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Review Article

Utilisation and application of implementation science in complex suicide prevention interventions: A systematic review

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ABSTRACT

Objectives: Little is known about how complex, multilevel, and multicomponent suicide prevention interventions work in real life settings. Understanding the methods used to systematically adopt, deliver, and sustain these interventions could ensure that they have the best chance of unfolding their full effect. This systematic review aimed to examine the application and extent of utilisation of implementation science in understanding and evaluating complex suicide prevention interventions.

Methods: The review adhered to updated PRISMA guidelines and was prospectively registered with PROSPERO (CRD42021247950). PubMed, CINAHL, PsycINFO, ProQuest, SCOPUS and CENTRAL were searched. All English-language records (1990–2022) with suicide and/or self-harm as the primary aims or targets of intervention were eligible. A forward citation search and a reference search further bolstered the search strategy. Interventions were considered *complex* if they consisted of three or more components and were implemented across two or more levels of socio-ecology or levels of prevention.

Results: One hundred thirty-nine records describing 19 complex interventions were identified. In 13 interventions, use of implementation science approaches, primarily process evaluations, was explicitly stated. However, extent of utilisation of implementation science approaches was found to be inconsistent and incomprehensive.

Limitations: The inclusion criteria, along with a narrow definition of complex interventions may have limited our findings.

Conclusion: Understanding the implementation of complex interventions is crucial for unlocking key questions about theory-practice knowledge translation. Inconsistent reporting and inadequate understanding of implementation processes can lead to loss of critical, experiential knowledge related to what works to prevent suicide in real world settings.

1. Introduction

In recent decades, understanding of suicidal behaviours and the complex interplay of several interwoven and associated risk factors has grown substantially. Consequently, a host of interventions have been developed and found effective across a variety of contexts, such as schools, workplaces, and community settings (Mann et al., 2021; Turecki and Brent, 2016; Zalsman et al., 2016). However, standalone suicide prevention interventions have not necessarily led to a substantial decline in suicide rates (Althaus and Hegerl, 2003; Zalsman et al., 2016). From a socio-ecological perspective, multicomponent, multilevel, complex interventions target the social determinants of suicidal behaviour at

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multiple ecological levels (Trickett and Beehler, 2013). Recently, evidence from high income countries has indicated that such suicide prevention interventions are effective in reducing rates of suicide as compared to individual evidence-based strategies (Hegerl et al., 2008; Knox et al., 2010; Motohashi et al., 2007).

The World Health Organization's LIVE LIFE approach to suicide prevention details practical aspects of implementing four evidence-based interventions for suicide prevention (World Health Organization, 2021). However, several challenges remain. Firstly, suicide research and prevention are complex endeavours and highly resource and labour intensive. Secondly, greater attention has been on observational studies as opposed to intervention studies (Reifels et al., 2018), due to significant methodological, ethical, and resourcing challenges involved in delivering and evaluating suicide prevention interventions (Huisman et al., 2010). Without applied intervention research, understanding of *what works* remains limited. Thirdly, while a combination of strategies within complex interventions has gained prominence in addressing the multifaceted nature of suicide, little is known about their characteristics and underlying change mechanisms. Other methodological challenges related to inconsistencies in defining complex interventions (Krishnamoorthy et al., 2022), documenting underlying processes, and measuring anticipated and unanticipated effects need to be tackled (Hawe et al., 2009).

Hence, a lot can be learned by conducting a more systematic investigation of the implementation of complex, multicomponent suicide prevention interventions. Research translation does not happen by chance or by itself. Passive strategies such as dissemination of guidelines are often insufficient on their own (Grimshaw et al., 2004). A deliberate effort in the form of active strategies is often required. Therefore, a systematic examination of complex interventions can help in understanding as well as translating what works, for whom, and potentially the mechanisms of how.

1.1. Implementation science in suicide prevention

Implementation science is focused on understanding the factors affecting systematic uptake of evidence-based interventions in real life settings, to further improve the quality and effectiveness of healthcare services (Bauer et al., 2015). Gustavson et al. (2021) summarise the intersection between implementation science and suicide prevention research and propose three important ways in which it can be harnessed: a) by using implementation frameworks to understand program delivery; b) systematic and standardised use and reporting of implementation strategies to understand how the intervention was implemented; and c) by focusing on the quality of program delivery.

Implementation science offers two approaches to better understand how and why interventions operate and arrive at a common understanding of events that occur during the process of implementing interventions (McIntyre et al., 2020). These are - conducting process evaluations and using theoretical approaches. Process evaluations gather data on the processes involved in the delivery of the intervention, its reception, and the setting of the intervention (Munro and Bloor, 2010). Theoretical approaches enhance our capacity to theorise about mechanisms of change and serve a variety of functions (Nilsen, 2020). These include, describing the process of translating research into practice (process models), understanding factors influencing implementation (determinant frameworks; classic and implementation theories), and evaluating implementation (evaluation frameworks). It is important to note that it is not established whether the use of theoretical approaches contributes to more effective implementation (Nilsen, 2020), and that the term *theory based* can have multiple connotations along a spectrum (Painter et al., 2008). For instance, a theory or framework may merely be cited in relation to a discussion point, whereas studies may be designed on a theory or framework, adopting data collection materials and analysis approaches that are explicitly derived from the theory. Michie and Prestwich (2010) propose criteria to assess the level of theory use which is helpful to avoid over-estimating use of theory in any literature.

In comparison to evaluation approaches, implementation approaches focus on the behaviours of healthcare professionals as they deliver care to healthcare consumers; for instance — what staff *do* in their roles as healthcare providers. Process evaluations by contrast focus on the healthcare intervention itself — whether it is delivered and received as planned, how it works, and whether contextual factors might influence its effects (Moore et al., 2015). Hence, although there may be some overlap between these two approaches (e.g., in relation to fidelity of an intervention as delivered), the rationales behind the approaches, and their methods, are substantially different.

Implementation science focuses on the *how*, that is — how can evidence be used to drive practice and thereby be routinised. This includes understanding implementation outcomes such as acceptability, reach, adoption, fidelity, feasibility, and sustainability (Proctor et al., 2011). It is possible that effective programs may be delivered poorly, or conversely ineffective programs may be delivered with rigor (Reifels et al., 2022). Hence, questions addressed through effectiveness research and implementation research are interrelated. Effectiveness research could be further bolstered if it anticipates and includes issues related to dissemination and implementation processes (Glasgow et al., 2012). Furthermore, implementation science is concerned with identifying barriers and facilitators involved in the uptake of interventions across *multiple levels* of the context; and with developing and applying strategies to overcome barriers and leverage facilitators to increase uptake of interventions (Bauer and Kirchner, 2020).

Given the immense resources required to plan, initiate, and sustain complex suicide prevention interventions, there is a necessity to understand how these interventions are delivered in real life settings (Zbukvic et al., 2020). Yet, despite the merits involved in the application of implementation science approaches, they remain underutilised. This suggests missed opportunities to guide and better understand the processes involved in the implementation of complex interventions in suicide prevention. A recent overview of complex suicide prevention trials found a lack of literature on process findings and highlighted the need for a systematic review investigating inconsistent use and reporting of implementation related processes and outcomes (Zbukvic et al., 2020).

Therefore, the current systematic review aimed to examine and synthesise literature on implementation science approaches and their utilisation in complex suicide prevention interventions. We sought to answer the following research questions:

1) Do complex suicide prevention interventions use implementation science to understand the methods used for adoption, delivery, and sustainment?

Furthermore, we sought to understand the *extent* of utilisation (Painter et al., 2008) of implementation science approaches related to complex suicide prevention interventions. In this regard, we sought to answer the following question:

2) To what extent have implementation science approaches (process evaluations and theoretical approaches, not mutually exclusive) been applied and used as part of understanding and evaluating the adoption, delivery, and sustainment of complex suicide prevention interventions?

2. Methods

The systematic review was conducted following the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance (Page et al., 2021) and was pre-registered on PROSPERO (registration number: CRD42021247950). Some amendments were made to the initial protocol and registered in PROSPERO. More specifically, the scope of the review was broadened to include all

data related to implementation processes and the use of implementation science approaches.

2.1. Definitions

For this review, *interventions* were broadly understood as programs, practices, processes, policies, and guidelines (Rabin et al., 2006). A type of intervention is a *complex intervention*. The difficulty in defining complex suicide prevention interventions based on existing research has been described elsewhere (Krishnamoorthy et al., 2022). Suicide prevention interventions were considered *complex* if they were *multilevel* and *multicomponent*. To be considered *multilevel*, interventions needed to be implemented across at least two levels of a socio-ecological system (e.g., an intervention implemented at the individual level and at the organisational level within a health care setting) and/or levels of prevention (e.g., a universal intervention such as restricting access to means and a selective intervention such as gatekeeper training for general physicians). To be considered *multicomponent*, interventions needed to be comprised of three or more distinct intervention components (e.g., screening for depression, educational workshops, media campaigns). Other factors contributing to complexity such as the diverse recipients or targets of the intervention activities (target populations), by whom the intervention was delivered and the context of delivery (Skivington et al., 2021) were also observed and documented. For this review, implementation was defined as the use of systematic methods to adopt, deliver, and sustain evidence-based interventions within real-life settings (Rabin and Brownson, 2017). This was understood as comprising two parts: a) implementation research – which aims to build evidence around approaches that work best to translate research; and b) implementation practice – which involves the application of evidence informed approaches in real world settings to achieve outcomes.

An *intervention study* was defined as an investigation (Page et al., 2021) of type 2 evidence (relative effectiveness of the intervention) and type 3 evidence (design and delivery, contextual circumstances of delivery and how the intervention was received) (Rychetnik et al., 2004). This understanding of a *study* is more nuanced in case of a complex intervention, comprising multiple settings, approaches, and audiences (Rabin and Brownson, 2017). Hence, a complex intervention could potentially involve a *study* – of effectiveness and implementation evaluation of the entirety of an intervention, sum of all parts; and *sub-studies* – of the different features of an intervention. A *sub-study* asks a separate research question from the main intervention study, is subsumed within the main study, and contributes to its objectives. It uses a part or all the data from the study participants (Centre for Clinical Trials, 2000). An offshoot of the main study could also be an *ancillary study* arising out of varying interests and pursuits of the investigators in the main intervention study (Centre for Clinical Trials, 2000). Hence, sub-studies and ancillary studies could be of varying kinds addressing different research questions within the main study. A variety of sub-studies using different study designs were identified following this definition.

According to PRISMA guidelines (Page et al., 2021), a *record* is defined as a title or abstract (or both) of a report indexed in a database or website, whereas a *report* supplies additional information about a record type. For this review, a *cluster* of *reports* pertaining to a complex suicide prevention intervention were considered as the unit of analysis. Reports having shared characteristics such as — authors, intervention name, population demographics, intervention conditions and experiences were identified and grouped together; and treated as a *cluster*. Hence, noticeably, each cluster included different kinds of reports. It is important to note that some reports represented studies (entirety of the intervention) or sub-studies (specific parts of the intervention); whereas others were narrative reviews, commentaries, government reports, and short reports.

To summarise, the term *intervention* (or *complex interventions)* was used when describing its overall characteristics (context, target population, components, levels etc.) from a program perspective; the term *intervention cluster* or *cluster* was used when referring to the aggregate of information extracted from multiple reports of the same intervention. The term *study* was used to refer to an effectiveness and/or implementation investigation of the whole intervention (sum of all parts); whereas the term *sub-study* was used to refer to all subordinate and ancillary studies conducted within the main study. The term *report* was used to refer to a document included in the review, providing relevant information about an intervention. A report supplied information about a study, sub-study, or general information about the intervention and its activities.

2.2. Eligibility criteria

All English-language reports related to complex suicide prevention interventions were included in the study. Records and reports describing suicide prevention interventions that did not satisfy the definition of multilevel and multicomponent were excluded. Different types of study designs (intervention, observational, qualitative, and mixed methods) and reports such as research articles, protocols, narrative reviews, grey literature such as government/public reports, and editorials identified through multiple search strategies (outlined in the next section) were included with the objective of gathering all information related to an intervention, its context and implementation related activities. Systematic literature reviews were excluded. Given the infancy of implementation science in the field of suicide prevention (Zbukvic et al., 2020), studies and sub-studies included did not have to be an implementation research study/trial (Bauer et al., 2015) or hybrid design study (Curran et al., 2012).

Booth et al. (2013) describe and illustrate a systematic technique for cluster searching especially relevant for complex interventions. It has been defined as — "a systematic attempt, using a variety of search techniques, to identify papers or other research outputs that relate to a single study" (Booth et al., 2013, p. 3). Multiple search strategies were used in this review, to aid comprehensiveness of information about the range of activities involved in the implementation of a complex suicide prevention intervention.

2.3. Search strategy and screening

Three different search strategies were used. Firstly, searches were conducted across six electronic databases from January 1, 1990, to April 30, 2021. Databases included CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), ProQuest, PsycINFO, PubMed, and SCOPUS. Search terms were suicid*; self harm*; AND complex intervention*, complex trial*, multilevel intervention*, multilevel trial*, multimodal intervention*, multimodal trial*, systems approach*. This search was further updated to include records from May 1, 2021 to December 8, 2022. Secondly, to further explore how reports identified have contributed to and shaped subsequent research and scholarship, a forward citation search was conducted. The search was applied to Google Scholar and was not restricted to any specific period. This helped identify all the records that cite back to a specific record included in the study through database search.

Thirdly, a thorough reference search of all included records was conducted. Since the key search terms were focused on identifying complex interventions, a purposive and thorough reference search of included records was conducted. This focused on identifying additional eligible records as well as reports on intervention activities in the public domain (grey literature).

Duplicates were removed from the search results electronically using Microsoft Excel and then checked manually. Independent screening was conducted by two reviewers (involved authors S.K., S.M. and K.K.) for all records and reports identified through database and reference search and 25 % of the records and reports identified through forward citation search. Records and reports were classified into *Yes*, *No* or *Maybe* categories, along with comments to substantiate the ratings. The primary

reason for discrepancy between independent reviewers was inconsistencies in the usage of terms and lack of included definitions around complex interventions and therefore in determining whether an intervention qualified as a complex intervention according to the eligibility criteria. Discrepancies were resolved in consensus meetings with the review team whereby specific examples of reports were discussed.

2.4. Data extraction

Data extraction occurred in two phases. In the first phase, the review team refined and developed a data extraction form. Details from reports belonging to one intervention cluster were enlisted together on an excel sheet to assist in collation. Broad categories were used to extract all data related to the intervention and its implementation from each report. The following information was extracted:

- report type
- objective of the report
- intervention description
- target population
- country setting
- study design
- components of the intervention
- levels of the intervention
- reference to implementation science approaches
- implementation strategies
- data collection on implementation processes including nature of data collected and methods
- implementation outcomes/measures (process related measures)
- outcome measures
- key findings.

It is important to note that data for *study design*, *implementation science approaches* and *implementation strategies* often had to be inferred in the absence of direct references within the reports. Established taxonomies of implementation science approaches (Nilsen, 2020) and implementation strategies (Kirchner et al., 2012; Powell et al., 2015) were used for this purpose. In the event a report described an approach or strategy not listed in the taxonomies, these were extracted exactly as reported. Considering the paucity of published data on the use of implementation science approaches in complex suicide prevention interventions, information related to the intervention and processes such as context, collaboration, relationship building, barriers and facilitators, negotiation of conflicts and learnings were extracted from the reports. Specific reports of an intervention that explicitly referred to or cited an implementation science approach were then taken forward to phase 2 of the data extraction. These reports represented studies, sub-studies, or general information related to intervention activities. Eligible reports were appraised for the *extent* to which implementation science approaches were used to guide, explain, and evaluate the adoption, delivery, and sustainment of complex interventions. Appraisal criteria were adapted to quantify the *extent* of use of implementation science approaches (Painter et al., 2008), based on methods used in a previous systematic review of process evaluations of behaviour change interventions (McIntyre et al., 2020). Responses were recorded (Yes/No) along with evidence to support the response items (Table 1).

Table 1
Appraisal criteria for assessing the extent to which implementation science approaches were utilised.

Appraisal criteria		Response items	Evidence
Are implementation science (IS) approaches explicitly mentioned?		Yes/no	Evidence: Reference to process evaluations/ theories/models/ frameworks
(If yes) Is there a rationale for the IS approach?		Yes/no	Evidence
Reference to implementation science approaches	Which approach(es) have been mentioned?	Name of the approach (es)	
	Is the description of the approach provided?	Evidence	
	Are these approaches discussed to support the purpose, aims or objectives?	Yes/no	Evidence
To what extent is the study/sub-study informed by these approaches?	Are these approaches used to describe/explain the results? Are the study findings linked to the approach?	Yes/no	Evidence
	Are these approaches used to justify the design?	Yes/no	Evidence
	Are these approaches applied in the selection of study materials – data sources and measures?	Yes/no	Evidence
	Are theoretical constructs from these approaches measured?	Yes/no	Evidence
	Is the approach used to analyse data?	Yes/no	Evidence
	Any other evidence of the use of the approach?	Yes/no	Evidence
To what extent has the study/sub-study applied these approaches?	Are approach-informed mechanisms of impact tested?	Yes/no	Evidence
	Is support/ refutation of the approach based on appropriate analyses?	Yes/no	Evidence

Note: Adapted from McIntyre et al. (2020).

2.5. Data synthesis

Intervention clusters were used to derive information on intervention characteristics as well as references to implementation science approaches and implementation strategies. These were summarised in descriptive tables.

References to implementation science approaches per intervention cluster were mapped using the different categories of theoretical approaches established within the Nilsen (2020) taxonomy. The extent of usage (Painter et al., 2008) of implementation science approaches based on the appraisal questionnaire was mapped and documented for each intervention cluster.

3. Results

3.1. Search and screening results

Through the database search, a total of 3701 records were retrieved, of which 162 were duplicates. Following title/abstract screening of the remaining records, 110 reports were identified for full text screening. Of these, 24 reports met the eligibility criteria for inclusion. The forward citation search yielded a total of 5834 records including 1991

duplicates. Out of these, 35 reports were assessed for full text screening and 31 reports met the eligibility criteria for inclusion (Fig. 1). A thorough search of record reference lists was conducted to identify eligible reports with additional information about delivery of specific components, process of developing standardised measures, evaluation of a range of primary and/or secondary outcomes in the form of sub- studies within the larger complex intervention cluster. The reference search yielded another 84 reports which met the eligibility criteria. These reports contained specific information about intervention and evaluation activities. Identification of a number of reports through the reference search is likely a function of the differences in the language used across the field and the fluidity in defining complex interventions. This resulted in 139 reports finally included in the study.

From the 139 reports eligible for this review, 19 complex suicide prevention intervention clusters were identified. A trend of publishing multiple reports about different features of the same complex intervention was observed. The median number of reports identified across interventions was 2. However, the spread varied from 32 records for the People Awakening intervention in Alaska, USA to one report each for other intervention clusters such as the School Based Multimodal Program in the Netherlands (Gijzen et al., 2018), and the Police Suicide Prevention Program in Canada (Mishara and Martin, 2012). The number of reports published per intervention, at times, seemed to be a function of the intervention status — whether it was ongoing or completed. Multiple reports within an intervention cluster helped in developing a global understanding of the implementation of a variety of intervention activities. A brief description of these intervention clusters and the characteristics contributing to complexity, have been summarised (Supplementary Table 1).

Most complex interventions were implemented in high and upper middle-income countries such as Australia (n = 4), Japan (n = 4), USA (n = 4), New Zealand (n = 2), Netherlands (n = 2) and Canada (n = 1). Within Europe, the European Alliance Against Depression (EAAD)/ Optimising Suicide Prevention Programs and their Implementation in Europe (OSPI) included a network of 17 initial member countries. India was the only low- and middle-income country identified.

Fig. 2 highlights the diverse groups of target populations. Most complex interventions (n = 13) adopted a whole-of-population approach, targeting diverse age groups in a region, country, or hospital/healthcare setting with a focus on universal and selective levels of prevention. Two interventions specifically focused on suicide prevention in indigenous populations in Alaska in the USA (*People Awakening*) (Allen et al., 2014a) and New Zealand (*Te Ira Tangata*) (Hatcher et al., 2011). Regarding age groups, interventions in Japan were focused on older adults (Motohashi et al., 2007; Oyama et al., 2005, 2006), while other interventions had specific components focused on youth such as LifeSpan in Australia (Shand et al., 2020). Interventions in the USA and Canada have also targeted specific workplaces, such as the Airforce and the police (Knox et al., 2010; Mishara and Martin, 2012). A few interventions (n = 5) adopted a general population approach with specific components focused on the needs of priority populations such as young people, men, indigenous people, LGBTI people and other people at risk and/or with lived experience of suicide.

3.2. *Do complex suicide prevention interventions use implementation science to understand the methods used for adoption, delivery, and sustainment?*

This question broadly aimed to understand whether implementation science approaches have been used to guide research and practice of complex interventions. Out of the 19 complex intervention clusters identified, 13 intervention clusters (EAAD/OSPI in 7 reports; People Awakening in 6 reports; LifeSpan and NSPT in 4 reports; Zero Suicide framework in 3 reports; SUPRANET, Te Ira Tangata and Colorado National Collaborative-CNC in 2 reports; MATES, MISP-NZ, NOCOMIT-J, National Model Suicide Prevention Project and Suicide Prevention and Implementation Research Initiative-SPIRIT in 1 report) made an explicit reference to an implementation science approach. The primary focus of

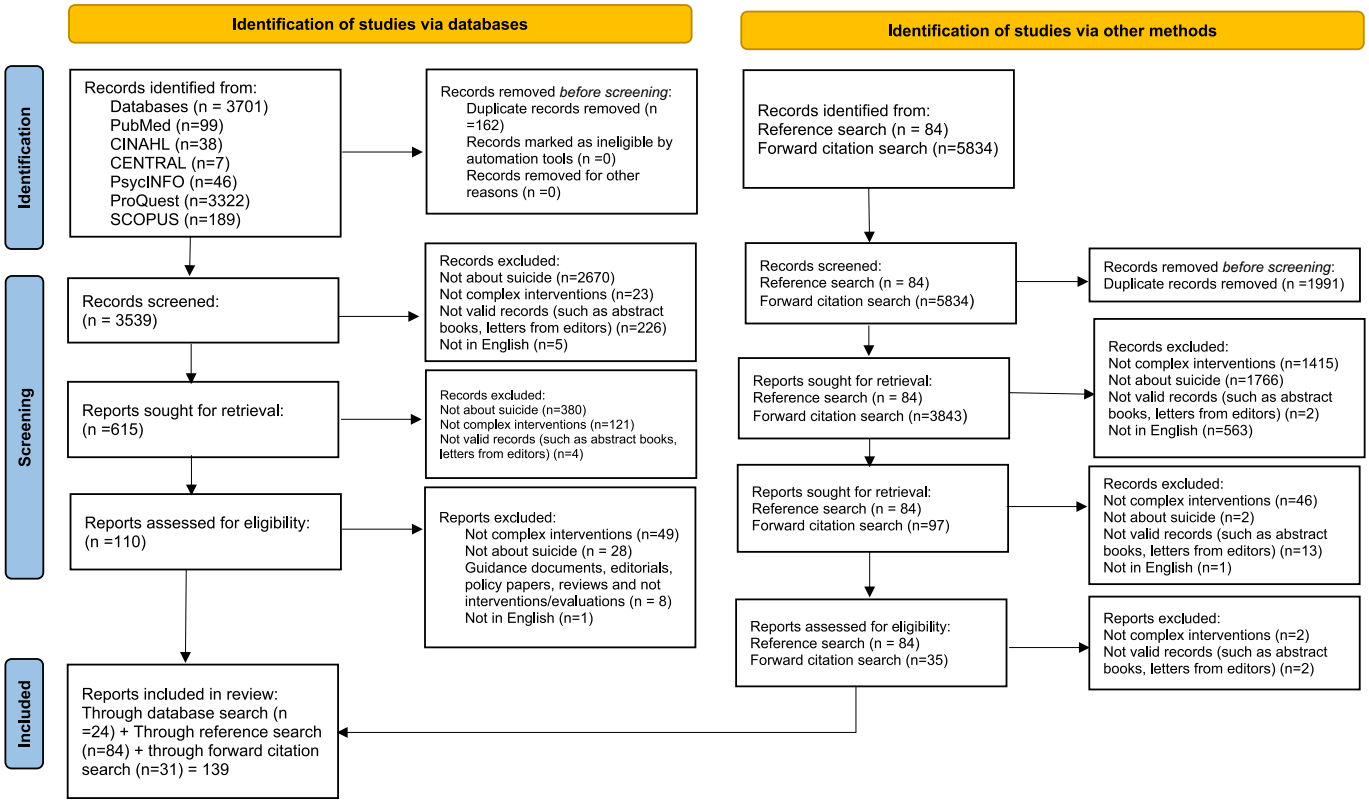

Fig. 1. PRISMA flow diagram showing number of studies included at each stage of the search.

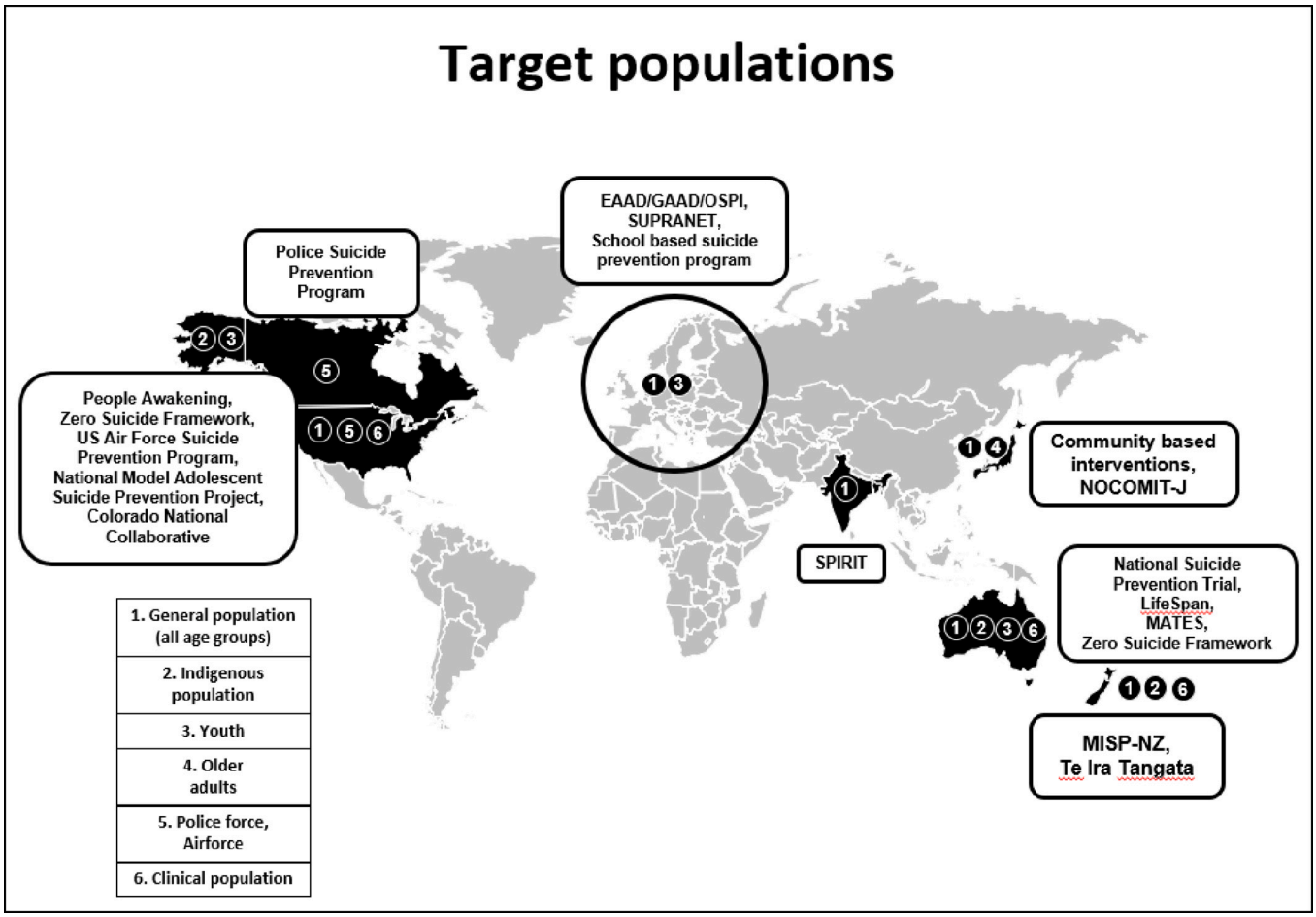

Fig. 2. Distribution of interventions and respective target populations around the world.
Note. Abbreviations and their expansions:
EAAD: European Alliance Against Depression
GAAD: German Alliance Against Depression
OSPI: Optimising Suicide Prevention Programs and their Implementation in Europe
SUPRANET: Suicide Prevention Action NETwork
NOCOMIT-J: No expansion
MISP-NZ: No expansion
MATES: No expansion.

the remaining intervention clusters (n = 6; Community based intervention in Akita prefecture, Yuri town, Minami district, Airforce Suicide Prevention Program, Police Suicide Prevention Program, School based multimodal program) was on evaluating effectiveness with minimal information related to implementation processes. Apart from references to implementation science, these reports also offered a glimpse into other process related qualitative information such as contextual details, barriers and facilitators, important learnings as well as researchers' reflections on the implementation process. This however, needed to be extracted from the reports and was not consistently reported across all interventions.

3.2.1. *Implementation strategies*

Several implementation strategies were inferred from multiple reports within intervention clusters, as these were not explicitly stated (Table 2). This was found to be challenging as there were many possibilities to choose from a variety of implementation strategies mentioned in established taxonomies (Powell et al., 2015; Kirchner et al., 2012). Different categories of implementation strategies were used (Kirchner et al., 2012). Typically, implementation strategies related to *developing stakeholder interrelationships*, which involved building coalition(s), network weaving, using advisory boards and workgroups and conducting local consensus discussions. Other popular categories of strategies included *evaluative and iterative strategies* (e.g., developing an implementation blueprint, local needs assessment); *training and educating stakeholders* (conducting ongoing training, train-the-trainer approaches); *adapting to context* (promoting adaptability, tailoring strategies); and *engaging consumers* (using mass media, building awareness).

3.2.2. *Implementation outcomes/measures*

Implementation outcomes were mentioned (Table 3) and defined as "…the effects of deliberate and purposive actions to implement new treatments, practices, and services" (Proctor et al., 2011, p. 65), as distinct from outcome measures of intervention effectiveness (e.g., a reduction in suicide rates). Implementation measures serve as important indicators of implementation processes. Specific reports of interventions which cited an implementation science approach had varied objectives. Some reports pertained to studies of implementation processes (process evaluations), feasibility, delivery, adoption, and acceptability of the whole intervention program. However, reports also represented substudies within the larger intervention cluster. For instance, these substudies focused on evaluating effectiveness of a training component of the complex intervention, exploring the feasibility and/or acceptability

Table 2
Reference to aspects of implementation science in complex suicide prevention intervention clusters.

Intervention/cluster name	Approaches mentioned	Strategies (categories)	Implementation measures	Reference to complex intervention
European Alliance Against Depression (EAAD)/German Alliance Against Depression (GAAD)/Optimising Suicide Prevention and their Implementation in Europe (OSPI)	Process evaluation with a realist evaluation approach (Pawson and Tilley, 1997), MRC process evaluation guidelines (Moore et al., 2015), Putnam's social capital theory (Putnam, 2000)	**Use evaluative and iterative strategies:** create an implementation blueprint, purposely re-examine implementation. **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** promote network weaving, build a coalition, use advisory boards and workgroups **Train and educate stakeholders:** conduct ongoing training; develop and disseminate educational materials, train the trainer strategies **Engage consumers:** use mass media, identify and train local champions	Fidelity, acceptability, barriers and facilitators, cost effectiveness	"…regional community-based four-level intervention programmes" (Hegerl et al., 2008, p. 54) "An integrated approach…" (Hegerl et al., 2013, p. 2405) "…a complex, community based, multilevel intervention" (Hegerl et al., 2019, p. 21)
LifeSpan	Process evaluation; The Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2020), The Exploration, Preparation, Implementation and Sustainment Framework (EPIS) (Aarons et al., 2011)	**Evaluative and iterative strategies:** assess for readiness and identify barriers and facilitators, local needs assessment, develop an implementation blueprint, purposely re-examine implementation, develop quality monitoring systems, audit and provide feedback. **Provide interactive assistance:** centralise technical assistance, use data experts **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** build a coalition, build academic partnerships, obtain formal commitments, use advisory boards and workgroups, local consensus discussions **Train and educate stakeholders:** ongoing training, develop and disseminate educational materials, train the trainer, recruit designate and train for leadership, provide ongoing consultation **Engage consumers:** use mass media, prepare consumers to be active participants	Fidelity (exposure/dose, quality), penetration (reach), sustainability, acceptability, feasibility, barriers and facilitators, cost effectiveness	"...large-scale, community-wide trial for suicide prevention… implementing nine strategies ranging from universal interventions to indicated interventions" (Shand et al., 2020, p. 2).
SUPRANET	Process evaluation, The Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2020), Normalisation Process theory (May and Finch, 2009)	**Use evaluative and iterative strategies:** conduct local needs assessment **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** use advisory boards and workgroups	Penetration (reach), feasibility, acceptability, barriers and facilitators	Reference to SUPRANET as — "a network of local multidisciplinary teams and organizations with shared ownership and responsibility for preventing suicide within a geographical area" (Gilissen et al., 2017, p. 2)
NOCOMIT-J	Process "monitoring"	**Provide interactive assistance:** centralise technical assistance **Develop stakeholder interrelationships**: build a coalition, use advisory boards and workgroups	Fidelity or "adherence"	"…multimodal community-based suicide prevention program" (Ono et al., 2008, p. 2)
Community based program in Akita prefecture	Not mentioned	**Train and educate stakeholders:** develop and disseminate educational materials, conduct educational meetings in the community, conduct ongoing training **Engage consumers:** prepare consumers to be active participants	Not mentioned	"Community based intervention for suicide prevention emphasising empowerment of residents and civic participation…" (Motohashi et al., 2007, p. 594).
Community based program in Yuri town	Not mentioned Not mentioned	**Provide interactive assistance**: centralise technical assistance **Develop stakeholder interrelationships:** build a coalition	Fidelity (dose), penetration (reach)	"Community based suicide prevention…" (Oyama et al., 2005, p. 337)

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Table 2 (*continued*)

Intervention/cluster name	Approaches mentioned	Strategies (categories)	Implementation measures	Reference to complex intervention
Community based program in Minami district (SUPPRESS)		**Provide interactive assistance:** centralise technical assistance **Develop stakeholder interrelationships:** build a coalition	Fidelity (dose), penetration (reach)	"Local community intervention…" (Oyama et al., 2006, p. 110)
People Awakening	Process evaluation, Community Based Participatory Approach (Green and Mercer, 2001; Schwab and Syme, 1997), Cultural Theory of Change (Weiss, 1997)	**Use evaluative and iterative strategies:** purposely re-examine implementation **Provide interactive assistance:** centralise technical assistance, facilitation **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** build a coalition, develop academic partnerships, conduct local consensus discussions, local implementation team, use advisory boards and workgroups, promote network weaving, capture and share local knowledge **Train and educate stakeholders:** provide ongoing consultations **Engage consumers:** prepare consumers to be active participants **Others:** collaborative community participation at all stages of research	Fidelity (dose, quality)	"…community initiated and community driven process" (Rasmus et al., 2014, p. 141) "…a cultural intervention in an indigenous setting." (Rasmus et al., 2014, p. 141)" …localized practices for intervention that are customized to each community setting, and ideally, 'owned' by each community that implements them as locally created and designed elements of their own project." (Rasmus et al., 2014, p. 141)" …culture is a central focus of the intervention activities and underlying theory guiding the intervention which itself is indigenous to the culture" (Rasmus et al., 2014, p. 141)
MATES	Program logic (Cooksy et al., 2001)	**Use evaluative and iterative strategies:** purposely re-examine implementation, develop quality monitoring systems **Provide interactive assistance:** centralise technical assistance Adapt and tailor to context: promote adaptability, tailor strategies **Develop stakeholder interrelationships:** build a coalition **Train and educate stakeholders:** conduct ongoing training, train the trainer	Fidelity (dose, quality) penetration (reach), adoption (uptake), acceptability, cost effectiveness	"…multimodal prevention and early intervention program" (Gullestrup et al., 2011, p. 4182)
MISP-NZ	Process evaluation	**Use evaluative and iterative strategies:** Conduct local needs assessment **Develop stakeholder interrelationships:** capture and share local knowledge **Adapt and tailor to context:** promote adaptability, tailor strategies	Fidelity (dose)	"…a multilevel intervention" (Collings et al., 2018, p. 1)
US Airforce Suicide Prevention Program	Not mentioned	**Train and educate stakeholders:** develop and disseminate educational materials, conduct educational meetings in the community, conduct ongoing training	Fidelity (quality)	"…sustained, community-based effort that directly addresses suicide as a public health problem" (Knox et al., 2010, p. 2457)
Police Suicide Prevention Program: Together for Life	Not mentioned	**Train and educate stakeholders:** develop and disseminate educational materials, conduct educational meetings in the community, conduct ongoing training **Engage consumers:** use mass media	Fidelity (quality, dose), penetration (reach), acceptability	"…multifaceted program…" (Mishara and Martin, 2012, p. 167)
National Suicide Prevention Trial	Process evaluation; Program logic (Cooksy et al., 2001), Participatory Action Research (Baum et al., 2006), Empowerment Evaluation and Utilisation-Focus Evaluation (Patton, 2008)	**Use evaluative and iterative strategies:** purposely re-examine implementation, develop quality monitoring systems **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** build a coalition, local consensus discussions **Train and educate stakeholders:** conduct ongoing training	Fidelity (quality), penetration (reach), acceptability, barriers and facilitators, sustainability	"…systems approach to suicide prevention" (Currier et al., 2020, p. 29)
National Model Suicide Prevention Project	Process evaluation	**Use evaluative and iterative strategies:** develop an implementation blueprint,	Fidelity (quality), penetration (reach), adoption (uptake)	"Suicide prevention program…" (May et al., 2005, p. 1238)

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Table 2 (*continued*)

Intervention/cluster name	Approaches mentioned	Strategies (categories)	Implementation measures	Reference to complex intervention
		monitoring and evaluation plan **Develop stakeholder interrelationships:** build a coalition, network weaving **Train and educate stakeholders:** conduct ongoing trainings, develop and disseminate educational materials, conducting local consensus discussions and meetings **Engage consumers:** prepare consumers to be active participants, disseminate findings		
Zero Suicide Framework	Process evaluation, use of a program logic model (Cooksy et al., 2001), Precede-Proceed evaluation framework (Green and Kreuter, 2005), Normalisation Process theory (May and Finch, 2009)	**Use evaluative and iterative strategies:** assess for readiness and identify barriers and facilitators, create an implementation blueprint, purposely examine implementation, develop and implement tools for quality monitoring **Provide interactive assistance:** facilitation **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** use advisory boards and workgroups, recruit designate and train for leadership **Train and educate stakeholders:** conduct ongoing training, develop educational materials, provide ongoing consultations **Engage consumers:** prepare consumers to be active participants **Support clinicians:** organise clinician implementation meetings, facilitate relay of data to clinicians	Fidelity (dose, quality), adoption (uptake), penetration (reach), feasibility, acceptability, sustainability, barriers and facilitators	"…a framework.to coordinate a multilevel approach to implementing evidence based practices for suicide prevention" (Brodsky et al., 2018, p. 1) "…adopts a systems approach" (Turner et al., 2021, p. 242)
Te Ira Tangata	Process evaluation using MRC, United Kingdom guidelines (Moore et al., 2015)	**Provide interactive assistance:** facilitation **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** capture and share local knowledge **Engage consumers:** prepare consumers to be active participants **Others:** a culturally situated process for implementing the intervention package	Fidelity (dose, quality), penetration (reach), barriers and facilitators	"…package of care" (Hatcher et al., 2011, p. 2)
Suicide Prevention and Implementation Research Initiative (SPIRIT)	Process evaluation	**Use evaluative and iterative strategies:** purposely re-examine implementation **Provide interactive assistance:** centralise technical assistance, facilitation **Adapt and tailor to context:** promote adaptability, tailor strategies **Develop stakeholder interrelationships:** build a coalition, promote network weaving, conduct local consensus discussions, using advisory boards and workgroups, capture and share local knowledge **Train and educate stakeholders:** conduct ongoing training, develop and distribute educational materials, train-the-trainer **Engage consumers:** prepare consumers to be active participants	Sustainability, feasibility adoption (uptake), acceptability	"..a comprehensive suicide preventive intervention programme with three evidence-based interventions…" (Pathare et al., 2020, p. 2)
School based multimodal program	Not mentioned	**Train and educate stakeholders:** conduct ongoing training, develop and distribute educational materials		"Multimodal stepped-prevention program…" (Gijzen et al., 2018, p. 3)

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Table 2 (*continued*)

Intervention/cluster name	Approaches mentioned	Strategies (categories)	Implementation measures	Reference to complex intervention
Colorado National Collaborative	Not mentioned; reference to a Collaborative, Participatory and Empowerment (CPE) approach to evaluation (Fetterman et al., 2010), Program logic model (Cooksy et al., 2001)	**Engage consumers:** prepare consumers to be active participants **Evaluative and iterative strategies:** develop a formal implementation blueprint, develop and implement tools for quality monitoring, **Develop stakeholder interrelationships:** building a coalition, identify and prepare champions, promote, network weaving, use advisory boards and workgroups	Fidelity (dose, quality), reach	"…a real-world test of the public health approach to suicide prevention by helping community coalitions deliver a package of evidence-informed activities in geographically defined community systems." (Reed et al., 2021, p. 1)

The text highlighted in bold represents categories of implementation strategies, under which other strategies have been enlisted.
Note. Abbreviations and their expansions:
MRC: Medical Research Council;
MATES: no expansion;
MISP-NZ: no expansion;
NOCOMIT-J: no expansion;
SUPRANET: Suicide Prevention Action NETwork;
OSPI: Optimising Suicide Prevention Programs and their Implementation in Europe.

of the complex intervention within a specific context. For a few interventions, aspirations to measure implementation outcomes were noted in the protocol publications.

Measures such as reach, feasibility, fidelity, adoption, cost, and acceptability were reported inconsistently and were deduced for most studies and sub-studies. For example, the term *process monitoring* (Ono et al., 2008) was used to indicate an assessment of fidelity of the intervention activities against a manualised intervention or protocol. This was also indicative of measuring the quality of delivery. In a record from the MATES intervention (Doran et al., 2019), *consumer feedback and satisfaction* were used as a metric for quality and acceptability of the program. In another record for the Zero Suicide Framework, the *number and nature of people affected by a program* (Turner et al., 2021) was indicative of reach and penetration. In a record for the MATES, cost effectiveness of the program was assessed (Doran et al., 2016). An aspiration to evaluate cost effectiveness was also mentioned in protocols of LifeSpan (Shand et al., 2020) and SPIRIT (Pathare et al., 2020) interventions. Overall, fidelity of an intervention — understood as adherence to protocols, quality, and dose/exposure was found/planned to be assessed in most intervention clusters (n = 15). Data on *how* these outcomes were measured was found to be scarce and inconsistently reported.

3.2.3. Implementation science approaches

Implementation science approaches were reported and used for a variety of objectives. These approaches were mapped according to Nilsen's (2020) taxonomy (Table 3), which is further indicative of *how* and for what purpose they were used. For example, determinant frameworks specify types of determinants on implementation outcomes, whereas implementation theories provide explanation of aspects of implementation. It is important to note that in some reports, the use of implementation science was closely aligned to implementation (research and practice) of the intervention and/or its components. For example, in these reports results from process evaluations (in combination with other approaches) were discussed. In some reports, the focus was on testing the effects of the intervention and/or its components while gathering preliminary information on implementation. In other reports, the implementation approach was embedded in the study design for evaluation for the intervention. Disentangling this varying usage of implementation approaches across reports was found to be challenging.

The most common approach reported was a process evaluation (noted in n = 11 clusters). As mentioned, some process evaluation studies pertained to the whole intervention whereas other sub-studies were conducted within specific contexts where a multisite intervention was implemented. Process evaluations were usually guided by other implementation science approaches. For instance, in a healthcare facility-based intervention in New Zealand (Te Ira Tangata), the process evaluation referred to the UK Medical Research Council's (MRC) guidelines (Moore et al., 2015). The objective of using a process evaluation was to understand the delivery of the intervention as well as contextual factors influencing its adoption, delivery and thereby its effects. For the intervention – OSPI (an extension of the EAAD), the process evaluation was guided by the MRC guidelines and a Realist Evaluation Approach (Pawson and Tilley, 1997) to identify the drivers involved in successful implementation. For the same intervention, Putnam's (2000) classic theory of bonding and bridging social capital was used to explain the mechanisms that facilitate engagement in interventions. For SUPRANET in the Netherlands, the process evaluation was guided by the Normalisation Process Theory (NPT) (May and Finch, 2009) and proposed to be used to understand factors influencing the adoption and delivery of the intervention, fidelity in a real-life setting, and context related barriers and facilitators. The NPT was also used in an implementation evaluation of the Zero Suicide Framework. In another study of Zero Suicide, the Precede-Proceed evaluation framework (Green and Kreuter, 2005) was proposed to be used to assess stakeholder related factors affecting implementation success.

The Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2020) was used in sub-studies of 2 intervention clusters (LifeSpan and SUPRANET). In both sub-studies, the CFIR was used as a theoretical framework to define factors influencing implementation. A sub-study within the LifeSpan cluster used the Exploration, Preparation, Implementation and Sustainment (EPIS) framework (Aarons et al., 2011) to identify barriers and facilitators and further develop a tailored implementation action plan. A community based participatory research approach (CBPR) (Green and Mercer, 2001; Schwab and Syme, 1997) was also cited as a framework for intervention design, measurement development, implementation, and evaluation for People Awakening in Alaska. For the same intervention cluster, the cultural theory of change was used to provide a rationale for a cultural intervention, where *culture* is not only the focus of implementation activities but also explains how and why an intervention works (Weiss, 1997). A program logic model (Cooksy et al., 2001) was cited in specific reports of other intervention clusters (MATES and NSPT in Australia and CNC in USA). The logic model functioned as a guide for testing a set of evidence-informed assumptions in terms of inputs, outputs, impacts, and outcomes.

Table 3
Implementation science approaches (process evaluations and theoretical approaches) referred to, per intervention cluster.

Intervention/cluster name	Process evaluations	Process models	Evaluation frameworks	Determinant frameworks	Classic theories	Implementation theories	Others
OSPI	✓	–	Realist evaluation (Pawson and Tilley, 1997), MRC process evaluation guidelines (Moore et al., 2015)	–	Putnam's social capital theory (Putnam, 2000)	–	–
LifeSpan	✓	EPIS framework (Aarons et al., 2011)	–	CFIR framework (Damschroder et al., 2020), EPIS framework (Aarons et al., 2011)	–	–	–
SUPRANET	✓	–	–	CFIR framework (Damschroder et al., 2020)	–	Normalisation Process Theory (May and Finch, 2009)	–
NOCOMIT-J	✓	–	–	–	–	–	–
Community based program in Akita Prefecture	–	–	–	–	–	–	–
Community based program for the elderly in Yuri town	–	–	–	–	–	–	–
Community based program for the elderly in Minami district	–	–	–	–	–	–	–
People Awakening	✓	–	–	–	–	CBPR (Green and Mercer, 2001; Schwab and Syme, 1997), Cultural theory of change (Weiss, 1997)	–
MATES	–	–	–	–	–	–	Program logic (Cooksy et al., 2001)
US Airforce Suicide Prevention Program	–	–	–	–	–	–	–
Police suicide prevention - Together for life	–	–	–	–	–	–	–
MISP-NZ	✓	–	–	–	–	–	–
National Suicide Prevention Trial	✓	–	Empowerment Evaluation and Utilisation-Focus Evaluation (Patton, 2008)	–	–	–	Program logic (Cooksy et al., 2001), Participatory Action Research (Baum et al., 2006)
National Model Suicide Prevention Project	✓	–	–	–	–	–	–
Zero Suicide Framework	✓	–	Precede-Proceed (Green and Kreuter, 2005)	–	–	Normalisation Process Theory (May and Finch, 2009)	Program logic (Cooksy et al., 2001)
Te Ira Tangata	✓	–	MRC process evaluation guidelines (Moore et al., 2015)	–	–	–	–
Suicide Prevention and Implementation Research Initiative (SPIRIT)	✓	–	–	–	–	–	–
School based multi modal program	–	–	–	–	–	–	–
Colorado National Collaborative	–	–	–	–	–	–	Collaborative, participatory and empowerment (CPE) approach to collaboration (Fetterman et al., 2010), Program logic model (Cooksy et al., 2001)

Note. Symbols/abbreviations and their expansions:
✓ — indicates presence of an implementation science approach;
– indicates absence of an implementation science approach;
MRC: Medical Research Council;
CFIR: Consolidated Framework for Implementation Research;

EPIS: Exploration, Preparation, Implementation Sustainment Framework;
CBPR: Community Based Participatory Research;
MATES: no expansion;
MISP-NZ: no expansion;
NOCOMIT-J: no expansion;
SUPRANET: Suicide Prevention Action NETwork;
OSPI: Optimising Suicide Prevention Programs and their Implementation in Europe.

3.3. To what extent have implementation science approaches (process evaluations and theoretical approaches, not mutually exclusive) been applied and used as part of understanding and evaluating the adoption, delivery, and sustainment of complex suicide prevention interventions?

This question specifically aimed to understand the extent to which implementation science is used in research (studies and sub-studies) around complex interventions. To understand the extent of use, reports explicitly stating the use of an implementation science approach, were assessed using detailed appraisal criteria (Table 1). The extent of use was explored within and across intervention clusters. The results of this appraisal are presented in ascending order of extent of use below and in Table 4.

3.3.1. Citing and providing a rationale for the approach

At the most preliminary level, intervention clusters were assessed to understand whether they have explicitly cited an approach (n = 13 clusters, 68.4 %), provided rationale for using a specific approach (n = 11 clusters, 57.8 %), and described the approach (n = 10 clusters, 52.6 %).

Diverse reasons were provided for using an approach. For example, a process evaluation was used to better understand intervention outcomes, understand the transferability of an intervention, to document and describe processes, the context, and the experience of being a part of the trial. The Normalisation Process Theory (May and Finch, 2009) was used to understand how practices are operationalised and routinised within health care systems. The Precede-Proceed framework (Green and Kreuter, 2005) was proposed to be used to understand intervention consistency, adherence, and integration into practice. As an analytic framework, the CFIR (Damschroder et al., 2020) was used to structure and organise data, whereas the EPIS (Aarons et al., 2011) was used to identify barriers and facilitators to implementation of a specific sub-intervention and to design strategies. A program logic (Cooksy et al., 2001) was used as a planning and implementation tool and to create a shared understanding of the program.

3.3.2. Informed by an implementation science approach

Simply citing an approach does not ensure its application to inform implementation processes. Different characteristics were assessed. In 9 out of 19 clusters (47.3 %) the use of an approach was linked with data sources or measures; and in 8 clusters (42.1 %), the approach was used to justify the study design and linked to the study findings. By contrast, in 5 clusters (26.3 %) theoretical constructs from the approach were measured and in 3 clusters (15.7 %) the approach was used to analyse findings. However, it is difficult to conclude that interventions per se were informed by an implementation approach.

For instance, within intervention clusters like LifeSpan, NSPT, SUPRANET and Zero Suicide, different implementation approaches were used to inform different sub-studies. In approximately 66 % of the reports for NSPT, the data sources and study findings were linked to the approach; in 50 % of the reports, the approach was used to justify the study design; and in 16.6 % of the reports theoretical constructs were tested. This intervention was an exception since it included sub-process evaluation studies as well as the use of a program logic for the entirety of the intervention. In the rest of the intervention clusters, less than 23 % of the reports respectively linked the approach with data sources or measures; less than 20 % of reports used the approach to justify the study design; and less than 7 % of reports tested theoretical constructs or used the approach to analyse findings. Hence, no conclusive statements can be made about whether interventions were informed by an implementation approach.

There were other examples of intervention clusters where implementation science approaches were used to inform studies the whole intervention. In the People Awakening cluster, the CBPR and cultural theory of change were linked to data sources and study findings in 6.2 % of reports; used to justify the design in 12.5 % of reports; and in 3 % of reports were theoretical constructs from the approach tested and the theory used to analyse findings. This gives a glimpse into the extent to which the complex intervention per se was informed by the approach according to the appraisal criteria.

3.3.3. Applied an implementation science approach

In only 1 out of 19 clusters (People Awakening; 5.2 %) were the mechanisms of impact from the approach tested. This was represented in 1 report of the intervention and involved a test of a culturally grounded theoretical model for prevention of alcohol abuse and suicide risk, using culturally appropriate measures to study the process of change and outcomes (Allen et al., 2014b).

To sum up, when appraised on a continuum of ascending extent of use (superficial to comprehensive use of an approach), most clusters focused on a relatively superficial use of an approach (n = 13 clusters, 68.4 % cited an approach; n = 11 clusters, 57.8 % provided a rationale for an approach; and n = 10 clusters, 52.6 % described an approach). This was in contrast with 9 clusters (47.3 %) where the use of an approach was linked with data sources or measures and 8 clusters (42.1 %), where the approach was used to justify the study design and linked to the study findings. In 5 clusters (26.3 %) theoretical constructs from the approach were measured; in 3 clusters (15.7 %) the approach was used to analyse findings; and in 1 cluster (5.2 %), the approach informed mechanisms of impact were tested. The extent of use seemed to gradually reduce in these ascending criteria of engagement.

4. Discussion

This systematic review aimed to examine literature on the extent implementation science approaches (process evaluation and theoretical approaches; Nilsen, 2020) were utilised. To our knowledge, this is the first systematic review examining utilisation of implementation science in understanding the adoption, delivery, and sustainment of complex interventions in suicide research. We identified 19 interventions that met the definition of complex suicide prevention interventions as per the review criteria (i.e., two or more levels of prevention and utilising three or more intervention components) across 139 reports published between 1990 and 2022. A combination of search strategies was used to identify relevant records contributing to richness of data on context, concept, underlying theory of interventions (Booth et al., 2013).

Collings et al. (2018) argue that published results for complex suicide prevention interventions are rare, despite many trials. Several reasons such as delays in trial completion and publication of results, and a publication bias against reporting of *negative* findings, have contributed to this gap. Moreover, complex interventions are highly time consuming and resource intensive, and hence, infrequently implemented and reported in published literature. Limitations on reporting placed by individual journals and their respective guidelines further constrain reporting of data (Booth et al., 2013). In this systematic review, several reports for different interventions were found; however, the range of

Table 4
The extent of use of implementation science approaches (process evaluations or theoretical approaches) per intervention cluster.

Intervention/ cluster name	Total no. of records	Approach mentioned	Rationale for the approach mentioned	Description of the approach provided	Study findings linked to the approach	Approach linked to data sources/ measures	Approach used in justifying design	Theoretical constructs from the approach measured	Use of approach to analyse findings	Approach tested
European Alliance Against Depression (EAAD)/German Alliance Against Depression (GAAD)/ Optimising Suicide Prevention and their Implementation in Europe (OSPI)	25	7 (28 %)	7 (28 %)	3 (12 %)	6 (24 %)	3 (12 %)	3 (12 %)	1 (4 %)	1 (4 %)	0
LifeSpan	20	4 (20 %)	3 (15 %)	3 (15 %)	2 (10 %)	2 (10 %)	2 (10 %)	1 (5 %)	0	0
SUPRANET	5	2 (40 %)	2 (40 %)	2 (40 %)	1 (20 %)	1 (20 %)	1 (20 %)	0	0	0
NOCOMIT-J	2*	1	0	2	0	0	0	0	0	0
Community based program in Akita prefecture	2	No specific reference to an implementation science approach								
Community based program for the elderly in Yuri town	1	No specific reference to an implementation science approach								
Community based program for the elderly in Minami district	1	No specific reference to an implementation science approach								
People Awakening	32	6 (18.7 %)	5 (15.6 %)	3 (9.3 %)	2 (6.2 %)	2 (6.2 %)	4 (12.5 %)	1 (3.1 %)	1 (3.1 %)	1 (3.1 %)
MATES	17	1 (5.8 %)	1 (5.8 %)	1 (5.8 %)	0	0	0	0	0	0
MISP-NZ	2*	1	0	1	0	0	0	0	0	0
US Airforce Suicide Prevention Program	2	No specific reference to an implementation science approach								
Police Suicide Prevention – Together for life	1	No specific reference to an implementation science approach								
National Suicide Prevention Trial	6	5 (83.3 %)	5 (83.3 %)	4 (66.6 %)	4 (66.6 %)	4 (66.6 %)	3 (50 %)	1 (16.6 %)	0	0
National model adolescent suicide prevention project	3*	1	1	0	0	1	0	0	0	0
Zero Suicide Framework	13	3 (23 %)	3 (23 %)	3 (23 %)	2 (15.3 %)	3 (23 %)	2 (15.3 %)	1 (7.6 %)	1 (7.6 %)	0
Te Ira Tangata	2*	2	1	0	1	1	1	0	0	0
SPIRIT	2*	1	1	0	1	0	0	0	0	0
School based multimodal program	1	No specific reference to an implementation science approach								
Colorado National Collaborative	2*	2	2	2	0	2	1	0	0	0
	Total no. of intervention clusters = 19	Total no. of clusters which cited an approach = 13 (68.4 %)	Total no. of clusters which provided a rationale for an approach = 11 (57.8 %)	Total no. of clusters which provided a description of the approach = 10 (52.6 %)	Total no. of clusters where study findings were linked to the approach = 8 (42.1 %)	Total no. of clusters where data sources/ measures were linked to the approach = 9 (47.3 %)	Total no. of clusters where an approach was used to justify design = 8 (42.1 %)	Total no. of clusters where theoretical constructs were measured = 5 (26.3 %)	Total no. of clusters where an approach was used to analyse findings = 3 (15.7 %)	Total no. of clusters where the approach was tested = 1 (5.2 %)

Note. Abbreviations and their expansions:
IS: Implementation Science;
NA: not applicable;
MATES: no expansion;

MISP-NZ: no expansion;
NOCOMIT-J: no expansion;
SPIRIT: Suicide Prevention Implementation Research Initiative;
SUPRANET: Suicide Prevention Action NETwork;
OSPI: Optimising Suicide Prevention Programs and their Implementation in Europe.
* Percentages not calculated when the total number of records per intervention is below 5. The number is too small to convey results through percentages.

reports per intervention cluster varied. This seemed to be a function of the status of the intervention (whether ongoing or completed) and the duration for which it has been ongoing. The two intervention clusters with the maximum number of reports — People Awakening (n = 32 reports) and EAAD/OSPI (n = 25 reports) were started over 20 years ago.

To develop a global picture of the complex intervention in question, relevant reports were grouped and considered together as a cluster. Even then, all reports could not give a complete picture of complexity and the real-world application of complex interventions. Complexity arises from many dimensions each with their own ideas, priorities, and endpoints (Guise et al., 2017; Skivington et al., 2021). This could be related to the nature of the problem under consideration, such as the complex aetiology of suicidal behaviour; the characteristics of the intervention such as the number of components and levels, synergies, phase changes and feedback loops; the characteristics of the context (the research environment) within which the intervention is implemented and evaluated; as well as the resources involved in delivering an intervention in a real-world setting. It is not possible to explore and address all these variables contributing to complexity of an intervention in publications. Effectiveness outcomes may be prioritised with little space or attention given to implementation factors (even in situations where the research team are highly aware of and engaged with implementation processes on a day-to-day basis).

Inconsistencies were noted in reporting of implementation related data, such as — implementation strategies and implementation outcomes. Specific implementation science terms such as — *process evaluations*, *theories*, *models*, *frameworks*, *implementation strategies*, were inconsistently mentioned across the included reports. In the absence of explicit references, information related to *how* the complex intervention was delivered in a real-life setting had to be inferred based upon established taxonomies (Kirchner et al., 2012; Nilsen, 2020; Powell et al., 2015). Process evaluations were frequently reported and used in comparison to other approaches. This might be due to the recent emphasis and guidance on the design, conduct and reporting of process evaluations by the Medical Research Council, U.K. (Moore et al., 2014, 2015). The guidelines provide a useful rubric for researchers to understand and utilise process evaluations. These guidelines may have led to increased recognition of process evaluations as an important component to understand implementation processes, as opposed to other approaches. Moreover, the decision to design, implement and disseminate findings pertaining to a complex intervention is heavily reliant on funding, which may drive the components of the evaluation and prioritise reporting of health outcomes/effectiveness outcomes. Complex interventions supported by larger funding grants are more likely to be able to implement at scale as well as publish more diverse findings. Funding bodies can play a crucial role in encouraging researchers to publish findings related to *how* a complex intervention was implemented and *what* contributed to its effectiveness (or not).

Other implementation related information included indirect references to the use of discrete, multifaceted, and blended implementation strategies (Powell et al., 2015) to achieve desired implementation related goals (fidelity, quality, reach, dose etc.). These strategies were not necessarily spelled out using existing taxonomies (Mazza et al., 2013; Powell et al., 2015; Kirchner et al., 2012). In the absence of clear citations of implementation strategies, the review team had to rely on conjecture. As a result, several strategies could be labelled for an intervention. Similarly, implementation measures or process measures were also inferred.

Within 13 intervention clusters (68.4 %) an explicit reference to an implementation science approach was found. Consequently, a few observations were made: First, implementation approaches were not cited in reports of all the interventions included in the review. Second, implementation approaches (if cited) were used varyingly – in research and/or practice. This information regarding *how* implementation science approaches were used was challenging to discern. Third, reports of an intervention cluster which cited an approach were of diverse types and were not strictly studies or sub-studies. This further contributed to complexities around understanding the purpose for which implementation approaches were cited and utilised. In case of sub-studies, multiple implementation approaches were cited within the same intervention cluster. Hence, it is difficult to conclude whether these interventions in their entirety, were guided by an implementation approach. In some cases, singular sub-studies were guided by the approach. Fourth, the extent of use of the approach to justify data sources and measures (n = 9 clusters, 47.3 %), the design (n = 8 clusters, 42.1 %), justify study findings (n = 8 clusters, 42.1 %), measure theoretical constructs (n = 5 clusters, 26.3 %), analyse study findings (n = 3 clusters, 15.7 %) and finally test the approach (n = 1 cluster, 5.2 %), seemed to dwindle. Hence, even though implementation approaches were cited for varied objectives, a comprehensive use of these approaches was not necessarily noted.

Complex interventions such as the ones identified in this review, are often large scale and extensive. The objective of sub-studies within a large study is to address a variety of research questions which can potentially contribute to the question of effectiveness. On the other hand, questions related to how the intervention in its entirety is delivered and whether it works in real life settings is also important to address. As mentioned, not everything that happens in the process of delivering an intervention can be reported in publications. In addition, qualitative information about barriers, facilitators, and learnings (often inconspicuously reported) provides an opportunity to explore what happened. While multiple publications of an intervention (as noted in this review) provide a glimpse into these activities, processes, and efforts; the intervention story is often fragmented. The question of how these different studies come together to understand the intervention and how do we, as the scientific community, piece together the whole intervention story (Trickett et al., 2014), needs to be explored further.

Another important emphasis in on the use of theoretical approaches. The benefits of using theory in research have been debated. When utilised in an intervention, theories can make them amenable to measurement, and enhance their generalisability and replicability (Nilsen, 2020). Studies exploring theory utilisation in complex public health and behaviour change interventions indicate a consistent pattern — that interventions may cite theories but are not necessarily transparent about whether they are informed by, apply and/or test theoretical approaches (Fynn et al., 2020; McIntyre et al., 2020; Michie and Prestwich, 2010; Painter et al., 2008). Multiple possibilities exist: some authors only use theory superficially to provide credentials for their choice of intervention, others use features of a theory, still others provide little detail of the theory (or omit it all together) due to limitations of publication conventions (Booth et al., 2013). A research tool to reliably describe what *theory-based* means for an intervention has been described (Michie and Prestwich, 2010). Our review had similar findings.

Inconsistent and incomprehensive use of implementation science theoretical approaches in suicide prevention interventions is not surprising. There are several proposed reasons for this inconsistent utilisation. In the context of several theoretical approaches, there are

difficulties in choosing the most appropriate approach which further hinders its use and application (ICEBeRG, 2006). Theories can often be restrictive, sometimes leading researchers to overlook challenges or concerns that do not fit within the framework and thereby blinding them from a new perspective on the problem (Greenwald et al., 1986). More importantly, there are practical and methodological challenges in translating theoretical constructs into meaningful interventions in real life settings (ICEBeRG, 2006). Perhaps another important reason contributing to their underutilisation is the absence of real-world examples of *using* implementation science approaches in the context of suicide prevention that further help understand *what* constitutes best practice. This review provides an important overview of and documents examples to comprehensively explore implementation science approaches.

4.1. Implications

Existing knowledge and experience from this review can be transferred to the field of suicide research. Firstly, reference to and the intended use of an overarching implementation science approach guiding the complex intervention (research and practice) in its entirety; along with a description and rationale of the implementation plan can clarify the theory guiding the intervention. The intention to conduct a study, sub-studies and ancillary studies could be noted in protocols. Documenting *how* an intervention was conceptualised and *what* was done as part of the intervention is essential (Datta and Petticrew, 2013). Secondly, as illustrated in the current review, complex interventions can be informed by a taxonomy (Nilsen, 2020) and/or inventory of models (Tabak et al., 2012) to design, deliver and evaluate programs. This can help better understand and standardise program delivery. Thirdly, implementation strategies are the building blocks of implementation processes. The current review revealed that although implementation strategies are used, they are inconsistently and/or inadequately reported. Use of taxonomies (Kirchner et al., 2012; Powell et al., 2015; Proctor et al., 2013) can help clearly document the implementation strategies. There is also a need to document the factors that influence its selection, and adaptations to the strategy, which can help clarify *what was done* to affect implementation outcomes. Lastly, to advance an evidence base around *successful* (or *unsuccessful*) implementation in suicide research, it is important to make a distinction between implementation and clinical outcomes (Proctor et al., 2011). Framing implementation outcomes as key variables can help clarify research questions, and their evaluation can help understand underlying mechanisms and causal relationships in implementation processes.

Unless there is a systematic use of existing approaches, there will be no experience-based knowledge regarding its advantages and pitfalls. What we need is more practice-based evidence. To effectively consolidate and harness this practical wisdom, it is important for researchers to identify and appraise evidence-practice gaps, adopt implementation science frameworks to conduct research to address these gaps and contribute to an evidence base for effective implementation strategies in suicide prevention (Reifels et al., 2022).

4.2. Limitations

Some limitations must be acknowledged. The study inclusion criteria may have limited our findings as we only included studies published in English language, between 1990 and 2022. Information regarding some interventions was incomplete since those interventions were found to be ongoing. Hence, latest publications for these interventions may have been either not accessible or were beyond the scope of the review timeline.

To ensure interventions reached a minimum threshold of complexity, the review team adopted a specific definition of complex interventions. This led to the use of specific key terms which may have limited the search, such as the number of components within interventions. This could have led to the exclusion of some interventions. Conversely, studies about interventions that may have satisfied the threshold, but did not utilise terms (due to inconsistent usage within the suicide prevention literature; Krishnamoorthy et al., 2022) may have also been missed. Additionally, in the absence of information on implementation strategies, implementation outcomes and other process related information, the review team had to infer from the available data. While this was based upon established taxonomies (Kirchner et al., 2012; Nilsen, 2020; Powell et al., 2015) it is possible that some strategies were missed. Disentangling the varying uses of implementation science approaches — for research and/or practice was challenging with limited available study information.

5. Conclusion

This review provides a comprehensive overview of current understandings in relation to complex interventions in the field of suicide prevention and the utilisation of implementation science and theory. While there was some evidence of the use of implementation science approaches, the extent to which these were applied within and across interventions varied. There is a need within the field to systematically refer to and adopt implementation science strategies, outcomes, and approaches to better understand evidence-practice gaps and ways to address these gaps. This is a crucial step toward understanding implementation of quality care. The current review represents further exploration of complex suicide prevention interventions, their synergistic potential, and their mechanisms of change to advance the science and practice of suicide prevention.

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CrediT authorship contribution statement

S.K.: conceptualization, data search, data screening, data extraction, quality appraisal, data synthesis, writing—original draft, writing—review, and editing; S.M.: data screening, data extraction, quality appraisal, data synthesis, writing—review, and editing; G.A.: supervision, writing—review, and editing; V.R.: supervision, writing—review and editing; J.F.: supervision, writing—review; L.R.: supervision, writing—review; K.K.: conceptualization, data screening, data curation, supervision, writing—review, and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no competing interests.

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