The Prediction of Alcohol Use Disorder: A Scoping Review

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***Abstract*—The prediction of Alcohol Use Disorder (AUD) may help to alleviate the number of deaths caused by alcohol related diseases, which had amounted to 3.3 million in 2014, worldwide. This article reports on the results of a scoping review of literature which focused on the prediction of AUD. A search in the academic databases including Medline, Web of Science and EBSCOhost had identified 28 articles which were published from 1980 to 2018, and which fulfilled our inclusion criteria related to the prediction of AUD. The findings suggest that research focusing on the prediction of AUD has been solid, with majority of the investigations focusing on genetics and family history, and psychological factors. It was observed that no study had tried to extract the predictor variables of AUD from their collected samples. Further, while a few studies had applied the machine learning approach in this domain, most investigations were based on statistical methods. Our review also suggests that compared to other regions where the rate of harmful drinking and mortality caused by alcoholism is high, Denmark is a country that has been less explored.**

Keywords—Alcohol use disorder, prediction, scoping review

I. INTRODUCTION

Alcohol Use Disorder (AUD) is a broad term used to refer to any problem that is related to the drinking of alcohol. AUD is the most common and undertreated disorder in developed countries [25]. Affected individuals have impaired control over their alcohol consumption; they continue to drink despite the serious adverse effects alcohol has on their health and the lives of their spouses, children, family members, friends, and workmates. AUD refers to the excessive use of alcohol, and if left untreated, can lead to numerous diseases, such as liver cirrhosis, chronic pancreatitis, upper gastrointestinal cancers, cardiomyopathy, polyneuropathy, and dementia. Uncontrolled use of alcohol is also the contributing cause of many road accidents [11].

According to a World Health Organization (WHO) report in 2014, approximately 3.3 million people or 5.9% of deaths worldwide are caused by alcohol consumption [24]. Globally, alcoholism is the world's fifth leading cause of death [20], and it is also the leading risk factor for premature deaths and disabilities. Using the Diagnostic and Statistical Manual of Mental Disorders, 5th edition, as the diagnostic criteria, it was noted that between 2012 to 2013, about 36.0% of male and 22.7% of female adults in the USA fulfilled the criteria for AUD, at some point in their lives, with the report stating that 17.6% of men and 10.4% of women became qualified for AUD in the past few years [12]. In Europe, it was noted that 3.5% of those between 18 to 64 years of age, had been estimated to be alcohol-dependent, while 11.1% were estimated to be heavy drinkers [25].

Although AUD stands to be the second highest burden for most mental disorders, after depression [26], the treatment rates have been low, with only about 10% in Europe getting treatment in the past decade [27]. Different studies seemed to suggest that there are different reasons causing the low treatment rate for AUD in Europe. For instance, Üstün and Sartorius [40] claimed that primary care physicians were unable to recognize AUD, hence treatment was delayed. This is because the conventional method for detecting alcohol-related problems was through self-test reports [29]. It appears that patients' dishonesty, patients' lack of memory, taboo issues and many other reasons, could have contributed to the misguidance in the self-test reports that were used in the diagnosis of AUD. This implies that self-test reports are no longer suitable, hence other objective techniques are necessary.

AUD causes many unnecessary health issues, and there are a variety of factors which are associated with the increased level of AUD. These factors, if dutifully studied, may enable scientists to predict the cause of AUD. For instance, AUD could be family-bound, such that AUD detected in a biological family member can serve as a strong positive predictor of AUD in other family members [6]. AUD is also psychologically driven. Psychological factors such as the

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stress level experienced [4], personality disorder [28], behavioural factors like a gambling problem [13], social influences [9], and many more, may increase risky drinking, and so lead to AUD. The rapidly increasing number of health records contain a lot of useful information, which can be beneficial to the medical staff in their decision-making process, such as for the prediction of AUD. Although literature shows an extensive number of studies looking at the prediction of AUD, there has been a lack in its systematic review.

A systematic review is a research design which is capable of summarizing and evaluating the existing data. Scoping reviews are systematic reviews which are used to assess the extent of a body of literature as a means to ensure that further research in that area is a beneficial addition to knowledge [2]. Besides exploring the extent of the literature in a particular domain, and summarizing the findings, scoping reviews may also help to identify a more specific research question, based on what is already known or not known.

Although there are systematic reviews in AUD related areas [10; 30], little focus has been given to the prediction of AUD. Literature search in the Web of Science Core Collection, Medline and EBSCOhost (July 2018) was able to identify some scoping studies which were related to AUD [5], but thus far, none had focused on the prediction of AUD. The current scoping review aims to provide an initial summary of evidence which were gathered from previous studies to highlight the prediction of AUD, both in terms of study characteristics and principal findings. The current scoping review is intended to serve as a platform for a more in-depth analytic review for the etiological investigation of AUD.

II. METHODS

A. Design

This scoping study uses the framework drawn by Arksey and O'Malley [2]. It is based on five stages of review: identifying the research question(s), identifying the relevant studies, selection of studies, charting the data, collating, summarizing, and reporting the data and consultation. This method follows the narrative synthesis approach which is mainly suitable for the evaluation of a contrasting body of studies that are principally qualitative in nature. It is based on an iterative, conceptual and interpretative approach that emphasises on the importance of developing an assessment that is based on relevance, credibility, and evidence, rather than by the strictly determined methodological considerations of analysis and synthesis.

B. Identifying the research question and objectives

The aim of this review is to evaluate the status of the scoping studies within the field of predicting AUD. The current scoping study aims to identify the extent, range, and nature of studies done on the prediction of AUD by exploring the processes used by previous studies. The research question guiding the present scoping review is based on previous works done on the prediction of AUD which is: "What is the extent and nature of the published academic literature on the prediction of AUD?" This paper will also focus on how the prediction of AUD is being addressed in previous studies. To do this, a few perspectives such as the type and format of predictive approaches and methods used, the dimensions of prediction being addressed, and the impact of these dimensions on the prediction of AUD, who the studies aimed at, and in what settings, are included.

C. Identifying the relevant studies

In this study, the eligible scientific papers were identified from a variety of data sources encompassing Medline, Web of Science Core Collection and the EBSCOhost. Search tools include looking for medical subject headings (MeSH) while the Boolean logic was used to narrow or expand on the search terms, including: "Alcoholism", "Alcohol Use Disorder", "Prediction", and "Prognosis". In line with Arksey and O'Malley's recommendations [2], our search strategy and key terms were augmented and revised iteratively as preliminary searches were completed. All peer-reviewed articles, book chapters or reports published in English from 1980 and which were available publicly or via the University of Southern Denmark's library, were included.

D. Screening and study selection

All article titles and abstracts were screened. The inclusion criteria focused on studies or reviewed literature that were related to alcoholism by any method, to predict AUD. However, studies which did not report on the original empirical findings, studies which assessed only the outcome of alcoholism treatment or alcoholism lapses, studies which predicted other substance abuse and not alcohol as well as studies focusing on the quality of post-treatment of other diseases, were excluded. Our selection process followed the PRISMA guidance [19]. No restriction was imposed on outcomes for children and youths, but studies on animals were excluded. Figure 1 presents the study selection process.

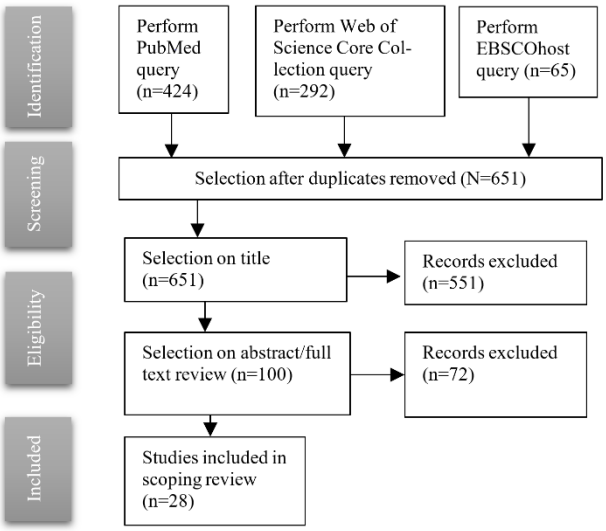

Fig. 1. Data selection process based on PRISMA flowchart

E. Charting data

The final papers that were selected for this scoping review were read in full. Data were extracted using a template that was especially developed for the review. Data from each of the papers were then sorted in relation to the purpose and

objectives, methodology, search and analytical strategies, outcomes and origins of the studies, year of study, sample data type and size, gender of participants and their age and country.

III. Results and Discussion

Our search resulted in 28 articles which include reports published between 1980 to 2018. The oldest of these studies was the one conducted by Croughan et al. [8] (1981). Except for one article which was a review [1], the rest were either qualitative or quantitative studies. In the review article, Akerlind and Hornquist [1] studied the interplay between loneliness and AUD. They claimed that loneliness may be significant at all stages of AUD and sufferers of AUD tend to feel more lonely than other groups. This is one of the many high negative characteristics noted in AUD patients. Consequently, this trait can cause the poor prognosis of AUD. Akerlind and Hornquist [1] could not find any obvious relations between AUD with the external social situation (network) or with the amount of drinking.

Turning to participant characteristics (data sample), 21 of the studies or 75%, had mentioned the gender of their participants with six studies or 28.5%, investigating only men. One study or 4.8%, investigated only women and 14 of the studies (66.7%), focused on both genders. Majority or 82% of these studies had also mentioned the age of the participants. Among these, 13 of them (56.5%) were investigating young adults and adolescents. Almost all the studies mentioned the size of the samples used with 60% of them using a sample size of less than 400. Four of the studies (14.3%) examined a sample size of more than 2500 participants while two studies (7%) used a sample size of 844,109 participants who were extracted from the national Swedish dataset [15] to identify the risk of AUD, based on family history. Another study used a sample size of 658,172 [14] to report the transmission of AUD in three generations. The range of follow up was found to be another significant indicator that might increase the accuracy of the prediction of AUD. Amongst the targeted studies, our analysis noted that more than half of them followed their samples for about five years, while only five studies claimed to have followed their samples for more than 16 years. One of the studies conducted by Thomas-Dobson et al. [35] tried to determine the variables that were predictive of two weeks prognosis in men who were identified with a drinking problem. Linked to this is the study by Chartier et al. [6] who studied the family history of three generations of samples for AUD. Migration factors were also included for identifying the change of AUD amongst these samples.

We observed that more than half of these studies (n=19) had been conducted in the USA, seven studies were conducted in European countries, one was done in Russia [37] and one in India [36]. Amongst those studies focusing on European countries, four were conducted in Sweden [1; 7; 14; 15], one in Italy [9], one in Norway [28] and one in Denmark [16]. It appears that AUD has a high prevalence rate among Western populations, particularly in Europe [22]. Nonetheless, recent studies have shown that the Danish population is also becoming more inclined, with 20 percent being heavy drinkers and 14 percent being harmful alcohol users [11]. In another study, Westman et al. [39] noted that the mortality rate in Denmark has been higher than other European countries with similar populations, such as Sweden and Finland. However, based on our finding, only one study had been conducted in Denmark [16], and this was done decades ago in 2003. In this particular study, Knop et al. [16] had identified different sets of markers that maximized the prediction of AUD among sons of treated alcoholic fathers, and among sons who were matched with biological fathers who had no record of treatment for alcoholism. The researchers had used a variety of methods for multiple domains, including perinatal records, pediatric records, school records, teacher ratings, school physician records and a series of structured interviews and psychometric tests, for those aged 19-20 years and those aged 30 years.

Returning to the focus on AUD, it has been said that self-test reports may misguide the diagnosis. This occurs when critical information is omitted due to patients' lack of memory (the patients cannot accurately measure their amount of alcohol consumption), or due to their dishonesty. In some cultures, discussing alcohol consumption is also a social 'taboo', hence little information can be gathered. Based on our analysis, it was noted that almost all studies had collected sample data based on self-reports, except for two studies that explored the national health care databases [14; 15]. One investigation was based on the data collected from the Magnetic Resonance Imaging (MRI) [41]. The other study was based on clinical datasets [18]. In other words, all the studies were based on textual and numerical data, except for one, which used the MRI data collected from 92 individuals (46 controls and 46 AUD). Here, Zhu et al. [41] aimed to identify the features that were predictive of alcohol dependence, in a multivariate fashion. They used machine learning algorithms to identify the biomarkers which were involved in AUD. They also quantitatively compared the performance of the within-network, and between-network features that contributed the most to the classifier. The aim was to identify the features that can best-detect alcohol dependence. Using the feature elimination method, they were able to show that the within-network features can better distinguish AUD from controls, instead of the between-network features. Thus, it was suggested that the connectivity within the executive control networks, and the reward network might be informative for predicting AUD.

Two studies which examined the electronic patient records for predicting the AUD used the national Swedish healthcare database as samples. One was by Kendler et al. [14] who reported on the transmission of the AUD across three generations. They defined the AUD based on three sources: main and secondary diagnoses from the Swedish medical and Cause of Death registries, the anatomical therapeutic chemical codes in the Prescribed Drug Register, and the registration of individuals in the Swedish Crime Registers. Statistical methods were employed. It was claimed that the familial transmission of AUD is relatively stable over the last three generations in Sweden.

In another study, Kendler et al. [15] identified the risk of AUD through the family history (FH) analysis. AUD was then defined using main and secondary diagnoses, such as alcohol-related psychiatric disorders, alcohol-related polyneuropathy,

and alcohol related cardiomyopathy. Information was taken from the Swedish Medical Registries and statistical methods were applied. It was concluded that AUD is substantially familial among the Swedish population.

Currently, a vast amount of data are being compiled in the electronic patients' records system in hospitals, both as numerical data (test results, etc.) and free-text data, which contain a lot of useful information. To be able to assist the staff in their medical decision-making process, this data should be efficiently processed and transformed into useful and structured formats. It has long been recognized that electronic clinical reports are beneficial for secondary use. A number of researchers across the globe had employed machine learning algorithms to explore useful information (such as medical concepts or medical entity) from clinical reports. However, in the prediction of AUD, such techniques have not been used much. We noted that most of the articles identified for this study used statistical approaches to identify the prediction of AUD except for two [4; 41]. Of these, one is Zhu et al. [41] mentioned earlier. They had employed machine learning algorithms to identify the features that were predictive of alcohol dependence in a multivariate fashion. The other study was by Bi et al. [4] who had proposed using a support vector machine to construct a classifier which can identify the drinking behaviour of individual college students, for a period of 30 days. After that, the combination of the cluster analysis and feature selection was proposed, where the cluster analysis was used to identify the drinking patterns, based on the average daily drinking behaviour. Following this, the feature selection was used to identify the risk factors which were associated with each pattern. Although this study used machine learning algorithms, their data were also derived from self-reports.

FH of AUD, such as the sociocultural, demographic and psychological factors, are associated with an increased risk for AUD. The relationship between these factors and AUD served as the most common key factor being investigated in several studies. Of the psychological factors being examined, personality disorder (PD) was a factor frequently being explored. Almost all the studies we analysed were investigating adolescents and young people as well as people of both genders. However, Beardslee and Vaillant [3] only looked at men in their study whereas Rosenstrom et al. [28] included 5000 adult twins in their study in order to identify which individual PD criteria can predict AUD, even after the other (correlated) criteria have been taken into account. They also explored whether those criteria predicted AUD better or worse than the composite PDs to which they belong, and whether the detected associations between the selected criteria and AUD, were mediated by genetic factors or environmental factors. The researchers also assessed the Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV) PDs which consist of 80 criteria by using a structured interview that was based on the WHO's International Diagnostic Interview. The Elastic Net model was also employed to conduct a cross-sectional variable-selection analysis so as to determine which individual PD criteria can predict AUD. It was claimed that among the 80 PD's criteria of the DSM-IV that was used to examine disorder, self-harming impulsivity was the foremost risk trait for AUD.

Besides self-harming impulsivity, level of stress was also a common psychological factor used by previous studies to predict AUD [13; 32]. Other psychological factors used as a predictor of AUD [4; 9] include level of sadness and depression, and social and familial influences. Of the studies that had focused on psychological factors, most had followed their human subjects for a long time, except for Schuckit et al. [32] who followed their 530 male and female college student-samples for 30 days. Their aim was to gather patient-input from the multi-wave cohort-sequential's daily activities by using two machine learning approaches. Another study by Harvanko et al. [13] followed their samples, comprising 58 individuals, for a whole year. Their aim was to determine the association between risky decision making, such as gambling, with AUD. In a subsequent study using only two weeks follow-up, Gabbiadini et al. [9] investigated the predictive power of social influence on the binge drinking determinants of 404 young people.

AUD may be strongly spread within families too. Twelve studies had considered using genetics or FH to predict AUD. For instance, Kuperman et al. [17] explored 674 adolescents between 14 to 17 years old to examine the improvement of the published model's ability to predict alcohol initiation by including genetic information. Kuperman et al. [17] testified that genetic factors as well as positive and negative environmental factors can be used to predict AUD among the adoptees. Focusing only on women, Michels et al. [21] investigated the development of AUD, based on patients' childhood and FH. This was the only study that investigated the prediction of AUD in women. About 309 women aged between 20 to 50 years old were tracked for about two weeks. The aim was to find a pattern between their childhood, FH, and the development of AUD. The women were divided into three categories, based on their age, race, and case (alcoholic or non-alcoholic).

In contrast, Schuckit and Smith [31], Knop et al. [16] and Schuckit et al. [32], explored the effects of familial indicators only on men. Two of these studies also examined the risk factor of alcoholic fathers as the development of AUD on the sons. Schuckit and Smith [31] followed 133 sons of alcoholic fathers for eight years. They used familial indicators to examine AUD risk among sons of fathers suffering from AUD.

In comparison, Knop et al. [16] followed 330 subjects including 223 sons of treated alcoholic fathers (high-risk group) and 107 matched sons, whose biological fathers had no record of treatment for AUD (low-risk group). Knop et al. [16] aimed to identify sets of markers that would maximize the prediction of drinking problem by age 30.

In another study, about 440 children were trailed by Croughan et al. [8] since their mothers' mid-pregnancy. Croughan et al. [8] aimed to assess the FH of drinking and drug abuse problems by examining the relative importance of prenatal alcohol exposure and the FH of AUD as the prediction of AUD in children.

Of the total of 28 studies identified for this paper, it was noted that some had considered more than one factor as the predictor of AUD in their studies. For instance, Noordsy et al. [23] studied 66 schizophrenic outpatients for a period of four years. They aimed to examine whether the association between FH of AUD is strong among schizophrenics. FH and PD were two factors used together to examine the relationship between self-esteem and alcohol problem [38]; they were also used to measure the risk factor of AUD [34]. Schuckit et al. [33] examined the relationship between LR and FH in 376 adolescents for about 20 years. Analysis was conducted using Pearson's Product–Moment correlations. The relationship between the two factors of FH and LR (level of response) demonstrated that the LR to alcohol was a better predictor of AUD in adolescents.

IV. Conclusion

This scoping review has described the research conducted on the prediction of AUD. Articles extracted for analysis were those published between 1980 to 2018. A total of 28 primary studies were selected from three different academic databases. The distribution of these articles were based on region, type of studies, duration of follow up, size and type of sample data, characteristics of participants for each study, and more importantly, what predictive approaches and factors were used in the selected studies. The main contribution of this scoping review is that it presents the extent and nature of published academic works examining the prediction of AUD. It further addresses the issue of how and which different dimension of predictive approaches should be followed and what factors may impact the prediction of AUD. This paper also stresses that the topic is one that is still emerging and continues to evolve. Nonetheless, there is still a need for future reviews to be conducted in this domain, in the form of a comprehensive systematic literature review which recapitulates the existing primary studies, and which maximizes the procedural decision analysis in different aspects. Future reviews should include the identification of datasets and their characteristics, pre-processing and sampling techniques, predictive feature identification processes, prediction techniques, performance metrics, and others. It is proposed that similar reviews of this kind can be conducted by engaging a librarian to prepare the list of related keywords to search for the relevant literature on the prediction of AUD. Data can be searched by referring to additional high-quality academic databases than those covered in the current study, for instance, Scopus, IEEEXplore, PubMed, ScienceDirect, Association for Computing Machinery, SpringerLink, and others.

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