3.1%)[43] used as diagnostic criteria radiographic changes, such as halo sign, endplate erosion, interbody cage subsidence, migration, or pedicle screw loosening and mentioned MRI abnormalities characterized by a hypointense signal on T1-weighted images, a hyperintense signal on T2-weighted images and ring enhancement after contrast infusion (Table IV).

Intraoperative criteria

Only 3 studies (9,4%) [36,48,53] applied intraoperative criteria, which include the observation of an abscess or other evidence of infection involving the deep incision that was found on the direct examination being conducted by the surgeon (Table V).

Definition for acute and/or late SSI

Only 8 studies[16,21,32,50,53,64,71,73] provided a definition for acute and/or late SSI. One study (12.5%)[16] described an acute postoperative infection as occurring within 20 weeks after surgery. Two studies (25%)[21,32] described acute postoperative infections as occurring within the first 6 weeks after surgery. In addition, 5 studies (62.5%)[50,53,64,71,73] defined acute infections as emerging within 30 days of surgery.

Late infection was only reported in 2 studies. One study (12.5%)[16] defined late infection as occurring later than 20 weeks postoperatively, while another study (12.5%)[21] defined it as occurring more than 6 weeks after surgery (Table VI).

Discussion

Aiming to guide future research initiatives, a systematic literature review was conducted to comprehensively map the current state of research on spine SSIs definitions and diagnostic criteria. In this scoping review, which included 64 articles, the focus was to identify prevalent trends and current gaps in the literature on this critical area of study.

Diagnostic Approaches

Many studies lack diagnostic criteria for detecting spine SSIs[12–14,20,21,28,30–35,39,40,46,47,51,57–59,66,67], indicating a discrepancy in reporting standards or a lack of consensus in spine surgical literature. In a systematic review from 2023[80] including spinal surgery with a posterior approach for degenerative causes and non-degenerative causes the authors, despite reporting the rates of infection, failed to describe how the infection was defined or the criteria to diagnose SSI. Also, a scoping review from 2022[81] including spinal surgery for degenerative causes, however including anterior approach and cervical spine, focused on medical complications after elective spine surgery but failed to mention the definition or the criteria to diagnose SSI.

The majority of the studies[15,17,22,23,25,27,36–38,42,44,45,48–50,52,54,60,61,63–65,68,71,73–75] used the guidelines provided by the CDC for the SSI diagnosis, demonstrating a commitment to using evidence-based methods and recognized standards in clinical research. The modifications of the CDC guidelines differ between studies, reflecting variations in clinical practices, preferences, and interpretations among researchers. However, these modifications also raise concerns regarding consistency and comparability across studies. It is also important to note that strict adherence to CDC guidelines might limit the exploration of alternative diagnostic methods and criteria that could be relevant but are not included in the guidelines.

In recent years, the most widely used guidelines have been those published by the CDC in 2017. However, it is worth noting that some recent studies have included guidelines from 1999 and 1992.[48,50,54,61,74] This suggests that healthcare professionals sometimes fail to remain updated on the latest guidelines. This can be attributed to various factors, including the overwhelming amount of new research and guidelines released and a lack of effective dissemination within the medical field.

A minority of the publications developed their own diagnostic criteria[16,18,19,24,26,29,41,43,53,55,56,62,69,70,72] for spinal SSI. This could be because current guidelines do not fully address all aspects of SSI diagnosis in specific contexts, causing authors to develop alternative criteria.

Diagnostic Criteria

In this scoping review laboratory criteria[16,18,19,24–26,29,36–38,41–45,48–50,53–56,61–64,69,70,72,73] were the most frequently reported criteria for diagnosing SSI after spine surgery, and microbiological exams, such as culture tests [36,42–45,49,56], were the most frequently diagnostic criteria used in the reviewed studies.

It is also noticeable how a significant proportion of the studies included in this review did not specify the diagnostic criteria to identify spine SSIs. Examples include clinical findings with no specification, microbiological exams with no specification and imagiologic criteria without detailing the findings. This might suggest that because spine surgery patients can present with an extensive variety of symptoms and clinical findings[5], leading to different diagnostic criteria across studies, the authors may use more vague criteria to account for this variability and document a wide range of potential SSIs presentations.

In a systematic review from 2021[82] including spinal surgery with posterior approach of degenerative causes and non-degenerative causes and also including the cervical spine, the authors, even though they mentioned diagnostic criteria, did not detail them, stating only that they had to be clinical, laboratory, and imaging based.

Clinical Criteria

Clinical symptoms were commonly used as diagnostic criteria for spine SSIs across the reviewed studies. This means that for early detection and intervention, patients must be aware of SSI symptoms and report any concerning signs as promptly as possible.[5]

Patients may present with symptoms and signs such as pain or fever, which can be attributed to a variety of causes beyond infection.[8] While clinical symptoms and signs provide valuable initial indicators of infection, they must be considered in association with other diagnostic modalities, such as laboratory tests and imaging studies, to achieve a comprehensive assessment of spine SSIs. [6]

Surgical site discharge, such as wound exudate, is an evident sign of a possible infection. In contrast to subjective symptoms such as pain or tenderness, discharge can be objectively noticed as well by patients and healthcare professionals, making it straightforward criteria to diagnose SSIs, this may suggest why it is the most used specific criteria. In a review article from 2015[1] including spinal surgery with posterior and anterior approach of both degenerative causes and non-degenerative causes and also including intervention on the cervical spine, the authors mentioned that increased wound exudate at approximately 10 to 14 days postoperatively is the most prevalent early sign of wound infection and is present in 67% of patients with SSI.

Laboratorial Criteria

Laboratory criteria in the diagnostic of spine SSI is the most common criteria across studies[16,18,19,24–26,29,36–38,41–45,48–50,53–56,61–64,69,70,72,73], with microbiological examinations[36,42–45,49,56] being the most employed laboratorial diagnostic modality. This could occur because microbiological testing provides useful information for guiding patient management and optimizing treatment outcomes, avoiding unnecessary antibiotic use.

Blood tests, such as CRP, ESR, procalcitonin and WBC count, are less commonly used as diagnostic criteria than microbiological testing. However, when applied, these tests can provide valuable knowledge about the inflammatory response and systemic effects of SSIs.[83]

A single article [56] provided cut-off values for blood markers meaning that the lack of a cut-off value in the other studies limits the ability to accurately identify SSIs entirely on blood marker levels.

Healthcare professionals may be unclear whether elevated levels of markers such as CRP, ESR, or WBC count are indicative of infection or other inflammatory processes.[83] In a review article from 2015[1], the authors mentioned that CRP is the most sensitive marker for the diagnosis of SSI and is elevated in more than 98% of cases, which validates their sensitivity, but not their specificity.

Histopathological examination is included in 6 studies, suggesting its significance in identifying the presence of tissue infection.

Imagiologic Criteria

Imaging criteria remain extensively utilized in diagnosing spine SSIs, but they often lack specificity regarding the expected findings suggestive of SSI, which might occur because imaging can be challenging due to overlap with other pathological conditions or postoperative changes.[84,85] As a result, just one article[43] in our review described the imaging findings associated with SSIs. This indicates a significant gap in the literature relating to standardized imaging criteria. The X-ray was the most used imaging modality[36,48,53,62,63,72,73], probably due to its cost-effectiveness and availability.

Intraoperative criteria

Only a small proportion of studies[36,48,53] adopted intraoperative criteria as part of their diagnostic approach. These criteria complement other methods of diagnosis by providing direct assessment of the surgical site and confirming the presence of infection.[85] However, their invasive

nature may limit the routine use of intraoperative criteria for identifying SSIs and they may be restricted to cases where other diagnostic modalities lead to inconclusive results or there is a high clinical suspicion of infection.

Definition for acute and/or late SSI

The definitions of acute and late SSIs vary significantly among the studies reviewed, which may result in discrepancies in the reported incidence and management of SSIs. Early or acute SSIs were defined as those that occur within 30 days[50,53,64,71,73] to 20 weeks after surgery[16]. Late SSIs were defined as infections that occurred more than 6 weeks [21] or later than 20 [16] weeks after surgery.

Areas for Improvement in Subsequent Studies

Subsequent studies on spine SSIs should focus on establishing definitions and criteria for the diagnosis. The most obvious issue raised in this review is the inconsistency in how SSIs are defined and diagnosed. This variability makes it challenging to compare results between studies and reduces the reliability of reported incidence rates.[9] Future research should attempt towards establishing standardized criteria, possibly based on the most employed guidelines, such as those from the CDC.

Recommendations for Clinicals Based on Results

The recommendations are to adopt a uniform set of definitions and criteria to diagnose SSIs. Nevertheless, the researchers must remain updated and change their methods to reflect current clinical practices by using the latest guidelines.

Apply specific diagnostic criteria rather than vague ones. For instance, specifying the precise criteria for laboratory tests, such as CRP levels and WBC counts, alongside describing the imaging findings that suggest SSIs, could improve diagnostic accuracy.

Use a combination of clinical, laboratory, imaging, and intraoperative criteria to provide an integrated diagnostic strategy. This multimodal strategy might help distinguish infection from other postoperative complications.

Regardless of the variability, certain findings were more homogeneous across studies. Microbiological examinations were consistently used and surgical site discharge was the most reported clinical criteria, likely due to its ease of identification. These results are in line with those from a previous systematic review from 2011[86] that also defined SSI as an erythematous or purulent wound that was culture-positive in all the studies.

It was also noticeable that the most common diagnostic criteria identified in the results are aligned with the criteria outlined in the CDC guidelines from 2024, which emphasize that these similarities indicate that some diagnostic practices are widely accepted and could serve as the foundation for standardized protocols.

Limitations

One limitation is the challenge in retrieving an extensive amount of potentially relevant studies and guidelines, which may have included useful data. Additionally, the review contained only studies published in English, potentially excluding relevant research in other languages. Another major limitation is that numerous studies employ criteria that weren´t specified. That lack of detail limits the ability to correctly identify SSIs.

A significant proportion of the reviewed articles did not provide explicit definitions or diagnostic criteria for spine SSIs. This lack of standardization makes it challenging to compare findings across studies and hinders the establishment of consensus guidelines for SSI diagnosis.

Conclusion

In conclusion, this scoping review gives an extensive review of the existing literature on spine SSI definitions and diagnostic criteria. Regardless of advances in healthcare standards and guidelines, there remains substantial variation in how SSIs are defined and diagnosed among studies. While most studies adhere to established guidelines, such as those provided by the CDC, modifications and adaptations to these guidelines are prevalent, demonstrating the importance of adaptability to local practices and clinical conditions over the years.

Overall, this review highlights the necessity for future research to focus on developing and establishing definitions and diagnostic criteria for spine SSIs, eventually improving the accuracy and reliability of SSI diagnosis and management in clinical settings.

Appendix

Table I – Surgical Site Infection Criteria. Adapted from Centers for Disease Control's definition (National HealthCare Safety Network). Published 2024.[10]

Table I: Diagnostic Criteria	**Superficial incisional Surgical site Infection (SII)** Must meet the following criteria:
	The event occurs within 30 days of the National HealthCare Safety Network (NHSN) operative procedure (day 1 = procedure date) and involves only the skin and subcutaneous tissue of the area of incision. The patient must have at least one of the following: a. Purulent drainage from a superficial incision. b. Microbiologic testing performed on an aseptically obtained specimen from a superficial wound or subcutaneous tissue for clinical diagnosis or treatment. c. a superficial incision that is deliberately opened by a surgeon, physician* and culture or non-culture based testing of the superficial incision or subcutaneous tissue is not performed and the patient exhibits any of the following symptoms: Localized pain or tenderness, swelling, erythema, or heat. d. A physician diagnoses a superficial incisional SSI. *To apply the NHSN SSI criteria, the term physician may refer to a surgeon, infectious disease physician, emergency physician, other physician on the case, or physician's designee (nurse practitioner or physician's assistant).
	Deep incisional SSI Must meet the following criteria:
	Date of event occurs within 30 or 90 days following the NHSN operative procedure (where day 1 = the procedure date) and involve deep soft tissues of the incision, such as fascial and muscle layers. Additionally, the patient must have at least one of the following conditions: a. Purulent drainage from the deep incision b. A deep incision intentionally opened or aspirated by a surgeon, physician*, or physician designee, or a deep incision that spontaneously dehisces. And organism(s) identified from the deep soft tissues of the incision by a culture or non-culture based microbiologic testing method for clinical diagnosis or treatment or culture or non- culture based microbiologic testing method is not performed. A culture or non-culture based test from the deep soft tissues of the incision that has a negative finding does not meet this criterion. And patient has at least one of the following signs or symptoms: fever (>38°C); localized pain or tenderness

	c. An abscess or other evidence of infection involving the deep incision detected on gross anatomical exam, histopathologic exam, or imaging test.
	Organ/Space SSI Must meet the following criteria:
	The event must occur within 30 or 90 days of the NHSN operative procedure (day 1 = procedure date) and involve any part of the body deeper than the fascial/muscle layers that was opened or manipulated during the procedure. Additionally, the patient must have at least one of the following conditions: a. Purulent drainage from a drain placed into the organ or space (for example, closed suction drainage system, open drain, T-tube drain, Computed Tomography-guided drainage). b. Organism(s) identified from fluid or tissue in the organ/space by a culture or non-culture based microbiologic testing method that is performed for clinical diagnosis or treatment. c. An abscess or other evidence of infection involving the organ/space detected on: • gross anatomical exam or • histopathologic exam or • imaging test evidence definitive or equivocal for infection And meets at least one criterion for a specific organ/space infection site found in the Surveillance Definitions for Specific Types of Infections.

Table II – Clinical criteria

Table II: Clinical Criteria (n (%))	n=22 (68,7%)
Clinical criteria not specified	4 (12.5%)
Localized:	
Surgical site discharge	15 (46.9%)
Inflammation nonspecific	1 (3.1%)
Pain	13 (40.6%)
Redness	9 (28.1%)
Tenderness	9 (28.1%)
Swelling	7 (21.9%)
Heat	4 (12.5%)
Induration	1 (3.1%)
Abscess	5 (15.6%)
Systemic:	
Fever with no specific value	9 (28.1%)
Fever >38ºC	4 (12.5%)
Febrile (37,2°C)	1 (3.1%)
Chills	1 (3.1%)

Table III – Laboratory criteria

Table III: Laboratory Criteria (n (%))	n=30 (93,77%)
Microbiological exam not specified	2 (6.2%)
Culture not specified	7 (21.9%)
Drainage culture	10 (31.3%)
Discharge wound culture	9 (28.1%)
Blood culture	1 (3.1%)
Blood analysis with no specific markers	2 (6.2%)
C-reactive protein with no cut-off value	7 (21.9%)
C-reactive protein >5mg/ml	1 (3.1%)
Erythrocyte sedimentation rate with no cut-off value	4 (12.5%)
Erythrocyte sedimentation rate >25mm/hr	1 (3.1%)
White blood cell with no cut-off value	4 (12.5%)
White blood cell >11,000/µl	1 (3.1%)
Procalcitonin	1 (3.1%)
Histopathological	6 (18.7%)

Table IV – Imagiologic criteria

Table IVI: Imagiologic Criteria (n (%))	n=17 (53,1%)
Imaging with no specifc findings	5 (15.6%)
Magnetic Resonance Imaging with no specifc findings	4 (12.5%)
Radiologic with no specifc findings	7 (21.9%)
Radiographic: halo sign, endplate erosion, interbody cage subsidence, migration, or pedicle screw loosening;	1 (3.1%)
Magnetic Resonance Imaging: hypointense signal on T1-weighted images, a hyperintense signal on T2-weighted images, and ring enhancement after contrast infusion	1 (3.1%)

Table V – Intraoperative criteria

Table V: Intraoperative Criteria (n (%))	n=3 (9.4%)
Abscess or other evidence of infection involving the deep incision that was found on direct examination	3 (9.4%)

Table VI – Definition for acute and/or late SSI

Table VI: Definition for acute and/or late SSI	n=8
Acute:	
Within 30 days of surgery	5 (62,5%)
Within 6 weeks of surgery	2 (25%)
Within 20 weeks of surgery	1 (12,5%)
Late:	
More than 6 weeks after surgery	1 (12,5%)
More than 20 weeks after surgery	1 (12,5%)

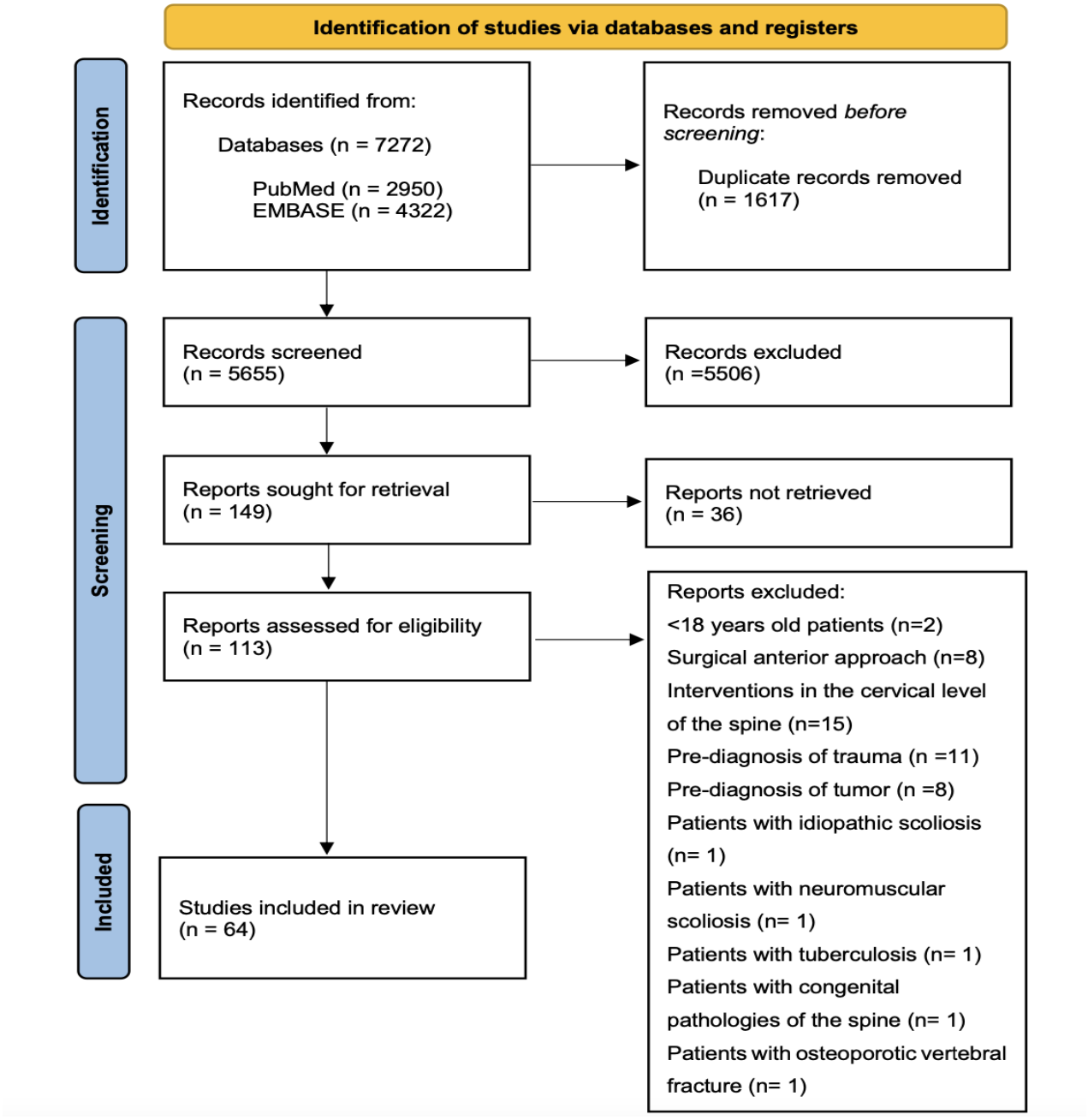

Figure 1 - Flowchart of the selection process

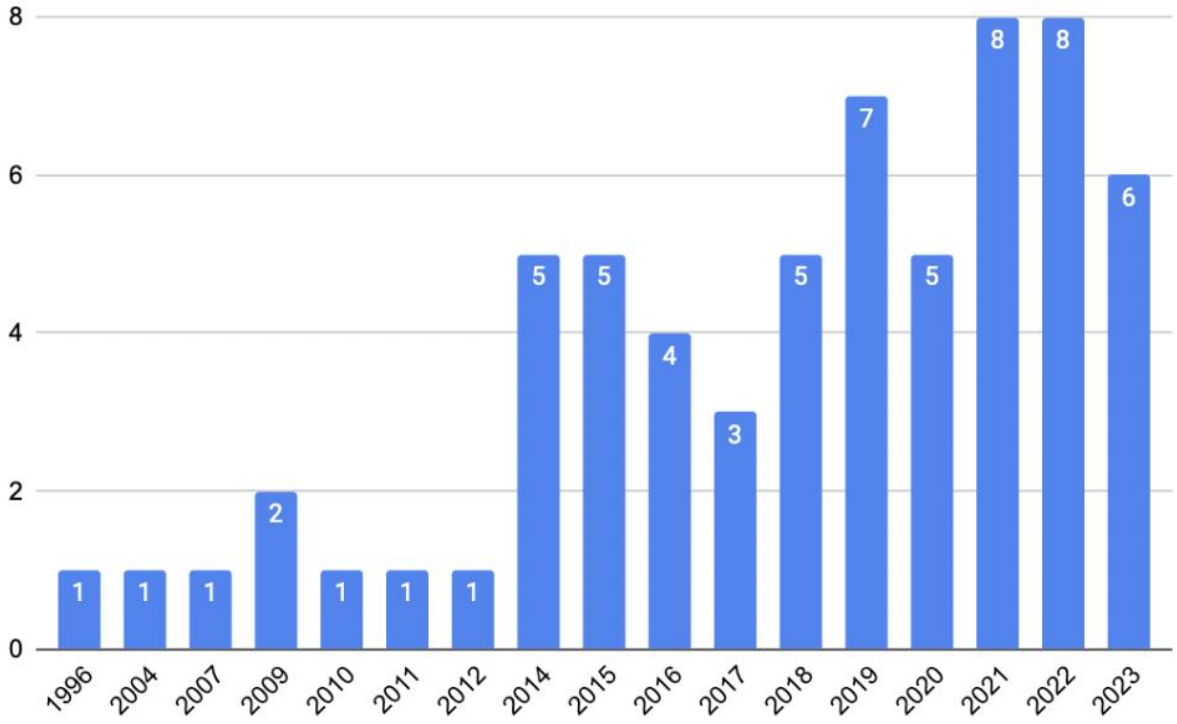

Figure 2 – Publication dates (studies)

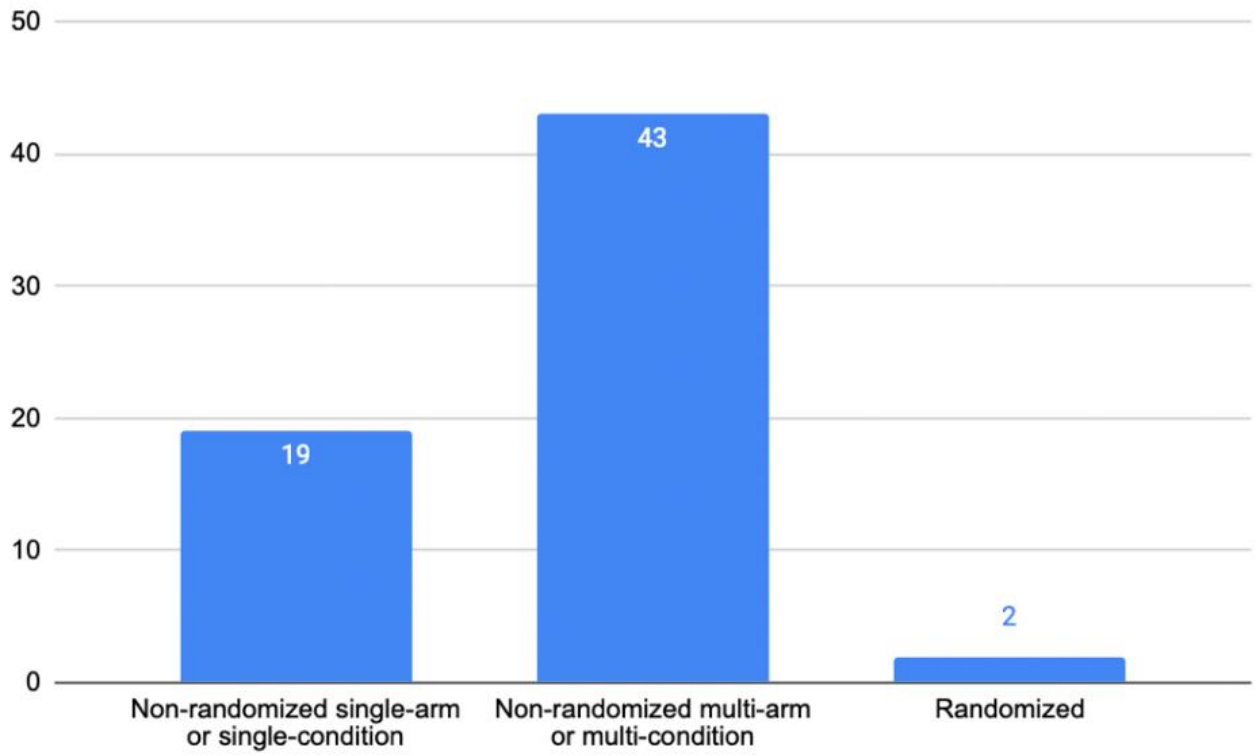

Figure 3 – Study design

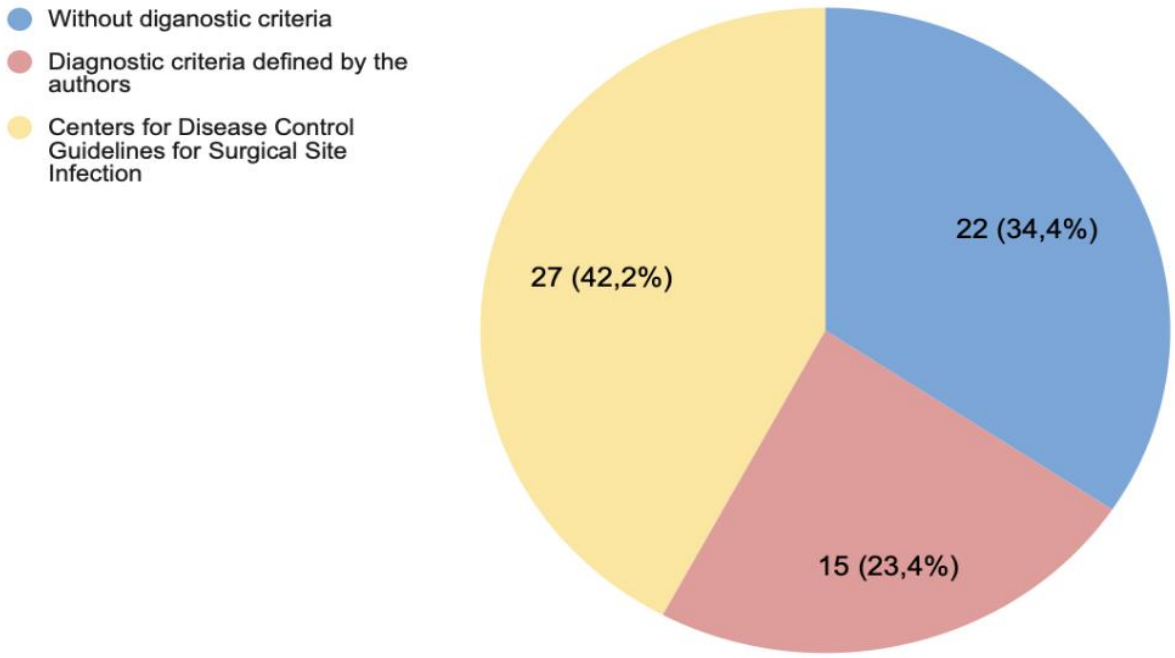

Figure 4 – Diagnostic approaches

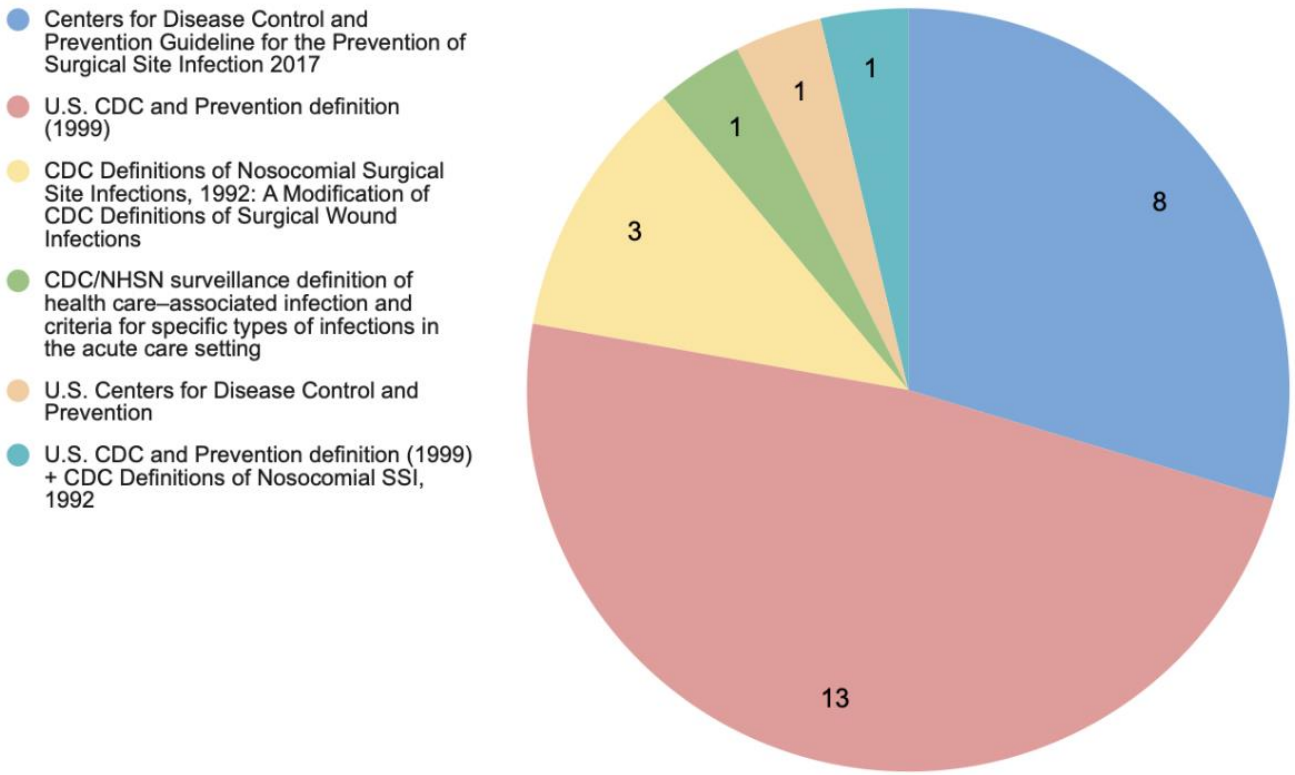

Figure 5 – CDC adaptations

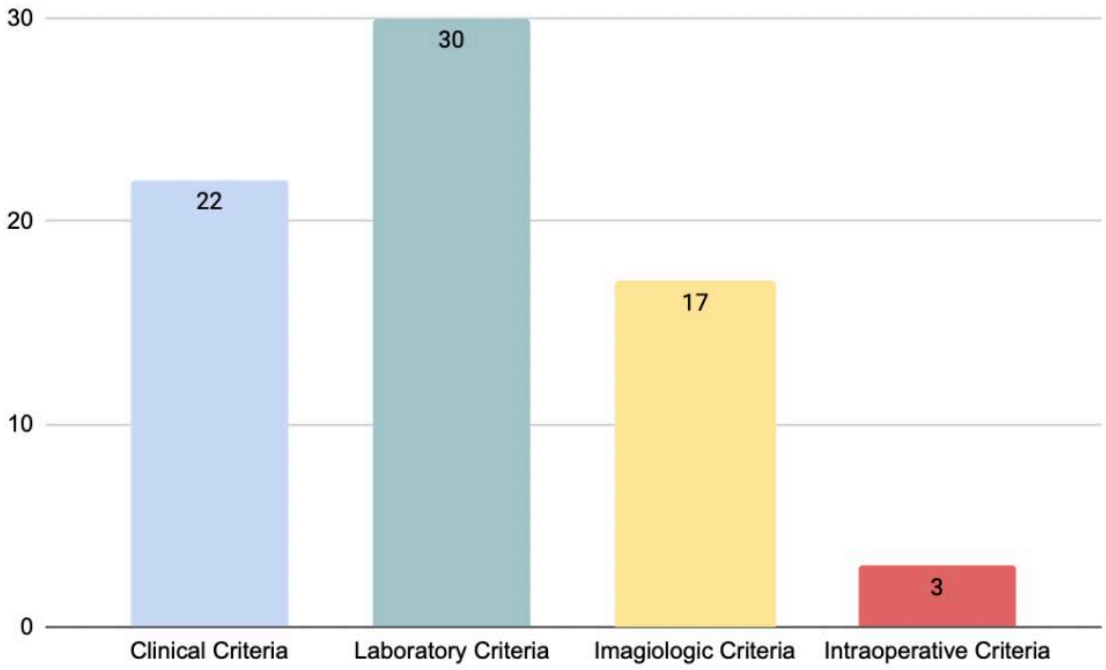

Figure 6 – Subdivision of the diagnostic criteria

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