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Review

Suicide Risk Assessment and Prevention Tools in the UK: Current Landscape and Future Directions

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Abstract: Suicide is a major global public health problem, with profound implications for individuals, families, and communities. In the United Kingdom (UK), despite efforts to detect and manage suicidal ideas, suicide rates persist, especially among middle-aged men and women, particularly those aged 45 to 54 years. Recent global challenges, such as the COVID-19 pandemic, climate change, conflict, and the environmental crisis, have raised concerns about an increase in suicide rates, particularly among young people. As a result, a population-wide preventive approach based on evidence is imperative to mitigate the projected increase in suicides. To evaluate the effectiveness of suicide prevention strategies, there is a need for an objective and universally accepted risk assessment approach that does not currently exist. This review examines the current landscape of suicide prevention in the United Kingdom and evaluates the strengths and limitations of existing suicide risk assessments tools. The current suicide prevention tools used, including machine learning and mobile applications are discussed. Also, the epidemiological trends in the various regions of the UK, risk factors including age, sex, and socio-economic status are assessed to provide context. Through this discourse, we hope to provide valuable insight for clinicians, researchers, and policy makers about the current landscape of suicide, especially within the United Kingdom, while presenting recommendations regarding areas that require further research and improvement. Accordingly, suicide prevention is and will continue to be a major focus of both the national health service and research in the UK in the strive to reduce the rate of suicide across all regions. Indeed, headways have been made in the use of technology in preventing suicide both locally and globally. However, research should in the future investigate the value of personalized interventions tailored to the various risk factors of suicide and based on appropriate screening and assessment tools.

Keywords: suicide; suicidal ideation; suicide prevention; mental health; COVID-19; public health; UK

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1. Introduction

Suicide is a global public health issue that has significant social and psychological consequences for individuals, families, and communities affected by it. The availability of mental health support for people at risk of suicide is crucial in suicide prevention and is a high priority in the United Kingdom [1]. Suicide among children and young people remains particularly worrying, as it is the leading cause of death in the UK for those aged 20–34 [2]. Since the COVID-19 pandemic, suicide has become a serious public health concern, with young people being disproportionately affected [2].

According to the World Health Organisation (WHO), suicide is the act of voluntarily and deliberately ending one's life. Furthermore, suicide attempts are defined as any non-fatal act of intentional self-harm including self-inflicted poisoning or injury, regardless of whether or not the individual intends to die [3].

Suicidal ideation (SI), also known as suicidal thoughts or ideas, is a broad term that encompasses a variety of contemplations, desires, and preoccupations with death and

suicide [4]. In addition, Harmer et al. recognised two categories of SI: active and passive SI. Active suicidal ideation refers to the presence of both present and clear suicidal impulses. Active suicidal ideation is present when there is a conscious desire to inflict self-harming behaviours and any level of desire above zero for death to occur as a result. Passive SI, on the other hand, refers to a general desire to die in the absence of lethal self-harm plans. It is essential to distinguish between the various types of SI as it allows clinicians to provide personalized interventions [5]. However, there is no universally recognised, consistent definition of SI, which presents clinicians, researchers, and educators with ongoing challenges [4].

The publication of national suicide prevention strategies for England and Scotland in 2002 demonstrated an increasing understanding of the magnitude of the problem two decades ago. These initiatives were designed to bring about reductions in completed suicides in England and Scotland by 2010 and 2013, respectively [6]. During the coalition government, a new strategy document titled "Preventing Suicide in England" was produced in 2012 [7]. Like the previous 2002 prevention strategy document, the 2012 strategy document set out to reduce the suicide rate in the general population across the UK and to provide better support for those bereaved or affected by suicide.

In February 2016, four years after "Preventing Suicide in England" was published, the NHS (National Health Service) Five Year Forward View for Mental Health was published. This marked the start of a ten-year effort to reform mental health care in the UK. The report included a commitment to reduce England's suicide rate by 10% (relative to 2015 levels) by 2020 [8]. The NHS Long Term Plan (January 2019) indicated that this target is achievable, although in England and Wales, the suicide rate in 2020 had not fallen compared with 2005.

This review focuses on the epidemiology of suicide in the UK, i.e., the rate of suicide across the UK, stratified by age and gender. In addition, we examined suicide risk factors and the need to examine the factors to identify people who are at a high risk for prevention strategies. Various screening and assessment tools as essential instruments for suicide prevention efforts were also discussed. Further, we review the use of machine learning and mobile applications to improve the identification of and support for people who are at risk of suicide. Finally, various recommendations and future directions for suicide prevention in the UK are put forward, underlining the importance of digital technology, data collection, and collaboration across sectors.

2. Epidemiology of Suicide in the UK

The epidemiological research into suicide provides vital insights into the complex patterns, various risk factors, and underlying dynamics of this truly tragic phenomenon. Using data from reputable sources like the Office of National Statistics (ONS), Public Health Scotland (PHS), and Northern Ireland Statistics and Research Agency (NISRA), suicide remains a major problem in the United Kingdom and the world. According to ONS records, there were an estimated 5583 suicides registered in England and Wales in 2021, which reflects a rate of 10.7 deaths per 100,000 population, which is higher than in 2020 (10.0 per 100,000) but consistent with the pre-pandemic rates in 2018 and 2019. However, the decline in the rate of suicide in 2020 and increase in 2021 has been linked to the delays in death registrations due to the COVID-19 pandemic [9].

According to Public Health Scotland data in 2022 [10], there were 753 probable suicides in Scotland in 2021, which equates to a concerning rate of approximately 13.8 deaths per 100,000 population. In addition, Northern Ireland experienced its highest incidence of suicide deaths since 2015, with 237 reported in 2021. This equates to approximately 14.3 deaths per 100,000 population, a startling increase of 18 deaths (8.2%) from the previous year's total, indicating a rising trend. The statistics depict an irregular but bleak picture and emphasise the need for holistic suicide prevention efforts across the United Kingdom.

Suicide rates in the UK exhibit striking disparities between various demographic groups. For instance, males consistently have higher suicide rates than females in the UK. In 2021, the male suicide rate in England and Wales was 16.0 per 100,000 population, an

increase in statistical significance from the previous year's rate of 15.4 per 100,000. Similarly, the death rate for females increased from 4.9 per 100,000 in 2020 to 5.5 per 100,000 in 2021. During the same period, Scotland reported both male and female suicide rates that were especially concerning. According to Public Health Scotland (PHS, 2022) statistics for the end of the year 2021, the crude suicide rate for males was 21.2 per 100,000 population, while for females it was 6.7 per 100,000. In comparison to England, Wales, and Scotland, Northern Ireland's age-standardized rates were significantly higher for both males and females. They report 21.5 suicides per 100,000 population and 7.3 per 100,000 for females, indicating a dire situation that requires immediate attention (Figure 1). Overall, the ratio of male to female suicides seems consistent at 3:1 across the UK.

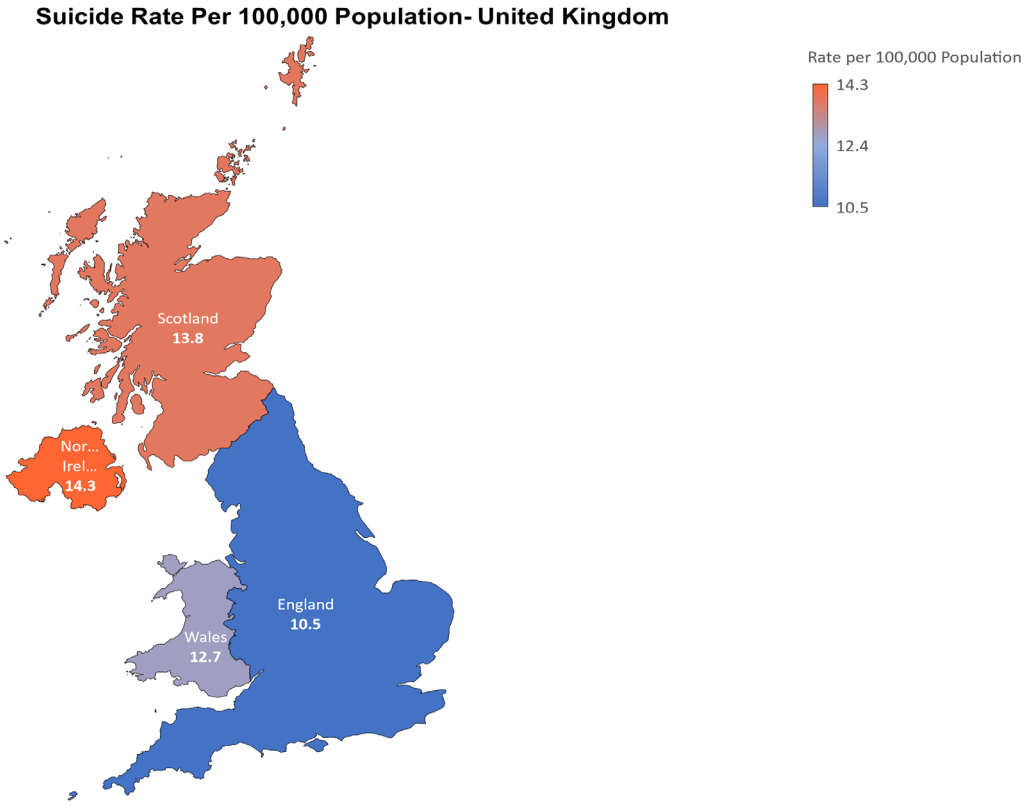

Figure 1. Suicide rates per 100,000 people in the United Kingdom showing the variation across England, Northern Ireland, Scotland, and Wales. The figure is based on publicly available data on the number of registered deaths due to suicide in the year 2021.

Suicide rates in the UK also differ across different age groups. According to data from the Office for National Statistics (ONS), it is evident that individuals in the middle-aged group exhibit the highest rates of suicide in England and Wales. The highest age-specific suicide rate for females was among those aged 45 to 49 (7.8 deaths per 100,000), while for males it was between those aged 50 and 54 (22.7 deaths per 100,000) [9].

Similarly, Scotland saw a troubling pattern among middle-aged men and women aged 45 to 54, who had particularly high age-specific suicide rates. According to PHS, there were around 32.3 male deaths per 100,000 population in this demographic group, which is almost three times more than the females, who had an average rate of 11.2 per 100,000 [10] and 50% more than those recorded in England and Wales. Unfortunately, statistics on Northern Ireland's suicide rate by age-group and per 100,000 population are currently unavailable; nonetheless, for men, the age ranges with the highest number of suicides are 25–29 (22 deaths) and 45–49 (22 deaths), while for females, the age ranges with the highest number of suicides are 20–24 (10 deaths) and 50–54 (8 fatalities) [11].

An increase in the suicide rate in the UK from 2014 onwards especially among middle-aged men has been linked with various factors including unemployment and economic hardship, especially linked with the global economic recession and austerity measures, as well as loneliness, especially resulting from breakdown in relationships and restriction of access to children.

Indeed, all these factors informed the 2016 report that was published by the NHS, setting out a five-year plan for reducing the suicide rate by up to 10% by 2021 [12].

However, the causes and implications of the epidemiological differences in suicide among men and women are complex and multifaceted. For instance, there are other factors that contribute to the higher suicide rates among men, including societal expectations surrounding masculinity, a lower likelihood of seeking help, information literacy, and the influence of risk factors such as substance abuse and economic stressors [13]. These disparities emphasise the need for a tailored suicide prevention approach that considers gender-specific risk factors and interventions. It is crucial to address this gender inequality to develop more comprehensive suicide prevention efforts in the UK and around the world. Specifically, this highlights the significance of promoting mental health awareness, reducing the stigma associated with suicide or seeking help for mental health, and providing tailored interventions to vulnerable populations, particularly middle-aged men, who have shown higher age-specific suicide rates within the UK's population.

3. Risk Factors for Suicide

Suicide risk in the UK is influenced by a variety of causes which may be environmental, individual and/or clinical in nature [14]. The environmental triggers could be due to societal structure, community dynamics, and negative or lack of relationships, while individual factors include mental disorders, economic shock, chronic diseases, etc. [15]. Generally, suicidal behaviour is strongly associated with mental health disorders, notably depression, social isolation, drug addiction, prior suicide attempts, and socioeconomic disadvantages, among others [16]. The presence of mental illnesses, including depression, bipolar disorder, schizophrenia, and anxiety disorders, has been found to be associated with an elevated risk of suicide. These conditions can contribute to feelings of hopelessness and despair, which may lead to suicidal thoughts or actions [17]. Misuse and abuse of alcohol and other drugs are also important risk factors. Substance or alcohol use problems can exacerbate mental health issues and contribute to feelings of hopelessness, making it more difficult for individuals to cope with stressors and challenges in everyday life [18]. Emotional problems, sudden significant life changes (such as job loss or divorce), and lack of or inadequate income are also risk factors for suicide.

The link between psychiatric disorders and suicide has been extensively studied and established even though suicide is not a disorder. Indeed, around 90% patients who died of suicide have been shown experimentally to have some sort of mental disorder [19,20]. The presence of multiple risk factors can also significantly increase an individual's susceptibility to engaging in suicidal behaviours. Multiple factors coexisting in an individual are likely to increase the likelihood of a fatal suicide attempt according to previous studies [21]. Indeed, according to the WHO, previous suicide attempts are a highly significant risk factor for suicide in the general population. Research suggests that individuals with a history of suicide attempts are more likely to make future suicide attempts [3].

There are various forms of suicide risk factors associated with the health system and society. These include challenges with accessing and receiving necessary health care, easy availability of means for suicide, inappropriate media reporting that sensationalises suicide and increases the risk of "copycat" suicides, and stigma towards people who seek help for suicidal behaviours, or for other mental health and substance abuse issues [22]. War and natural disasters, stresses of acculturation (such as among people of indigenous origin or displaced individuals), discrimination, a sense of isolation, violence, and abusive relationships are also situational risk factors that increase individual vulnerability which may increase the rate of suicide [23].

The presence of mental illnesses, including depression, bipolar disorder, schizophrenia, and anxiety disorders, has been found to be associated with an elevated risk of suicide. These conditions can contribute to feelings of hopelessness and despair, which may lead to suicidal thoughts or actions [17]. Misuse and abuse of alcohol and other drugs are also important risk factors. Substance or alcohol use problems can exacerbate mental health issues and contribute to feelings of hopelessness, making it more difficult for individuals to cope with stressors and challenges in everyday life [18]. Emotional problems, sudden significant life changes (such as job loss or divorce), and a lack of or inadequate income are also risk factors for suicide.

One of the most common mental disorders associated with suicidal thoughts and suicide is depression. The term depression defines a persistent mood disorder characterised by elongated periods of sadness, high irritability, loss of interest, emptiness and low motivation that may result in poor cognitive and physical functioning (2021). Thus, unipolar depression may lead to an inability to perform daily responsibilities and was estimated in 2002 by the World Health Organization (WHO) as the fourth highest cause of global disability and predicted to possibly rise to second place by 2030 [24]. Aside from the physical effects of depression, a persistent and chronic course of depression has been linked with suicidality and suicide. For instance, in a previous study that investigated the link between depression and suicide, Handley et al. showed a significant correlation between depression severity and suicidality, which was independent of sex. However, the duration of depression and the presence and number of psychiatric comorbidities were the only factors linked with suicide attempts [25]. This finding corroborated a previous similarly aimed study which reported that repeated self-harm is mainly linked with longer or repeated exposure to adverse childhood experiences [26].

Further, social isolation, which describes the feeling of not belonging to one's immediate social environment exemplified by lone living, self-reported loneliness, few or no friends, broken or conflicting family, social withdrawal, is a major driver of suicidal behaviour and suicide [27–29]. Indeed, the feeling of belongingness and social integration is classically considered a protective factor which is inversely correlated with suicide [30]. In a study involving over 500,000 adults between the age of 37 and 73 living in the UK, Shaw et al. showed that loneliness especially in single men (living alone or with a non-partner) increases the risk of death by suicide [31]. Thus, corroborating a previous study performed in Germany, which showed an increased risk of suicide linked with lone-living [32]. In a recent meta-analysis of 40 studies by Calati et al., objective and subjective social isolation were found to be significantly linked with suicidal thoughts and behaviour [27].

There is a body of evidence showing a strong link between drug dependence and an increased risk of suicide [33–35]. For instance, according to the 2010 Global Burden of Disease Study, psychoactive substances misuse is the second leading risk factor for mental-health-related suicide, surpassed only by depression [36]. Further, cocaine dependence was shown by Pavarin and Fioritti as a major risk factor for suicide in Italy [37]. Drug dependence is generally defined as a persistent, strong, and uncontrollable tendency to take substances and characterized by physical, social, physiological, and psychological dysfunction [38,39]. In a study performed by AL-Eitan et al. on 498 addicts, drug addiction was shown to be a significant driving factor for suicide [40]. This was recently corroborated by Bailey et al. who reported an increased risk of suicide in adults with a high blood alcohol concentration and cocaine use [41].

While depression and drug dependency are the main risk factors of suicide both in the UK and globally, other factors such as previous suicide attempts and socioeconomic disadvantage (e.g., poverty, financial debt, unstable family, poor education job loss, etc.) also contribute significantly to suicide (see [42] for more).

Finally, the risk of suicidal ideation and lethal suicide outcomes varies significantly with age independent of the other risk factors such as socio-economic status. Specifically, middle-aged adults consistently have a relatively higher rate of suicide compared with other age groups globally. Similarly, in England and Wales, the highest suicide rate has

always been reported to be among people aged between 45 and 54 years, while it was lowest among younger people below the age of 20 years and older adults above 70 years of age [43] (Figure 2). Termed as "midlife suicide", the surge in risk of suicide in middle age has been linked with the characteristic social, physical, and economic challenges associated with this period. Indeed, while the manifestation of these challenges may vary from person to person, midlife is generally a period of declining physical health, stress, and higher social expectations, all of which increase the risk of suicide [44,45].

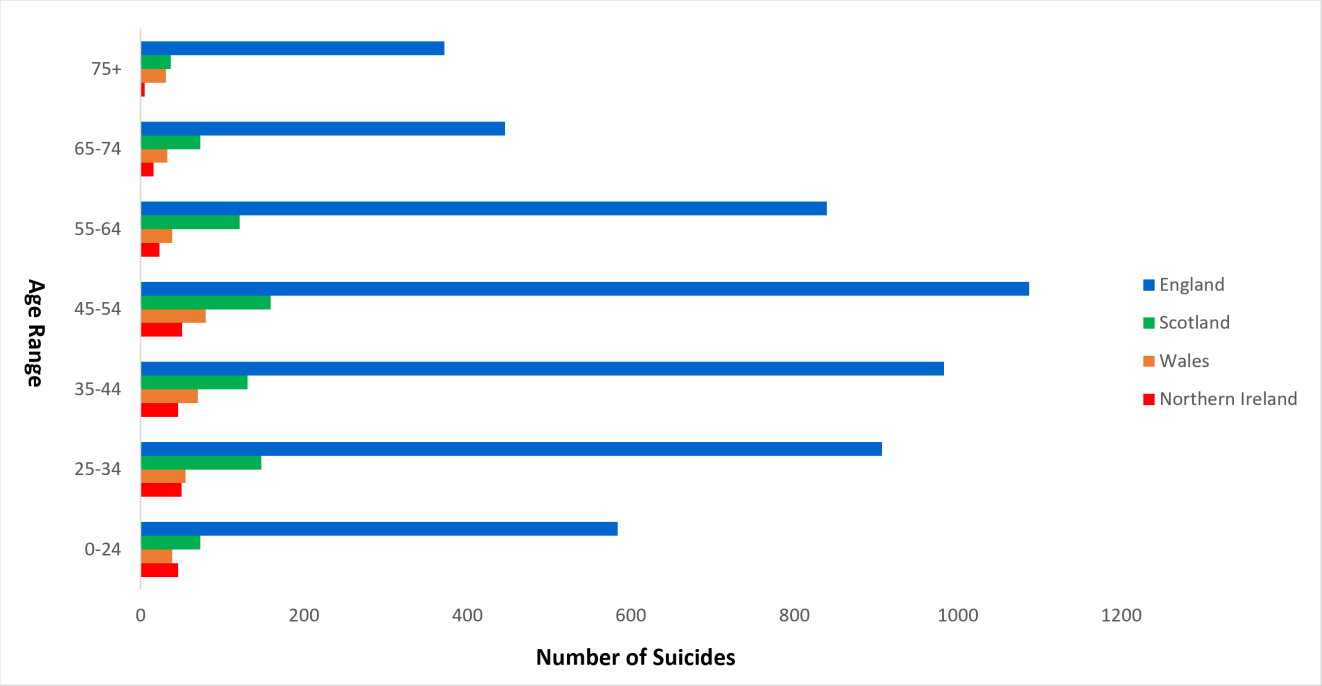

Figure 2. Number of suicides in England, Scotland, Wales, and Northern Ireland stratified by age range. Data represent suicides recorded in 2021.

4. Screening and Assessment Tools

Effective suicide prevention is a complex approach that involves rigorous screening and thorough assessment of those at risk. Suicide assessment tools or instruments are critical in the early identification and assessment of people who have suicidal tendencies [46]. Suicide assessment and screening instruments include self-reporting questionnaires, interviews, and clinician-administered assessments among others. Several criteria must be examined to make an accurate assessment of suicide risk. Variables such as previous suicide attempts, psychiatric history, present mental health condition, and access to means of self-harm are all factors to consider [47].

Healthcare professionals can better understand an individual's degree of susceptibility and design appropriate intervention strategies by obtaining information on these aspects through effective screening approaches. It is important to note that the effectiveness of suicide prevention measures may differ across regions or countries due to social or cultural factors influencing opinions and views towards mental health disorders, including suicide [48]. Indeed, several screening and assessment instruments have been developed and implemented in the United Kingdom to support healthcare professionals in identifying those at risk of suicide.

Primary care physicians, informal caregivers, school counsellors, and educators can play important roles in detecting and identifying suicidal ideation and behaviour among individuals. Primary care physicians are frequently the initial point of contact for patients with mental health issues such as suicidal ideation, especially in older adults in care homes. They can screen for suicidal ideation, assess risk factors, and initiate appropriate patient

care plans. In addition to receiving training in suicide prevention, primary care physicians can implement comprehensive approaches including screening, assessment, intervention, and referral [49,50]. Formal and informal caregivers include family, friends, caregivers, and significant others who offer support to individuals who have attempted suicide or have suicidal thoughts. They can assist in recognizing warning signs, offering emotional support, and connecting people with appropriate mental health resources [51].

Educators and school counsellors also play an essential role in suicide prevention especially in younger adults (adolescents) as they can identify behavioural and social/emotional warning signs of suicide risk among their students and ensure the implementation of preventative measures. In addition, they can raise awareness among students, families, and staff members about suicide risk factors, and provide students with referral resources. Educators and counsellors should undergo formal training in suicide prevention to better identify and support at-risk students [52]. Effective suicide prevention and intervention require collaboration between professionals and caregivers. By collaborating, they can create a supportive environment and provide the necessary resources to support those at risk of suicide.

To identify individuals at risk of suicide, using the right assessment tool is crucial. When choosing a suicide assessment tool, it is essential to consider its psychometric properties, including its reliability and validity. In addition, it is important for the tool to have qualities, such as ease of administration and interpretation. Furthermore, it should be based on evidence and validated for the specific population it is designed for evaluation. Indeed, while it may not be feasible to tailor risk assessment tools to specific risk factors, since various risk factors often overlap within specific study populations [53,54], the risk assessment tool should be married significantly with the appropriate population for which it was designed and validated (based for instance on age, demography, race, etc.). The following are a few of the suicide assessment tools that have been used and validated in the UK and globally.

4.1. The Columbia-Suicide Severity Rating Scale (CSSRS)

The Columbia-Suicide Severity Rating Scale (C-SSRS) was developed by a team of researchers at Columbia University, including "Kelly Posner, PhD and J. John Mann, MD, in the early 2000s", and has exhibited strong internal consistency (Cronbach's alpha = 0.95) and demonstrated satisfactory accuracy in identifying suicide-related behaviour within a 6-month timeframe (sensitivity ranging from 69% to specificity 65–67%). Furthermore, several studies have provided empirical evidence on the robust psychometric features of the Columbia-Suicide Severity Rating Scale (C-SSRS), subsequently demonstrating its validity as a tool for evaluating suicide risk [55,56].

The Columbia-Suicide Severity Rating Scale (C-SSRS) is a 19-item questionnaire commonly used to assess suicidal ideation and behaviour. It is suitable for both children and adults, and it has been used effectively with children aged 6 to 12 [57]. It assesses the intensity, duration, and frequency of suicidal ideation, as well as past suicide attempts, through a series of detailed queries [58]. Included in the questionnaire are questions such as "Have you thought about doing something to make yourself not alive anymore? What did you think about?" and "How many times have you had these thoughts?" and so on. The CSSRS has demonstrated high levels of validity and reliability and is utilised in a variety of research and clinical settings [59]. For instance, in a population of 1451 patients with Huntington's disease from various European countries (including the UK), van Duijin et al. successfully used the C-SSRS to detect suicidal ideation and behaviour [60]. Further, Manning et al. showed the C-SSRS as a valuable tool in assessing suicidal ideation and behaviour and correlated well with the Children and Young People-Mental Health Self-Harm Assessment in Paediatric healthcare Environments (CYP-MH SAPhE) scale [61]. However, the CSSRS has several limitations associated with self-reporting including recall error. Also, as suicidal ideation fluctuates over time, it may not convey the dynamic nature of suicide risk [62,63]. Indeed, in a study assessing the ability of the C-SSRS to accurately and fully

assess suicidal ideation and the behavioural spectrum, Giddens et al. purported the scale to be "conceptually and psychometrically flawed" [64].

4.2. Suicide Ideation Questionnaire (SIQ)

The Suicide Ideation Questionnaire (SIQ) was developed by "William M Reynolds in 1987". In a clinical study of adolescents aged 13–18, the psychometric properties of the Suicidal Ideation Questionnaire (SIQ) were evaluated. The Cronbach's coefficient alpha of SIQ was greater than 0.95, and the Cronbach's coefficient alphas of SIQ were relatively stable when each item was deleted. The SIQ has a high level of reliability and validity and should be used as a reliable measure of suicidal ideation [65,66].

The Suicide Ideation Questionnaire (SIQ) is a commonly utilised self-reporting instrument for assessing the severity of suicidal ideation in adults as well as in children and young people. In addition to the standard SIQ questionnaire, there are two other SIQ forms: a 30-item high school form for students in grades 10 through 12 (15–18 years old) and a 15-item junior high school form for children in grades 7–9 (12–14 years old), also referred to as the SIQ-JR [67]. It provides a structured method for measuring the frequency, duration, and intensity of suicidal ideation. The SIQ has demonstrated excellent psychometric properties, making it applicable in clinical and research settings. The efficacy of dialectical behaviour therapy (DBT) for adolescents at risk of suicide was investigated in a randomised control trial conducted by McCauley et al. The assessment of suicidal ideation was performed using the SIQ-JR form, with a sample size of 173 participants aged between 12 and 18 years [68]. As with other self-report measures, the SIQ may be susceptible to response biases and may not reflect the complex and dynamic nature of suicide risk, which may influence its evaluation [69].

4.3. Beck Scale for Suicide Ideation (BSSI)

The Beck Scale for Suicide Ideation (BSSI) was developed by "was developed by Dr. Aaron T. Beck, Dr. Maria Kovacs, and Dr. Arlene Weissman, in 1979". The psychometric features of the BSSI were determined to be good, with strong internal consistency ($\alpha = 0.96$) and high test–retest reliability ($r = 0.92$). In a study conducted in Tehran, the Persian translation of the Brief (BSSI) showed desirable psychometric qualities within a research setting. Nevertheless, further investigations are required to determine the clinical applicability of this scale [68]. The Beck Scale for Suicide Ideation (SSI) is a commonly employed self-report measure that assesses the intensity of suicidal ideation, comparable to the (SIQ). Further, the BSSI is designed for individuals aged 17 and older and has been widely employed in clinical and research settings [70]. It evaluates a person's attitude towards and preparedness for suicide. The SSI is practicable and simple to administer, making it appropriate for clinical and research applications. In research by Zhang and Brown, they examined high school students ($n = 292$) in China's rural areas using the Chinese translation of the Scale for Suicide Ideation. The findings showed that the SSI had good item-total correlations and internal reliability. These results showed that the SSI is a highly reliable psychometric tool for assessing suicidal thoughts in Chinese populations [71]. As a self-reporting instrument, the SSI may be susceptible to response biases and may not adequately capture the multifaceted elements that make up the risk of suicide. This is a significant limitation of self-reporting assessment instruments [69].

4.4. Manchester Self-Harm Rule (MSHR)

The Manchester Self-Harm Rule (MSHR) was developed by a team of researchers at the University of Manchester, including Keith Hawton, in the early 2000s. Several studies have validated the Manchester Self-Harm Rule (MSHR), which consistently demonstrates a high sensitivity and low specificity. A study conducted in the UK revealed a sensitivity of 97.8 percent and specificity of 21.3 percent for predicting self-harm within six months. In a separate study, high sensitivity (94–98%) and low specificity (14.7–26.0%) were observed in

various contexts. However, further research is required to determine their routine use in clinical settings [72,73].

The Manchester Self-Harm Rule (MSHR) is a clinical instrument designed for predicting the likelihood of future suicide attempts following self-harm presentations. The tool is designed for all individuals and has been administered to patients ranging in age from 10 to 98 [74]. It incorporates multiple risk factor indicators, such as previous self-harm, age, and gender, to identify high-risk individuals. A risk-stratification model was created for emergency department (ED) clinicians to use in assessing patients who present with thoughts of self-harm. The instrument yields encouraging results and may aid in ED evaluation and the provision of psychiatric services to patients at a higher risk [74]. While the MSHR has demonstrated high levels of sensitivity and specificity, its applicability to a variety of populations and settings requires additional research [74].

4.5. Ecological Momentary Assessment (EMA)

The Ecological Momentary Assessment (EMA) was developed by a team of researchers at the University of California, San Francisco, including "Arthur Stone, PhD, and Susan Smyth, PhD, in the 1990s." The Ecological Momentary Assessment (EMA) is not a specific assessment tool, but rather a research methodology used for real-time data collection in various fields [75]. The Ecological Momentary Assessment (EMA) has been used in a variety of research areas, and has been utilised in a variety of populations across research and multiple clinical specialties, including substance abuse and chronic pain, among others [76,77]. The EMA psychometric properties for suicide assessment are not well established [75]. In one study, inter-rater reliability ranged from 0.95 to 0.99, and the construct validity of the cognitive EMA in clinical and community samples was demonstrated. Additional research is required to determine the psychometric properties of the EMA, specifically for suicide assessment [78]. Furthermore, more research is necessary to generalise its recommendations to other age categories [79].

The Ecological Momentary Assessment (EMA) is the process of gathering real-time data on people's thoughts, feelings, and behaviours using mobile devices. It routinely checks people's psychological and behavioural features in real-time for a set length of time [80]. Technological advances have increased the feasibility of EMA measures: instead of undergoing assessments based on retrospective self-reporting or performed in non-representative laboratory settings, participants can now provide time and context-specific data via their smartphones. The EMA is a potentially beneficial tool in clinical practise, but it is not without limitations, such as questionnaire fatigue and issues regarding ethics [80,81].

4.6. Other Assessment Tools

For the adequate prevention of suicidal ideation and suicide, the usefulness of a good assessment tool cannot be overemphasized. Indeed, aside from the ones mentioned above, various other suicide assessment tools have been successfully used both in the UK and around the world. This includes the adolescent version of the suicide probability scales (SPS), developed in in 1989 by Cull and Gill [82] and later modified by Go et al. [83], and covers four main assessments for homelessness, hostility, negative evaluation of self, and suicidal ideation. The SPS is mainly limited by a lack of data on its validity. Also, the Beck hopelessness scale (BHS) measures overall negative perception of the future (pessimism). The BHS was developed by Beck et al. in 1974 [84] and validated by Kim et al. [85] recently in 2015 with reported good test–retest reliability and validity in predicting depression and anxiety. Also worth mentioning are the Reasons for Living scales [86,87], Screening for Depression and Thoughts of Suicide scale [88], Suicidal Imagery Questionnaire [89], Depressive Symptom Inventory-Suicidality Subscale [90], Suicide Risk Scale for Medical Inpatients [91], etc. For a comprehensive review on the various tools available for assessment of suicidal ideation and suicide, please see [92,93].

5. Machine Learning in Suicide Prevention

In recent years, machine learning and artificial intelligence have been used extensively in suicide research and prevention especially in terms of data generation through algorithms such as natural language processing (NLP), that use existing data from physical clinical records and electronic health records (EHRs) for the identification of people at a higher risk of suicide. Indeed, computational algorithms based on NLP can provide a low-cost and resource-efficient alternative to more expensive methods according to a recent systematic review [93]. Machine learning (ML) is a branch of artificial intelligence (AI) that describes various algorithms, associated with the efficient handling of data (especially big data) to perform various human tasks in a logical and reproducible manner [94,95]. Such task may include prediction of outcomes (prognosis), or detection of events (diagnosis) often below the threshold of human detection.

In the context of suicide research, machine learning (ML) has typically been applied to the prediction or intervention of suicide cases. In a South London hospital, Cliffe et al. applied machine learning techniques to electronic health records. The study found that attribute agreements for the precision of positive mentions of self-harm were 0.96 and for suicidality they were 0.80, demonstrating the dependability of the tools for identifying EHRs reporting self-harm or suicidal behaviour [96]. Another study, by Mens et al., used machine learning to predict suicide behaviour using general practise data. Their study utilised data from a nationwide representative primary care database including over 1.5 million patients to develop a risk stratification model that accurately identified individuals at high risk for suicide behaviour [97]. These machine-learning approaches have shown promise in enhancing the accuracy of suicide risk assessment by integrating diverse data sources and identifying patterns that may not be identifiable using conventional statistical methods.

Further, social media sites create massive volumes of user-generated content that can be used for suicide risk assessment. For detecting people at risk, machine learning algorithms can analyse language patterns, mood, and other indications in social media posts. For instance, [98] developed an algorithm that analysed tweets to predict suicide risk among young adults. Such techniques have the potential to provide early diagnosis and intervention for at-risk individuals using their historical data like Facebook posts or tweets.

6. Mobile Applications for Suicide Prevention

The proliferation of mobile technology has presented unique opportunities for the provision of mental health care and the implementation of suicide prevention measures. Mobile devices can support the deployment of personalised applications, commonly known as apps, which offer various functionalities such as emotional assistance, self-reporting, and behavioural coaching. Mobile applications have demonstrated significant potential in facilitating suicide prevention interventions due to their capacity to provide immediate support and interventions during critical moments and in real-life situations. This is particularly valuable given the volatile nature of suicide ideation and behaviour, which can change very quickly [99,100]. Indeed, mobile phones and mobile applications (apps) have gained significance in suicide prevention initiatives in recent years, providing new and accessible methods for screening and evaluation. The "Stay Alive" app, created by Grassroots Suicide Prevention, is one of the most popular smartphone apps in the United Kingdom. The NHS has validated the app, which is intended to assist people in crisis with quick help and services. The app includes information on local crisis helplines, self-help strategies, a safety plan, and a LifeBox in which users can keep important pictures and memories [101]. The "Stay Alive" app is a portable and accessible resource that allows users to get help when they need it. Apart from Stay Alive, ReMinder is another app that has gained popularity. ReMinder is an app that provides users with a configurable template to build their safety plan using a combination of free text and pre-added options. The software assesses the user's mood with a self-reported depressive test (K-10), allows users to store multimedia content for use in a crisis, gives information via a Tweeter feed, and

provides users with access to emergencies helplines and members of the user's support network via the smartphone application [102].

Torok et al. found in a randomised controlled trial that self-guided digital interventions that directly target suicidal ideation are efficacious immediately post-intervention. Indirect interventions (targeting depression rather than suicide) did not significantly reduce suicidal ideation. The study also suggests that digital interventions should be promoted and extensively disseminated, particularly in areas where access to health services is limited or non-existent [103]. Apart from mobile apps, emerging digital technologies such as online platforms, chatbots, and virtual reality have also shown promise in suicide prevention [104,105]. In their research, Lin et al. construct a virtual reality group counselling (VRGC) system that can be used to help students alleviate school-related stress [106]. The research demonstrates promising results and provides a platform for future clinical trials to evaluate and enhance the automated virtual reality chatbot counselling system. These digital tools provide individuals at risk with accessible and cost-effective means of receiving support, information, and interventions at any time and place. Although there are some encouraging ways to using apps and other digital solutions for suicide prevention and follow-up, the technical and human components have yet to be studied and analysed. For example, health professionals should be encouraged to support the design and development of applications that aid in suicide prevention in order to humanise these apps and improve the success of the intervention they support [107].

7. Conclusions and Future Directions

This review study has shown important developments in suicide prevention in the UK, highlighting the significance of comprehensive and integrated approaches to this urgent public health issue. Despite the recent significant advances, there are still important areas that need additional research and development for more successful preventative efforts.

Firstly, using digital technology to reach those who are at risk of suicide has been demonstrated to be quite promising. To evaluate the effectiveness of mobile applications particularly designed for preventing suicidal ideation, an additional study is however required. We can better understand these applications' potential significance in suicide prevention and adapt their capabilities to meet the varied requirements of at-risk populations by undertaking rigorous studies to assess their effect and integration with current mental health services.

Furthermore, various age groups and genders have significantly varying suicide prevalence rates, necessitating personalised interventions to address the problems that certain demographic groups face. In the UK, young adults aged 20 to 29 and middle-aged men and women, notably those aged 45 to 54, have been recognised as having greater suicide rates [9–11]. Because some of the risk factors for suicide are associated with poor mental health, substance and alcohol abuse, and other economic and social factors, providing accessible mental health services, increasing mental health awareness, creating mental health check-up clinics, promoting social interaction, introducing financial literacy initiatives, and addressing and implementing initiatives to reduce substance and alcohol abuse are a few recommendations that could support these population.

Additionally, it is crucial that we improve data gathering techniques to deepen our understanding of suicide trends and risk factors. To find discrepancies and create specialised preventive efforts, statistics on suicide must regularly contain demographic information, such as race and religious views. Additionally, uniform data collecting across the UK is essential for more accurate comparisons and assessments. England, Wales, Scotland, and Northern Ireland must work together to simplify data gathering procedures and guarantee a comprehensive strategy for suicide prevention on a national level.

Consequently, the development and deployment of several suicide screening and assessment tools have aided advances in suicide prevention in the UK. Among the commonly used tools are the Columbia-Suicide Severity Rating Scale, Manchester Self-Harm Rule, Suicide Ideation Questionnaire, and Beck Scale for Suicide Ideation, each with its own

strengths and limitations. Furthermore, new tools such as the Ecological Momentary Assessment (EMA), machine learning and artificial intelligence-based algorithms, and mobile applications such as the "Stay Alive" and "ReMinder" apps provide new prospects for enhanced suicide risk assessment and prevention. Thus, future studies should investigate and look to resolve the limitations of the various risk assessment tools discussed above. For instance, to improve the efficacy of these suicide assessment tools, a culturally sensitive approach that recognises and respects differences in how ethnic minority groups perceive suicide need to be incorporated. Some cultures do not stigmatise suicide, while others do; this can have a significant impact on the suicide risk [108]. In addition, comprehensive suicide assessment instruments should consider factors beyond race and ethnicity. Age, level of education, physical and mental health, gender identity, sexual orientation, occupation, and additional pertinent characteristics must also be considered. By incorporating these factors into the design of assessment instruments for suicidal ideation and attempts, more effective prevention tools can be developed.

Indeed, because of the high number of suicide risk assessment tools currently available, choosing the right tool for specific settings or patients group remains a challenge to researchers and clinicians. Perhaps, the understanding of the settings in which the tools mentioned above were validated could help inform the choice of tool most suitable for future studies. It would be interesting to have a systematic review (or meta-analysis) in future that precisely assesses the strengths and limitations of the various assessment tools in terms of suitability for various patient groups (younger adult, middle aged adults, elderly, veterans, etc.) and settings (clinical, research, community, online, etc.). Furthermore, future research could investigate the cross-cultural validity of different suicide evaluation instruments for different ethnic, age, and other populations. For example, the EMA has been shown to be an effective suicide assessment tool; however, research has not shown how effective it is in other populations. Understanding how different populations respond to these instruments can help to resolve differences and sensitivity problems.

Finally, this review emphasises the need of continued research and collaborative efforts in promoting suicide prevention in the UK. It also identifies the gap in research regarding how to identify appropriate suicide risk assessment tool suitable for specific settings or populations. We can make substantial steps in reducing the impact of suicide and establishing a culture that prioritises mental health and well-being for all by investing in novel digital tools, tailored interventions, and enhanced data gathering practises. Policymakers, academics, and stakeholders must collaborate to adopt evidence-based practises and create a comprehensive and humane strategy to suicide prevention across the country.

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