Digital mutual help groups for problematic alcohol use: characteristics, contexts, and commitment

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Mutual Help Groups (MHGs) such as Alcoholics Anonymous can enhance recovery from problematic alcohol use. However, they can also present barriers related to physical access, stigma, and ideological conflicts. The emergence of digital MHGs has presented opportunities for individuals to more conveniently and discretely engage in peer support. As this is an evolving area of research, a scoping review was conducted to characterize extant studies of digital MHGs for problematic alcohol use. Five mobile applications and 15 web-based platforms were directly studied, though several were found to be inactive or unavailable. Randomized trials were insufficient to establish effectiveness of digital MHG participation in enhancing recovery outcomes, though active digital MHG engagement was associated with favorable recovery trajectories in longitudinal analyses. Descriptively, recovery processes were characterized by participants engaging in reciprocal support, solidifying community ties, and developing recoverycentric identities. However, little has been comprehensively reported about patterns and contexts of engagement that typify such processes among new users of popular digital MHGs.

To contextualize patterns of digital MHG engagement, I collected two years of observational data from Reddit's /r/stopdrinking (SD) community and benchmarked forum activity, evaluated technical features, and identified contexts of engagement using quantitative and qualitative methods. SD was highly active and responsive, with cohesive rules and customs (e.g.,

common maxims, daily check-ins). Among 1,556 annotated posts, content reflected diverse motivations for change (e.g., mental, physical, and social concerns). Users commonly expressed cravings and directly asked for feedback and support. Based on multivariable models including supervised linguistic classifiers, expressing these contexts within the first week was not associated with sustained engagement among 18,517 new forum users. Above-average posting and commenting, and setting up a Sober Badge day counter in the first week, significantly predicted sustained weekly engagement through 4- and 13-weeks. Such committed engagement was identified in a minority (1-5%) of new forum users. Future studies should identify individual differences that can motivate initial commitment to digital MHG engagement as well as recovery trajectories associated with such involvement. This will allow for well-scoped trials and development of evidence-based recommendations for using popular digital MHGs in alcohol recovery contexts.

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Preface

This dissertation was inspired by experiences that I share with a great number of people who have seriously questioned the nature of alcohol use in our lives. I hope that we all find answers to our myriad questions and that we embrace opportunities to share our knowledge for the benefit of others. I am grateful to many people – health professionals, peers, and complete strangers – who have extended their time, experience, and support to me over the years. This is in addition to the growing number of people who anonymously share their recovery journeys online, where so many others can learn from them for years to come. It is with great respect that I pay this support forward through my commitment to recovery research and service.

This personal milestone would not have been possible without the loving support of my immediate and extended family – thank you all. Thanks to my parents for encouraging my personal growth and helping me through the growing pains along the way. To my wife and partner in all things – for your wit and compassion, which have helped me to remain positive and resilient in the face of challenges. To our daughter – your life has brought so much joy into the world. Thank you for the reminder that, through the eyes of a child, even mundane experiences can be awe-inspiring.

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1.0: Background and introduction

1.1 Epidemiology of alcohol use, mortality and morbidity

In a global perspective, a recent report from the World Health Organization (2018) is the most comprehensive guidepost for understanding patterns of alcohol use. *Globally*, 44.5% of the population over age 15 have never consumed alcohol, 12.5% are former but not past-year alcohol users, and 43% drank alcohol in the past-year. In the *US population* over the age of 15 years, 9.2% (4.4% male, 13.8% female) of the population has never drank alcohol and 19.2% (12.6% male, 25.5% female) are former but not past year drinkers. The 71.7% of past-year drinkers among the US population is *67% higher*, relative to the global benchmark. However, the average US drinker consumes 9.8L of ethanol per year (men: 15.8, women: 4.1), which is *35% lower* than the global average of 15.1L per person/year. So, while there are a proportionally greater number of past-year drinkers in the US, per-capita consumption is relatively lower than global averages. This is favorable for health outcomes that are associated with higher levels of consumption (e.g., alcoholic liver disease). It is unfavorable for more common health outcomes (e.g., accidental injury), which are associated with lower levels of consumption (Rossow & Mäkelä, 2021).

Globally in 2016, alcohol use resulted in an estimated 5.3% of all mortalities and 5.1% of all disability-adjusted life years (World Health Organization et al., 2018). In the US, a recent study of death certificates by White et al. (2020) indicated that an estimated 2.6% of mortality could be attributed to alcohol use, and this disproportionately affected males and indigenous peoples. Among this deceased US population, alcohol-related deaths generally increased over the lifespan from 21-75 years of age and were particularly high in groups older than 45 years. Despite earlier observations about relatively lower quantities of drinking presenting less risk of alcoholic liver disease (ALD), ALD was identified as the leading cause (30.7%) of alcohol-related mortality in this study. Using US Centers for Disease Control data, Esser et al. (2020), calculated that 2.7 million years of potential life (28.8 years per alcohol-attributable death; 71% involving males) are lost annually due to alcohol-attributable causes in the US. Among alcohol-attributable deaths, the majority (56%) occurred around mid-life (ages 35-64), 26% occurred after the age of 65, and the remainder occurred before the age of 35. Similar to White et al. (2020), Esser et al. (2020) identified the leading cause of alcohol-related mortality as ALD (19%) or unspecified liver cirrhosis (11%). Other chronic, life threatening conditions associated with alcohol use include cardiovascular diseases, digestive and gastrointestinal conditions, and various types of cancer (Esser et al., 2020). In the US, 55% of alcohol-related mortality can be attributed to chronic health conditions and 45% due to acute conditions such as homicide, suicide, accidental death, and poisoning due to alcohol or other substance (Esser et al., 2020).

1.2 Problematic alcohol use

1.2.1 Clinical features

Clinically, **Alcohol Use Disorder** (**AUD**) exists across a continuum of severity. For purposes of clinical diagnostics, one of two rubrics are typically used to determine common thresholds for presence and severity of AUD. In US psychiatric care settings, the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) is commonly used for these purposes (Hasin et al., 2013). DSM-5 includes eleven criteria for AUD (see Table 1.1) with diagnostic sub-categories of *Mild* if 2-3 criteria are met, *Moderate* if 4-5 criteria are met, and *Severe* if >5 criteria are met. The ICD-10 research version includes nine criteria which relate to categories of *harmful use* and *dependence* (see Table 1.1; "H" and "D", respectively). *Harmful use* is indicated if any one of the four corresponding criteria are met and *dependence* is indicated if at least three of the six corresponding criteria are met. While DSM-5 and ICD-10 produce comparable diagnostic results for severe AUDs, their agreement is less reliable for mild-to-moderately severe AUDs (Bond et al., 2012; Hoffmann & Kopak, 2015). Based on data from the NSDUH survey (2015-19), 7.8% of the US population is estimated to have an AUD, commonly mild, and relatively likely to co-occur with illicit drug use and other mental health conditions (Mintz et al., 2021).

AUD is considered a chronic condition, characterized by periods of remission and relapse. DSM-5 and updated ICD-11 criteria differ in how AUD *remission* is defined. For DSM-5, remission involves the absence of all symptomatic criteria (see Table 1.1), other than craving that is assumed to be present for an extended period of time. If these symptoms are consistently absent over time, *early remission* is conferred at three months and *sustained remission* is conferred at one year (Hasin et al., 2013). In contrast to DSM-5 that has no criteria related to alcohol use patterns, ICD-11 has a strict requirement for abstention or reduction of alcohol use and confers *early remission* at one month. Per ICD-11 criteria, sustained remission is subcategorized as *partial* in the case of a significant reduction in alcohol use and *full* in the case of abstinence from alcohol use, provided that no other symptoms are present. Similar to DSM-5, the ICD-11 framework confers *sustained remission* at one year of meeting the relevant criteria (Witkiewitz et al., 2020).

Based on US population data from the NESARC survey (2001-02), the probability of remission from AUD is estimated to reach 91% over the lifespan with a median of approximately 14 years between onset and remission. Based on these data, there was a 3% probability of sustained remission at one year after disease onset and 37% probability at ten years from onset (Lopez-Quintero et al., 2011).

DSM-5	ICD-10 Research Version
Tolerance	Tolerance (D)
Craving, strong desire, or compulsion to use	Strong desire or compulsion to use (D)
Withdrawal or using alcohol to relieve or avoid withdrawal symptoms	Withdrawal or using alcohol to relieve or avoid withdrawal symptoms (D)
Unsuccessful efforts to reduce use	Difficulties in controlling onset,
Taking larger amounts of the substance over time	termination, or level of use (D)
Sacrificing social, occupational, or recreational activities due to use	Neglect of alternate pleasures or interests / time spent to obtain, use, and recover from use (D)
Significant amount of time spent obtaining, using, or recovering from use	
Continued use despite having a physical, psychological, or cognitive problem related to use	Continued use despite having a physical, psychological, or cognitive problem related to use (D, H)
Failure to fulfill obligations at home, work, or school	Detrimental behaviors and social problems related to use (H*)
Interpersonal conflict related to use	Interpersonal conflict related to use (H*)
Use in dangerous situations	Use in situations where impairment could be dangerous (H*)

Table 1.1 Summary comparison of diagnostic criteria for Alcohol Use Disorder

For ICD-10, "D" indicates Dependence criteria and "H" indicates Harmful Use criteria (Hoffmann & Kopak, 2015). *Criteria that are present in the ICD-10 Research Version but not the Clinical Version.

Clinical treatments for AUD may include pharmacotherapy as well as a variety of psychological interventions (e.g., cognitive behavioral therapy, acceptance and commitment therapy, 12-step therapy). FDA approved medications for AUD treatment include naltrexone, acamprosate, and disulfiram, and there is a growing body of evidence indicating that off-label gabapentin, topiramate, and varenicline may be beneficial (Karoly et al, 2015). Clinical treatment settings can be highly intensive as inpatient hospitalization or as supervised sober-living communities (e.g., treatment center, group home). Other forms of clinical care include intensive outpatient treatment (IOP; generally including several structured group sessions per week) or lessfrequent outpatient counselling sessions. Among individuals receiving outpatient care, 61% are likely to drink within the first 12 weeks of treatment (Maisto et al, 2018). In the year after treatment engagement, nearly half of individuals transition between multiple remission-relapse episodes, and another 17% relapse entirely (Maisto et al, 2018). Despite regular clinical screening and many available treatment modalities, AUD remains undertreated. In the NSDUH survey, only 12% of individuals with AUD received a brief intervention, 5% were referred to treatment, and 6% received treatment (Mintz et al., 2021). Severity of AUD and associated problems predicts treatment seeking, (J. A. Tucker et al., 2020). It takes 18 years on average between AUD onset and treatment, though patients with comorbid anxiety exhibit shorter delays (Chapman et al., 2015).

1.2.2 Problematic alcohol use as a catalyst of personal change

While diagnostic criteria for AUD are well-operationalized and negative outcomes related to alcohol use can be clinically identified, the concept of *problematic alcohol use* remains ambiguous. For example, "lack of problem awareness" was the primary reason for not seeking treatment in a multinational sample of general practice patients diagnosed with AUD (Probst et al., 2015). These findings also indicated that self-identification of problematic drinking increased commensurate with AUD severity. In a similar study approach with male patients across VA primary care clinics, a majority of patients with AUD expressed some readiness to change (i.e., contemplation) or were already making changes to their alcohol use (Williams et al., 2006). Krenek et al. (2011) also found a strong relationship between AUD symptom severity and readiness to change alcohol use behavior. These findings align with the Transtheoretical Model of behavior change where problem identification is understood as an ongoing process of "consciousness raising." This is integral to moving from a stage of contemplation toward remedial action and maintenance of new patterns of behavior (Prochaska & DiClemente, 1982). Through this lens, problematic alcohol use can be understood as a state of increased awareness of alcohol-related concerns that, upon personal reflection, may warrant remedial action. This self-reflection can be appreciated across a broad spectrum of severity: from health-conscious abstainers or people who occasionally "overdo it" - to hospitalized inpatients with persistent denial of alcohol-related problems (Previte et al., 2015; Rinn et al., 2002). Clinical practitioners recognize that little can be therapeutically achieved by attempting to actively treat an AUD unless the patient recognizes their alcohol use as problematic (Rapley et al., 2006). In formative work by Cunningham et al. (1995), individuals who resolved alcohol problems through treatment were significantly more likely to report "hitting rock bottom" or receiving pressure from a spouse/partner as reasons for personal change. More common reasons to change alcohol use behaviors included evaluating pros-andcons, making a lifestyle decision, or being around someone else who was regularly intoxicated.

Resolving patterns of problematic alcohol use without treatment or supplemental recovery support is referred to interchangeably as *spontaneous remission* or *natural recovery* (Sobell et al.,

2000). Optimistically, a population survey by Sobell et al. (1996) indicated that more than 77% of individuals who resolved alcohol problems for at least one year did so with no help or treatment. However, a later review of longitudinal studies indicated that only up to 50% or as few as 14% of these AUD remissions are sustained through six months (Walters, 2000). Early predictors of three-year AUD remission among a natural recovery population include: lower levels of consumption, less severe alcohol use problems, more self-efficacy, and less avoidance coping (Moos & Moos, 2006). In a review by Carballo et al. (2007), pooled estimates across published studies resulted in a mean of 12.8 (SD = 4.9, Range: 6.0-19.7) average years of problematic alcohol use prior to natural recovery. Abstinence was the outcome for a mean of 57% of participants across studies and the remaining 43% was a "low risk drinking" outcome, which was inconsistently defined. An ongoing challenge in understanding natural recovery processes arises from inconsistent definitions of "recovery" across studies (Carballo et al., 2007; Sobell et al., 2000).

1.3 Recovery

1.3.1 Defining recovery

Similar studies by Ashford et al. (2019) and Witkiewitz et al. (2020) reviewed and synthesized definitions of recovery from national government and non-government organizations, medical societies, and the scientific literature. In total, this accounted for 16 working definitions of recovery, with 11 explicitly describing recovery as a "process" of change, and only six indicating abstinence from alcohol or substance use as a defining characteristic. As both resulting definitions carried unique and complementary concepts, a combination of Ashford et al. (2019; in

bold) and Witkiewitz et al. (2020; in italics) definitions of recovery can be stated as: "an individualized, intentional, dynamic, and relational process of behavior change involving sustained efforts to improve wellness, characterized by improvements in biopsychosocial functioning and purpose in life." In this context, recovery can be considered as a multifaceted process of goal-oriented behavior change associated with improved health outcomes. Doukas & Cullen (2009) posit that a terminal goal of being "recovered" ought to be left up to the individual to decide upon. However, recovery is commonly considered as a lifelong process once initiated, particularly when approached through clinical (i.e., AUD remission) or 12-step model perspectives (see Section 1.3.4.1). Witkiewitz & Tucker (2020) posit that the concept of recovery is (or ought to be) more closely aligned with longer term changes in patterns of behavior and overall well-being, with patterns of frequent controlled drinking and occasional heavy drinking notwithstanding. Kelly & Bergman (2020) counter that recovery – while not strictly requiring abstinence - remains conceptually incompatible with sustained patterns of heavy drinking that continue to put physical, mental, and social health at risk. Ignoring this, they argue, serves to normalize problematic alcohol use for people who sustain "functioning" status and perpetuates stigma against individuals who are in AUD remission but remain lower in overall functioning. Thus, quelling patterns of heavy drinking should be understood as a primary function of recovery in this context. This is consistent with my conceptual framing of recovery from problematic alcohol use, where individuals begin to identify alcohol use as a core problem to work on. Nonetheless, a broader conceptualization related to biopsychosocial functioning and life purpose extend the concept of *recovery outcomes* beyond a narrow purview of drinking-related goals.

Recovery can also be framed in broader social and interpersonal contexts, as in the *Social Identity Model of Recovery* (SIMOR; Best et al., 2016), which defines recovery as "*a social process, underpinned by transitions in social network composition, that includes the addition of new recovery-oriented groups, where such groups are perceived as attractive, beneficial, and relevant, and involves the concurrent emergence of a new recovery-based social identity.*" This definition is particularly helpful for framing processes of change that take place the context of social support (see Section 1.3.3). In this context, peer feedback can aide in the process of consciousness raising and provide extrinsic motivation and accountability to behavioral changes requisite for alcohol recovery.

1.3.2 Behavior and locus of control in recovery

In the context of health behavior change, the process of recovery is replete with complex interactions between general beliefs (e.g., about alcohol use and recovery), beliefs about one's ability to change (e.g., self-efficacy), motivations to change (see Section 1.2.2), and perceived control over the behavior in question. Based on the *Theory of Planned Behavior* (Ajzen, 1991), attitudinal and behavioral factors are specific to particular actions (e.g., turning down a beer that was offered...) within defined contexts (e.g., ... while at Friday happy hour with colleagues). While self-efficacy is likewise dynamic, one's *locus of control* (LOC) is theorized to be relatively stable across contexts and situations. That is, a person with *internal* LOC beliefs generally expects that outcomes (positive or negative) arise from their self-determination and behavior. Conversely, *external* LOC beliefs frame outcomes as reliant on outside forces (e.g., limited availability of options due to contextual factors, the influence of others, chance, fate, or a higher power). The orientation toward internal versus external LOC may also shift over time (Martin & Otter, 1996),

and is associated with engaging in different types of recovery support groups (E. C. Li et al., 2000). For example, participants in Alcoholics Anonymous are more likely to have external LOC beliefs, owing to the overall spiritual orientation of this community (E. C. Li et al., 2000; Murray et al., 2003). Unfortunately, external LOC beliefs have been associated with more expedient and intense bouts of drinking when lapses in sobriety do occur (Koski-Jännes, 1994), and with significantly shorter lengths of sobriety as compared to individuals with internal LOC beliefs (Murray et al., 2003). While people orienting toward external LOC beliefs have been found to receive a greater amount of social support (partly due to complaining more frequently), they are less likely to instrumentally benefit from social support compared to those with internal LOC beliefs who use feedback for behavioral reappraisal (Kowalski, 1996; Sandler & Lakey, 1982).

1.3.3 Social contexts and recovery identity

In the past decade, research has advanced new understandings about social contexts of recovery. In psychometric work by <u>Groshkova_et_al_(2011)</u>, a measure of recovery group participation was developed. Overall scores on this measure were most strongly associated with the number of people in recovery within one's social network and the amount of time spent with recovery peers, and these significantly predicted social quality-of-life. In a parallel study by this group, duration of sobriety was found to be significantly associated with having a social network comprised by a relatively large number of people in recovery, and also a mixture of substance non-users and current substance users (Best et al., 2012). Around this time, a study of US individuals receiving outpatient care for AUD found that the positive impact of Alcoholics Anonymous (AA) on alcohol use outcomes was primarily explained via social network changes and increases in *social abstinence self-efficacy* (Kelly et al., 2012). These formative studies as well as earlier

findings on benefits of recovery network size (<u>e.g., Zywiak et al., 2002</u>), contributed to theoretical development of the *Social Identity Model of Recovery* (**SIMOR**; <u>Best et al., 2016</u>).

SIMOR indicates that individuals who affiliate with recovery-oriented peer support networks become aligned with a *recovery identity* through socially mediated processes of peer engagement. Consequently, development of a recovery identity through support community participation has been associated with increases in self-efficacy and lower relapse rates (Buckingham et al., 2013), as well as increased sense of purpose and reduced distress (Cruwys et al., 2020). In another study, enhancements in recovery network and identity were found to be stronger predictors of quality-of-life than a culmination of primary indicators such as years of substance use, years in recovery, and years abstinent (Bathish et al., 2017). Socially ascribing to a recovery identity (i.e., identifying as "in recovery" to others) has also been found to mediate the negative effect of self-stigma on self-efficacy and well-being (Bliuc et al., 2019).

Through engaging in recovery-oriented activities and developing a recovery identity, *social recovery capital* is enhanced (Best & Laudet, 2010). This is reflected through developing personal strengths and resources through social exposure (e.g., by emulating recovery role models) and enhanced availability of community support and resources. Such supportive recovery relationships have been linked with changes in social status, increase in self-esteem, and acceptance of personal responsibility for changing substance use behaviors (Johansen et al., 2013). In the SIMOR framework, maintaining a positive balance of social recovery capital is intertwined with maintaining a recovery-oriented identity. A primary way of building social recovery capital is through regular and sustained engagement with mutual-help groups.

1.3.4 Mutual-help groups (MHGs)

"Mutual-help groups consist of individuals facing similar life difficulties who come together to help themselves and others" (Salem et al., 1997). MHGs are characterized by emotional supportiveness, cohesion, and reciprocity in giving and receiving support (Humphreys, 2003).

1.3.4.1 Alcoholics Anonymous and in-person MHGs

Alcoholics Anonymous is the largest mutual help *organization* for alcohol use, with an estimated 2.1M active members and 130K established groups worldwide (Alcoholics Anonymous World Services, 2020). Recent research has demonstrated that AA's abstinence-based, 12-step program, effectively contributes to long-term improvements in alcohol use trajectories (Kelly et al., 2020). However, only approximately 3% of the general population has been exposed to AA or similar 12-step programming (Kaskutas et al., 2008), and there are myriad reasons why individuals may not engage in this type of peer-based support. For AA in particular, the stigma associated with accepting an "alcoholic" identity and the spiritual orientation of 12-step programming can present substantial barriers to individuals' willingness to engage (Schmidt, 1996). Secular, peer-oriented programs, such as Self-Management and Recovery Training (SMART), LifeRing, and Women for Sobriety, may be more appealing and be comparatively effective in these contexts (Zemore et al., 2017, 2018). However, these alternative groups are more limited in reach and individuals may not have reliable access to them. For example, while the de-centralized nature of AA rapidly expanded its global reach and ubiquity (AA's founder, Bill W, described this as "benign anarchy"), alternative organizations have experienced substantially less growth on account of their more formal and controlled organizational structures (Kelly & White, 2012).

Other barriers to engagement with alcohol support groups are germane to the in-person nature of traditional peer support. As meetings occur at predetermined days, times, and locations, practical concerns of scheduling and transportation apply. Thus, individuals with physical disability or with demanding schedules due to their occupation or family responsibilities face heightened barriers to regular meeting attendance. Particularly in small towns and rural communities where meetings are sparse, attendance at meetings is not assuredly anonymous. For example, while meetings need to be discoverable for new individuals to join (Kang, 2019), community knowledge of meeting spaces can result in individuals' affiliation with AA being discovered, leading to deleterious social and legal consequences (e.g., State of Idaho v. Ashworth, 2009). Additionally, youth engagement and representation within mutual support organizations such as AA has been declining since the 1990s (Kaskutas et al., 2008). This may relate to a perceived lack of "fit" among young people in these settings (Kelly et al., 2008). Thus, while AA and similar mutual-help organizations can provide effective support in the recovery and management of problematic alcohol use, substantial barriers limit the capacity for individuals to effectively engage with these organizations. Since early-2020, due in large part to social distancing related to the COVID-19 pandemic, mutual-help organizations have shifted in-person meetings to video meeting formats, which may lower overall barriers to engagement (Bergman et al., 2021).

1.3.4.2 Digital MHGs for problematic alcohol use

While the recent shift from in-person to video meetings has been striking, mutual help organizations and their members have been aware of the useful potential of online resources and support for quite some time. AA members have been meeting on UseNet forums since as early as 1983 and the AA organization has maintained an organizational webpage since 1995 (Alcoholics Anonymous World Services, 2021; W. L. White, 2009). SMART Recovery was hosting online

meetings and message boards on its website by 1998 (SMART Recovery, 2021). By the turn of the millennia, the advances and ubiquity of Internet connectivity also gave rise to grassroots MHGs in the form of blogs, newsgroups, and chatrooms (Lievrouw & Livingstone, 2005). Formative research in this realm led to the development of the *Pathways Disclosure Model*, describing how severity of addictive behavior and associated stigma are associated with the intensity of one's engagement with MHGs, mapped across a continuum of personal disclosure (Cooper, 2004). In particular, passive "lurking" in digital MHGs was deemed a low-disclosure activity, though it may result in increasingly active digital engagement (greater disclosure) and/or initiating in-person MHG activities (even greater disclosure) over time. Thus, even superficial engagement with digital MHGs can be understood as a potential pathway toward more intense and intentional MHG engagement, as a recovery identity develops and personal disclosure becomes more comfortable.

In 2005, VanLear et al. published a formative study of observed behavior in AA forums and chats, which laid basic groundwork for understanding alcohol-related recovery contexts online. By 2006, AlcoholHelpCenter.net was recruiting participants to join its new recovery forum and inviting researchers to observe and evaluate forum engagement (Cunningham et al., 2008a). This work built upon the pathways disclosure model and provided formative understandings about the mechanics of web-based MHGs, particularly with respect to platform capabilities, moderation strategies, and types of support that community members share. Several other studies of AlcoholHelpCenter followed (Cunningham, 2012; Cunningham et al., 2017; Urbanoski et al., 2017), and other novel online recovery platforms came into research focus (e.g., Andrade et al., 2016; Carah et al., 2015; Chuang & Yang, 2012; Kosok, 2006). As digital technology has continued to evolve, studies have likewise shifted focus toward recent advances where MHGs are increasingly engaged via social media and mobile applications (Bergman & Kelly, 2021).

1.3.4.3 The role of social media data

Since MHG activities have taken root in highly active social media platforms (e.g., Facebook, Reddit, Twitter), there has been growing interest from researchers to leverage "big data" approaches to understand contexts of addiction recovery (Lu et al., 2019; Sznitman, 2015). This technological shift has propelled the research field of *computational social sciences* where researchers access large swaths of digital data and use statistical algorithms to examine social processes (Alvarez, 2016; Tang et al., 2014). Such *data-driven* approaches are typically descriptive observations or simulations that are not appropriate for causal inference (Cioffi-Revilla, 2017; Emmert-Streib & Dehmer, 2021). Particular caution is warranted around regarding descriptive or correlational big data analytics as terminal points for scientific inquiry, as some have proposed (Mazzocchi, 2015). However, computational social science approaches remain highly useful for refining social theory and generating testable hypotheses for causal models (Emmert-Streib & Dehmer, 2021; Maass et al., 2018). As online MHGs are rapidly evolving in new technological and social directions, continued attention to formative, descriptive, and theoretical work is critical.

For an example specific to MHGs for problematic alcohol use, the /**r**/stopdrinking (SD) forum on the Reddit social media platform has captured the attention of computational social scientists (Harikumar et al., 2016; Tamersoy et al., 2015, 2017), national press (Dewey, 2016), and the Recovery.org website (American Addiction Centers, 2015). Research-to-date on this platform has focused on computational approaches to uncover patterns of association among language (e.g., sentiment, semantics), network ties (e.g., responses sent and received), and user metadata. In

particular, studies used metadata from users' "Sober Badge" as a proxy for patterns of alcohol use or abstinence. While theory-driven hypotheses were not explicitly tested, descriptive findings indicated that quantifiable characteristics of unsupervised language models and network features were significantly associated with proxies of alcohol use outcomes. This work provided useful insights into novel data collection and analysis approaches in this milieu, though the findings warranted some reappraisal from theoretical and methodological perspectives (see Section 3.1.2).

Subscribership to SD has also grown nearly 10-fold since these earlier studies, with a boost in public interest due to coverage in the Washington Post (Dewey, 2016; /u/stratyturd [moderator], 2016). Figure 1.1 illustrates the timeline of research data collection, press coverage, and growth in subscribership. As prior research has demonstrated feasibility of conducting computational social science approaches in this forum and due to SD's growing popularity, this situation presents an opportunity to enhance understandings of this community through theory-driven contextualization and hypothesis testing. This will advance both theory and methods in understanding the role of digital MHGs in recovery from problematic alcohol use.



Figure 1.1 Timeline of /r/stopdrinking subscribership and data collection

1.4 Scope of the research chapters

The following three chapters represent distinct but inter-related projects that will elucidate *characteristics, content, and commitment* in the realm of digital MHGs for problematic alcohol use. **Chapter 2** is a scoping review of the scientific literature to describe the *characteristics* of digital MHGs for problematic alcohol use, and the approaches used to study them. **Chapter 3** is a descriptive analysis of SD forum activity, content posted, and critical evaluation of Sober Badge data to characterize *contexts* of digital MHG engagement. **Chapter 4** leverages computational social science approaches to test hypotheses about early engagement patterns that are associated with *commitment* (i.e., sustained engagement) of new SD users.

2.0: Scoping review of digital mutual help groups for problematic alcohol use

2.1 Introduction

2.1.1 Background

In recent years, a number of digital *mutual help groups* (MHGs) have emerged within the alcohol recovery support milieu. MHGs have been broadly defined by <u>Kelly & Yeterian (2011)</u> as "groups of two or more people who share an experience or problem and who come together to provide problem-specific help and support to one another." Due to this broad definition and less formal nature of MHGs as compared to recovery *organizations* like AA, MHGs may not necessarily have formal recovery *programs* or meeting structures. These groups can include video meetings as well as novel communication formats such as online forums and chat rooms (Bergman & Kelly, 2021). Mobile applications tailored to alcohol recovery offer additional ways to access MHGs alongside other features like in-person meeting finders or sobriety trackers (Savic et al., 2013). Additionally, popular social media platforms like Facebook and Reddit provide a framework to support ad-hoc MHGs (Bergman et al., 2018), and recovery-specific websites like InTheRooms serve as an online hub for members of several mutual help organizations and informal MHGs (Yao & Yarosh, 2016).

Digital MHGs offer diverse alternatives or supplements to in-person MHG engagement. These may be particularly appealing to individuals who have limited engagement with mutual help organizations for a variety of practical or personal reasons. For example, digital MHGs offer convenient access to informal support via computer and mobile devices. This may be appealing to individuals who are younger and more technology-savvy, or who have less severe alcohol use profiles and are unlikely to seek in-person support (see Section 1.2.1). Additionally, as digital MHGs are diverse with respect to program format and recovery goals (e.g., abstinence, moderation, harm reduction), individuals are likely to find relatable peers and this can help to sustain interest in MHG engagement (Sanger et al., 2019).

However, the research on this topic is not well cataloged, and understandings about digital MHGs for alcohol use recovery are spread across disciplines of health research and computer science. This presents problems in making recommendations about particular MHGs or particular approaches to MHG engagement that may be more-or-less beneficial. As this area of research is relatively young, a systematic review to test specific hypotheses in this realm may be premature and a *scoping review* was deemed more appropriate. A methodological paper from the Joanna Briggs Institute (Peters et al., 2015) describes the difference between systematic and scoping reviews: "Whereas a typical systematic review aims to answer a specific question or series of questions according to a rigid set of *a priori* delimiting factors detailed in the protocol, a scoping review will have a broader approach, generally with the aim of mapping literature and addressing a broader research question."

2.1.2 Aims of this review

The broad research question that framed the current review was: *What is the available evidence pertaining to the use and effectiveness of digital MHGs for problematic alcohol use?* As the literature review progressed, this broad question was further elaborated into specific questions:

- What alcohol-related digital MHGs have been studied and what are their defining characteristics?
- What methods have been used to establish evidence for the use and effectiveness of digital MHGs in alcohol recovery?

2.2 Methods

Methods were guided by the PRISMA-ScR framework for conducting structured scoping reviews (Tricco et al., 2018). Specifically, this framework involves a 22-item checklist outlining critical reporting aspects for conducting and reporting scoping review research. As the data for this study was limited to published literature and publicly available information, Institutional Review Board approval was not required. In accordance with dissertation requirements, this study was led by myself (**JC**) and collaborators were involved to the extent necessary to ensure rigor of the review procedures. Collaborator contributions are indicated by initials throughout the methods section, in order of appearance: Mary Lou Klem, PhD, MLIS (**MK**), Kevin Kraemer, MD (**KK**), Galen Switzer, PhD (**GS**), Beth Hoffman, MPH (**BH**), Kimberly Hsuing, MD (**KH**), Diana Samberg, MD (**DS**), and Sara Spinella, MD (**SS**).

2.2.1 Keyword selection

The primary author (JC) and a medical research librarian (MK) at the University of Pittsburgh Health Sciences Library System developed an initial set of literature search keywords within three conceptual domains of: (1) alcohol-related, (2) MHG-related and (3) digital-related. We used an iterative process involving in-person meetings and email correspondence to evaluate search performance and refine keywords within these three domains. For example, we expanded the alcohol-related domain to include keywords broadly related to substance use, in order to capture contexts of polysubstance use that may also include alcohol. For another example, the digital-related domain was refined to include relevant social media platforms (e.g., Facebook, Reddit) and methods of accessing other digital resources (e.g., mobile apps).

Searches included operators (e.g., *AND* and *OR* joining criteria) to narrow the scope of search results such that qualifying records would need to match for at least one term within each of the three conceptual domains. Search syntax was further tailored to match input criteria specific to each bibliographic search database and refined to optimize search performance. For example, some databases offer specific settings to match terms across specified metadata fields, while others lack such functionality. Specific search keywords and syntax are listed in Appendix A.

2.2.2 Database selection

Six bibliographic databases captured relevant literature across health sciences and information sciences disciplines. To ensure a broad scope of high-quality health sciences literature, we searched for peer-reviewed articles in PubMed, Current Index to Nursing & Allied Health

Literature (CINAHL), and PsycINFO databases. To capture emerging research, clinical trial protocols were also included in results. We supplemented this literature base by searching within three information sciences databases. Foremost, the Institute of Electrical and Electronics Engineers (IEEE) database indexes peer-reviewed journals that may publish relevant material related to digital technology, but as these journals are discipline-specific many are not included in the aforementioned health science databases. For example, *Internet Research* journal (indexed by IEEE) is a potential source of relevant articles, but is not indexed in the databases mentioned earlier. Two additional databases related to information science, ArXiV and Association for Computing Machinery (ACM) Digital Library, include full-text conference proceedings and "grey literature" such as unpublished technical papers and preprints of papers that may be published at a later date. These artifacts are important in information science contexts, as they may be the final product of record, particularly for peer-reviewed conference proceedings.

On 11/18/2019, MK conducted primary searches of three health science databases (PubMed, CINAHL PsycINFO) and one information science database (IEEE) of published research literature, resulting in 3429 bibliographic records. Bibliographic records were imported into DistillerSR software, deduplicated, and 2526 unique records were included in screening procedures. Figure 2.1 details the number of records per database. MK updated the search results on 8/30/2020, which yielded an additional 316 unique records to screen. JC ran queries of ArXiV and ACM on the same date. The online ArXiV and ACM searches differ from the previous methods in two functional ways: (1) the online search portals algorithmically return the most relevant matches first, and (2) the number of results may be limited due to functionality of the online search portals. In particular, the ArXiV database full-text search portal returned a maximum
of 200 results. This limit was encountered when the search strategy was broadened to match alcohol-related and MHG-related criteria; the digital-related criterion was removed as imposing this additional restriction resulted in sparse results from these two databases.

2.2.3 Screening and abstraction

JC developed an initial framework to screen titles and abstracts for potential relevance to the project scope, where bibliographic items were required to meet basic inclusion and exclusion criteria. JC sought feedback from MK, KK, and GS to refine the scope of inclusion and exclusion criteria. The initial screening form was piloted by JC and BH, who have previous experience in conducting systematic and scoping reviews. Both screeners worked independently on a set of approximately 100 abstracts. Screening data were adjudicated and the screening form was refined and clarified to provide clearer definitions (e.g., *mutual help group*) and to account for emergent themes within the literature. A copy of the final title and abstract screening form is included in Appendix B. JC trained three physician researchers as additional reviewers (KH, DS, and SS). Each of the 2842 unique records from the initial database search (PubMed, CINAHL, PsycINFO, IEEE) were independently screened by JC and one secondary reviewer, and disagreements were adjudicated via regularly scheduled teleconferences. For the ArXiV and ACM searches, titles and abstracts were screened in the online portal by JC and entries were added to the Distiller platform for unique records that were potentially relevant (1 for ArXiV and 15 for ACM). These were then screened and adjudicated with secondary reviewers.

JC developed an initial framework for screening and abstraction of the full-text of items that were included from the earlier screening process. JC then incorporated formative feedback

from KK and MK and sought additional feedback from BH, KH, DS, and SS on a group teleconference. JC further refined the form and piloted it by reviewing 20 full-text articles, with each secondary reviewer overlapping on five articles. JC collected feedback from that process via email and finalized the full-text screening and abstraction forms (see Appendix B). JC then proceeded through the screening and abstraction process for the remainder of the articles, with secondary review responsibilities split approximately evenly among BH, KH, DS, and SS. During the full-text screening process, data were abstracted to include broad study type, population, specific virtual MHGs mentioned, and narrative summaries of relevant findings. Reviewers adjudicated disagreements of full-text inclusion and exclusion criteria via regularly scheduled teleconferences. Two additional exclusion criteria were clarified through ongoing meetings among reviewers. First, reviewers agreed to explicitly exclude digital support groups that relate to alcohol use among family members (e.g., Al-Anon) since this does not necessarily relate to getting support for one's own alcohol use. Second, forums that mention substance use were excluded unless there was an explicit mention of alcohol use, either as a behavioral outcome (e.g., abstinence, severity of use) or as a topic examined via descriptive analysis in the study.

For relevant review articles (e.g., systematic reviews, meta-analyses), JC further examined the literature included in these reviews to determine if additional studies could be added to the current review. For this process, summary tables and narratives within the review articles were screened for primary research identified as being alcohol-related or having MHG features (e.g., forum, chat, peer support). Potentially relevant articles were screened included as appropriate.



Figure 2.1 Scoping review flowchart

2.2.4 Synthesis of results

Metadata from relevant full-text articles in the Distiller-SR platform were exported to a spreadsheet. This included basic reference information (e.g., ID#, title, authors, year of publication), abstract, and fields populated by annotators (e.g., name of MHG, platform type, study method, clinical context, primary findings). These data were further reviewed by JC for consistency and comprehensiveness, and full-texts were re-reviewed for clarification on points of uncertainty. During this process, study designs were further contextualized (e.g., observational studies subcategorized by methodological approaches used). Using a constant comparative method (Glaser, 1965), emergent themes were also noted with respect to the focus of articles. Example themes included digital MHG platform characteristics, outcomes related to sustained platform engagement or alcohol use outcomes, or the usability or acceptability of particular digital MHGs.

Narrative summaries were developed to synthesize research around each of the specific MHGs identified, which comprised approximately 20 pages of text. Narrative summaries were then reduced into succinct results narratives and merged into tables to facilitate easy cross-reference of studies within defined analytic frameworks (e.g., specific MHGs, study designs). The results section was then organized around the overarching research questions, with contextual examples and details drawn from the synthesis spreadsheet and narrative summaries.

2.2.5 Identification of digital MHG status

After MHG platforms were identified, JC conducted online searches to determine the status of each platform. This included following links from the primary research articles where available

and conducting searches for platform names using the Google search console. A platform was considered available if it had a website or presence in at least one mobile application marketplace (e.g., Google Play Store, Apple Store). When an online platform was identified, the corresponding website was accessed to determine if (1) MHG activity was publicly visible and if so, (2) if the MHG remains active as evidenced by forum activity. A platform was deemed "inactive" if there was no forum activity in the past year or "private" if forum activity was not publicly visible. These findings were summarized alongside each of the identified MHGs in Table 2.1.

2.3 Results

Results are organized with respect to the distinct research questions under investigation. First, specific digital MHGs identified within the literature are organized by platform. Second, literature is presented by study design with descriptions of methods and primary findings.

2.3.1 What alcohol-related digital MHGs have been studied and what are their defining characteristics?

Within the reviewed literature, 20 alcohol-related digital MHGs were directly studied. In Table 2.1, publications are organized chronologically within MHGs, which are grouped as *mobile applications* or *online sites. Representative publications* reflect studies that are informative about some aspect of digital MHG participation. For example, 11 publications are identified in Table 2.1 for A-CHESS. Other publications related to this app were omitted if they did not assess MHG features (i.e., focused on other app functionality or general app use). Two additional studies used

the Facebook social media platform (Haug et al., 2020; Ramo et al., 2019), but are not included here as they were staging social media interventions unrelated to MHG participation. Studies were also omitted if they used online MHGs as a recruitment point but did not directly assess aspects of the online MHG itself (e.g., Zemore et al., 2017) or if they were a general population survey where respondents self-reported using one or more online MHGs. Common characteristics of identified MHGs are discussed further in Section 2.4.1.

2.3.2 What methods have been used to establish evidence for the use and effectiveness of digital MHGs in alcohol recovery?

Through abstraction, study designs of primary research articles were broadly categorized as descriptive or inferential. Given the diversity of study designs observed, further categorization was desirable to clarify groupings. Results are thus grouped and ordered to reflect a modified hierarchy of evidence model (Evans, 2003). If multiple designs were used within an article, it may be listed in more than one category.

Category	Name	Description and status (as of April 2021)	Representative publications
Mobile apps	A-CHESS	Licensed to treatment providers and health plans by CHESS Health. Freely	(Gustafson et al., 2011)
		available to registered users in the US as the "Connections" app, sponsored	(McTavish et al., 2012)
		by Addiction Policy Forum.	(Gustafson et al., 2014)
			(Chih, 2014)
			(Ford et al., 2015)
			(Liu et al., 2017)
			(Kornfield, Sarma, et al., 2018)
			(Kornfield, Toma, et al., 2018)
			(Yoo et al., 2018)
			(Yoo et al., 2020)
			(Liu et al., 2020)
	CASA-CHESS	Spanish language version of A-CHESS. Undergoing research testing.	(Muroff et al., 2017)
	_	Public availability unclear.	(Muroff et al., 2019)
	Addict Free	App concept. Not available or unclear.	(Z. Yang et al., 2019)
	Daybreak	Formerly "Hello Sunday Morning" online forum. Available on Android	(Tait et al., 2019)
		and iOS app stores. Free in Australia and paid use elsewhere.	
	Seva	Unavailable.	(Quanbeck et al., 2018)
	Sober Grid	Freely available on Android and iOS app stores. Active forum and	(Ashford, Giorgi, et al., 2020)
		messaging features.	
Online sites	Alcoholics	Various forums and chatrooms of AA program members. Status of specific	(VanLear et al., 2005)
	Anonymous	forums varies.	(Lyytikäinen, 2016)
	Alcohol Help	Decommissioned. Some features were integrated into the "Evolution	(Cunningham et al., 2008a)
	Center	Health" platform, which is licensed to healthcare organizations. This	(Cunningham, 2012)
		platform maintains a public "Managing Drinking" program forum with	(Mierlo et al., 2015)
		limited activity.	(Cunningham et al., 2017)
			(Urbanoski et al., 2017)
	Alkoholhjälpen	Swedish language forum. Public, free, and active.	(Ekström & Johansson, 2020)
	Bebermenos	Spanish language online program. Availability unclear.	(Andrade et al., 2016)

Table 2.1 Digital MHGs, associated characteristics, and representative publications

Table 2.1 continued

Online sites (continued)	Drinking Diaries	Public blog for women. Inactive as of 2015.	(Y. Yang & Tang, 2018)
	HAMS	The "Harm reduction, Abstinence, and Moderation Support" (HAMS) site maintains an e-mail listserv, chatroom, and forum with unclear levels of activity.	(Haug et al., 2020)
	Hello Sunday Morning	Became the "Daybreak" app and the forum was subsequently decommissioned.	(Carah et al., 2015) (Pennay et al., 2016) (Carah et al., 2017) (Kirkman et al., 2018) (Pennay et al., 2018) (Black et al., 2020)
	InTheRooms	Online meeting hub including forums, chat rooms, and video meetings. Private, free, and active.	(Yao & Yarosh, 2016) (Rubya & Yarosh, 2017a) (Rubya & Yarosh, 2017b) (Bergman et al., 2017) (Zemore et al., 2018)
	MedHelp: Alcoholism	Forum for asking health questions and sharing medical advice. Public, free, and active.	(Chuang & Yang, 2012) (Polander & Shalin, 2013) (Chuang & Yang, 2014)
	Moderation Management	Scheduled chat meetings, email listserv, and private Facebook group available. Public forum inactive as of 2019. Private forum activity unclear.	(Humphreys & Klaw, 2001) (Kosok, 2006) (Hester et al., 2011)
	SMART Recovery	Scheduled video meetings available. Forum is public/private, free, and active.	(Hester et al., 2013)
	Sober Recovery	Forum, blog, and treatment linkage. Forum is private, free, and presumably active (based on site metrics).	(Polander & Shalin, 2013) (Bliuc et al., 2019)
	Soberistas	Forum for women in recovery. Private, paid use, and unclear activity.	(Chambers et al., 2017) (Sinclair et al., 2017)
	Reddit: StopDrinking	One of several alcohol forums on the Reddit social media platform. Public, free, and active.	(Tamersoy et al., 2015) (Tamersoy et al., 2017)
	Uncommon Forum: Addictions	Public, free, and active. However, posts over the past year are almost entirely cannabis related.	(Polander & Shalin, 2013)

2.3.2.1 Literature reviews

Among articles included for synthesis, one was a review of systematic reviews, one was a meta-analysis, four were systematic reviews (Ashford, Bergman, et al., 2020; Elaheebocus et al., 2018; Fowler et al., 2016; Hutton et al., 2020), and four were other types of literature reviews (Colbert et al., 2020; Gustafson et al., 2011; Meredith et al., 2015; Quanbeck, Chih, et al., 2014). The review of systematic reviews by Sundström et al. (2017) did not generate any additional records of relevance to be added to the current scoping review. The meta-analysis of computer-delivered interventions by Rooke et al. (2010) identified seven platforms with MHG features, two of which were relevant to alcohol use and were already captured in the current scoping review. In the meta-analysis, inclusion of an MHG feature did not have a significant moderating effect on reducing substance use behavior across clinical trials (Rooke et al., 2010).

All but one of the systematic reviews focused on technologies used in clinical interventions. The other systematic review focused on Digital Recovery Support Services (D-RSS), which is more closely aligned with the concept of digital MHGs (Ashford, Bergman, et al., 2020). A primary difference in scope between this and the present scoping review is that the D-RSS review inclusion criteria stipulated that trials must have identified individuals as having an alcohol use disorder or substance use disorder. Of the 22 articles included in the D-RSS review, 18 were captured in the present scoping review, three were outside of scope (i.e., not MHGs), and one was subsequently included for abstraction (i.e., Dugdale et al., 2016). No other review articles yielded additional records that directly approached digital MHGs for problematic alcohol use.

A commonality among five of the reviews was the inclusion of articles related to the A-CHESS mobile platform (Ashford, Bergman, et al., 2020; Fowler et al., 2016; Gustafson et al., 2011; Meredith et al., 2015; Quanbeck, Chih, et al., 2014). As this platform includes MHG features, the relevant articles were well represented in the current scoping review. However, not all A-CHESS related articles were included in the final literature synthesis, as only 11 of them mentioned MHG functionality among the other available platform features. Nonetheless, A-CHESS was the most widely studied digital platform across earlier reviews as well as within primary research identified through the present review (see Table 2.1).

2.3.2.2 Randomized trials

Results included six trial protocols and ten published trials that focused on alcohol use and integrated a platform or treatment including a digital MHG component. Selected results are described in the context of how digital MHG features were addressed within study designs.

Trial protocols. Six published trial protocols were included for synthesis (Cunningham et al., 2015; Garnett et al., 2016; Kay-Lambkin et al., 2015; McKay et al., 2018; Quanbeck, Gustafson, et al., 2014; Tait et al., 2018). Of these, four had associated results that were published and captured via the scoping review. One had no associated results directly related to MHG engagement but was included as it identified the Club Soda MHG as a study participant recruitment source (Garnett et al., 2016). The other described a three-arm trial including treatment enhanced with digital MHG access in one arm (Kay-Lambkin et al., 2015). However, results of this trial were either unpublished or not ascertainable through additional literature searches.

SMART Recovery engagement. One trial of heavy problem drinkers compared SMART Recovery meeting engagement (in-person or online; control condition) to a brief digital intervention without MHG features (experimental condition) and a third group with both SMART Recovery engagement and the brief intervention (Hester et al., 2013). By 3-month follow-up, all three groups significantly increased percent of days abstinent, decreased average drinks per day, and decreased alcohol or substance use related problems. Among participants exposed to the intervention, actual use of SMART online meetings was positively associated with percent of days abstinent. In the study control arm with SMART only, in-person meeting attendance was associated with greater average drinks per day at 3-months. Results indicated that outcomes were comparable between the brief digital intervention and SMART attendance, though attendance at in-person meetings was associated with more favorable outcomes as compared to attendance at online meetings. While in-person versus online meetings was not directly controlled for in the study, there is some evidence for in-person meetings being of potentially greater benefit.

Daybreak app use. MHG engagement was included as covariate in a trial examining health coaching within the Daybreak mobile application (Tait et al., 2019), which includes "blog" functionality. The authors report that nearly half of blog posts received five or more comments within 60 minutes. Posting of blogs was not independently associated with alcohol-related outcomes, though a time interaction indicated significant but modest associations with reduced alcohol use at 1- and 3-month follow-up. Frequency of commenting on others' blogs was associated with higher AUDIT-C scores overall, and significantly decreased scores at 1-month follow-up.

Harm-reduction among rural women. Two articles reported on a small harm-reduction trial for rural adult women with hazardous drinking, as defined by quantity and frequency criteria (Finfgeld-Connett, 2009; Finfgeld-Connett & Madsen, 2008). Standard care was the provision of printed educational and decision-making modules. The experimental group had access to these modules via a website that also included forum and chat features. There was no significant difference between groups with respect to treatment program satisfaction or drinking reduction at 3 months. MHG engagement was not independently evaluated as a predictor or covariate in either study report. Participants in the online group reported preferences for casual forum use over scheduled chat discussions and preferred reading posts over actively posting in the forum.

Other trials. The remaining trials offered limited information about digital MHG engagement, as this was not directly assessed. Hester et al. (2013) and Campbell et al. (2016) compared brief online interventions to an MHG participation condition, but in-person versus digital engagement was not differentiated. In Cunningham (2012), participation in an intensive online program that also included MHG features (versus a brief online intervention), predicted reduced quantity of alcohol consumed on the heaviest drinking day. No significant differences were found on AUDIT scores or drinks per week. In a similar study by Cunningham et al. (2017), an online intervention that included MHG functionality as well as other features performed no better than a brief online intervention. An additional trial (Gustafson et al., 2014) and secondary trial analysis (Glass et al., 2017) reported outcomes related to use of the A-CHESS platform that included MHG features, but the extent of participant engagement with these features was not reported.

Table 2.2 Summary of observational studies

Approach	Venue	Summary	Publications
Activity	A-CHESS app	Three studies describe patterns of activity with MHG app features (e.g.,	(McTavish et al., 2012)
monitoring		messages, discussion board). Recovery outcomes were not significantly	(Chih, 2014)
_		associated or were not evaluated in this context.	(Muroff et al., 2017)
		Language models predicted lapses more strongly than activity	(Kornfield, Toma, et al., 2018)*
		indicators did. *See Computational linguistics	
	Hello Sunday	Greater engagement with MHG features was associated with reduced	(Kirkman et al., 2018)
	Morning forum	alcohol consumption at 3-months.	
	SoberGrid app	Users who frequently used the check-in feature had shorter sobriety	(Ashford, Giorgi, et al., 2020)*
		length and greater number of relapses. *See Social dynamics	
Social	Alcohol Help	Forum traffic varied over time and clustered around nodes that	(Cunningham et al., 2008b)*
dynamics	Center forum	consisted of more active users. *See Content analysis	
		User rank followed a "power law" distribution of activity.	(Mierlo et al., 2015)
		The forum network was composed of one component. Forum	(Urbanoski et al., 2017)*
		moderators facilitated user connections. *See Content analysis	
	Reddit:	Providing support to others via commenting was associated with	(Tamersoy et al., 2017)*
	StopDrinking	reduced hazard of relapse (measured by Sober Badge).	
	forum	*See Computational linguistics	
	SoberGrid app	Users with a larger number of unilateral network connections had	(Ashford, Giorgi, et al., 2020)*
		longer sobriety length.	
Computational	A-CHESS app	LIWC software identified text features. Language models identified	(Kornfield, Sarma, et al., 2018)
linguistics		cravings and mental health concerns. Language models predicted lapses	(Kornfield, Toma, et al., 2018)*
		more strongly than activity indicators did.	
	Hello Sunday	Leximancer software was used for visual identification of topics prior	(Carah et al., 2017)*
	Morning forum	to and after 1-month of forum engagement. *See Content analysis	
	Reddit:	VADER software identified text features. Language models predicted	(Tamersoy et al., 2015)
	StopDrinking	sobriety length (Sober Badge). Self-attentional and present-tense focus	(Tamersoy et al., 2017)*
	forum	increased risk of relapse. Positive emotions and self-disclosure were	
		protective of relapse.	
	Sober Recovery	LIWC software identified text features. Self-stigma predicted weaker	(Bliuc et al., 2019)
	forum	group identification, which predicted selfefficacy and well-being.	
		Social identification with a recovery identity mediated these	
		relationships.	

Table 2.2 continued

Content A-CHESS app analysis	Qualitative content analysis of messages and responses. Emotional support was more likely to be provided in response to positive emotions and informational support was more likely to be provided in response to negative emotions, recovery problems, or requests for help. Among users with low self-efficacy, providing emotional support was associated with lower risk drinking and provision of informational support was associated with higher risk drinking. Among users with low self-efficacy, providing informational support was associated with low self-efficacy, providing informational support was associated with low risk drinking.	(Liu et al., 2017) (Liu et al., 2020)
	Computer assisted content analysis of messages. Emotional support was associated with improved coping and decreased distress.	(Yoo et al., 2018)
Alcohol Help Center forum	Qualitative content analysis of posts identified themes of: new introductions, greetings, supportive statements, suggested strategies, success stories, and difficulties.	(Cunningham et al., 2008b)*
	Themes among posts included: questions/answers about the program, encouragement and support, suggestions about effective behavioral strategies, and descriptions of personal motivations and hopes/fears for the future.	(Urbanoski et al., 2017)*
Alcoholics Anonymous forums	Qualitative content analysis of forum and chatroom. Forum dialogue had less superficial discussion and was more personal and supportive than chatroom dialogue. MHGs exhibited greater intimacy of self- presentation behaviors, more agreement and acceptance, and less rejection as compared to online general interest groups.	(VanLear et al., 2005)
	Qualitative content analysis of a Russian AA forum. Users appreciated the online modality, though many emphasized the importance of face- to-face groups. Internet discussion was viewed as a complementary but insufficient standalone resource, though video meetings were reported as a reasonable compromise.	(Lyytikäinen, 2016)
Drinking Diaries blog	Qualitative analysis indicated narratives of age, gender roles, rebellion, and stigma among female alcohol users.	(Y. Yang & Tang, 2018)

Table 2.2 continued

alysis Hello Sunday D Morning forun	Thematic analysis of MHG posts indicated themes of "selfhood" related to abstinence and building resilience. Barriers to abstinence included stress, fatigue, social contexts, and negative effects of cessation. Useful strategies included the use of online support, self-talk, non-alcoholic drinks, and sober activities.	(Pennay et al., 2016) (Pennay et al., 2018)
	Posts in the first month of engagement uniquely reflected themes of current drinking patterns and personal goal setting. Later posts included reflections on social identity, self-evaluation, and recommendations for others.	(Carah et al., 2017)*
MedHelp: Alcoholism forum	Among types of nurturant support appearing in MHG content, emotional support appeared more frequently than network or esteem support. Nurturant support was sought and received primarily via journal posts and comments. Informational support was sought and received primarily via the forum.	(Chuang & Yang, 2012) (Chuang & Yang, 2014)
	Participants typically to conveyed concrete psychosocial content via narratives and abstract content via figurative language across conceptual domains.	(Polander & Shalin, 2013)
Other / various online venues	Thematic analysis across three UK-based MHG forums. Themes included: disclosure about problematic drinking experiences (i.e., "sharing"), supporting others through encouragement and feedback, and having mutual goals in maintaining sobriety. Support included: empathy, understanding, validation, and encouragement.	(Coulson, 2014)
	Thematic analysis of two public MHG forums for dual-diagnosis. Themes included: loss of control, focusing on mental illness, meaningful life activities, and honesty. Individuals sought and received advice related to treatment and condition management.	(Edward & Robins, 2012)
	Qualitative analysis of online forums for pregnant women in France. Users were aware of alcohol-related risks in pregnancy though they debated "zero alcohol" guidelines.	(Toutain, 2013)

2.3.2.3 Observational studies

Studies were sub-categorized by approach as *activity monitoring*, *social dynamics*, *computational linguistics*, and *content analysis*. These categories are not discrete as several studies used multiple approaches. Table 2.2 includes a summary of observational studies. Studies included in more than one category are marked with an asterisk, with summaries of findings reported within the relevant approach category.

2.3.2.4 Surveys

Surveys are subcategorized as *geographic population surveys* that examined national or international samples, *online sampling surveys* that used convenience samples or snowball strategies, and *MHG-specific user surveys* that focused on particular digital MHG environments. Results are presented chronologically within these groupings.

Geographic population surveys

US National Recovery Study. (Bergman et al., 2018) conducted a secondary analysis of the National Recovery Study survey, which provides a representative sample of 2,002 US adults who have resolved an alcohol or substance use problem. Results indicated that 11% of participants engaged in lifetime use of "recovery-related use of online technology" and 48% of these technology users reported alcohol as their primary substance. Among all respondents, 4.9% used a general interest social networking site (e.g., Facebook: 3.4%), 4.1% used an online mutual-help organization (e.g., AA: 2.1%), 3.0% used a recovery-specific social networking site (e.g., InTheRooms: 1.0%), and 5.6% used another digital resource (e.g., mobile app without MHG features). Predictive factors of recovery technology use included younger current age, older age of

first substance use, Hispanic ethnicity, use of anti-craving/relapse medication, use of recovery support services, having a drug court arrest, and psychological distress. Controlling for demographic factors, users of online technology were four times more likely to indicate symptoms of Internet addiction. While relevant to digital MHGs related to alcohol use, these results relate to the broader substance use recovery population and not specifically to the 60% of respondents who indicated alcohol as their primary substance.

UK Life in Recovery Survey. (Graham et al., 2018) reported findings from the 2015 UK Life in Recovery Survey, which included a sample of 766 UK residents. Among 301 participants who endorsed any digital modality use (online groups, static websites, mobile apps), 32% had used online recovery groups and the most popular were SMART Recovery (n = 50) and Facebookbased groups (n = 50). Other online groups related to alcohol use included AA (n = 35), InTheRooms (n = 12), and Soberistas (n = 8). Among those using online groups, 45% rated them as helpful and 25% as extremely helpful. Use of online groups was not significantly associated with recovery stage, gender, employment status, or having dependent children. The most commonly endorsed alcohol-related smartphone apps included AA (n = 22), the Joe & Charlie AA app (n = 10) and an app by Hazelden (n = 13), though it was not determined whether these apps were used in an MHG context (e.g., versus being used as sobriety trackers, meeting finders, informational resources).

<u>Global Drugs Survey</u>. Davies et al. (2019) reported findings from 82,190 respondents across 12 countries, from the 2017 Global Drug Survey (GDS). Overall, digital modalities (online resources or mobile apps) were the preferred source of support among respondents who wanted to reduce

alcohol use (n = 15,367), as endorsed by 37% of this group. Digital support was significantly more favorable among individuals with lower severity alcohol use (i.e., AUDIT scores), those with higher educational attainment, and those not receiving medication for a comorbid mental health condition. Digital modalities were particularly popular in English-speaking countries, including Australia, the United Kingdom, and New Zealand in particular.

Online sampling surveys

<u>12StepChat.org survev</u>. Hall & Tidwell (2003) recruited individuals from various recovery websites and email listservs and directed them to a survey posted on 12stepchat.org. Respondents spanned 20 countries and US respondents participated in numbers roughly proportional to their respective state populations, though specific geographic frequencies were not reported. Among 1001 respondents (66% female, 90% white), 31% had been active in Internet-based recovery activities for a year or less and more than half had been active for two years or less. Duration of online recovery activity was positively associated with age, male gender, and participation in a greater number of programs. 63% of respondents reported affiliation with one online recovery program, 25% with two programs, and the remainder were active in three or more. Just over half of the sample identified AA as their primary online recovery affiliation among more than 50 sources of online recovery support that were identified. Individuals who indicated a primary affiliation with a 12-step program had a significantly shorter duration of time using online recovery sites and engaged with a lesser number of online MHGs. Given that these results are from 2003, they should be interpreted cautiously with respect to the current digital MHG landscape.

Online snowball sampling. In Dugdale et al. (2016), an online snowball sampling strategy was used to recruit 130 participants (48% female) who identified as using online substance use

recovery resources. The most prevalent methods of accessing online resources were: mobile devices (64% of respondents), followed by laptop (60%), tablets (48%), and computers (42%). Ceiling effects were prominent in descriptions of online resources use patterns, with 45% of participants indicating 3+ years of online resource use and 45% indicating 3+ hours per week spent using online resources in recovery contexts. One significant trend was identified where individuals who considered themselves "in recovery" were more likely than their counterparts ("working towards recovery" or "not working towards recovery") to use online resources in the evening hours, but not at other times of day. Individuals in recovery were no more likely to use online forums than their counterparts. Qualitative summaries indicated that online resources were favorable with respect to accessibility and for those who had other mental and social concerns (e.g., social anxiety, fear, self-esteem), which may preclude accessing in-person resources. Online resources were viewed as complementary and as an in-route to engaging in in-person support. However, barriers to use of online resources included having technological challenges or experiencing connection issues in video meetings. Other concerns included individuals isolating into virtual contexts and not seeking out in-person support.

Peer Alternatives in Addiction Study. Zemore et al. (2017) completed the Peer Alternatives in Addiction Study baseline survey of 651 individuals with lifetime AUD. Participants were recruited from 12-step MHGs via InTheRooms website advertising and via organizational contacts at SMART Recovery, Women for Sobriety, and LifeRing. Demographic differences among the organizations are detailed in the publication, though details were not provided as they related to digital MHG participation. Among the 12-step sample, the average number of past-month online meetings (5.9, SD = 16.3) was not significantly different from that of the Women for Sobriety

sample (5.1, SD = 18.2) but was higher than the SMART (1.1, SD = 3.3) and LifeRing (0.5, SD = 3.2) samples.

Facebook convenience sample. Grant & Dill-Shackleford (2017), analyzed 196 complete surveys (72% female, 86% white) from a convenience sample of Facebook users who were engaged in both in-person and online recovery activities related to alcohol or substance use. Survey responses were used for psychometric development of the Sobriety Support Preference Scale, which measures orientation toward face-to-face and digitally mediated support contexts. Results indicated that respondents had a preference toward face-to-face support and were significantly more likely to be honest with others in this context. Conversely, participants were also significantly more likely to lie about their amount of time sober and to be intoxicated in face-to-face support contexts. The use of digitally mediated support was found to detract from the frequency of ongoing face-to-face engagement. Preference for face-to-face support was positively associated with sobriety duration and indicators of sobriety success, while digitally mediated support was negatively associated with sobriety duration and not associated with indicators of success. Generalizability of these results should be interpreted cautiously as 37% of respondents knew the study investigator in a personal capacity and a sensitivity analysis indicated that 22% of the sample who were professional colleagues of the investigator (i.e., "sobriety professionals") were relatively less enthusiastic about digitally mediated support.

MHG-specific user surveys

Moderation Management user surveys. Two surveys assessed engagement in in-person and online Moderation Management harm reduction programming. In (Humphreys & Klaw, 2001),

use of the online MHG format (versus in-person) was associated with greater educational attainment, atheist/agnostic beliefs, and more drinking days per week. Online-only MHG participants were more likely to be female and to have more intense alcohol use profiles (i.e., days per month intoxicated, percent of heavy drinking days, alcohol dependence scores). Per Kosok (2006), online-only MHG participants were younger than counterparts of in-person only or online plus in-person groups. The online-only group had more heavy drinking days per week and previously sought help for alcohol-related problems less often prior to MHG initiation, as compared to the in-person only group. Results should be interpreted cautiously for these studies as they were conducted prior to 2006 and as the Moderation Management MHG is oriented toward individuals with relatively less severe alcohol use profiles.

In TheRooms user surveys. In Bergman et al. (2017), 123 survey respondents from InTheRooms indicated using the platform for an average of approximately 30 minutes per day, several times per week. Respondents indicated perceived benefits of engagement related to increased self-efficacy and motivation to maintain abstinence. Perceived benefit was similar among those abstinent for less than one year versus at least one year. Rubya & Yarosh (2017b) conducted a survey of 285 InTheRooms users and found that 22% attended in-person meetings only, 15% attended video meetings only, and 52% attended both formats. Descriptive patterns indicated that users of video meetings were newer to recovery and reported less time in continuous recovery. Just over 60% of users identified in-person and online meetings to be equally useful and about 30% identified online meetings as less helpful than in-person meetings.

Soberistas user survey. Among 432 survey respondents from the women-only Soberistas MHG (Sinclair et al., 2017), nearly half reported no prior alcohol-related support and 12% had used another digital MHG prior to Soberistas. Since joining the group, 34% ceased alcohol use, 11% maintained abstinence, and 24% reduced alcohol consumption. The majority of participants were from the UK (72%) and reported having an alcohol problem for at least 10 years (63%). Reasons for maintaining paid membership on the site included: community support, site resources and features, commitment to alcohol-related goals, and wanting to provide support to other community members. Fee-paying members were more likely than counterparts to be sober for less than one year, but were not significantly different with respect to history of previous support or duration of problematic alcohol use. Site features, in decreasing order of perceived helpfulness were: personal stories, blogs and forums, expert webinars, "Ask the Doctor", and chat rooms. The order of these features was the same when ranked by reported frequency of engagement.

Harm reduction, Abstinence, and Moderation Support (HAMS) user survey. Haug et al. (2020) used a retrospective cross-sectional survey to assess alcohol use patterns prior to and after engaging in an online program based on the HAMS harm reduction model and website. Available MHG features included a private Facebook group (68% of participants reported regular engagement), e-mail listserv (42%), chat room (30%), and discussion forum (18%); 40% engaged in two or more features. The number of MHG features used was associated with reductions in retrospectively reported drinks per week and drinking days per week. However, as 74% of participants continued engaging in high-risk drinking, the authors cautioned that personalized harm reduction goal setting may result in normalization of heavy alcohol use.

2.3.2.5 Focus groups and interviews

<u>A-CHESS clinical implementation interviews</u>. Interviews with treatment providers related to the A-CHESS mobile application indicated strategies for sustaining application use among clients (Ford et al., 2015). One agency indicated that clients were encouraged to use the MHG features, though this strategy was not among the primary recommendations brought forth in the paper.

InTheRooms user interviews. In two overlapping studies by Rubya & Yarosh (2017a, 2017b), members of ITR defined anonymity with themes of "identifiability" (e.g., not using full name), "social contract" (e.g., not violating others' anonymity), and "program over individual" (e.g., treating others as equals). Active users on ITR (at least three past-year engagements) were significantly less likely to enact anonymity through unidentifiability. Respondents indicated that online forums provided convenience, immediacy of support, and diversity of viewpoints. Respondents further indicated scheduled video meetings as supplemental to primary support accessed via digital forums and that online forums provided convenience, immediacy of support, and diversity of support, and diversity of viewpoints.

<u>Soberistas user interviews</u>. In Chambers et al. (2017), interviews with women from the Soberistas MHG identified staged processes of engagement on the platform which corresponded to distinct social identities. These included *lurking* (reading but not engaging), active participation, assuming leadership roles, and finally disengagement from the platform when it is no longer needed.

Non-12-step digital MHG user interviews. Sanger et al. (2019) interviewed participants from five non-12-step digital MHGs and synthesized results via thematic and template analysis. Across interviews, "finding someone like me" was identified as the most salient theme, with respondents indicating challenges finding relatable peer support in 12-step MHGs. Other identified differences with 12-step framework included flexibility of recovery programming and in setting recovery goals (e.g., moderate drinking). Other themes included "recovery is possible" as evidenced by the presence of peers with relatable or comparably more severe alcohol use problems, with successful recovery trajectories. A noted advantage of digital forums was the permanence of information, whereby individuals could find a compendium of relevant advice (e.g., early-recovery, going through divorce) that was previously discussed in the MHG. Problems identified in the forums included argumentativeness by members who were oriented with 12-step approaches, incoherent posts by intoxicated individuals, and groups that were too active. The latter problem could result in failure to form more intimate connections or to form cliques within digital MHGs

Facebook intervention usability focus group. One focus group study collected feedback for usability testing of a Facebook-based intervention (Ramo et al., 2019). Results were largely limited to collecting feedback about the favorability of health-related images and the study provided limited insight into MHG contexts among users.

<u>Hello Sunday Morning user interviews</u>. In Black et al. (2020), interviews with users of the Hello Sunday Morning MHG identified appealing aspects of MHG participation within themes of: social support, normative strategies, goal setting, and self-monitoring.

2.3.2.6 Reviews of mobile applications

Savic et al. (2013) reviewed 87 addiction recovery-related apps and associated consumer reviews from the Google Play store. Among these, 31% of apps were focused specifically on alcohol use, 46% were focused on addiction generally, with the remaining focusing on other substances or addictive behaviors. Digital MHG features or links to external online MHGs were available in 18 (21%) apps. The top decile of most-downloaded apps were significantly more likely to include some form of MHG functionality. Individual apps were not identified in this review.

Penzenstadler et al. (2016) reviewed 52 English language apps related to problematic alcohol use from Apple's iTunes Store. The presence of MHG features was assessed as one of the eight dimensions of Abbott's Interactivity Scale, but this dimension was not ascertainable since only composite scores were reported. One unidentified app "was a forum for patients in recovery".

Tofighi et al. (2019) performed a systematic search and review of alcohol and substance use apps in both the Google Play and iTunes app stores. Of 904 apps identified using keyword search criteria, 74 apps (26 iTunes and 48 Google Play; 54% alcohol-related) were evaluated using the Mobile App Rating Scale (MARS) criteria, which includes an "interactivity" dimension relevant to digital MHG features. Among apps identified as having MHG features, SoberGrid received relatively high MARS ratings and had "global newsfeed" forum and "instant help" chat features. The remaining apps' MHG features were either inactive (e.g., Addicaid posts were over a year old) or unusable (e.g., Pocket Rehab and SoberWorx apps were unable to connect with other users).

2.3.2.7 Technology development papers

Four articles described the development of a new technology that integrated digital MHG features. The earliest article included in this review (Matano et al., 2000), reported on development of the Employee Stress and Alcohol Project website, which included an unmoderated forum for staff to discuss alcohol problems. However, engagement with the forum was not evaluated and participant outcomes were not assessed.

Two mobile app development papers were identified. This included an early description of A-CHESS app features (Gustafson et al., 2011), which was followed by several A-CHESS studies identified through the present review. The Addict Free app was developed more recently (Z. Yang et al., 2019), and it was not able to be located in app stores or within subsequent publications.

Yao & Yarosh (2016) developed the Group Finder algorithm to recommend InTheRooms groups based on user characteristics, though it is unclear if has undergone additional research, development, or implementation.

2.4 Discussion

This scoping review sought to understand characteristics of digital MHGs related to problematic alcohol use. Guiding questions asked what digital MHGs had been studied and what methods had been used to study them. Through the process of abstraction and synthesis of results, overarching themes related to social engagement and recovery identity were also identified (see Section 2.4.2). Limitations and possible future directions are discussed in the context of current procedures and identified gaps in the literature.

2.4.1 What alcohol-related digital MHGs have been studied and what are their defining characteristics?

2.4.1.1 Mobile applications with MHG features

Overall, the existing literature describes the presence of 5 distinct mobile applications that that have been studied with respect to having alcohol-related MHG features. Among these, three appeared to be publicly accessible to varying degrees. For example, the A-CHESS app, which has the largest scientific literature base, is accessible only to US users through sponsoring health care organizations. The Daybreak app, which was based on earlier studies of the Hello Sunday Morning platform, remains freely available to Australian users and to paid subscribers elsewhere. The SoberGrid app appeared more recently in the literature and is a popular, freely-available option in mobile app marketplaces (Tofighi et al., 2019). These apps include additional features beyond digital MHG access, which may further enhance recovery.

2.4.1.2 Web-based digital MHGs

The 15 identified web-based MHGs included those dedicated specifically to alcohol use (e.g., Soberistas) or to addiction recovery more broadly (e.g., InTheRooms). These also included broader social media platforms with relevant subcommunities (e.g., Reddit's /r/stopdrinking). Based on the National Recovery Study survey (Bergman et al., 2018), Facebook was the most popular social media site for recovery-oriented MHG activity. Through the present review, at least three MHG organizations (AA, HAMS, Moderation Management) were identified as having

available Facebook groups, though little is known about other MHGs on this platform. Twelve additional social media platforms (Instagram, YouTube, Twitter, Myspace, Pinterest, Snapchat, Tumblr, Foursquare, Google Plus, Meetup, Flickr, and Vine) were identified via National Recovery Study survey as being used for recovery support (Bergman et al., 2018), though no studies specific to these sites were identified through the present scoping review. This indicates a relatively wide gap in the research, where additional research is needed to understand common characteristics among these platforms.

2.4.1.3 Characteristics of alcohol-related digital MHGs

Commonly, digital MHGs include forums where participants can contribute new topics or questions (i.e., posts) and respond to others' posts (i.e., comments). Forums, sometimes referred to as "bulletin boards" or "blogs" (Finfgeld-Connett, 2009; Tait et al., 2019), might be further classified as general or topical. In topical forums, posts are grouped within categorical topics or sub-forums (e.g., new member check-in, questions and answers area). In general forums, posts are aggregated into a common feed. Posts in general forums could be organized and navigated chronologically, by popularity, or through use of metadata tags (e.g., hashtags, topic labels). A defining characteristic of forums is that they are asynchronous, where posts are persistently available and engaged by users who access the forum at a time that is convenient. This is in contrast to synchronous "chat" features (described below). Useful metrics for describing forums might include average time from post to initial response and average number of responses per post. Such metrics provide a sense of forum activity and responsiveness that can be used to compare forums across platforms and contexts (e.g., seasonal changes). Additionally, the contexts of engagement can be characterized by thematic content and topics. In observational research that was reviewed, it was common to find comments categorized by frequency and type of support provided (e.g.,

informational support, emotional support). If used consistently, these types of metrics would allow for meaningful benchmarks and comparisons to be made among digital MHG forums.

The user interface of forums can differ drastically among platforms. For example, is the forum strictly text-based or can posts include inline multimedia like images or videos? Is the forum conducive to access via mobile phones, tablets, and computers? While user experience is understood as an important driver of digital platform engagement among individuals with behavioral and mental health conditions (Neary & Schueller, 2018; O'Leary et al., 2017), relatively few of the reviewed studies evaluated relevant user experience characteristics such as usability of post or comment features, availability of multimedia content, or operability across devices. This is an important consideration, as Dugdale et al. (2016) identified that digital MHG users regularly access these platforms using a variety of devices; preferentially via mobile devices but often on more than one device. Additional research is warranted on MHG user experiences, specific to platform characteristics that might encourage sustained use of forum features.

Chat features are distinct from forums in that they are synchronous rather than asynchronous. That is, they are time and context specific and engagement is limited to users who are logged in to the virtual chat room at a given moment. Defining characteristics of chat features were not well-detailed in the reviewed literature, though these features were as present in at least three platforms (Finfgeld-Connett & Madsen, 2008; Haug et al., 2020; Sinclair et al., 2017). In <u>Finfgeld-Connett (2009)</u>, participants indicated a preference for asynchronous forums over synchronous chat features. Additional research is warranted into the dynamics of chat environments and whether there are important differences between scheduled chats (i.e., meeting room) versus unscheduled chats (i.e., drop-in room), and the extent to which moderators play a

role in managing chat discussions. Chat rooms with too few participants would certainly be problematic (e.g., empty rooms), though highly active exchanges may be problematic in other ways (e.g., disorientation related to multiple parallel discussions). Thus, it would be valuable to better contextualize the dynamics of MHG chat environments with regard to typical activity level. Such metrics might include the average number of users logged in at a given time or the number of chat posts over a given timeframe.

The presence of **private messaging** features was indicated on a limited number of mobile apps (e.g., A-CHESS, Daybreak). In these contexts, messaging features could be used to communicate with healthcare professionals, but these features were not described in detail in peerto-peer contexts. As the scope of this review was on mutual help groups, studies that included only one-to-one digital communication were generally excluded unless other MHG features were identified. For example, studies that examined only mobile phone text messages were not included in this review. A separate review may be warranted to explore the role of private messaging features in the milieu of problematic alcohol use and other behavioral health contexts.

Video meetings are another common modality of digital MHG engagement. Qualitatively, these are seen as a compromise between online forums and in-person MHG meetings, as an inroute to engaging in-person MHGs (Lyytikäinen, 2016), or as a supplemental form of support among users of online forums (e.g., InTheRooms platform). Alcohol-related outcomes among inperson meeting attendees may be better than those for online-only video meeting attendees in SMART Recovery contexts (Hester et al., 2013). However, there is a paucity of research that makes direct comparisons between the two formats as well as the diverse format of such meetings.

(e.g., seminars, topic-oriented meetings, book clubs). As with other digital MHG delivery formats, it will be worth exploring how video meetings might complement, displace, and serve as pathways to in-person MHG engagement for individuals with various recovery trajectories and needs.

2.4.1.4 Privacy and availability of digital MHGs

Privacy, anonymity, and content moderation approaches are important considerations for understanding characteristics of digital MHGs. These warrant additional research and evaluation, particularly as problematic alcohol use (including AUDs and "alcoholism") reflects a sensitive and culturally stigmatized health context. In Ekström & Johansson (2020), respondents indicated concerns around privacy on digital MHGs, which is likely to be a barrier to engagement. However, as individuals become more closely affiliated with MHGs, anonymity is less of a concern (Rubya & Yarosh, 2017a). Nonetheless, attendees in the Schmitt & Yarosh (2018) workshops further indicated safety concerns and indicated the ability to control privacy as an integral aspect of digital MHGs. Further, the anonymity afforded by digital MHGs is particularly important for individuals with comorbid mental illness, as dual-diagnosis can be particularly sensitive and stigmatizing (Edward & Robins, 2012). Thus, another important consideration for researching digital MHGs is the extent to which aspects of privacy and anonymity, and the extent to which these norms are codified and enforced by platform restrictions and content moderators. For example, while users having personal profiles on a platform may enhance a sense of community and relatability among users with similar backgrounds, requiring this type of information would detract from autonomy of control over privacy and anonymity. MHG users with concerns about privacy and stigma may be more open to using forums and chats versus more intimate video meetings (Cooper, 2004), so each of these approaches is integral to the broader MHG ecosystem.

An overarching challenge of studying digital MHGs is hitting moving targets as the digital ecosystem shifts. For example, the Hello Sunday Morning MHG underwent redevelopment into the Daybreak mobile app (Tait et al., 2019). As both the access point and features changed through this process, it is unclear how findings related to Hello Sunday Morning translate to Daybreak or how the active user base may have been impacted. Upon completing a series of online searches for the MHG platforms identified in this review, several other platforms were found to be either unavailable (e.g., Alcohol Help Center), inactive for at least a year (e.g., Drinking Diaries), or not alcohol-related (e.g., Uncommon Forum: Addictions). This highlights the importance of comprehensively and consistently assessing characteristics and metrics of MHG engagement across studies. While the specific platforms will continue to evolve or become unavailable, understanding common metrics and processes among platforms will result in transferable knowledge about MHG engagement more broadly.

2.4.2 What approaches have been used to establish evidence for the use and effectiveness of digital MHGs in alcohol recovery?

As specific study designs are summarized in Results (Section 2.3.2), they are not repeated here. However, additional discussion is warranted around broader themes that cut across these studies. These include considerations about the potential effectiveness of digital MHGs and understandings of MHG engagement contexts that can be synthesized from this scope of research.

2.4.2.1 Effectiveness and beneficence of digital MHGs

The present scoping review did not identify published randomized trials where digital MHG availability or engagement was uniquely included as a study arm. However, analyses of

associations related to digital MHG use within trial arms yielded relevant findings that provide some support for the benefits of digital MHG engagement. For example, Hester et al. (2013) indicated that participation in SMART online meetings was positively associated with recovery outcomes. However, this study also found that participants engaging with in-person MHGs had more improvement as compared to online-only participants. Findings from this and other identified trials should be interpreted cautiously as digital MHG use was not directly controlled for. Future trials that randomize on digital MHG participation or that directly compare digital to in-person MHG use will be beneficial to provide insights into effectiveness of digital MHGs.

Nonetheless, there is emerging evidence indicating potential benefits of engaging with digital MHGs in the context of alcohol use. In a longitudinal study of SoberGrid app users (Ashford, Giorgi, et al., 2020), having a greater number of peer connections was associated with favorable recovery trajectories. Conversely, users who used the informal "check-in" feature fared worse overall. This seems to indicate some qualitative difference where engagement that involves stronger peer-orientation is more helpful than simply using social features to indicate presence. However, these associations may also relate to latent differences among MHG participants (e.g., comfort with self-disclosure). In future studies, it will also be beneficial to control for potentially confounding psychosocial differences among MHG users.

Evidence from longitudinal studies provides particularly interesting findings related to *providing* peer support via digital MHGs. In a broad sense, Kirkman et al. (2018) found that engaging with others through comments was not predictive of improved alcohol-related outcomes when controlling for other engagement behaviors such as the number of sign-ins, posts, and using

like and follow features. A closer look at users of A-CHESS MHG features indicated that users who provided emotional support to peers had better alcohol-related outcomes, while users who provided informational support fared worse unless they also had high self-efficacy (Liu et al., 2020). Conceptually, this may indicate that that individuals with greater emotional investment in the MHG community are conferred greater recovery capital. However, a study by Yoo et al. (2020) found no main effect of emotional support provision on alcohol-related outcomes, though providing emotional support did moderate the effect of emotional distress on risky drinking days. Thus, potential relationship between providing digital MHG peer support and alcohol-related outcomes seems to be more psychosocially complex than direct associations might indicate. Provision of support on digital MHGs warrants further study, particularly with regard to informational versus emotional support, which occur in different relational contexts (Chuang & Yang, 2012, 2014; Liu et al., 2017). In future studies, it will be beneficial to contextualize both the quantity and the quality of support provided over time, particularly if this might change as individuals develop stronger group identification through longer-term MHG engagement (Coulson, 2014; Sanger et al., 2019).

To echo the sentiment from a recent systematic review on digital recovery support services for substance use disorders (Ashford, Bergman, et al., 2020), there is insufficient evidence to make clear recommendations for the use of digital support modalities in this milieu. Conversely, there is not substantial evidence to recommend against the use of these digital MHGs. Appropriate clinical and individual judgement should be exercised when deciding on whether reliance on such groups may be beneficial under particular circumstances. While engagement with digital MHGs may yield potential benefits, particularly when other sources of support are lacking, limited clinical research in this milieu warrants cautious optimism about their widespread use.

2.4.2.2 Identity change and community engagement

Aspects of personal identity change were apparent in numerous studies of digital MHGs and such change is a broader indicator of success in recovery (Best et al., 2016). Of particular interest are longitudinal studies that observed participants within the Hello Sunday Morning group (Carah et al., 2017; Pennay et al., 2016, 2018). Taken together, these studies reflect a process of change whereby sustained MHG engagement leads to redefining a sense of self as a non-drinker. While this reflects a broader literature of identity change playing an integral role in alcohol use recovery (Best et al., 2016, 2018; Montes et al., 2017), it is particularly interesting in the context of this MHG because of its rather unique focus on setting temporary abstinence goals. That is, while identity change has received much focus in traditional 12-step programs where long-term abstinence and accepting of a sustained "alcoholic" identity is idealized (Hill & Leeming, 2014; Pawlukewicz, 2004; Wittke, 2017), the Hello Sunday Morning studies focus on incremental and transient identity changes in the context of alcohol use. Similarly, Chambers et al. (2017) indicated a process whereby participants on the Soberistas MHG transition from passive to active engagement, then assume leadership roles, and ultimately leave the platform when some measure of recovery success is achieved. These types of naturalistic observations and narratives offer novel insights into processes of identity change that may support recovery through both short-term and long-term MHG engagement. Additional studies are warranted to understand the timeline of this process among diverse MHGs, recovery goals, and user typologies.

Two additional longitudinal observations of /r/stopdrinking indicated that linguistic cues within user posts were associated with alcohol use outcomes (Tamersoy et al., 2015, 2017). These results indicate that narrative contexts of MHG engagement can be effectively modeled to predict alcohol-related trajectories among MHG users. By using forum metadata (i.e., Sober Badges) and computational linguistic approaches to evaluate post content, these types of analyses can be undertaken on a large scale. Additional studies of this sort will be valuable to contextualize common engagement patterns that may reflect beneficial use of popular social media MHGs.

A number of cross sectional and interview studies were identified in this review. While these do not offer direct insights into digital MHGs contributing to alcohol-related outcomes, they do offer insights into potential mechanisms that might contribute to favorable outcomes. For example, digital MHG engagement can contribute to the development and refinement of personal goals and strategies for overcoming alcohol problems (Black et al., 2020; Carah et al., 2017; Coulson, 2014; Sanger et al., 2019). While these do not directly equate to improving alcohol use outcomes, they are well-aligned with social and behavioral models of recovery (see Section 1.3).

2.4.3 Limitations and future directions

While this review was extensive, some important studies related to digital MHGs were not included in the scope. In particular, as this review focused specifically on alcohol use, digital MHGs related to other substances or behavioral health conditions were excluded (unless alcohol use was specifically mentioned in the respective articles). Additional context from these studies would be beneficial to understand common mechanisms of digital MHGs across behavioral health conditions. For example, MHGs related to other substances or addictive disorders, as well as
MHGs extending support for individuals directly impacted by others' alcohol use (e.g., Al-Anon), may provide complementary or alternate perspectives to those of the present review. Furthermore, as research on digital MHGs is evolving rapidly, updated reviews may also be warranted at regular intervals to capture new developments related to alcohol-specific groups.

Given the lack of randomized trials in the literature, it is premature to conduct systematic reviews to test hypothesis that are specific to alcohol-related digital MHGs. However, such reviews may be beneficial in a broader scope of health-related digital MHGs. For example, a recent scoping review was conducted in relation to online diabetes support groups (Litchman et al., 2019), which offers complementary perspectives to the current review. In particular, examining contexts of information quality, MHG privacy, and user activity would be valuable across health contexts. Aggregating digital MHG studies across related health contexts (e.g., substance use, addictive behaviors) may be fruitful for contextualizing digital MHG effectiveness in a broader sense.

Future work should account for typologies and defining characteristics of digital MHGs under investigation. For example, experience and training of forum moderators is an important consideration for ensuring the safety of group participants (Cunningham et al., 2008b), though these training procedures have not been detailed in the literature. Also, characteristics of digital MHG activity (e.g., forum posts per day, community response time) would be useful for benchmarking across digital MHGs and over time. Such details were seldom found in the studies included in this scoping review and some of the identified MHGs were subsequently found to be decommissioned or inactive for a year or more. A comprehensive review of available web-based MHGs for problematic alcohol use is warranted. This could be accomplished similarly to mobile application reviews that were reported in Section 2.3.2.6. When compiled, this will be a beneficial resource for treatment providers and community members, to inform choices about engaging with viable and supportive digital MHGs in this context.

As identified through this review, additional attention to digital MHGs is warranted in population surveys related to alcohol and substance use, as well as in clinical trials that examine mobile applications and MHG engagement more broadly. The lack of attention to digital support modalities in prior studies has provided limited evidence related to their use and effectiveness. Future studies should independently evaluate the use of in-person and digital MHGs, while controlling for conceptually relevant factors (e.g., recovery identity) to fill this gap in the literature.

2.5 Conclusions

This study reports on a scoping review of digital MHGs related to problematic alcohol use. We identified a substantial amount of literature in this realm, though much research remains to be done. While the format and functionality of digital MHGs has been well articulated, several gaps remain with regard to understanding populations who use these resources as well as the effectiveness of digital MHGs in improving alcohol-related outcomes.

Digital MHGs are diverse outlets for individuals to seek out and access support in overcoming problematic alcohol use. The diversity is underscored by several modalities (e.g., forums, scheduled and unscheduled chats, video meetings, online versus mobile app based), which offer varying degrees of convenience, immediacy of support, and privacy. Digital MHGs also span

a variety of topics such as general addiction, alcohol-specific support, dual-diagnosis support, medical-specific questions, as well as population-specific foci (e.g., women only, geographically constrained). While reviews of recovery-related apps have provided insights into more-or-less useful platforms, no such study has reviewed the comparatively larger scope of web-based MHGs.

The present review offers limited insight into general characteristics of users who engage with digital MHGs. In particular, national surveys have focused on populations of individuals with broader substance use issues or those who are already in recovery. Other surveys were drawn from convenience samples of digital MHG users from specific platforms. Thus, little is objectively known about population trends related to early-engagement with digital MHGs related to alcohol use – particularly among individuals with less severe alcohol use profiles. Further surveys are warranted if we are to understand the extent to which general populations engage with digital MHGs for problematic alcohol use.

Overall, the evidence base supporting the use of digital MHGs remains limited with respect to effectiveness of digital MHGs in enhancing alcohol-related outcomes. However, the breadth of studies is growing and a variety of novel study approaches have contributed to understandings about the potential utility of digital MHGs in alcohol recovery. Additional research is warranted before clear recommendations can be made for the use of specific digital MHGs or for specific engagement strategies. Yet, digital MHGs are highly acceptable to participants, decrease barriers to MHG access, and offer contexts of support that align with conceptualized recovery pathways. Further research is warranted to understand how digital MHGs may be effective and for whom. 3.0: Contextualization of recovery-related content on the /r/stopdrinking forum.

3.1 Introduction

As described in Chapter 2, there are a variety of modalities available for individuals to engage in digital mutual help groups (MHGs) focusing on alcohol recovery. Based on a US survey of individuals recovering from substance use disorders, online social media sites (e.g., Facebook, Twitter, Reddit) are the most common modality that individuals use to engage with digital MHG support (Bergman et al., 2018). These social media sites have diverse privacy settings and data use agreements, so comprehensive observation of MHG activities can be ethically problematic and pragmatically challenging. Nonetheless, contextualizing recent advances in technologically mediated support warrants ongoing research to enhance understanding of how these technologies are used in recovery processes. This ultimately serves to provide evidence-based considerations and recommendations for the use of digital MHGs in alcohol recovery contexts. Observational research is an ideal approach for understanding digital MHGs, as this provides perspectives into naturalistic patterns of behavior that cannot be reliably captured via retrospective surveys. Given the ethical considerations and pragmatic limitations of conducting observational research in this milieu, careful consideration is warranted around privacy, anonymity, and accessibility of data.

3.1.1 Platform and forum considerations

In the process of selecting a social media platform to observe, I considered the format, interpersonal dynamics, and terms of use of popular social media platforms, as well as ethical considerations of what is considered "public behavior" that can be ethically observed for research purposes. The Reddit platform was deemed to be the most appropriate social media environment for conducting observational research of digital MHGs. As Reddit ascribes itself as "the front page of the Internet" and as public forum content is accessible without logging in (forums can explicitly be set as private), expectations of privacy were considerably defined. Reddit also offers Application Programming Interface (API) connectivity, which can be used to programmatically obtain content from the platform to ensure systematicity and comprehensiveness of data collection.

3.1.1.1 Reddit platform characteristics

The Reddit social media platform is composed of *subreddit* communities that are dedicated to various themes and interests. Subreddits are officially denoted with a "/r/" prefix. For example, /r/funny ("Reddit's largest humour depository") and /r/AskReddit ("the place to ask and answer thought-provoking questions") are among the most popular subreddits based on the number of subscribers (Clement, 2019). Similar to conventions for subreddits, users are denoted with "/u/" prefixes (i.e., /u/*username*). After signing up for a user account by choosing a pseudonym (i.e., username), Reddit users can *subscribe* (i.e., include subreddit content on their personal newsfeed) to public subreddits. While personal details such as actual name and user demographics are not collected, and as email addresses are not required to be verified, this platform provides additional protection of user anonymity (Proferes et al., 2021). In particularly stigmatizing social contexts, users may also set up "throwaway" accounts to maintain a separate, anonymous online identity

(Ammari et al., 2019). This makes Reddit an ideal platform for users to post candid narratives and solicit public feedback about potentially sensitive topics such as mental health and addictive behaviors (Choudhury & De, 2014).

Within the Reddit platform, *upvote* and *downvote* features allow users to provide evaluative feedback on others' posts and comments (i.e., responses). Individual posts and comments are attributed a real-time composite score of upvotes minus downvotes. As users engage with Reddit, they accumulate *karma* points for their post and response scores separately. For example, if a user has two posts with scores of 300 and -23, their overall post karma would be 277 and this would appear on their user profile page. The karma system incentivizes users to engage in ways that are likely to be valued by other Reddit users and this is one way that the Reddit platform normalizes pro-social and community-aligned behavior (Kilgo et al., 2016).

New subreddits can be established by any Reddit user, who then becomes the *moderator* of the subreddit. Additional moderators can be approved by existing moderators and the moderation team is responsible for administrative tasks such as setting subreddit guidelines and removing posts or responses that fall outside the subreddit scope or violate established guidelines. Subreddit guidelines are typically included in the sidebar section of the webpage, so they are visible while engaging with the subreddit. Subreddits can also set up separate "wiki" pages with more detailed information and resources. While there is a common Reddit framework for users to flag posts or responses that may require moderation, the moderation process is uniquely approached by individual subreddits (Squirrell, 2019). This process may include automated

strategies that take into account keywords in posts and user characteristics such as karma scores (Juneja et al., 2020).

Within subreddits, conversations are structured as primary posts and associated response threads of indefinite depth (i.e., responses nested under other responses). Posts can contain unstructured text, hyperlinks, and a single image or video, depending on subreddit-specific restrictions. Posts and users can also be tagged with user-defined "flair", within limitations set forth by the subreddit moderators. For example, in the /r/Science community, user flair relates to scientific credentials (e.g., *PhD Neuroscience*) that have been submitted to and verified by the moderator team. Users and posts with flair are distinguished from other contributions and might be considered more authoritative than those without flair (Hara et al., 2019).

Overall, Reddit is community-centric platform comprised of diverse subreddits, which operate relatively autonomously and with flexible constraints related to developing and moderating subreddit communities. This allows for individuals to self-select into or independently develop digital MHGs that fit their particular needs and interests. With regard to alcohol-related MHGs, popular subreddits identified through the SD resources page include: /r/alcoholism (~39K subscribers), /r/alcoholicsanonymous (~31K), /r/AlAnon (~29K), /r/SMARTRecovery (~4K), and /r/AtheistTwelveSteppers with ~3K subscribers in February 2021 (/r/stopdrinking, 2021c; *Subreddit Stats*, 2021). Among popular subreddits related to alcohol use – other than /r/holdmycosmo (~1,492K) and /r/drunk (~290K), which are intended for humorous posts about intoxication – /r/stopdrinking is the most well-subscribed alcohol-related subreddit, with more than 277K subscribers in February 2021 (*Subreddit Stats*, 2021).

3.1.1.2 /r/stopdrinking (SD) forum characteristics

My current research focuses on the /r/stopdrinking (SD) subreddit (established December 2010), which has received popular media attention in the Washington Post as "the surprising Internet forum some alcoholics are choosing over AA" (Dewey, 2016). At that time, in early 2016, SD had just over 30,000 subscribers and it has since grown nearly ten-fold in the intermediary years (*Subreddit Stats*, 2021). Within this subreddit, posts are limited to text-only and may be contributed by any Reddit user. SD also sponsors community-themed posts where moderators or selected users conform to defined post scripts. For example, the "daily check-in" post uses a common narrative script and encourages users to respond with a brief affirmation to remain sober for the day. SD provides a list of six rules in the sidebar of the main forum page (see Table 3.1), as well as a more comprehensive Frequently Asked Questions page to address common questions about community engagement (/r/stopdrinking, 2021b).

The SD **Sober Badge** (**SB**) is optional user flair indicating a self-reported number of days sober. This value is set through a process where a user sends a message including a sobriety date to a moderator-monitored account whereby the flair is set by a moderator and is then automatically incremented for all users at the end of each day. Prior to August 2019, the process of setting SB dates was manually handled by SD moderators, but this transitioned to an automated process as the demand for SBs became too burdensome for the moderation team and detracted from other activities (/u/stratyturd [moderator], 2019). Among identified alcohol-related subreddits, the SB feature is unique to SD. This facet of metadata makes SD particularly interesting from a research perspective, since alcohol use trajectories and outcomes can be monitored using these metadata.

Table 3.1. SD forum rules

/r/stopdrinking (2021) Rules

- 1. <u>Please only participate while sober.</u> We recognize that many people spend months "lurking" this subreddit while drinking. You are welcome to read as much as you'd like while not sober. However, for the sake of everyone here, and for the sake of your own recovery, please only post or comment when you're sober. "Sober" means "not currently intoxicated or under the influence in any way."
- 2. <u>Speak from the "I."</u> We ask that you refrain from speaking in the imperative. That means don't tell others what they should or must do. Phrase your advice in terms of your own story, talking about what worked for you. Comment that will be removed: "You should do X" Comment that will not be removed: "When I was in your situation, I did X, and here is how it worked out for me..." "Strongly recommending" and saying "I would do this if I were you" are therefore not appropriate either.
- 3. <u>Be kind.</u> A post or comment may come along that angers or frustrates you. Remember, there is a real-life person sitting behind that username. A little kindness goes a long way for yourself, and others.
- 4. <u>No promotion.</u> This subreddit is a support group. We don't allow promotion of any kind. This includes, but is not limited to: Links and mentions of outside websites, social media accounts, and recovery centers. Personal blogs. Excerpts from recovery method specific literature when not appropriate to the thread. When we were featured on the Washington Post and a variety of other news sources, we allowed linking. The members have a right to access information when their support system is being written about.
- 5. **Don't solicit/offer PM's or outside communication.** It is inappropriate to request or offer to communicate with someone via PM [*private message*], Skype, text message, telephone, email, etc. We strive to create a helpful and safe environment. /r/stopdrinking is most helpful when all community members have a chance to weigh in. /r/stopdrinking is safest when all communications are done out in the open.
- 6. <u>Be careful with medical advice.</u> We are not doctors. Please try to avoid asking for and giving medical advice. This doesn't mean that you can't discuss your experience with certain procedures or medications, or ask others to share their experiences. But please recognize that talking to a physician is the best (and safest) way to get medical advice.

3.1.2 Prior research on SD

SD has been the focus of formative research studies in the field of computational social science (Harikumar et al., 2016; Tamersoy et al., 2015, 2017), which focused largely on analyzing SB data as an outcome measure. For example, <u>Tamersoy et al. (2015)</u> "constructed ground truth information on [/r/stopsmoking] smoking and [/r/stopdrinking] alcoholism abstinence from the crawled badges of the users." This study used complex computational linguistic methods that will be detailed further in Chapter 4. In a basic sense, the study used exploratory linguistic approaches

to classify language that was predictive of SD users having SB values ≤ 44 days (short-term abstinence) versus \geq 333 days (long-term abstinence), based on the observed distribution of SB values. Findings indicated that short- versus long-term abstinence could be predicted with 85% accuracy using linguistic models. In a later study of SD and /r/StopSmoking, Tamersoy et al. (2017) used "the information displayed via the badges as a proxy for self-reported ground truth data on abstinence status." This study used SB values to monitor relapses (i.e., SB values decreased or were reset) in a survival analysis. Based on linguistic models from the earlier study, engagement and language were used as predictors of relapse outcomes. Findings indicated that linguistic characteristics such as personal pronoun use and present-tense narratives were associated with increased risk of relapse. Linguistic features related to "self-disclosure" and disclosure of "health" and "addiction" contexts in particular were found to be protective of relapse. A study by Harikumar et al. (2016) used similar methods to <u>Tamersoy et al. (2015</u>) in order to identify linguistic predictors of SD users having SB values \leq 30 days versus \geq 365 days. Findings indicated that linguistic features associated with short-term abstinence included words that might relate to cravings, sleeplessness, anxiety, and work-related issues. Linguistic features related to long-term abstinence included words that might be associated with topics of incarceration and spirituality, among other clusters of topically similar words. Taken together, these findings indicate that language patterns and contexts of personal narratives within SD dynamically relate to contexts of alcohol use happening outside of the platform. While informative, the aforementioned studies have limitations that warrant further appraisal of SB data as well as content shared by SD users.

3.1.2.1 Research gaps and opportunities

While SB data were considered as *a priori* "ground truth" or "gold standard" indicators of sobriety duration in prior studies, this assumption has not been formally tested. This metric may

be biased if SD users do not actively reset their SBs after a lapse in sobriety occurs, which limits the validity of related study findings. Additionally, the use of short-term versus long-term sobriety groupings does not account for users with approximately more than one month but less than one year of abstinence (i.e., a medium-term sobriety group was omitted). As this is a critical and clinically meaningful time in recovery (see Chapter 1), additional research is warranted to evaluate ground truth along a continuum of SB data.

Formative studies in this realm used computational linguistic approaches to identify themes in the content that users posted. Approaches relied on the *Linguistic Inquiry and Word Count* (LIWC) or *Valence Aware Dictionary for sEntiment Reasoning* (VADER) software, which use pre-trained, rule-based models and common word dictionaries to categorize text (Hutto & Gilbert, 2014). As these models were not calibrated on text from alcohol- or recovery-related forums, they are not apt to detect contextual nuance within these domains. Conversely, supervised machine learning classifiers trained on alcohol-specific contexts have performed well in prior social media research (Aphinyanaphongs et al., 2014; T. Huang et al., 2017; Kornfield, Sarma, et al., 2018). Such approaches have also outperformed LIWC models in identifying other context-specific psychological and social constructs (Cutler et al., 2021; Hartmann et al., 2019). Supervised classifiers for social media data require careful attention to human annotation of training data as well as a conceptual framework to guide such annotation (Colditz et al., 2018). While this represents considerable effort, it also presents an important opportunity to qualitatively explore indepth themes that have not been ascertainable using computational linguistic approaches alone.

3.1.3 Project aims

To develop novel approaches and to overcome aforementioned limitations of prior research in this milieu, the present study focused on three primary aims:

- Develop robust methodological processes for collection, management, and analysis of data from the Reddit social media platform. This is demonstrated through successful collection and summation of data collected from the SD forum over time.
- Critically evaluate the characteristics of SB metadata as indicators of sobriety duration. This involves annotation of self-reported sobriety duration (i.e., utterances in SD posts) and quantitative comparison of these utterances to SB values captured in the metadata.
- 3. Qualitatively contextualize the content of posts and responses on the SD forum. This allows for understanding the contexts in which individuals engage on this platform. It also contributes new methodological and conceptual understandings for conducting in-depth observational research on SD or similarly large digital MHGs.

3.2 Methods

3.2.1 Data collection

Data were collected from the Reddit platform using a custom Python script in the "ReReddit" code repository, which I developed and made publicly available (Colditz, 2017/2020). The data collection process was hosted on a Linux-based virtual machine at the University of

Pittsburgh Center for Research Computing. This allowed for data collection with minimal interruption and provided access to appropriate software resources (e.g., Python, Jupyter Lab) for data management and analysis. The ReReddit script runs an infinite program loop with functions that that: (1) regularly check Reddit for new posts, (2) check metadata of collected posts for indications of new response activity, and (3) monitor available posts and responses for metadata updates (e.g., post deletion or moderator removal, text edits, community upvotes). For the current project, ReReddit was set to collect data only from the SD subreddit in order to ensure real-time responsiveness and to limit extraneous data overhead.

To broadly understand the levels of activity on SD, post and response frequency were assessed over a broad timeframe when primary data collection was active (2018-02-19 through 2020-04-30) and a time-frequency graph was created to contextualize overall forum engagement over this time period. Secondary analysis of trends in these data – particularly as they related to activity prior to and during COVID-19 social distancing – have been subsequently published elsewhere (Colditz et al., 2021). To reduce the data to a concise and reasonable scope for the present analysis, one complete year of data was selected from the middle section of available data (2018-10-01 through 2019-09-30). This allowed for initial codebook development and annotation procedures to commence in late-2019, which was aligned with my approved dissertation timetable.

3.2.2 Sober Badge (SB) analysis

SB values are present in the "user flair" metadata field, which was captured alongside each post and response using the ReReddit script. Within SD, the user flair metadata follows a predictable format that indicates the number of days sober as standard text (e.g., "365 days" for

one year). This field is empty if a user had not established an SB. The ReReddit script parsed numeric values from user flair and stored these in a structured file alongside other metadata. As the data collection script continued to loop-back to previously captured posts and responses, the SB value was regularly updated by adding new rows to the data file with associated timestamps of data monitoring. As SB values are not updated immediately on the platform, SB metadata updates may be delayed by up to 24 hours. For example, if a user had a SB value of 14 when they initially posted, this value would be expected to increase to 15 when the post was checked for updates at least 24 hours later. Conversely, if a user reset their SB due to a lapse in sobriety, the SB value would be expected to decrease within the subsequent 24 hours. The ReReddit script and associated data management strategy accounted for this. As such, analysis of SB data included both immediate SB values (when a post was detected) as well as regularly incremented values to conduct sensitivity analysis around 24-hour adjustment windows.

To establish validity of SB values, SB data were compared to **self-reported sobriety duration** (**SSD**) based on utterances present in users' posts. SSD was annotated using procedures for qualitative coding described below and direct comparisons were made among posts that had the presence of both SB and SSD values. For quantitative analysis, SB and SSD were first assessed for normality using the Shapiro-Wilk test to indicate if it would be appropriate to make comparisons using parametric statistical approaches. As assumptions of normality were not met, SB and SSD values were assessed using Spearman's Rho and Kendall's Tau tests of nonparametric association. These are more conservative tests as compared to Pearson's R, which assumes a normal distribution of data. Additionally, the Kruskal-Wallis K statistic was used to identify significant differences in underlying rank-ordered distributions between SB and SSD values. Inspection of data also included scatterplots to visually indicate patterns of bivariable discrepancy.

3.2.3 Preliminary codebook development

An initial coding framework was developed on the basis of theoretical indicators of alcohol recovery within an MHG context (see Chapter 1). This included broad psycho-social constructs such as locus of control, identification with a higher power, identification with the recovery group, and specific types of support seeking. The codebook also included constructs of abstinence versus harm reduction orientation, alcohol-related concerns, craving, clinical care, and in-person MHG involvement. Two annotators (described in Section 3.2.4) independently reviewed and discussed a preliminary set of ~100 SD posts on the Reddit website to refine and come to consensus on initial coding definitions. The codebook was further refined in an iterative fashion during subsequent rounds of independently double-coded annotation and adjudication.

For responses to posts, a standard annotation framework was adapted from a conceptual model of social support from <u>Heaney & Israel (2008)</u>. Table 3.2 indicates categories and definitions used for annotation. Annotation categories were inclusive (i.e., multiple categories per reply were possible). Responses to "daily check-in" community posts were manually excluded.

Construct	Definition (Heaney & Israel, 2008)		
Emotional support	"provision of empathy, love, trust, and caring."		
Appraisal support	"provision of information that is useful for self-evaluation purpose —in other words, constructive feedback and affirmation."		
Informational support	"provision of advice, suggestions, and information that a person can use to address problems."		
Instrumental support	"provision of tangible aid and services that directly assist a person in need."		

Table 3.2. Coding framework for responses

3.2.4 Annotation of posts

To balance representativeness of data and feasibility of annotation (i.e., content coding), a random 2% subsample of posts was drawn from each day of data, resulting in a sample of 1,556 posts to evaluate. As posts can be lengthy and contain multiple themes, post text was split into paragraph-level units where line breaks naturally occurred in the original post. The post title was considered part of the post as a separate paragraph. This reduced extraneous overlap among themes within posts and provided a manageable data scope for annotators to review and explore themes.

To facilitate secondary annotator training and to inform emergent qualitative themes, annotation proceeded by highlighting code occurrences, recording memos on hard copy printouts, and entering summary data into structured Excel spreadsheets. Annotators discussed progress via weekly in-person meetings, which included myself (JC; primary annotator) and Eleanna Melcher (EM, pre-med honors college student; secondary annotator). Annotators followed a process where five hard copy pages with approximately 20 paragraph units per page were annotated and adjudicated at weekly intervals. Through this process, annotators further refined the codebook to identify sub-themes and to account for emergent thematic contexts. For example, themes that related to physical, mental, social, and legal/financial concerns were refined with a secondary code to flag whether the concerns were directly related to alcohol use. In this case, previously annotated data were revisited to ensure conformance of recorded data to updated coding definitions. In other circumstances, such as when a new context of physical concern (e.g., digestive issue) was newly identified in the data, the codebook was amended for clarity but revisiting annotations from prior weeks was not deemed necessary.

After 10 weeks (n = 251 posts; n = 1000 paragraphs), the codebook was considered final and inter-rater agreement was calculated on the final set of coded data (n = 103 paragraphs) using Cohen's Kappa coefficient as an indicator for reliability of annotator judgements and validity of the coding definitions. A commonly used interpretation of Kappa coefficients is that 0.41 to 0.60 indicates moderate agreement, 0.61 to 0.80 indicates substantial agreement, and above 0.80 indicates almost perfect agreement (Landis & Koch, 1977). In Kappa calculations, all thematic categories were treated as dichotomous variables except for "days sober" which was an interval. In this case, Kappa was calculated as annotators' assessments exactly matching or mismatching. After inter-rater agreements were calculated (see Table 3.3), JC proceeded to independently annotate the remainder of posts using the finalized codebook (see Appendix C). At the time of data collection, post flair was not used on SD, so community-themed posts were manually identified by evaluating common phrases (e.g., post title included "daily check-in"). As this project focused on individual user posts and associated responses, community-themed posts were designated as not applicable when encountered in annotation procedures.

3.2.5 Annotation of responses

To contextualize supportive engagement on SD, a subset of responses to posts was selected for annotation. To ensure consistency and feasibility of these procedures, JC randomly selected one post per day from the available data (n = 365) and the first-available response was selected for annotation. Responses to community-themed posts or responses to self were manually excluded, leaving 346 relevant posts for analysis.

As the codebook for annotating responses was defined through a well-defined theoretical framework (Heaney & Israel, 2008), codebook definitions were not altered as annotation progressed. The annotation process otherwise followed the aforementioned procedures of independent coding and adjudicating disagreements at weekly intervals with a student research assistant (Lily Hsiao). The final set of 64 independently annotated responses was used to calculate inter-rater agreement. This indicated substantial agreement for appraisal support (K = 0.77) and almost perfect agreement for emotional support (K = 0.84) and informational support (K = 0.81). No instances of instrumental support were identified in the data.

3.2.6 Qualitative analysis and synthesis

Basic descriptive analysis of annotations included frequency and percentage of occurrences as indicated within Table 3.3 (posts) and Figure 3.3 (responses), and associated narratives. To further contextualize the annotated data, I approached qualitative synthesis through a descriptive phenomenological methodology, which is both an epistemological framework as well as a formal research approach for generating interpretive description (Finlay, 2009). Epistemologically, I recognized that observed narratives may not fit strictly within the scope of conceptualized codebook definitions, but that these constructs would benefit from further contextualization. Thus, each of the codebook constructs were treated as distinct phenomena to explore. This methodological approach is reflected in prior mixed-methods work, which phenomenologically contextualized electronic cigarette use narratives within social media data (Colditz et al., 2019).

As a formal research methodology, Giorgi (1997) describes a three-step phenomenological approach: (1) reduction, (2) description, and (3) search for essences. The initial step of reduction involved categorizing data using codebook definitions from the earlier annotation process. I referred to a spreadsheet of annotated data and approached categorical codes as unique phenomena. In the process of description, I reviewed all of the paragraphs identified within categorical codes and identified direct quotes as they indicated salient, common, or unique experiences. Through this process, I made no assumptions about the latent intent of individuals, but included the quotes that described experiences in individuals' own words. Finally, in the search for essences, variations of emergent themes were compared and contrasted to identify common structures among diverse descriptions of individual experiences. This involved refining descriptions to reflect parsimonious themes and reduce extraneous information in order to present cohesive findings. At this point in the process, I must also acknowledge that synthesis was no longer phenomenologically grounded in a strict sense (i.e., I brought my understandings of psychosocial concepts to bear on the data). This is a necessary accommodation as the research process of interpreting findings requires the researcher to draw upon discipline-specific contexts in a manner that is conceptually meaningful and interpretable (Finlay, 2009; Giorgi, 1997). The resulting synthesis is organized to: identify emergent cross-cutting themes within particular constructs, include descriptive narratives that incorporate quotes from diverse perspectives, and summarize impressions of essential themes.

To respect the privacy of SD contributors and reasonably prevent re-identification, direct quotes were reviewed and modified by removing selected words and by rephrasing segments of text that were unique enough that they could be reasonably used to identify the original version online. This is an important step when reporting quotes from potentially sensitive contexts of public online data (Moreno et al., 2013; Proferes et al., 2021). As a confirmation step, modified quotes were searched on the Reddit platform to ensure that the original content was not readily retrieved and additional refinements were made as necessary. For transparency, modified phrasing has been indicated with brackets in the results. While quotes were modified in this way, great care was taken to preserve the essential meaning of content.

3.3 Results

3.3.1 SD forum activity

Over the broader data collection time period (March 2018 through April 2020), there were a mean of 18,575 engagements per week (SD = 1,998), inclusive of posts and responses. In a secondary analysis described elsewhere by <u>Colditz et al. (2021)</u>, engagement was significantly low in the initial two months of COVID-19 social distancing. Figure 3.1 illustrates weekly engagement trends on the SD platform with dashed vertical lines accentuating the months of March and April across years. Differences between predicted and observed values during the COVID-19 pandemic are indicated in red. As illustrated in the figure, the SD platform has historically experienced peak engagement on New Year's Day followed by a sharp decline and subsequent regularization with patterns of seasonal variation. This is consistent with common "Dry January" resolutions, as described further in Section 3.3.3.4.

The 1-year observation period (2018-10-01 through 2019-09-30) used in subsequent analyses is roughly a middle section of the available data indicated in Figure 3.1. These data included a total of 77,275 posts and 895,172 responses. Among the responses, 580,100 were *direct* responses to posts (i.e., not responses to other responses). There was a median of 209 posts per day (*IQR*: 196-226 posts) and the median number of direct responses to posts was 4 (*IQR*: 2-7). It took 11.6 minutes (*Median*; *IQR*: 5.1-29.2 minutes) for a post to receive an initial response and community activity continued within posts for 6.5 hours (*Median*; *IQR*: 2.2-14.5 hours).





Note: Red-shaded area corresponds to significantly low engagement related to initial COVID-19 social distancing. Dotted lines accentuate months of March and April across three calendar years. See also Colditz et al. (2021).

3.3.2 SB values and self-reported sobriety duration (SSD)

Among the valid sample of annotated posts (n = 1,551), 1107 (71.4%) included an indicator of sobriety duration as Sober Badge metadata (SB; 726, 46.8%), self-reported sobriety duration (SSD; 680, 43.8%), or both (299, 19.3%). Distributions were non-normal and positively skewed for both SB (*Shapiro-Wilk* = 0.25, p < 0.001; *Mean* = 226, *SD* = 734, *Median* = 48, *IQR*: 12-200) and SSD (*Shapiro-Wilk* = 0.17, p < 0.001; *Mean* = 126, *SD* = 574, *Median* = 12, *IQR*: 3-61). Among 299 posts with both SB and SSD, these values were moderately correlated (*Spearman* r =0.71, *Kendall Tau* = 0.66). Correlation strengthened (r = 0.82, *Tau* = 0.77) when a 24-hour adjustment window allowed for later SB updates to occur, though underlying distributions of SB and SSD remained significantly different (*Kruskal-Wallis K* = 63.5, p < 0.001). While there was zero median difference (*IQR*: -1,+1) between adjusted SB and SSD values, SB was a mean of 19 (*SD* = 154) days higher.

Differences are illustrated by scatterplots (see Figure 3.2), which demonstrate general pattern of discrepancy where SB remained high when SSD values were nearer to zero, suggesting that SBs were not updated by users when they lapsed (see Section 3.3.3.1). For illustrative purposes, larger red dots indicate original SB values and smaller black dots indicate 24-hour adjusted SB values. As seen in Figure 3.2, the 24-hour adjustment window appropriately corrected for some discrepancies (i.e., red dots without black centroids near zero on the x-axis), but also resulted in some over-correction (i.e., black dots without red halos near zero on the y-axis). Such over-correction appeared when users posted an SSD and then indicated a lapse via the SB feature within the subsequent 24 hours.



Figure 3.2. Scatterplots of SB compared to SSD Note: Red dots are unadjusted SB values and black dots are 24-hour adjusted values.

3.3.3 Post content

Based on the sampling framework, 1,556 posts (6,937 paragraph units of text) were available for annotation. Eleven community-oriented posts (e.g., "daily check-in") were manually excluded and 87 posts had no identifiable constructs, leaving 1,458 posts for qualitative synthesis. Frequency of annotated constructs are reported in Table 3.3 and qualitative synthesis resulted in conceptually rich phenomenological narratives, as organized by conceptual domain subheadings.

3.3.3.1 Self-reported sobriety duration (SSD)

Just under half of annotated posts included an SSD. As indicated in Section 3.3.2, SSD frequently did not match SB values. Minor discrepancies in quantification arose from individuals indicating a non-specific SSD such as "a few days", "almost a week", or "just over a year." Content of posts revealed three common themes that may explain broader patterns of discrepancies. First, individuals reported SSD while also reporting technical difficulties updating their SBs (e.g., "my *[SB is] incorrect. I can't figure out how to fix [it]*"). In another example within this theme, an individual posted to the forum with a message requesting a SB reset and indicated the appropriate value, though this is not the process for resetting an SB. <u>Second</u>, individuals indicated within a post that an SB reset was needed, but that it had not yet been initiated (e.g., "*I know my [Sober Badge] needs resetting*", "*I'll reset later*"). <u>Third</u>, individuals expressed uncertainty about what quantity of drinking should trigger an SB reset. For example, one individual indicated: "*I took [a small drink]. Should I reset my [SB]?*" Resetting as such would result in SBs being set to lower values by using stricter abstinence criteria (e.g., resetting SB after a sip), while SSDs would remain higher as individuals reported being "*sober*" for a longer duration.

Table 3.3. Inter-rater agreement and prevalence of constructs within post data

Construct	Cohen's Kappa, paragraphs: n = 103	Frequency (%), paragraphs: n = 4,299	Frequency (%), posts: n = 1,458
Self-reported sobriety duration	0.95	887 (20.6)	680 (46.6)
Lurking	1.00	48 (1.1)	48 (3.3)
Support seeking	0.78	711 (16.5)	494 (33.9)
Recovery orientation: Abstinence Harm reduction	0.56 -0.01	378 (8.8) 159 (3.7)	279 (19.1) 121 (8.3)
Locus of control: Internal External	0.68 0.58	1071 (24.9) 373 (8.7)	723 (49.6) 276 (18.9)
Identification with a higher power the SD community	0.82	32 (0.7) 405 (9.4)	30 (2.1) 345 (23.7)
Use of in-person MHGs clinical support	1.00 1.00	226 (5.3) 208 (4.8)	134 (9.2) 132 (9.1)
Personal concerns: Mental Physical Social Legal / Financial	0.94 0.94 0.69 0.79	850 (19.8) 460 (10.7) 218 (5.1) 144 (3.3)	534 (36.6) 311 (21.3) 359 (24.6) 119 (8.1)
Craving	0.91	390 (9.1)	284 (19.5)

3.3.3.2 Lurking

Passive forum observation by users was often referred to as "*lurking*" or as being "*a lurker*" in SD narratives. This terminology, while seemingly pejorative in tone, is common and consistent with prior literature on online communities (Han et al., 2014). Users indicated this type of passive observation (i.e., reading but not engaging) prior to making initial posts (e.g., "*I've been reading [many] posts here*"). However, lurking was also contextualized as "*I usually just [upvote] or*

[respond]" by one user who reflected on lurking as including forum activities other than contributing posts. Users indicated past lurking behavior when it had been occurring for "a while" or "a long time", and users specified lengths such as "several months", "about a year", or longer. The transition from lurking to posting included contexts of seeking out peer accountability, wanting to become active in the community, and being inspired to "finally quit drinking" based on reading others' posts. While this construct appeared relatively infrequently, low frequencies may be expected as users generally mentioned lurking only in contexts of their first introductory posts.

3.3.3.3 Support seeking

Roughly a third of posts directly solicited support. This was typically in the form of asking a question or seeking advice about a particular issue that the individual was facing. For example, questions about physical and mental health issues were common. Among support-seeking posts, 22% also indicated physical health concerns and 37% indicated mental health concerns. Questions of this type often indicated a desire for a sense of normalcy or improved functioning (e.g., "*is it normal to…*", "*when will this get better?*"). Other types of support seeking included seeking recommendations for strategies to overcome alcohol cravings or to deal with triggers to drink (e.g., going out with friends, a romantic partner who drinks at home). Individuals also sought out recommendations for more tangible resources such as books to read or non-alcoholic drinks to try. No annotated posts included direct requests for tangible resources such as money nor solicitations for contact outside of the forum, which was aligned with SD forum rules forbidding such activities (see Table 3.1).

3.3.3.4 Recovery orientation

Recovery orientation was particularly challenging to reliably annotate, as demonstrated by the relatively low inter-rater agreement coefficients for both abstinence- and harm reduction orientated themes (see Table 3.3). Expressions of abstinence orientation generally fit within two themes of goal-orientation and identity-orientation. Abstinence goal-orientation was typified by "never going to drink again" or "I quit drinking" types of statements, indicating a temporal finality to alcohol use. Shorter durations, such as "not going to drink today" were not annotated as such, since these were universal among SD content, and they applied to both harm reduction and abstinence goals. Abstinence identity-orientation was related to a user posting that they identify as someone who does not drink or that their lifestyle is one that does not include alcohol use. For example, users would describe their experiences from the perspective of being a "non-drinker" or "former drinker", or that they were "living a sober life". In some cases, the temporal finality was unclear, such as when a user framed a post with "since getting sober...". These types of statements were generally annotated as abstinence oriented, but it was not always clear if that was the intent of the individual. This presented a challenge for maintaining clear criteria for inclusion into the abstinence orientation conceptual category.

Similar annotation difficulties arose in the harm reduction orientation category. In general, the few posts that were annotated as such indicated a goal-related intent to limit frequency (i.e., fewer drinking days) or quantity (i.e., fewer drinks per day) of alcohol use. Identity-orientation posts were rare and indicated a desire to be a "normal drinker" or "social drinker", often on specific occasions (e.g., "happy hour with coworkers", "on vacation"). This orientation also included goals of temporary abstinence (e.g., "Dry January", "90-day sobriety challenge") and

these presented a particular challenge for annotation. For example, it was unclear (to annotators and ostensibly to some users) if the goal was intended as only a temporary reprieve from drinking or as a first step to longer-term abstinence (e.g., "*see how it goes*"). A salient theme of *controlled drinking goals* appeared to be distinct from the broader harm reduction domain.

3.3.3.5 Locus of Control (LOC)

Among posts that provided an indication for LOC, internal LOC was more than twice as prevalent as external LOC. However, internal LOC was also found to have some qualitative gradation and 53% of internal LOC posts were flagged as "general" or what might be considered superficial. For example, SD has a common platitude of "*I will not drink with you today*" that is more commonly expressed as a shorthand acronym of "*IWNDWYT*". This was frequently used as a salutatory closing in posts. As this phrase met the formal codebook criteria for internal LOC, it was annotated as such but this also justified a separate indicator to flag this type of content within the category. If a more stringent criteria were used and general statements were excluded, indicators of internal LOC would have been reduced to 30% prevalence among annotated posts. This still remains 1.5 times more prevalent than the 20% of posts indicating external LOC.

Internal LOC generated diverse and conceptually salient themes. In particular, *recovery self-efficacy* – expressing confidence or determination to maintain sobriety – was intertwined with the internal LOC construct and this was a common theme among posts. In parallel with this theme, individuals indicated developing lifestyle approaches and strategies to facilitate or maintain sobriety (e.g., "*I'm going to [an AA meeting] tonight [and I am moving toward] not drinking.*", "*I will [improve my health] physically and mentally [through exercise, to avoid drinking].*", "*I [started a] diet which forbids [drinks other than] tea or coffee [and this reduces my] stress.*

[drinking alcohol] is no longer a decision I [need to think about]."). In other examples, life events triggered motivations or led to the use of specific motivations or strategies to abstain from alcohol use (e.g., "[I had a child and] it's important that [they not] go through [what I did]. I'm putting in the work to break the [family cycle of alcohol addiction].", "[My partner left me and] I wanted to drink, but instead I listened to [particularly sad and meaningful music] and just [cried]. It was [a helpful emotional release].").

These examples stand in contrast to themes within the external LOC domain, where intervening circumstances were identified as causal to either drinking or maintaining sobriety (e.g., "I [experienced a trigger] and suddenly I've been drinking again.", "pregnancy [caused me to stop drinking]. [This is] a miracle."). A similar theme indicated use of alcohol in coping with challenging circumstances, which indicated external influences on alcohol use behavior (e.g., "I had a bad day [so] I got drunk.", "I was dealing with [a parent's death] and I started to [drink heavily].") Themes also included identifying a lack of self-efficacy related to controlling alcohol use which was described in various ways (e.g., "Why don't I have control over anything?", "I cannot limit myself.", "I find something that gives me pleasure and [always overdo it].", "I can't find the will power.", "I was sober [for many years until recently]. I know what [it requires]. I just can't do it.").

Overall, the internal and external LOC domains were highly complex and interconnected with regard to drinking. For example, life events related to becoming a parent could be expressed as external LOC (i.e., parenthood causing sobriety) or as internal LOC (e.g., ceasing alcohol use to become a better parent). Similarly, medication use was indicated as an external factor (e.g., adverse interactions with alcohol prevent drinking) as well as an internal factor (e.g., actively seeking medication to aid in maintaining sobriety). Through thematic synthesis it became clear that categories of internal and external LOC, while conceptually meaningful, capture a broad array of information that might be contextualized across narrower conceptual domains such as: recovery self-efficacy, drinking to cope with challenging circumstances, alcohol use or cessation related to major life events, or challenges controlling compulsive alcohol use.

3.3.3.6 Identification with a higher power

This construct was the rarest and inter-rater agreement could not be calculated due to scarcity of data. Contexts included general "thank God" or "praise the Lord" utterances, particularly when reflecting on being able to initiate or maintain sobriety in light of challenging personal circumstances (e.g., "thank God I chose [to get help]."). Individuals also indicated complex relationships with spiritual traditions, such as noting that "I am [religious] by most standards [so I can attend an AA meeting]" or "I'm lacking faith in [a higher power due to recent adversity]". Spiritual practices of prayer were primarily identified when individuals requested prayers from the community. In one circumstance, a short prayer was submitted as a post. In general, the scarcity of content and contextual themes appeared to indicate a largely secular environment in the SD forum.

3.3.3.7 Identification with the SD community

Group identification was coded when a user made direct reference to the SD community – generally in the form of giving thanks or praise. Common examples among these posts included statements such as "*I love reading your stories*" or "*thanks for being here*". Less formalized statements of affiliation were also included in this category, such as opening posts with "*Greetings*"

friends!", closing posts with "*thank you all*" or making similar statements where the user formally acknowledged SD as a cohesive entity. Identification with the SD group was also coded when users indicated engaging in normative community behavior such as discussing setting up an SB or submitting a new post as a "*daily check-in*".

In other cases, users more formally indicated belonging, such as: "*I've found my people*", "*[you are] my fellow sobernauts*", or "*[you are a] community that understands*". Other types of group identification included offering unsolicited, personal advice to the community (e.g., "*if you're anything like me…*", "*I wanted to post this for anyone who…*"). Such statements were typified by expressions of empathy or understanding (e.g., "*I feel you*", "*this is completely normal*", "*if I can [not drink], so can you*"). Contextually, these expressions appeared to be distinct from the earlier themes (i.e., thanks and praise, greetings) in that they hinged on users framing their experiences for the benefit of the larger community. Thus, there appeared to be gradations of intimacy and affiliation within the larger domain of identification with the SD community.

3.3.3.8 Use of in-person MHGs

Posts discussing in-person MHG engagement generally referred to experiences with AA or 12-step programs; SMART recovery was mentioned four times and Moderation Management and LifeRing were each mentioned once.

A salient theme of alcoholic identity emerged in the context of experiences with in-person groups. For example, one individual noted that they observed a SMART Recovery attendee who reached out for help managing a relatively mild pattern of alcohol use, but she was offered little help as someone who was not drinking at *"alcoholic"* levels. Others indicated personal

experiences of learning about an alcoholic identity from these groups (e.g., "*I learned… by asking* [others] what made me an alcoholic"), but not necessarily identifying with that label outside of meetings (e.g., "*I* [have said that I'm an alcoholic] at AA meetings… [but tell others that] I have AUD"). Other individuals identified more strongly with an alcoholic identity. For example, one post indicated that the AA program has been beneficial to develop empathetic relationships with "other actual alcoholics" rather than relying on the sympathies of people who do not understand this perspective. Another indicated that "[I needed to get] out of my [comfort zone] and help other alcoholics." In this way, recognizing and identifying with a commonly accepted alcoholic identity served as a way to maintain cohesion within in-person groups.

Another salient aspect of in-person group participation included having access to comradery (e.g., "I had to find people who would want me to be around", "everyone was so welcoming"). In the context of AA, this was described specifically as "fellowship" and also included developing one-on-one relationships with program sponsors who served as regular points of contact between formal meetings. A number of individuals reflected that they were socially anxious about attending an initial in-person meeting, but that the meeting was not as challenging as anticipated (e.g., "I enjoyed it more than I thought I would"). Conversely, other individuals expressed a sense that they "didn't belong" in cases when their "problem wasn't big enough", or if they were not meeting the social expectations of calling sponsors regularly or attending regular meetings (e.g., "90 meetings in 90 days [is not reasonable]"). An additional concern included unwanted advances by meeting attendees (e.g., "[a male attendee] kept saying [that I was] so beautiful", "[he made me] very uncomfortable", "he hugged me [multiple] times", "during the serenity prayer [he moved seats to hold my hand].") In general, individuals expressed appreciation

for comradery available through in-person groups, but also indicated that the expectations of engagement were too intense or that personal boundaries were not being respected.

Orientation to AA's 12-step program was another salient theme in this realm. Several people noted aversion to the 12-step framework, both in the context of general criticism (e.g., "[I've tried] 12 step programs [and they don't interest me]."), as well as more nuanced ways (e.g., "I just don't believe in the [12-step program] like most of the other people do", "they believe [the steps are magical] and when [adversity happens], it's because their [12-step work] is weak or they need to [do additional work on the steps]"). Individuals also expressed reservations about the "God" or "Higher Power" aspects of the program, which were not aligned with their personally held philosophies or spiritual beliefs. Individuals expressing aversion to 12-step programs generally indicated that such programs were good for "other people". More commonly than aversion, individuals expressed praise of 12-step programs. One user indicated that they "tried all sorts of [approaches] to get sober [(e.g., Moderation Management, sobriety tracker apps, selfhelp books, yoga, nutritional supplements)]" but when those didn't work, they turned to the 12step program. They indicated that this was "a lot less stressful than trying to figure out everything [independently]". Others indicated that "working the steps" was an integral part of their recovery process (e.g., "I worked the steps with a sponsor [which] saved my life.") Overall, SD users who indicated involvement with in-person groups expressed mixed feelings about 12-step programs. While some posts identified them as a core feature of personal recovery processes, others described such programs as incompatible with philosophical perspectives or personally held spiritual beliefs. While there were conflicting perspectives in this domain, individuals were generally accepting and tolerant of conflicting perspectives that they perceived others having.

3.3.3.9 Use of clinical support

Contexts of clinical care were identified relatively infrequently and it was feasible to further quantify sub-themes of *medication use* and *counseling* within this domain. Among posts that indicated clinical care, 34% included mentions of prescribed medications and 58% included mentions of counseling-related activities (10% included both).

Medication use included prescription drugs used in the context of treating alcohol or other substance use (e.g., naltrexone, gabapentin), associated withdrawal symptoms (e.g., chlordiazepoxide, diazepam), as well as those used to treat comorbid mental health conditions (e.g., bupropion, propranolol). These were generally referred to by brand name rather than generic names. In many cases, individuals more generally referred to medications as "*the meds*" or similar. Contexts of medication use included inpatient detoxification and aftercare, "*home detox*", and general use. While it was not always clear from narratives who prescribed these medications, no one specifically noted that medications were diverted or obtained illicitly.

Counseling was generally noted in contexts of outpatient care though it was also indicated in group home recovery settings. For outpatient care, individuals commonly referred to "*therapy*" or seeing "*my therapist*" and four posts specifically mentioned "*IOP*" (i.e., intensive outpatient care) or "*aftercare*". While residential treatment contexts were rarely mentioned, one individual reflected as "*I didn't want to go… but I [took the advice that I heard here]*" and they indicated that they had been engaging in the SD forum for two years, in addition to pursuing clinical care. Another 17% of posts in the clinical care category did not include references to medication use or counseling. These generally included contexts of primary care or emergency care. In primary care settings, individuals noted "being honest" with their providers about drinking histories and reflected on concerns about liver function (e.g., "I'm going to have [my doctor] run a liver function [test]", "to have a [health check] - [particularly for my] liver"). With respect to emergency care, contexts generally involved receiving immediate support for detoxification (e.g., "[I went to the emergency room] because of alcohol poisoning", "I asked for an ambulance [to go to clinically supervised detoxification]"). One individual noted a severe neck injury that resulted in emergency care and clinical evaluation for alcohol use, but this was not explicitly identified as an alcohol-related injury.

3.3.3.10 Personal concerns

Concerns were categorized as *mental, physical, social,* or *legal/financial.* Concerns were annotated if they were current issues as well as if they were resolving (e.g., "*Since I stopped drinking, I no longer …*"), or if they were emerging concerns (e.g., "*I'm worried that my…*"). Concerns could be sub-classified as *general* or *alcohol-specific*, and this was sub-classified during annotation of these domains.

Among posts expressing mental concerns, 63.5% indicated alcohol-specific concerns within this domain. This was the lowest proportion among the four domains, as general concerns (i.e., not alcohol-related) included a number of comorbid conditions (e.g., depression PTSD, bipolar disorder, agoraphobia) that were not directly attributed to alcohol use within posts. Within the alcohol-related context, mental concerns were both attributed to intoxication (e.g., "*in a fit of rage*", "*crying uncontrollably*") and acute alcohol withdrawal or hangover (e.g., "*woke up in a*").

state of panic", "*too depressed to get out of bed*"). Thus, mental concerns included both specific conditions as well as more general feelings of dysphoria related to emotional concerns. This domain also included cognitive concerns, which were primarily related to amnesia (e.g., "blacked out") during drinking episodes or reduced mental acuity (e.g., "*groggy*", "*confused*") related to intoxication or withdrawal.

Among posts expressing physical concerns, 82.6% indicated alcohol- specific concerns within this domain. Concerns broadly related to physical fitness along themes of weight gain or loss, physical endurance and fatigue, and sleep disturbance. Other common themes included gastrointestinal issues of bloating and diarrhea from drinking or constipation from abstaining. Skin issues such as rosacea (e.g., *"blotchy face"*) and swelling (e.g., *"puffy face"*) were typically mentioned retrospectively, as improvements became noticeable. Alcohol-related concerns also included liver issues (e.g., cirrhosis, alcoholic hepatitis, fatty liver, jaundice), pancreatitis, and neurological issues (e.g., headaches, loss of balance, numbness or tingling). While relatively rare, severe withdrawal symptoms (e.g., delirium tremens, seizures) were also identified in posts.

Among posts expressing social concerns, 66.3% indicated alcohol-specific concerns within this domain. Alcohol-related social concerns generally related to alcohol use (or sometimes sobriety) causing conflicts among family, friends, and coworkers. A primary theme was when the individual directly engaged in conflict while intoxicated (e.g., "*I said some horrible [things]*", "*I threw a glass at my [partner]*"). This would sometimes result in the end of a relationship (e.g., "*I scared off someone I love*", "*my wife left me*", "*we've not spoken since*"). Other reflections of problematic behavior included engaging in abnormally risky situations (e.g., "*I [fell asleep] in*
public", "I remember inviting a stranger over"). Another theme related to having difficulties maintaining relationships more generally. For example, individuals reflected that while they were drinking, friends did not want to be in their company (e.g., "I [was] a toxic person", "friends [said] they couldn't trust me because [I do dangerous things when drinking]"). Conversely, after stopping drinking, friends who continued to drink became estranged (e.g., "I [now have] no social life because my friends just drink", "my friends weren't really friends, just [drinking partners]", "a friend urged me to [start drinking again]"). Others indicated problems with making new friends or initiating romantic relationships without alcohol (e.g., "I [don't know] how to make friends", "being sober [and flirting] triggered feelings [of guilt and] shame"). Within the domain of social concerns, in addition to general and alcohol-specific social concerns, there were salient concerns about estrangement from peers and social circumstances that hinged on alcohol use.

Among posts expressing legal or financial concerns, 82.4% indicated alcohol-specific concerns within this domain. Among these, a common theme was related to occupational issues, such as losing a job (e.g., "*I was fired for being [regularly] late*") or under-performing at work (e.g., "*I start drinking [in the morning and then I don't] work because I drank*."). Other types of financial concerns related to losing one's home, mode of transportation (e.g., car, motorcycle), or other valuable property (e.g., wallet, phone). In some cases, loss of a mode of transportation was directly related to a motor vehicle accident, being arrested for driving while intoxicated, or both (e.g., "*I totaled [my car when] I got my DUI*."). Individuals also indicated ongoing issues with the legal system (e.g., ''*I need a lawyer but [can't afford one]*", "*I'm [already several] months [sober] and am [only now] being sentenced*."). In the minority of posts that were general concerns, primary themes related to unemployment or under-employment, being unable to pay bills, or not having

health insurance (e.g., to get clinical care for AUD). Only one individual indicated general concerns related to law enforcement, as "*police [came to perform safety checks] because friends* were concerned [about my mental health]."

3.3.3.11 Cravings

Essential themes of cravings included *environmental triggers, contextual triggers,* or *impulses* without clear triggers. Environmental triggers were indicated when an individual perceived alcohol (i.e., physical environment) or when alcohol was mentioned or offered by others (i.e., social environment). A number of posts indicated seeing alcohol as a trigger (e.g., "*I look at the [liquor cabinet and] imagine that warm feeling*", "*I saw my neighbor partying and having a good time*", "*I [saw] the liquor store on my way home*"). Others indicated the smell of alcohol as a trigger (e.g., "*smelling [my drink of choice] is making me crave*", "*the smell of alcohol triggered me*"). In the social environment, this also included invitations to environments where alcohol would be a focal point (e.g., "*I [was invited to] a house party*", "*[my coworker] said she was skipping [our gym routine] and having a [drink]*"). Individuals posted after successfully overcoming environmental triggers (e.g., removing alcohol from the environment, avoiding triggering social events) and none of the posts indicated drinking in response to purely environmental triggers.

Contextual triggers related to events or circumstances that reminded an individual of drinking or would have normally involved drinking. Examples included social activities (e.g., "*I will be [out of town] for my friend's [wedding engagement] party*", "you have to drink or [a particular holiday] won't be fun"), pastimes (e.g., "*I played a game that [I've never] played [while sober]*"), or household activities (e.g., "*I always had [my preferred drink] while cooking dinner*").

Other triggering contexts included drinking as a response to stress or emotional distress (e.g., "*I* had a bad day at work", "when I have [a craving], it's because I'm hungry, angry, lonely or tired"). Individuals also indicated an internal monologue that would justify drinking as earned or deserved (e.g., "You've earned it!", "work is busy - I deserve a drink").

In other circumstances, no environmental or contextual triggers were identified. Such posts framed cravings as impulses or intrusive thoughts. For example, individuals portrayed cravings as a "voice" that enticed them to drink (e.g., "*out of nowhere that little voice is back*"). In other examples, cravings were objectified (e.g., "*cravings are still present and strong*").

3.3.4 Response content

None of the responses indicated instrumental support, as the SD forum discourages sharing tangible resources (e.g., money) and engaging with other users outside of the public forum space (see Table 3.1). Of types of support that were identified, emotional support was the most common and appeared in 78% of responses. Appraisal support was less common and appeared in roughly half of responses (52%) and informational support appeared in 16%. Co-occurrences of support type within responses is indicated in Figure 3.3.



Figure 3.3 Co-occurrences of support type within responses (n = 346) Note: values sum to 101% due to rounding

Emotional support was indicated in 78% (*n* = 269) of responses. A primary context of emotional support on the SD platform included praise for positive steps in recovery (e.g., "*[well done] on the positive changes*"). This also included praising specific sobriety milestones (e.g., "*congratulations on 3 days*") or maintaining sobriety through challenging situations (e.g., holidays, personal concerns). Another common context was providing reassurance (e.g., "*you can get through this*", "*you're stronger than you know*") and other general encouragement (e.g., "*keep it going*"). Other contexts of emotional support included connecting through empathizing (e.g., "*I felt that way too*"), sympathizing (e.g., "*sorry to hear that*"), and welcoming (e.g., "*so glad you're here*") for newcomers in particular.

Appraisal support was indicated in 52% (n = 180) of responses. 64% of responses that included appraisal support also included emotional support. This overlap relates largely to empathy

and reassurance expressed as responders conveyed appraisals. In the context of affirmations, responders indicated that the original poster's experience was favorable or typical (e.g., "you're on the right path", "relapses are normal"). This was present for both positive experiences (e.g., "waking up early and feeling great is [how to enjoy a vacation]") and for negative experiences (e.g., "I would [also feel] shameful and hopeless [if I had done that...] be kind to yourself"). Responses also included aspects of storytelling, where self-appraisal narratives served as vehicles for delivering advice or considerations. Narratives included information about negative health experiences (e.g., "I [told] myself it was something else causing [my health issues], but I knew deep down [that alcohol was causing them]", "I speak from experience as I was [prescribed a medication for insomnia] and became addicted"). Narratives also included cautionary tales about returning to moderate drinking after a period of abstinence and escalating into patterns of highintensity drinking. In other contexts, appraisals were leading questions (e.g., "Have you read...?", "[What are the drinking] activities you look forward to that you couldn't do sober?", "Can you forgive yourself [as you would] forgive a [close friend]?"). In rare cases, responders directly provided critical feedback. This included responses asking the original poster to reappraise situations like hesitancy to seek additional help (e.g., "[I] strongly [encourage] you to consider [going to] detox and AA.") or returning to moderate drinking after a period of abstinence (e.g., "that you [once needed to go] to detox says something... you should [abstain from alcohol]").

Informational support was indicated in 16% (n = 56) of responses. On the SD forum, informational support consisted of recommended resources (e.g., self-help books, in-person support groups), factual information about the recovery process, and strategies for maintaining sobriety. Recommended resources include self-help books (e.g., "*This Naked Mind is a favorite*

here"; this particular book was mentioned frequently), recovery-oriented movies to watch (e.g., *"Clean and Sober*", *"28 Days*", *"Leaving Las Vegas*"), alternatives to alcoholic drinks (e.g., *"La Croix"* sparkling water, *"virgin cocktails*"), as well as in-person support (AA and SMART Recovery in particular). Factual information about the recovery process was primarily related to withdrawal symptoms that can happen in early sobriety (e.g., insomnia, anxiety, gastrointestinal changes), how to safely detoxify (e.g., clinical supervision, medications, nutritional supplements, alcohol tapering), and how to effectively manage cravings. This also included recommendations for how to engage with associated resources and information (e.g., *"[ask your doctor to] check your liver function"*, *"12 step work is done on your own [but] a sponsor [can guide you]"*). Responders also referred to static resources in the SD *"sidebar"* and associated information pages, which provide listings of recommended resources and answers to frequently asked questions.

3.4 Discussion

This chapter fills an important gap in the literature by characterizing the use of /r/stopdrinking (SD); an online community related to alcohol recovery on the Reddit social media platform. Specifically, I benchmarked overall forum engagement, critically evaluated the characteristics of Sober Badge (i.e., sobriety tracker) metadata, and provided detailed descriptions of content that users shared on the forum. This expands upon prior research, which omitted these contexts while focusing primarily on computational approaches. By understanding common contexts of SD user engagement, individuals who seek digital support in alcohol recovery can better understand what to expect (or not to expect) from this particular social media community.

3.4.1 SD forum activity

Activity trends over the data collection period indicate a highly active support community with more than 200 daily user posts on average as well as regular community-themed posts (e.g., "daily check-in", "Sunday Solutions"). Posts generally received multiple responses, typically beginning within several minutes and lasting several hours from the time of posting (see Section 3.3.1). Comparable activity metrics are not commonly reported across other web-based alcohol recovery MHGs, though <u>Tait et al. (2019)</u> did report average number of responses per post/hour. Engagement metrics from the present study should be considered as benchmarks for such future work. Electronic resources like the Subreddit Stats website (*Subreddit Stats*, 2021) may be used to compare activity among recovery-oriented communities on the Reddit platform. However, this particular site does not provide metrics for responses-per-post or time-to-response, which may be particularly valuable for contextualizing community activity.

Immediacy of support (i.e., time-to-response) is particularly important for individuals who are experiencing acute mental distress or crisis (I. M. Tucker & Lavis, 2019). As these concerns are prominent early-on in alcohol recovery when individuals are at high risk of relapse (Charney et al., 2010), an online community with low time-to-response latency may be preferable in early recovery. However, there is no indication whether initial responses are the most helpful. That is, other online resources (e.g., SD's off-site chat room) or offline options (e.g., calling an AA sponsor) may be preferable to engage in a real-time, dynamic dialogue. Additional research is warranted with respect to the efficacy of using SD or similar digital forums for time-sensitive support, though initial studies in this milieu do show promise (see Section 2.4.2.1).

Supporting others is an integral process in online peer-based recovery and the regular provision of support is necessary to maintain reciprocity and sustained viability of peer-support communities (Liu et al., 2017). As providing support to others is particularly important in developing a long-term recovery identity (Best et al., 2016), forums with many new posts could facilitate sustained engagement from more experienced users. That is, users who have benefitted from earlier community support when facing alcohol-related challenges can develop leadership identities and support others who are newly experiencing these challenges (Chambers et al., 2017). Overall, forums where new posts occur frequently and where content includes diverse experiences offer a greater number of engagement opportunities for experienced users. SD appears to be one such forum, as it has relatively stable post and response engagement activity over recent years (Colditz et al., 2021).

3.4.2 Sober Badge characteristics

Current findings raise some concerns about the use of Sober Badge (SB) metadata as an indicator of sobriety, as has been done in prior research (Harikumar et al., 2016; Tamersoy et al., 2015, 2017). In particular, SB values and self-reported sobriety duration (SSD) values were from significantly different distributions and were only moderately correlated. Measures of central tendency and patterns of association indicated that SB values were generally greater than SSD when discordance was present. This indicated a broader pattern where users textually describe lapses in sobriety more readily than they reset their SB values. Qualitative synthesis of SSD lapses further indicated salient reasons for not resetting SB, which included technical issues in submitting SB reset requests and being unsure of what amount of alcohol use warrants a SB reset.

These findings raise measurement concerns about using SB values as a gold standard of sobriety status on the SD forum. In particular, using SB resets as an outcome indicator in survival analyses warrants more careful consideration. For example, SSD lapses (where indicated) might be the final lapse of record before individuals disengage from the forum. Not accounting for this would bias results in favor of erroneously observing longer durations of sustained abstinence or risk inappropriately grouping individuals (and their observed predictors) into longer-term abstinence categories. Further, it is important to account for the more-than-half of user posts that do not have associated SB metadata, as these users may have different latent characteristics. Thus, using SB as an outcome is not recommended until such limitations can be addressed. Continued work might instead focus on the presence or absence of SB indicators as a predictor of more objectively observed outcomes, such as sustained forum engagement (see Chapter 4).

Overall, having access to SB metadata is alluring from an observational research perspective, as it facilitates large-scale collection of sobriety indicators. However, SB metadata do not appear to be a reliable indicator of latent alcohol use patterns. The present study and another recent study by <u>Naserianhanzaei & Koschate-Reis (2021)</u> incorporated human annotation of SSD related to lapses in sobriety. While these manual approaches capture additional nuance, they are time consuming and infeasible for large-scale analysis. Future research might be enhanced with the use of natural language processing and machine learning approaches to detect SSD utterances at scale. This would substantially enhance large-scale detection of lapses in sobriety when observing data on SD or similar online communities. Such computational approaches could quickly and efficiently identify community members who described a lapse and who may benefit from supplemental and more immediate peer support.

3.4.3 Reconceptualizing and contextualizing SD content

SD users exhibited diverse experiences as they engaged with this online community. In an effort to understand this diversity, posts and responses were annotated using coding frameworks which were developed from conceptual domains and emergent themes in the observed data. While many of these codes were well-contextualized and the annotation of posts resulted in strong interrater reliability, other codes would benefit from further refinement. Qualitative, phenomenological syntheses within coding domains offered additional insights into future directions for refining conceptual frameworks that may be valuable for observational studies of online recovery communities like SD. Thus, in addition to contextualizing content on the SD forum, the content analysis/synthesis process: provided a guidepost for understanding conceptual domains that can be reliably observed, explicated challenges faced within particular domains, and offered alternate strategies for defining conceptually meaningful domains related to digital MHG support in alcohol recovery. For a primary example of when conceptual frameworks posed challenges in observational coding, orientation toward abstinence and harm reduction were particularly complex and inter-rater reliability was relatively poor. However, the process of phenomenological synthesis identified cross-cutting themes of goal orientation and identity orientation.

3.4.3.1 Drinking goals

Goal-orientation generally related to pursuing long-term abstinence or a month of temporary abstinence (e.g., *Dry January, Sober October*). In rarer cases, individuals indicated goals of reducing their quantity/frequency of continued alcohol use or wanting to return to controlled drinking patterns after a period of temporary abstinence. However, there was substantial presence of content indicating that these harm reduction goals seemed personally unattainable

based on prior experiences (i.e., past failure to sustain lower risk drinking patterns), and this was reflected in both posts and response feedback. Therefore, the overall goal-orientation of the SD community can be considered as synonymous with its namesake (i.e., to "stop drinking"), though the temporal duration or permanence of intended abstinence was variable among individuals who posted about specific goals. The common maxim of "I will not drink with you today" (IWNDWYT; often used as a closing salutation) is a further indication that community is generally oriented toward day-to-day abstinence. Thus, SD appears to be particularly supportive for individuals who are committed to a period of abstinence lasting from one month up to a lifetime.

3.4.3.2 Alcohol-related identities

Identity-orientation was most salient in contexts of abstinence (i.e., non-drinker or former drinker identities) and rarely appeared in a harm reduction context (e.g., becoming an occasional or social drinker). Based on these findings, future observational work might focus more narrowly on constructs such as alcohol use identity (e.g., former drinker or non-drinker) as well as specific alcohol reduction or cessation goals, which could be expected to fluctuate over time. This is consistent with theoretical work in the Social Identity Model of Recovery (SIMOR; Best et al., 2016), which "frames the mechanism of recovery as a process of social identity change in which a person's most salient identity shifts from being defined by membership of a group whose norms and values revolve around substance abuse to being defined by membership of a group whose norms and values encourage recovery." In the context of SD, considering overlapping identities such as former- or non-drinker, identification with the SD group (annotated separately), and use of in-person support (annotated separately) could provide more holistic understandings of individuals' commitment toward an abstinence-centric identity. While identity-related domains were challenging to assess in a purely observational context, complementary research might

employ additional strategies (e.g., self-report surveys, focus groups) to understand the complex interplay of alcohol use and recovery identities among online support communities and individual community members.

3.4.3.3 Locus of Control

In another example of qualitative synthesis enhancing domain understandings, the Locus of Control (LOC) domain, as originally operationalized, had relatively poor inter-rater reliability. Qualitative comparison of these posts indicated a complex interplay between internal and external LOC, where life events such as birth of a child could be simultaneously interpreted as both internal (directing lifestyle changes to become a better parent) and external (parenthood imposing new restrictions and responsibilities). Qualitative synthesis provided additional perspective to clarify how this theoretical domain could be refined or realigned to provide valuable context into salient experiences of alcohol recovery. For example, recovery self-efficacy was cross-cutting theme that emerged from qualitative synthesis of LOC. However, content synthesis indicated substantial challenges for reliable observation and annotation of recovery self-efficacy, as this construct appeared to function along a continuum and was not amenable to categorical grouping. While this construct may be challenging to objectively assess in observational data, the concept of selfefficacy is complementary to understanding LOC-related constructs (AbuSabha & Achterberg, 1997), so this remains worthy of consideration for future work. If the concept of recovery selfefficacy can be reliably applied in observational research contexts, it could also offer complementary perspectives on understanding recovery identities (Foster et al., 2014).

Related to the LOC domain, identification with a higher power (annotated separately) can provide an indication of external LOC orientation in peer recovery contexts (E. C. Li et al., 2000). However, as this construct appeared infrequently in the observed data, it offers limited utility beyond concluding that the SD forum appears to be a largely secular space for engaging in peer support. This observation is nonetheless relevant, as individuals with secular and internal LOC orientation related to alcohol use have been found to experience longer-term sobriety (Murray et al., 2003). Within the SD forum, a relatively low prevalence of content related to higher power identification and external LOC (as compared to greater content prevalence of internal LOC) may indicate that SD is a particularly ideal peer support venue for individuals with more secular or internal LOC orientations.

3.4.3.4 Personal concerns

Quantitative thematic analysis indicated that a substantial number of posts included personal concerns related to health and well-being across domains of mental (37%), social (25%), physical (21%), and legal/financial (8%). Inter-rater agreement was particularly strong in physical and mental domains and relatively weak in the social domain. This was to be expected, as social health and well-being is a particularly complex construct, involving understandings of personal relationships that extended beyond the confines of SD. Given the limited context available within individuals' posted narratives, social concerns were difficult to distinguish from descriptions of challenging social encounters that might not be particularly or persistently concerning. As this domain was broadly defined, narrowing it to more salient themes like *alcohol-related embarrassment, social anxiety*, or *relationship estrangement* may be beneficial when there is a theoretical precedent to examine this domain more closely.

Taken together, the concerns domains – particularly as they related to alcohol-specific concerns – may reflect various experiences within a broader construct of "hitting bottom" (i.e.,

adverse circumstances leading to reappraisal of alcohol use patterns; Kirouac et al., 2015; Kirouac & Witkiewitz, 2017). That is, individuals posted when they experienced personal circumstances that were particularly noteworthy or concerning, which may have catalyzed reappraisal of drinking patterns and subsequent SD community engagement. In some cases, posts directly sought community reassurance or feedback about personal concerns. In other cases, concerns were presented as part of broader narratives or served as cautionary tales for others. Nonetheless, the expression of personal concerns was a common and salient feature of SD posts, which reflected motivations for users to engage in this peer support community.

Additional research is warranted to understand how particular concerns lead to support seeking via online forums versus other modalities (e.g., in-person AA meetings, clinical care). As online forums can be used to elicit feedback about personal circumstances that are uncomfortable to present in person, they may be valuable for individuals who have particularly sensitive concerns (Haverfield & Theiss, 2014; M. White & Dorman, 2001). Conversely, as peer support on social media platforms like Reddit is ephemeral (i.e., responses are unpredictable, peers are largely anonymous strangers), advice about serious concerns such as medical or legal problems may be unreliable or detrimental (Briggs et al., 2002). Reassuringly, analysis of responses to posts indicated that SD community members regularly recommended clinical care and other off-forum support in risky circumstances (e.g., monitoring alcohol withdrawal, managing comorbid mental health concerns). Thus, SD offers a bridge to more intensive models of support for individuals whose severity of alcohol use patterns could benefit from alternative or supplemental attention.

3.4.3.5 Cravings

Similar to the concerns domain, identification of cravings was relatively common, as observed in nearly one-in-five posts. While inter-rater agreement was excellent in this domain, qualitative synthesis did uncover additional nuance around particular types of cravings that were observed (i.e., environmental triggers, contextual triggers, and impulses). Interestingly, individuals posted about environmental triggers (e.g., seeing/smelling alcohol, being offered a drink) only after successfully managing the craving, generally by altering or leaving the offending environment. Conversely, individuals did indicate drinking due to contextual triggers that related more closely to internal processes (e.g., stress, anger, loneliness, celebration) and due to impulses without clearly defined triggers. These qualitative findings align with a quantitative study of individuals with AUD, where emotional triggers in particular were found to be strongly associated with craving intensity (Ghiță et al., 2019). Thus, the identification of environmental and contextual cues that trigger cravings is important to consider in contexts of digital MHG engagement.

Community support from digital MHGs like SD may offer individuals additional perspectives and strategies for managing cravings. In particular, as individuals engage in discussion to explore and identify specific environmental and contextual triggers for cravings, targeted coping and relapse prevention strategies can be developed and mobilized (Stalcup et al., 2006). While this process has not been well researched outside of clinical treatment contexts, there are indicators of similar processes occurring on the SD forum. Specifically, observed responses to posts provided informational support (e.g., recommending coping strategies for cravings) and appraisal support (e.g., asking questions to uncover specific triggers of cravings). Continued research is warranted to understand effective mechanisms of online peer support in mitigating

lapses through craving feedback and management. Additional evidence in this realm could allow online communities to provide evidence-based recommendations for how users can most effectively post about and respond to others' posts about cravings. Based on current findings, such recommendations might include: (1) explaining cravings in a way that specifies environmental or contextual triggers, rather than as impulses, and (2) responding to posts about cravings in a manner that helps individuals to identify the nature of triggers, and to share effective strategies to reduce the influence of such triggers.

3.4.4 SD and alcohol recovery

From the observed data discussed thus far, I have described several potential mechanisms through which SD could be beneficial to a recovery process (e.g., developing recovery identities, garnering support in managing cravings and addressing personal concerns, offering opportunities to provide recovery support to others). However, a limitation of the current approach is that such mechanisms, while qualitatively salient and conceptually plausible, were not tested for association with recovery outcomes. To test such associations, additional study of individual SD users over time would be required. While prior research has examined SD users longitudinally, the use of SB metadata as a primary outcome was found to be methodologically problematic and a poor quantitative proxy for abstinence, much less an indication of broader recovery outcomes.

While sustained abstinence contributes to other beneficial aspects of recovery (Dennis et al., 2007), it is not conceptually equivalent with a broad conceptualization of recovery as "an individualized, intentional, dynamic, and relational process involving sustained efforts to improve wellness" (Ashford et al., 2019). That is, abstinence is important in alcohol recovery and is a

primary focus of the SD community, but direct benefits of SD engagement may relate to other holistic aspects of recovery. For example, the relatively large proportion of emotional support within responses in the present study is similar to other recent studies of online alcohol recovery MHGs (Liu et al., 2017). This emotional support serves to enhance commitment to a recovery community and to engender relationship building (Liu et al., 2017), which conceptually aligns with the Social Identity Model of Recovery (Best et al., 2016). Thus, understanding supportive relationships, commitment to the community, and social recovery identity may be more conceptually meaningful than a narrower focus on short-term abstinence outcomes.

In the observed data, transitions of identity could be understood through narratives where individuals engaged in lurking behavior (i.e., passive observation) for sometimes years before to initially posting. In a study of users on the Soberistas online forum, lurking was similarly identified as a key stage prior to actively participating and leading, as individuals further developed and solidified peer group identities (Chambers et al., 2017). There was also substantial content observed in the domain of identification with the SD group, indicating that identities form around a central affiliation with this community. This was exemplified in statements that regarded community members such as "fellow sobernauts" or that indicated "you are my people". Further, the diversity of individuals who engage on SD – including those with long-term sobriety, whom regularly participate in in-person support groups or whom receive intensive clinical support – indicates a community that extends beyond individuals who are contemplating alcohol cessation or who are early-on in alcohol recovery. This diversity of lived experience is beneficial in a peer-support environment, as there are many potential pathways to recovery which vary by the nature and severity of alcohol use or comorbid issues (W. White & Kurtz, 2006). Thus, the SD community

is both cohesive and diverse with respect to lived experiences. This reflects favorably on SD's ability to provide support for individuals with diverse life experiences and across a continuum of problematic alcohol use.

3.4.5 Limitations

This study was limited in three notable ways. Foremost, as it was purely observational, important indicators of recovery or challenges that occurred outside of the platform were not ascertainable. Such indicators were sometimes identified within annotated domains such as personal concerns or LOC, though not always reliably due to the complex interplay of cross-cutting themes that were identified through qualitative synthesis. Thus, the present study contributes alternate conceptualizations and approaches that may be useful for future observational research in this realm. Additional consideration should also be given to integrating complementary research approaches (e.g., self-report assessments, interviews), which would be more effective to elicit – rather than passively observe – important conceptual domains related to alcohol recovery.

Second, demographic variables are notably missing from this study. This was due to the anonymous nature of the Reddit platform where such information is not systematically obtained from users and is infrequently volunteered through personal narratives (Chew et al., 2021). While Reddit user demographics (as compared to the general US population) over-represent young adults who are predominately white and have relatively high educational attainment (Pew Internet Research, 2016), this may not hold true for the SD forum in particular. The age of SD participants would be particularly valuable to understand patterns of online peer-support engagement in young adulthood, as in-person recovery support through AA is largely (90%) attended by individuals

over the age of 30 (Kaskutas et al., 2008). SD moderators conducted a user survey in 2014 (/r/stopdrinking, 2014), but these results are explicitly not intended for academic research purposes. Additionally, the user base had grown more than 10-fold since that time (*Subreddit Stats*, 2021), so an updated survey of this community may be warranted.

Finally, given the broad scope of available data (i.e., tens-of-thousands of engagements per week), it was infeasible to comprehensively annotate and characterize it all. Thus, a one-year timeframe and 2% random subsample of posts was considered sufficiently representative while maintaining feasibility of annotation. Due to limited availability of secondary annotators and the smaller scope of conceptual codes for responses, a modest sample was selected for response annotation (i.e., one per day of the observed year). While this was sufficient for qualitative exploration, additional annotation would be warranted to more reliably estimate prevalence of particular types of support in SD responses. Doing so would also lend well toward other methodological approaches, such as discourse analysis, which were beyond the exploratory scope of the present approach. Understanding particular types of support that are requested and subsequently provided on this platform remain an interesting direction for future work.

3.4.6 Next steps

Given the substantial number of annotated posts and the relevance of identified conceptual domains to alcohol recovery, a secondary analysis using these data will be worthwhile. In particular, by selecting conceptual domains that have reasonable prevalence and inter-rater agreement, machine learning models can be trained to classify these domains at-scale across the collected data. This will also allow for the inclusion of user-level metadata (e.g., engagement duration, number of posts or responses, use of SB functionality). This approach aligns with my formative training and research experiences working with social media data (Chu et al., 2019; Visweswaran et al., 2020), and is the primary focus of Chapter 4 of this dissertation. See also Appendix D for a diagram that maps data processing steps that bridge Chapters 3 and 4.

3.5 Conclusions

Based on this exploratory study, the SD community is highly active and cohesive, and demonstrates potential to support individuals along a continuum of problematic alcohol use. While the community is generally oriented toward fostering alcohol abstinence, the observed social processes indicate broader mechanisms by which recovery may be enhanced (e.g., support for cravings and personal concerns, development of recovery-oriented social identities). High activity and diversity of experiences within this platform frame it as particularly useful for individuals who are contemplating or initially pursuing alcohol abstinence, even on a temporary basis. As individuals move from a process of passively lurking to actively engaging in the SD community, they may benefit from additional support and feedback, reassurance, and strategies for managing challenging situations. Community-recommended strategies also included the use of off-site support (e.g., AA and SMART Recovery, various clinical care modalities), which can further enhance recovery support. Future research should carefully consider the limitations of using Sober Badge metadata as a proxy of recovery outcomes, as these data were prone to measurement bias. A realigned focus on predictors of sustained SD engagement will provide formative insights into contexts of users who initially engage and those who actively integrate into this digital MHG.

4.0: Patterns and predictors of committed engagement on /r/stopdrinking

4.1 Introduction

4.1.1 Background

As described in Chapter 3, the /r/stopdrinking (SD) forum is a highly engaged, supportive, and dynamic online mutual help group (MHG). A substantial number of posts indicated explicit contexts of support seeking, expression of cravings, and disclosure of personal concerns (e.g., mental, physical, social). Users' messages further indicated personal identification with the community, perceived benefit from engagement, and gratitude to the community. Thus, SD appears to be a viable source of social support for individuals pursuing alcohol abstinence and recovery. However, understanding potential benefits of SD engagement are limited without contextualization of how individual users engage and seek support there. In particular, online MHG users have been found to gain greater benefit commensurate with higher levels of engagement (Kirkman et al., 2018). In a recovery context, this can be understood through the concept of accumulated **social recovery capital**, understood as "the sum of resources that each person has as a result of their relationships, and includes both support from and obligations to groups to which they belong" (Cloud & Granfield, 2008).

Social recovery capital reflects both the support received from and the fulfillment of obligations to an MHG. For in-person MHGs such as Alcoholics Anonymous, voluntary obligations include regular attendance (e.g., 90 meetings in 90 days), reciprocity of support,

working the program, and providing tangible service to the community (Borkman, 2008; Caldwell & Cutter, 1998; Munn-Giddings & Borkman, 2017). Online MHG obligations are less welldefined and may vary among myriad digital communities and formats (see Section 2.4.1). However, regular engagement and reciprocity of support are critical to sustaining the functionality of online MHGs (Liu et al., 2017), which can be understood as the responsibility of community members.

4.1.2 Social recovery capital and recovery identity

Social recovery capital can be enhanced through regular engagement and the development of group cohesion within online alcohol support MHGs (Best et al., 2018; Bliuc et al., 2017). Users who regularly engage over a sustained period of time are understood to be building and maintaining social recovery capital through "informal social connectedness" and this can be particularly beneficial to supporting mental health in alcohol recovery (McGaffin et al., 2018). A study of participants on the Hello Sunday Morning online alcohol support group indicated that participation was associated with significantly reduced AUD symptoms, with highly engaged participants faring the best (Kirkman et al., 2018).

In a similar realm, <u>Best et al. (2018)</u> conducted a longitudinal study of Facebook group activity among 67 current and former clients of a recovery-oriented community organization. Results indicated that the overall use of words associated with a sense of affiliation, belonging (e.g., *we*, *us*), and achievement (e.g., *success*) increased over time. These patterns of language were associated with being a longer-established community member and having more central ties to other members (e.g., commenting, liking each other's posts). A separate study of this online community found that receiving positive feedback in the form of "likes" predicted sustained engagement (Bliuc et al., 2017). These findings demonstrate that detectable patterns within text content and the social context of engagement played a complementary role whereby individuals sustained use of this online group and increasingly identified with the respective community.

Regular engagement with recovery-oriented peers contributes to establishment of a personally held and socially affirmed **recovery identity** (Best et al., 2016, 2018). Identifying with recovery in this way is associated with benefits such as lower relapse rates, increased self-efficacy, decreased emotional distress, as well as enhanced quality-of-life, wellbeing, and sense of purpose (Bathish et al., 2017; Bliuc et al., 2019; Buckingham et al., 2013; Cruwys et al., 2020). While forum engagement can be understood a valuable indicator of social recovery capital and development of a recovery identity, relatively little is known about what initial factors predict committed engagement among new users of SD or similar forums. Insights into this would be valuable to inform recommendations for users and moderators of such forums. For example, contexts of initial user engagement that predict sustaining might include disclosure of difficult situations (Lee et al., 2020), frequency of posting and commenting (Kirkman et al., 2018), and the use of novel community features (e.g., SD's Sober Badge). Observing, describing, and evaluating such factors will provide a clearer sense of effective engagement strategies and set benchmarks for continued research on SD and similar online MHGs.

4.1.3 Study objectives

- A <u>first objective</u> of this study is to develop train, and test machine learning classifiers to extend qualitative findings from Chapter 3 into quantitative analysis frameworks used in the third objective of this study.
- A <u>second objective</u> of this study is to describe patterns of engagement among new users of the SD forum. This includes characterizing overall post and comment activity and how these are sustained through conceptually meaningful recovery milestones (as defined in Section 4.2.2.3).
- A <u>third objective</u> of this study is to test hypotheses about contexts of early engagement predicting sustained engagement. In particular:
 - **Hypothesis 1**: New users who take the initiative to post early-on will be more likely to exhibit sustained engagement at recovery milestones.
 - **Hypothesis 2**: Among users who post early-on, sustained engagement at recovery milestones will be predicted by: above average frequency of initial forum engagement, relatively high levels of supportive feedback from the community, early use of the Sober Badge tracking feature, and indicators of self-disclosure within post content.

See also Appendix D for a diagram that maps data processing steps that bridge Chapters 3 and 4.

4.2 Methods

4.2.1 Machine Learning classification of recovery contexts in posts

The first objective of this study was to develop, train, and test machine learning classifiers to extend qualitative findings from Chapter 3 into quantitative analysis frameworks. Overall, this process includes steps of text formatting, feature engineering, classifier training, and classifier testing. The best performing classifiers were then deployed to conduct text analysis in the third objective of this study.

4.2.1.1 Source data characteristics

Annotated training data. Drawing from the data detailed in Table 3.3, observations for machine learning procedures included 1,458 annotated posts (4,299 paragraphs of text), which originated between 2018-10-01 and 2019-09-30. To ensure reliability of the classified data, classifiers were developed only for dichotomous constructs where annotators' Kappa coefficients indicated at least *substantial agreement* (K>0.60) with preference given to constructs with *almost perfect agreement* (K>0.80). Additional considerations included prevalence of per-construct annotations within the paragraph data (>5% to ensure adequate representation for classifier training) and conceptual utility of the constructs. For example, the *identification with the SD community* construct was omitted because – while it had reasonable prevalence and inter-rater agreement – the trained classifier would be unable to differentiate between the "I will not drink with you today" maxim in salutations and more meaningful reflections of community identity (see Section 3.3.3.7). Further, the intended scope of classifier application includes only the first week of engagement in the

present study. Identity would be expected to develop over longer-term, sustained community engagement (Best et al., 2018). Based on these considerations, five constructs were identified for classifier training: *support seeking, personal concerns (mental, physical, and social),* and *cravings.*

Language features: tokenization and n-grams. Text-based classifiers rely on language *features*. These features can include punctuation, individual words or combinations of words, syntactic variants such as word stems (i.e., prefixes or suffixes removed), as well as parts of speech. A common approach to Natural Language Processing (NLP) feature engineering includes the use of *n-grams*: e.g., unigrams (i.e., single word or punctuation features) and bigrams (i.e., pairs of unigrams). To define common feature sets, *documents* (in this case, paragraphs) are *tokenized* – splitting documents them into n-gram series. Both unigrams and bigrams were included as features in the present study. Various NLP approaches were then evaluated to determine optimal pre-processing steps for feature extraction and modeling.

Language feature pre-processing. This study leveraged the Natural Language Toolkit (NLTK) software library for Python. This allows for formatting text in various ways to potentially improve comprehensibility and comparability of the features. For example:

- Basic *normalization* of text includes making all words lowercase, removing redundant punctuation marks (e.g., "!!!" becomes "!"), normalizing contractions (e.g., "haven't" becomes "have not"), and standardizing all numeric features as "_number_".
- *Negation tagging* is a process whereby words that come after a negation are flagged within sentence clauses. For example, "I'm not going to drink and drive" would become "I'm not

neg_going neg_to neg_drink and drive". This can help to contextualize latent meaning of features that were intended in a negative context.

- Stemming words removes suffixes for consistency across syntactic contexts (e.g., "pain<u>ful</u>" or "pain<u>ed</u>" becomes "pain"). Stemming can be particularly helpful for collapsing groups of similar words so that they are weighted more strongly into classes where they belong. For example, the "pain" stem would have more entries in the *physical concern* class making it more predictive, whereas "pained" or "painful" would be more sparsely present. Conversely, this can obscure meanings of phrases (e.g., "I'm a drink<u>er</u>" vs. "I'm a drink").
- Removal of common *stopwords* (e.g., "a", "an", "it", "that", "to") that may not add thematic context. Removing stopwords can bring more informative words closer together, which can result in richer context within bigram windows. Conversely, stopword removal can obscure the latent meaning of phrases in subtle ways (e.g., "it wasn't funny that he did that" and "wasn't it funny that he did that" both become "wasn't funny he did").

In the present study, several combinations of language feature pre-processing were evaluated and refined. Typical refinements include updating the order of NLP processes to avoid conflicts (e.g., stopword removal removes conjunctions that are required in negation tagging processes). Five combinations of NLP procedures were tested in machine learning models:

<u>NLP 0</u>: Basic normalization of numeric features, capitalization, and punctuation

<u>NLP 1</u>: Includes NLP 0 plus negation tagging

<u>NLP 2</u>: Includes NLP 1 plus stemming

NLP 3: Includes NLP 1 plus stopword removal

<u>NLP 4</u>: All NLP pre-processing procedures were used

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After pre-processing, all documents were aggregated and a term frequency index was created. This index ranks features that most commonly appear across the dataset. The total number of unique features differs among NLP approach used. For example, NLP 0 resulted in 87,803 unique features and this increased to 89,141 in NLP 1 as a result of including the additional negated features in the lexicon. The numbers of unique features were reduced when using additional stemming and stopword removal procedures, with 79,209 and 83,030 unique features in NLP 2 and NLP 3, respectively. Finally, NLP 4 resulted in the most parsimonious set of 74,049 unique features. Features were entered into a vector space such that features from individual posts could be compared to features from other posts of the same document class (e.g., *mental concerns* = *True*) and of the inverse document class (e.g., *mental concerns* = False), to calculate *term* frequency-inverse document frequency (TF-IDF) weights for n-grams. Term-document matrices can be conceptualized as having as many rows as there are valid documents and a number of columns corresponding to the number of included n-gram features. As not all features are informative for classification (particularly features that occur infrequently), a smaller number of features was selected to reduce matrix sparsity. Through analyses of varying the size of the term feature matrices, using approximately 3,000 most frequent features appeared to be a reasonable benchmark for baseline models. Alternate sets of 2,000, 2,500, 3,500, and 4,000 features were also explored but did not improve classifier accuracy or performance across NLP pre-processing conditions, so a set of 3,000 features was deemed suitable for modeling.

4.2.1.2 Classifier selection

Classifier models. As the present project developed new classifiers, rather than using preconfigured models, it was important to compare multiple classification approaches to benchmark performance on this task. This process involved the development of analysis code using the scikitlearn Python library, which offers several families of available classification algorithms (Raschka & Mirjalili, 2017). For the present project, I chose three classification approaches (Naïve Bayes, Logistic Regression, and Random Forest) that were used in previous work classifying text from the Twitter platform (Visweswaran et al., 2020). Bernoulli Naïve Bayes was used as a baseline model as it is a fairly basic classifier for dichotomous outcomes. A common use case for this type of classifier is email spam filtering where particular features flag that a message might be spam (Raschka, 2014). Logistic Regression classifiers can be interpreted in the typical sense of a regression model, where each feature is assigned a beta coefficient and a prediction is made based on coefficient weights. Random Forest models are based on a decision tree framework, whereby predictions are based on features being present alongside combinations of other predictive features. Random Forest models offer enhanced performance over Logistic Regression when the data are particularly complex or the decision boundary is non-linear (Kirasich et al., 2018). However, they are more of a black box approach than the other models as the prediction relies on complex combinations of features rather than individually weighted features.

<u>Classifier training</u>. Classifier development involves splitting data into separate training sets and testing sets, where predictive models are built from the training set and the resulting classifier is applied to the testing set to assess its performance. Relevant paragraph units of text were randomly

shuffled and 80% (n = 3,439) were selected for classifier training procedures, leaving 20% heldout for classifier testing. During training, a 5-fold cross-validation strategy was employed. Through this strategy, the available data were randomly split into five roughly equal groups and training procedures were repeated five times using a leave-one-out approach (four groups used for classifier development, one used for calculating performance statistics). Across the five folds, average scores for accuracy, precision, recall and area under the Receiver Operating Characteristic curve (AUROC) were calculated to evaluate classifier performance. This process was repeated for each of the five NLP approaches among each of the three classification algorithms (i.e., 15 distinct models), for each latent variable. For each variable, the best performing fold of the best performing model was kept for classifier testing and application.

Classifier testing. In order to minimize the potential influence of the earlier training processes on testing procedures, 20% (n = 860) of posts withheld from classifier training were used to validate classifier performance in the testing phase. Classifiers for each of the latent variables were applied to this dataset and final performance metrics were calculated. As before, accuracy, precision, recall, and AUROC were calculated, with AUROC considered as the best overall indicator of performance among these (J. Huang & Ling, 2005). Additionally, the F1 score was calculated as a more discriminant metric of overall classifier performance (Musa, 2013). Training performance metrics were then evaluated alongside testing performance metrics for comprehensive comparison of classifier performance across domains.

4.2.2 Forum engagement

Prior studies of the SD forum, as well as other online alcohol support groups (see Chapter 2), have not characterized engagement among new users over time. Thus, an important objective of the present study was to identify normative patterns of engagement behavior for new users who engaged with the SD forum.

4.2.2.1 Scope of observation

Any users who engaged in the SD forum from the initiation of data collection on 2018-02-18 through 2018-06-30 (133 days) were excluded to narrow the scope of analysis to newly identified users. New users were included in analysis if they had an initial forum engagement (post or comment) between 2018-07-01 and 2019-06-30, which included 40,341 users. The observation window remained active through 2020-02-29, which represents the last date prior to COVID-19 related disruption of user activity on this platform (Colditz et al., 2021). This allowed for a minimum observation window of just over 8 months (244 days) for all new users. An 8-month observation window is also consistent with prior research on a Facebook MHG (Best et al., 2018). For consistency of per-user observation windows, all user data were truncated to 244 days of observation.

4.2.2.2 Characterizing engagement over time

For each user, the data of all available engagements (i.e., posts and comments) were relativized to the date of the first engagement. This means that the first engagement would always be considered as "Day 0" for each user. Engagement frequency was assessed to determine the number of users who engaged on and beyond Day 0. The number of engagements occurring after Day 0 were then aggregated into weekly intervals so that the number of posts and comments per week could be directly compared across users. Histograms were developed to visualize trends in overall engagement (i.e., total number of posts and comments) and the frequency at which new users engaged over time. As nearly half of new users did not re-engage beyond Day 0, a second category of 21,129 "returning new users" was used to maintain visual space in histogram plots. Descriptive statistics were presented to explore trends over time for new users' posting and commenting behavior.

4.2.2.3 Milestones of sustained engagement

Two follow-up timeframes of 4-weeks and 13-weeks were delineated as milestones of sustained engagement over time. The 4-week timeframe approximates one month, which is clinically relevant with regard to early-remission from AUD (ICD-11 criteria; see Chapter 1) and is culturally relevant with regard to 1-month abstinence challenges (e.g., Dry January), which are common to the SD forum (see Section 3.3.3.4). The 13-week timeframe approximates 3 months which is also clinically relevant with regard to early-remission from AUD (DSM-5 criteria; see **Chapter 1**), and is culturally relevant with regard to the contemporary "90 meetings in 90 days" approach in Alcoholics Anonymous (Caldwell & Cutter, 1998). Observation windows of 1- and 3-months are also consistent with a prior study of the Daybreak digital MHG (Tait et al., 2019), and 3-month endpoints were used in digital MHG studies by <u>Hester et al. (2013) and Kirkman et al. (2018)</u>. Users were not expected to engage each day, so they were considered to have **sustained engagement** for the duration that they consistently posted or commented at least once per week, following Day 0.

4.2.3 Hypothesis testing

4.2.3.1 Associations between introductory posting and commitment

The first hypothesis was that new users who take the initiative to post early-on will be more likely to exhibit commitment (i.e., sustained weekly engagement) at recovery milestones (i.e., 4- and 13-weeks). In order to test this hypothesis, $2x2 \chi^2$ models were employed to test for patterns of association between introductory posting behavior and sustained engagement. Individuals who submitted at least one post within Day 0 or subsequent week were considered to have made an introductory post. Patterns were examined at 4- and 13-week milestones separately with alpha set at 0.05 to test significance.

4.2.3.2 Early engagement contexts predicting commitment

A second hypothesis posited that among users who posted early-on, commitment at recovery milestones would be predicted by: greater than typical frequency of initial forum engagement, relatively high levels of supportive feedback from the community, use of the Sober Badge tracking feature, and indicators of self-disclosure within post content. As in the previous analysis, outcome variables reflected sustained weekly engagement through 4- and 13-weeks.

Data scope and formatting. A subset of 18,532 users was selected based on the criteria that they must have had at least one post within the first week of engagement (considered as the baseline observation period). This ensured that each user had text content available for machine learning classification models. If a user posted more than once in the first week, then all available posts were used in classification procedures. In this case, presence of a construct among any of the available posts was considered as an overall indicator of presence.

For each post in this first-week dataset (n = 26,470), metadata were collected pertaining to: total number of responses received, total upvote score (see Section 3.1.1.1), and presence or absence of a Sober Badge for the user at the time of posting. As multiple posts were available for some users but not others, the maximum upvote score and maximum number of comments among posts was used as the user-level indicator for each of these variables. Similarly, if a Sober Badge was present in any of multiple posts, it was indicated as present for the user.

Post text was split into paragraph units (n = 123,237) and formatted using NLP 4 procedures, as described in Section 4.2.1.1. Machine learning text classifiers were applied to each paragraph and the resulting probability scores were cut at a standard 0.5 threshold to determine presence of constructs. To remain consistent with the annotation framework (see Section 3.2.4), presence of a construct among any of the paragraphs was considered as an overall indicator of presence in a post. Construct presence among any of multiple posts was considered as an overall indicator for a user.

<u>**Predictor variables**</u>. Predictor variables reflected contexts of user activity within their first week of engaging on SD. With respect to content of user posts, each of the text classification constructs were treated dichotomously (i.e., present or absent). This was also the case for Sober Badge data.

Baseline engagement was measured using two separate variables indicating the frequency of *posts* and *comments sent* by the user over the initial week of engagement. Community feedback was assessed using two variables of *maximum upvote score* and *maximum number of replies* to a user's posts. Maximum values were used as getting a "high score" is more salient and memorable than having a high average of scores or comments across multiple posts – metrics that users may not be cognizant of. These composite variables were screened for central tendency and dispersion to determine appropriate cut points for developing categorical indicators. For posts and comments sent, a dichotomous indicator was used to determine above average (median) engagement frequency (versus median-or-below engagement). For community feedback indicators, categories of Low, Moderate, and High were developed from tertile groupings. Operational definitions, specific cutoffs, and categorical distributions are elaborated further in Results, Tables 4.5-4.7.

Regression models. Simple logistic regression models were used to assess associations between each predictor variable and the outcomes of sustained engagement separately at 4-weeks. Associations that were significant at an alpha of 0.05 were considered to be viable for multiple logistic regression. Multicollinearity of predictor variables was examined using correlation matrices. As intercorrelations of |r| > 0.7 can distort model selection and prediction (Dormann et al., 2013), variables were selected to ensure that intercorrelation was minimized. Variance inflation factor (VIF) was examined for all predictor variables in the model to detect potential issues of multicollinearity and confounding. A VIF value of 4 or higher indicates likely issues (Hair, 2010), and values approaching this threshold were scrutinized by re-examining VIF values under a leave-one-out condition. Multivariate logistic regression models with maximum likelihood estimation were used to assess outcomes of sustained engagement over 4-weeks and 13-weeks separately. Alpha was set to 0.05 for significance testing and Odds Ratios with 95% confidence intervals were calculated. Statistical analyses were conducted using the *statsmodels* (version 0.12.2) Python library.

4.3 Results

4.3.1 Machine learning classifiers

Machine learning classifiers included five domains which had sufficient inter-rater agreement, prevalence, and conceptual relevance. The *mental concerns* domain was selected as a starting point, as it had the highest prevalence and inter-rater agreement among included domains (see Table 3.3). The procedures were then replicated for *physical concerns*, *social concerns*, *cravings*, and *support seeking* domains.

Model	Accuracy	Precision	Recall	AUROC
Naïve Bayes				
NLP 0	0.72	0.36	0.55	0.73
1	0.72	0.36	0.54	0.73
2	0.72	0.36	0.54	0.73
3	0.75	0.41	0.50	0.75
4	0.75	0.39	0.50	0.75
Logistic Regression				
NLP 0	0.82	0.57	0.40	0.78
1	0.82	0.55	0.41	0.76
2	0.83	0.58	0.42	0.78
3	0.83	0.63	0.41	0.80
4	0.83	0.62	0.42	0.80
Random Forest				
NLP 0	0.83	0.75	0.23	0.83
1	0.84	0.78	0.25	0.83
2	0.85	0.78	0.31	0.84
3	0.84	0.74	0.34	0.85
4	0.85	0.75	0.37	0.86

Table 4.1 Training performance for mental concerns (5-fold cross validation)
Based on training data in the *mental concerns* domain, the best performing classifier was Random Forest with full NLP parameterization (i.e., NLP 4; see **Table 4.1**). Using this model, the number of n-gram features was adjusted to determine an optimally sized feature set in both the training and testing data. In this sensitivity analysis of feature set size, 3,000 n-gram features remained ideal based on performance in the testing phase, with recall and F1 score being relatively high for this approach (see Table 4.2). For consistency of feature processing, 3,000 n-grams were used for feature extraction among all domains.

 Table 4.2 Feature set comparison for mental concerns

		Train	ing			T	esting		
Features	Accuracy	Precision	Recall	AUROC	Accuracy	Precision	Recall	AUROC	F1
2000	0.85	0.73	0.38	0.86	0.85	0.72	0.40	0.86	0.51
2500	0.85	0.74	0.36	0.85	0.85	0.79	0.33	0.86	0.46
3000	0.85	0.75	0.37	0.86	0.86	0.77	0.43	0.88	0.55
3500	0.85	0.76	0.34	0.87	0.84	0.72	0.36	0.88	0.49
4000	0.85	0.77	0.39	0.86	0.85	0.75	0.39	0.86	0.44

Note: Using Random Forest and NLP 4 procedures



Figure 4.1 ROC curve and confusion matrix for testing mental concerns

As the classifier evaluation process (i.e., Table 4.1) was carried out for the remaining domains, Random Forest with the full NLP 4 parameterization was consistently found to have superior overall performance, though tradeoffs between precision and recall were apparent among approaches. Results for training and testing for all domains are reported in Table 4.3. While overall accuracy of classifiers was reasonable, recall was consistently low. This means that, while the classifiers functioned reasonably well at ruling out cases that were true negatives (e.g., see confusion matrix in Figure 4.1), they were poorer at detecting true positives than a trained human annotator would have been. Conceptually, this means that the classifiers correctly identified many explicit examples and reasonably controlled for noise in the data, but missed more nuanced examples that a trained annotator would have indicated. Thus, the classifications should be considered as conservative.

Based on overall performance parameters (see Table 4.3), all tested classifiers were maintained for the next step of classifying user posts for subsequent analysis. Specifically, accuracy was at or above 0.85 for training and testing of all classifiers. AUROC was at or above 0.80 in all cases. Based on F1 scores, domains of physical and social concerns preformed poorest overall. As physical and social concerns had relatively low recall and modest prevalence in the data (see Tables 4.3 & 3.3), they were ultimately combined with mental concerns as an overall indicator of disclosing personal concerns. Conceptually, this is consistent with a broader conceptual domain where self-disclosure of personal concerns can reflect enhanced motivation and relational capital in a recovery context (Lee et al., 2020).

Domain	Accuracy	Precision	Recall	AUROC	F1 score
Mental concerns					
Training	0.85	0.75	0.37	0.86	
Testing	0.86	0.77	0.43	0.89	0.55
Physical concerns					
Training	0.90	0.65	0.12	0.84	
Testing	0.89	0.63	0.10	0.84	0.17
Social concerns					
Training	0.88	0.69	0.06	0.84	
Testing	0.87	0.33	0.02	0.80	0.03
Cravings					
Training	0.93	0.75	0.24	0.85	
Testing	0.92	0.78	0.24	0.90	0.37
Support seeking					
Training	0.92	0.89	0.61	0.95	
Testing	0.93	0.93	0.60	0.95	0.73

Table 4.3 Classifier performance across domains

4.3.2 Engagement patterns

In the current analysis, a total of 40,341 new users were considered to have had a first engagement between 2018-07-01 and 2019-06-30. From Day 0 through the first full week of engagement, 87% of new users commented and 46% posted at least once. For users who both commented and posted over the full observation window of 244 days, initial engagements typically happened on the same day (*Median difference* = 0, *IQR*: 0-1), though the distribution was skewed and trended toward commenting prior to posting (*Mean difference* = 9 days, *SD* = 48). While only 52% of new users returned to engage beyond Day 0, *returning new users* (*n* = 21,129) continued to generate a substantial amount of engagement over the subsequent weeks (see Figure 4.2). Overall frequency of comments fairly consistently outnumbered posts by more than 10:1 over the observed weeks of engagement. Individual users also more frequently engaged by commenting versus posting on a week-to-week basis (see Figure 4.3).

Among all new users on Day 0, 11,904 (30%) engaged again in the first week, primarily through commenting and the remainder of returning users re-engaged in later weeks (see Figure 4.3). This yielded a total of 85,517 engagements in the first week (see Figure 4.2). Among users who engaged in the first week, 5,172 (43%) also engaged in the second week. Among those engaging in the first two weeks, 3,079 (60%) engaged in the third week. Among those who engaged in all of the first three weeks, 2,115 (69%) engaged in the fourth week. This pattern indicates that as the duration of engagement increased, so did the proportion of users who consistently sustained engagement from week-to-week.

To test the first hypothesis (i.e., making an introductory post is associated with sustained engagement), two separate $2x2 \chi^2$ models were evaluated. Cross-tabulations for both analyses are presented in Table 4.4. Both χ^2 analyses yielded significant patterns of association. Users who sustained engagement over 4-weeks were characterized by a larger proportion who made introductory posts, as compared to non-sustaining counterparts ($\chi^2 = 302.3$, df = 1, p < 0.001). This pattern of association was also present for users who sustained engagement over 13-weeks ($\chi^2 = 37.3$, df = 1, p < 0.001). Thus, making a post in the first week (versus responding only) was significantly associated with patterns of sustained engagement at both 4- and 13-weeks.



Figure 4.2 Cumulative engagement among users who returned after Day 0



Figure 4.3 Engagement patterns among users who returned after Day 0

	Sustained e	engagement	Sustained engagement		
Posted within	through 4 weeks		through 13 weeks		
first week	No	Yes	No	Yes	
No	21,054 (52.2%)	755 (1.9%)	21,677 (53.7%)	132 (0.3%)	
Yes	17,172 (42.6%)	1360 (3.3%)	18,314 (45.4%)	218 (0.6%)	
Totals	38,226 (94.8%)	2,115 (5.2%)	39,991 (99.1%)	350 (0.9%)	

Table 4.4 Cross-tabulations for χ^2 analyses (N = 40,341)

4.3.3 Regression analysis

A primary sample of 18,532 users who posted in the initial day or subsequent week met criteria for inclusion in regression analysis. As text of posts was required for machine learning procedures, the sample was further reduced to 18,517 because the text of 15 posts was irretrievable (i.e., post content was blank or deleted). Descriptive statistics were first examined for all predictor variables (see Table 4.5), with particular attention paid to identifying skew and outliers in the measures of *MaxScore*, *MaxReplies*, *PostsSent* and *CommsSent* (see Table 4.6). As these raw count variables had both outliers and positive skew, they were collapsed into categorical indicators using tertiles for MaxScore and MaxReplies and binary indicators for PostsSent and CommsSent based on median cutoffs (see Tables 4.5 & 4.6).

The aforementioned machine learning classifiers were applied to all available posts captured during this first week. Due to the low classification recall for *physical concerns* and *social concerns* (see Table 4.3), they were combined with *mental concerns* to form a composite domain of *Concerns*. Conceptually, this is consistent with a broader domain where self-disclosure of concerns can reflect enhanced motivation and relational capital in recovery (Lee et al., 2020).

Table 4.5 Description of predictor variables

Predictor	Description
(variable ID)	Description
Posts sent (PostsSent)	Number of posts sent by the user within the first week. Treated dichotomously (median or below vs. above median).
Comments sent (CommsSent)	Number of comments sent by the user within the first week. Treated dichotomously (median or below vs. above median).
Max replies per post (MaxReplies)	Number of responses received on the user's post(s) within the first week. If multiple posts, the maximum value is retained. Treated as tertiles (low, moderate, high). Excluded from final model.
Max score per post (MaxScore)	Number of upvotes-downvotes received on the user's post(s) in the first week. If multiple posts, the maximum value is retained. Treated as tertiles (low, moderate, high).
Sober Badge active (Badge)	A Sober Badge value was present in (any of) the user's post(s) within the first week. Treated dichotomously (yes / no).
Asked for support (AskSup)	Text classifiers identified support seeking in one or more of the user's post(s) within the first week. Treated dichotomously (yes / no).
Expressed concerns (Concerns)	Text classifiers identified (any of) mental, physical, or social concerns in one or more of the user's post(s) within the first week. Treated dichotomously (yes / no).
Expressed cravings (Crave)	Text classifiers identified cravings in one or more of the user's post(s) within the first week. Treated dichotomously (yes / no).

Table 4.6 Descriptive characteristics of metadata predictors

Predictor variables	Median (IQR)	Mean (SD)	Range
Posts sent	1 (1-1)	1.4 (1.2)	1-28
Comments sent	2 (0-6)	5.8 (12.2)	0-381
Max replies per user post(s)	7 (4-12)	10.4 (14.6)	0-278
Max score per user post(s)	6 (3-13)	23.7 (86.1)	0-3020

4.3.3.1 Multicollinearity and variable inclusion

When initially examining raw counts (i.e., prior to collapsing variables into dichotomous or tertile indicators), the Spearman correlation between MaxReplies and MaxScore was 0.78, indicating a potential issue of multicollinearity. After collapsing variables, moderate

intercorrelations of MaxReplies on MaxScore and CommsSent persisted (see Figure 4.4). Variance inflation factor (VIF) values provided further evidence for potential issues, with all three of these variables having relatively high VIF and MaxReplies approaching VIF = 4 (see Table 4.7), which indicates possible cause for concern (Hair, 2010). As MaxScore and MaxReplies both measure community feedback, MaxScore was retained as a more straightforward indicator of *positive* feedback (i.e., some replies may be negative or neutral). MaxScore was also empirically favorable to retain as it had a greater *pseudo-R*² than MaxReplies for predicting 4-week engagement (see Table 4.7) and had relatively low correlation with CommsSent (see Figure 4.4). After removing MaxReplies as a potential source of confounding, adjusted VIFs were approximately 2 or below, indicating that multicollinearity was no longer a likely issue for a multivariable model using these predictors. All other variables were retained as they significantly predicted 4-week engagement in simple logistic regression models (see Table 4.7).



Figure 4.4 Spearman inter-correlation matrix after collapsing variables

		Simple Logisti	c Regressio	ns	
	%	Odds Ratio		pseudo-	Model-wise
Predictor, w/in first week		(95% CI)	р	R^2	VIF (adjusted)
Posts sent					
Minimum & median $(= 1)$	79.0	ref.			
Above median (> 1)	21.0	8.47 (7.53, 9.53)	< 0.001	0.135	1.69 (1.69)
Comments sent					
Median or below (0-2)	54.4	ref.			
Above median (> 2)	45.6	23.90 (18.90, 30.24)	< 0.001	0.168	2.60 (2.08)
Max replies per post					
Low (0-3)	33.7	ref.			
Moderate (4-8)	32.7	1.57 (1.34, 1.85)	< 0.001		
High (> 8)	33.7	2.83 (2.45, 3.28)	< 0.001	0.023	3.90 (removed)
Max score per post					
Low (0-2)	35.9	ref.			
Moderate (3-8)	31.0	2.43 (2.03, 2.89)	< 0.001		
High (> 8)	33.0	4.84 (4.12, 5.69)	< 0.001	0.047	2.89 (2.07)
Sober Badge active					
No	85.0	ref.			
Yes	15.0	4.88 (4.34, 5.48)	< 0.001	0.065	1.26 (1.26)
Asked for support					
No	57.4	ref.			
Yes	42.6	1.36 (1.22, 1.52)	< 0.001	0.003	1.58 (1.43)
Expressed concerns					
No	56.6	ref.			
Yes	43.4	1.68 (1.50, 1.88)	< 0.001	0.009	1.61 (1.60)
Expressed cravings					
No	91.5	ref.			
Yes	8.5	2.19 (1.87, 2.56)	< 0.001	0.007	1.14 (1.14)

Table 4.7 Description of predictors and preliminary model characteristics

4.3.3.2 Predictors of sustained engagement

In both multivariable models, the strongest predictors of sustained engagement related to the frequency of engagement in the first week (see Table 4.8). There was a particularly strong association between sustained engagement and commenting at above-median levels (i.e., > 2comments) or posting more than once within the first week. Having an active sober badge was also significantly associated with sustaining engagement at both 4- and 13-weeks. Receiving a relatively high score (versus low score) on a post in the first week predicted sustained engagement at 4-weeks but not at 13-weeks. When accounting for these predictors in multivariate models, the content of first-week posts (i.e., asking for support, expressing concerns or cravings) did not significantly predict sustained engagement at either timepoint. Overall models significantly predicted sustained engagement at both 4-weeks (*pseudo-R*² = 0.246, df = 8, p < 0.001) and at 13-weeks (*pseudo-R*² = 0.163, df = 8, p < 0.001).

	4-week engagem	ent	13-week engagem	ient
	AOR		AOR	
Predictor, w/in first week	(95% CI)	р	(95% CI)	р
Posts sent				
Minimum & median $(= 1)$	ref.		ref.	
Above median (> 1)	3.06 (2.66, 3.53)	< 0.001	2.04 (1.46, 2.83)	< 0.001
Comments sent				
Median or below (0-2)	ref.		ref.	
Above median (> 2)	12.94 (10.15, 16.49)	< 0.001	25.16 (11.02, 57.44)	< 0.001
Max score per post				
Low (0-2)	ref.		ref.	
Moderate (3-8)	1.18 (0.97, 1.43)	0.090	1.20 (0.76, 1.90)	0.428
High (> 8)	1.36 (1.13, 1.64)	0.001	1.47 (0.94, 2.28)	0.086
Sober Badge active				
No	ref.		ref.	
Yes	2.52 (2.21, 2.87)	< 0.001	2.24 (1.67, 2.99)	< 0.001
Asked for support				
No	ref.		ref.	
Yes	1.03 (0.91, 1.17)	0.633	1.29 (0.97, 1.71)	0.080
Expressed concerns				
No	ref.		ref.	
Yes	1.04 (0.92, 1.19)	0.471	0.95 (0.72, 1.26)	0.731
Expressed cravings				
No	ref.		ref.	
Yes	1.01 (0.85, 1.21)	0.870	1.19 (0.82, 1.71)	0.357

Table 4.8 Results of Multiple Logistic Regression models

4.4 Discussion

This study had three primary aims of (1) developing machine learning (ML) classifiers to explore contexts of posts on the /r/stopdrinking (SD) forum at scale, (2) describing engagement trends among new users, and (3) leveraging the ML classifiers and user engagement data to predict sustained engagement through conceptualized 4- and 13-week milestones. The first hypothesis was supported, as posting within the first week was significantly associated with sustained engagement. The second hypothesis was partially supported. All hypothesized contexts of initial engagement predicted sustained engagement at 4-weeks in simple logistic regression models, though language-based factors were not significant in multivariable models at either milestone.

4.4.1 Machine learning (ML) classifiers

In the first aim, five supervised ML classifiers (mental / physical / social concerns, support seeking, and cravings) were developed and tested, based on the available training data annotated in Chapter 3. Three classification approaches (Naïve Bayes, Logistic Regression, Random Forest) and several natural language processing (NLP) models were evaluated to determine the most appropriate classification approach. Results indicated that the strongest approach was Random Forest with full NLP parameterization (i.e., format regularization, negation tagging, stemming, and stopword removal) using the 3,000 most frequent n-gram (unigram and bigram) features weighted through a TF-IDF approach. This represents an alternative to manual annotation of posts on the SD forum, which is reproducible and computationally inexpensive (as compared to more advanced deep learning approaches).

Classifiers for *support seeking* and *mental concerns* performed particularly well. Classifiers for *physical concerns* and *social concerns* had relatively low recall and were unlikely to perform well as standalone predictors, so they were combined with mental concerns to form an overall domain of *concerns expressed*. The classifier for *cravings* had modest but acceptable performance to be included as a conceptually important, standalone construct. Recall was lower than precision for all domains, so the classifiers should be considered conservative when a standard 0.5 threshold is used to allocate probability estimates into discrete categories. This approach was suitable for the current purposes, as conservative estimates limited the number of false positives to provide a clearer signal for constructs that were readily detectible.

However, the classifiers could be improved upon and this should be considered for future work where recall is more critical (e.g., estimating overall prevalence of constructs over time). To this end, additional annotation of data may improve classification performance. This could be done through a reinforcement learning process where human annotators adjudicate edge cases that the classifiers identify. For example, supplementing training data with human annotations in cases where the classifiers produced estimates around 0.5 may add clarity around this decision boundary.

4.4.2 New user activity

Analyses included a sample of 40,341 new SD forum users whose first post or comment (i.e., engagement) occurred over the span of one year. Each users' engagement activities were observed over 35 weeks and commenting was generally more common than posting over time. Overall, new SD forum users sustained engagement at markedly low rates, with only about half of new users returning to post or comment on the forum after their initial engagement(s) on Day 0.

While overall engagement dwindled over the weeks observed, the likelihood of returning users engaging for consecutive weeks increased over time. The overall rate of engagement became relatively stable over the observed timeframe as many of the new users disengaged, leaving a fraction of actively sustaining users. Only 5% of users sustained engagement through 4-weeks and 1% sustained through 13-weeks. As typical engagement with this forum was generally short-lived and sporadic, users with this level of sustained weekly engagement were relatively exceptional in their commitment to SD. The present study identified several contexts from the initial week of engagement that were predictive of sustained, committed engagement on SD.

4.4.3 Predictors of sustained engagement

4.4.3.1 Posts sent

The act of posting within the first week (versus commenting only) was significantly associated with sustained engagement at both 4- and 13-weeks and this supports Hypothesis 1. Among users who posted valid content within the first week (n = 18,517), individuals who posted more than one time (vs one time only) had 3 times greater odds of sustaining engagement through 4-weeks and 2 times greater odds of sustaining engagement through 13-weeks. This indicates that posting early-on plays an important role in predicting sustained activity at these milestones and this is consistent with Hypothesis 2.

It is plausible that posting early-on – regardless of particular post content – indicates a sense of commitment to the SD community. Theoretically, this would provide an initial boost to social recovery capital by fulfilling the community-oriented obligation of generating forum content. Posting also provides an opportunity to generate reciprocity more centrally around a

particular user (i.e., conversations stemming from submitted posts). This aligns with prior work where generation of user content and reciprocity in online communities was associated with enhanced motivation and relational capital (Lee et al., 2020). This also reflects SMART Recovery online forum restrictions, which require an introductory post in order to access other forum features such as commenting on others' posts (*SMART Recovery Online Community*, 2021). However, the process of passively "lurking" or commenting on others posts can be an important early step as individuals acclimate to online recovery contexts (Chambers et al., 2017). While *encouraging* initial posts may be valuable in forums such as SD, it is also important to note that some individuals spend substantial time lurking and commenting on SD prior to ever posting (see Section 3.3.3.2), so requiring initial posts may be limit the potential of online MHG contexts that are similar to SD.

4.4.3.2 Comments sent

Above-average commenting activity during the first week strongly predicted sustained engagement through 4-weeks and 13-weeks, with adjusted odds ratios of 12.94 and 25.16, respectively. While significant and conceptually relevant, these magnitudes should be interpreted cautiously due to sparsity of outcome data, which can inflate odds ratios (Greenland et al., 2000). In particular, the estimate at 13-weeks may be biased owing to the low proportion of individuals whose initial comment frequency was at or below average and who also sustained engagement (n = 6). This is reflected by a relatively wide confidence interval at 13-weeks (see Table 4.8).

Comment frequency predicting sustained engagement is consistent with the Social Identity Model of Recovery (Best et al., 2016), which posits that individuals develop and strengthen their recovery identities through engagement and affiliation with recovery-oriented peers. This includes the concept of "keeping it by giving it away", meaning that individuals sustain recovery through a process of supporting others who are in recovery (Best et al., 2016). This is also reflected in outcomes from Project MATCH, where AA participants who helped peers experienced longer term sobriety then non-helpers when controlling for number of AA meetings attended (Pagano et al., 2004). Similarly, research on gambling-related support groups found that providing social support (but not receiving it) mediated relationships between recovery group identification and abstinence self-efficacy (Hutchison et al., 2018). In the context of SD, commenting is a primary vehicle for supporting other community members (see Section 3.3.4). Thus, the relatively strong associations between comment frequency and sustained engagement in the present study reflect conceptually meaningful contexts of MHG engagement. This finding warrants further consideration and future research might endeavor to understand if particular types of support provided through SD comments are predictive of sustained engagement and recovery trajectories.

4.4.3.3 Maximum score per post

Users who received a high score (> 8 upvotes) on one or more posts in the first week had 36% greater odds of sustaining 4-week engagement, as compared to users with all low scores (0-2 upvotes). This effect is relatively small and not directly relevant to individual user engagement as it is technically beyond the control of a user. Nonetheless, the finding aligns with a study of a Facebook recovery support group, which indicated that receiving "likes" is personally validating and predicts continued community engagement (Bliuc et al., 2017). However, this Facebook group was much smaller (n = 609) than Stop Drinking and the dynamic may be different across platforms or among online MHGs of different sizes.

A possible future direction would be to investigate the types of posts that are "upvote worthy" within this community (Weninger, 2014). For example, a prior study of SD used unsupervised topic model classification to identify themes among posts (Harikumar et al., 2016), and it may be beneficial to use similar approaches to identify differences between high-scoring and low-scoring posts. Consistently scoring highly may reflect successful alignment of shared norms, language, and narratives within the community. These aspects of community assimilation are attributed to Alcoholics Anonymous engagement in particular (Holleran & Macmaster, 2005; Wilcox, 1998), and may reflect a shift toward an identity where online recovery support plays a more central role. However, posting with the goal of scoring points may be detrimental to genuine self-disclosure (Lee et al., 2020). So, while scoring points should not be considered as a recommended engagement strategy, high-scoring posts could provide additional insight into the collective recovery culture and popular norms within the SD community.

4.4.3.4 Sober Badge presence

Among those who posted in the first week, setting up a Sober Badge tracker during this time was associated with 2.5- and 2.2-times greater odds of sustaining engagement at 4- and 13-weeks, respectively. As setting up badges can sometimes be complex or confusing for users (see Chapter 3), this extra effort may indicate some additional commitment to abstinent recovery. This may drive increases in forum engagement to garner peer recovery support. Additionally, as the Sober Badge feature is embedded in the forum, users must visit the forum to access it. This may encourage users to return and check progress and provide greater opportunities for engagement.

The act of counting sober days may itself be a driver of self-improvement and positively impact recovery identity, particularly among people who are making a 30-day sobriety pledge (Robert, 2018). As month-long pledges are common in the SD forum (see Section 3.4.3.1), the badge feature should be considered integral to such efforts. However, this circumstance does not explain the observed association between having a badge and sustaining engagement through 14weeks. Based on current findings, using the Sober Badge feature adds value beyond progress tracking, as its early use is also predictive of sustained engagement with the SD community.

This result is also important in the context of previous studies which relied on Sober Badge data as an indicator of alcohol abstinence (Tamersoy et al., 2015, 2017). Based on the present findings, early adopters of the badge have more than twice the odds of being highly committed users over time. This presents additional perspective to studies that relied solely on users with Sober Badge tracking data, who do not necessarily represent the broader SD population. This is a particular challenge among new users, as the present study identified that among new users who posted within the first week, only 15% had an active Sober Badge. This figure is substantially lower than prior estimates of 47% Sober Badge prevalence among overall SD posts (see Section 3.3.2). This may indicate initial technical hurdles to badge setup (see Section 3.3.3.1) or that new users transition into Sober Badge use over a longer time period. These are important considerations for future research using Sober Badge data as a predictor or outcome indicator of recovery.

4.4.3.5 Text content of posts

While all of the constructs (i.e., support seeking, expressing concerns, expressing cravings) were significant in univariate models, none remained so after other variables were included in multiple regression models. This null finding ran counter to the hypothesized premise of self-disclosure reflecting enhanced motivation and relational capital in a recovery context (Lee et al., 2020). While indicators in the present study were limited to those from viable ML classifiers, other studies have proposed alternate text classification strategies. In particular, linguistic indicators of group identification and personal achievement predicted sustained engagement in a separate online

recovery community (Bliuc et al., 2017). However, these constructs were not available or not conceptually viable in a first-week context for the present approach. Additional constructs and classification approaches will be valuable to consider in studies of SD user content, and these may be complemented by unsupervised approaches of earlier SD studies (Tamersoy et al., 2015, 2017).

An additional consideration for this domain is that individuals' language patterns change over time and through experience with online recovery communities. This was particularly evident in formative work describing the evolution of "we" language and sharing of positive emotions as individuals developed recovery identities (Best et al., 2018). While the present study classified the content of first-week posts only, future work may benefit from extending these models to content that users post over longer-term online recovery dialogue. The *identification with SD* construct could be particularly valuable within a longitudinal timeframe of language use (see Chapter 3).

4.4.4 Limitations

Two specific limitations related to potential biases were addressed in their respective sections above. These included low recall for some classifiers (see Section 4.4.1) and the potential for inflated Odds Ratios due to sparse cells in the context of comments sent (see Section 4.4.3.2). There are three broader limitations and considerations for this work.

Foremost, as this study was observational in nature, many factors relevant to recovery that occurred off of the forum were unable to be ascertained. The use of machine learning classifiers did provide an indication of whether individuals disclosed experiencing personal concerns or cravings. However, these should be understood primarily as observations of personal disclosure behavior and not necessarily as a reliable indicator of latent experiences. In particular, lack of disclosure about particular concerns should not be construed as a lack of having such concerns. An ideal focus for future work will be to collect self-report data directly from users – new users in particular – to account for individual differences and external factors influencing sustained engagement with and commitment to this community.

With respect to interpretation of findings, sustained engagement in this context does not necessarily reflect optimal recovery trajectories. Reasons for disengaging are myriad and include (1) deciding that consistent online support is not necessary to meet recovery goals or (2) moving on to another source of peer support (e.g., other forum, in-person group). As such, new SD users who sustained weekly engagement should be considered as a narrowly defined, highly committed population, but without inference that this leads to relatively favorable alcohol-related outcomes. To echo Section 2.4.2.1, controlled and pragmatic trials remain lacking in this area of research.

Similarly, the measure of sustained engagement (i.e., engaging at least once weekly for consecutive weeks) might be considered a conservative metric. Setting a lower threshold such as every-other-week could have provided a larger sample for analysis, but at the cost of interpretability and presumably allowing observed results to steer the analysis framework. As such, the present study sets a concise benchmark for sustained engagement which may be relaxed if justifiable in the scope of future work. While sustaining for 4- and 13-weeks is conceptually meaningful, alternate milestones or analytic approaches (e.g., survival analysis) may also provide novel perspectives on engagement patterns among new SD users.

4.5 Conclusions

This study developed and tested machine learning text classifiers related to recovery themes in the SD online MHG. This resulted in text classification models for support seeking, concerns expressed (mental, physical, social), and cravings. These models were applied along with metadata pertaining to early engagement patterns to predict sustained weekly engagement on SD. In multivariable models, the strongest early predictors of sustaining engagement at 4- and 13-weeks were above median frequency of commenting and posting, and having an active Sober Badge. While the text classification models did not predict sustained engagement, this may be due to relatively low recall or to latent changes in recovery identity and language patterns over time. Additional research is warranted to understand the language of online recovery, how it can be reliably modeled, and how it may predict patterns of committed MHG engagement and specific recovery-related outcomes.

This study provides additional evidence to warrant caution in using Sober Badge data as an outcome. In addition to measurement issues raised in Chapter 3, current findings indicate that badge users have unique characteristics with respect to patterns of sustained engagement. Thus, Sober Badge users may not be an accurate representation of SD users more broadly. These limitations should be accounted for in future studies that leverage Sober Badge data.

The present study provides novel understandings and sets benchmarks for understanding highly active online MHGs. Foremost, sustaining regular engagement on SD is the exception rather than the rule. Roughly half of new users did not return after an initial day of engagement and only 5% and 1% sustained weekly engagement through 4- and 13-weeks, respectively. This type of

committed engagement was strongly predicted by above average first-week engagement patterns, which may be useful to identify users who show early indicators of commitment to this digital MHG. For example, new users who post at least twice, comment a minimum of three times, or set up a Sober Badge within the first week are exceptional. Based on multivariable analysis, the content of initial posts did not significantly predict engagement outcomes, though frequency of posting did. This may be reassuring to users who are hesitant or unsure of what to post about.

While these first-week activities are not causal for sustaining high levels of engagement, they were strong predictors and represent conceptually meaningful activities for online MHG participation. Future work might test whether setting and achieving early engagement goals is effective in enhancing MHG commitment and to what extent this translates to enhanced recovery outcomes associated with digital MHG use. As prior research has indicated recovery capital and recovery identities emanating from digital MHG use, future studies may explore how these benefits might be enhanced by manualizing recommendations for new user engagement. This may help new users to effectively navigate, sustain engagement, and reap the greatest potential benefit from digital MHG use.

5.0: Conclusions

There are many pathways of recovery from problematic alcohol use. In addition to contemporary in-person mutual help groups (MHGs), digital MHGs represent an important source of social recovery capital and support for many who are engaged in a recovery process. The importance of these groups became particularly clear over the course of completing this dissertation, now 16 months into the COVID-19 pandemic. The pandemic has resulted in drastic changes to clinical practice and MHG meetings being delivered via digital technology. Up through this point, in-person meetings for Alcoholics Anonymous, SMART Recovery, and other mutual help organizations have shifted almost entirely online. Many meetings can be expected to remain in that state as the use of digital technology has become increasingly normative in this context. Given this changing landscape and migration toward digital support, research on digital MHGs is timely and critical for understanding the downstream impacts of this shift. For example, the increasing presence of digital MHGs presents opportunities for individuals to access recovery support with lower barriers to engagement, greater convenience, and increased anonymity. Given the growing ubiquity of digital MHG meetings, it is plausible that a relatively large number of people will access MHG support for the first time in a digital format. While there is relatively strong evidence for the effectiveness of in-person MHG engagement in enhancing alcohol recovery outcomes, potential benefits of digital MHGs are less well understood.

To better understand the body of available evidence in this realm, a scoping review of research literature about alcohol-related digital MHGs was undertaken in **Chapter 2**. While controlled trials were insufficient to establish a causal pathway for digital MHG engagement on

recovery-related outcomes, a number of studies yielded promising results with regard to acceptability of digital MHGs, perceived benefits of engagement, generation of social recovery capital, and development of recovery identities. Common findings emerged across studies, indicating that digital MHGs served similar functions of in-person MHGs and were often used in conjunction with them. Individuals tending toward digital MHGs were found to be relatively younger, earlier on in recovery, and with less severe alcohol-related problems. Findings were largely consistent with the Pathways Disclosure Model (Cooper, 2004), which presents digital MHG engagement as a pathway to greater personal disclosure and involvement within digital MHGs, and movement toward in-person MHG engagement. This also parallels the Social Identity Model of Recovery (SIMOR; Best et al., 2016), where sustained and intensified engagement with MHGs provides a vehicle for the development of a recovery identity and accumulation of social recovery capital. It is also plausible that digital MHGs serve as a stopgap for individuals who may sufficiently benefit from digital support and neither desire nor require more intense engagement via in-person MHGs. Additional research is warranted to understand the use of digital MHGs and trajectories of alcohol recovery among this conceptualized stopgap population in particular.

The scoping review identified five mobile apps that contained peer support features, which were directly studied. Among these apps, the A-CHESS mobile app was the most rigorously researched and should be considered as a possible option to enhance recovery from problematic alcohol use. However, it remains unclear how much direct benefit A-CHESS's peer support features may confer, as compared to other core app features. As availability of this app is limited, SoberGrid or Daybreak might be alternately considered as viable options for accessing digital support via mobile app. Among the 15 web-based MHGs that were identified, Alcohol Help

Center, Hello Sunday Morning, and InTheRooms were among the most studied. Of these, only InTheRooms remains available and active. Recent research has also focused on social media platforms that host MHG forums. The Reddit platform – and the **/r/stopdrinking** (**SD**) forum in particular – presents an anonymous, public social media forum where individuals can seek out and exchange virtual peer support.

SD subscribership has grown nearly tenfold since this MHG received mainstream press coverage in January 2016. Around this time, SD was also receiving research attention from computational social scientists who leveraged "big data" from SD to uncover complex patterns of platform use that predicted users' Sober Badge values. However, no published studies had approached SD in a more formative sense; to describe overall patterns of user engagement (particularly among new users), to question underlying data assumptions (e.g., Sober Badge is a gold standard for sobriety status), or to contextualize engagement using conceptually grounded descriptive analysis. To begin addressing gaps in this area of research, in February 2018, I began collection of publicly available data from the Reddit API, capturing real-time updates on SD activity. Data collection proceeded without major interruption through the initial months of the COVID-19 pandemic in the spring of 2020. This resulted in a dataset with sufficient breadth to identify longitudinal trends and fidelity to contextualize nuanced characteristics of user activity.

In **Chapter 3**, I provided benchmarks of SD forum activity, appraisal of forum features, and synthesis of community content. Overall, the SD forum set a strong benchmark for activity and responsiveness, typified by 209 new posts per day, upwards of 4 direct responses per post, and threaded discussions among the responses. The first response to a post typically arrived within 12

minutes and the community continued to engage around new posts over six subsequent hours in most cases. Support received through direct responses was primarily emotional in nature. More than half of the responses provided appraisal support (i.e., feedback and affirmation) and informational support was relatively rare. More than a third of reviewed posts were seeking support for a particular question or concern. Nearly one-in-five posts expressed issues with cravings. There were also salient indicators of a distinct recovery identity associated with the SD community. This was expressed through explicit affiliation (e.g., "fellow sobernauts", "my people"), the use of customary salutations (i.e., "I will not drink with you today", "IWNDWYT"), and considering SD as a primary source of recovery support. A number of users also indicated engaging with in-person support and presenting distinct recovery identities there (e.g., "alcoholic" in AA meetings but not on SD forums). Some users identified relatively severe alcohol-related problems requiring intensive treatment (e.g., emergency care, clinically supervised detoxification, residential rehabilitation) as well as serious mental, physical, social, and legal concerns. Such narratives also reflected a sense of "hitting bottom", accompanied with making commitments to long term abstinence as well as ongoing SD engagement. In other cases, individuals rallied around monthto-month recovery challenges (Dry January in particular) to improve overall health, gain perspective about drinking behaviors, or as a personal achievement. This reflects a plurality of experiences and available support within the SD community, particularly among individuals who are initially pursuing alcohol abstinence, even temporarily.

Community features included clear guidelines for engagement (e.g., only post when sober, speak from the "I"), an extensive Frequently Asked Questions page and resource library, a consistently operated "daily check-in" thread, and a Sober Badge day counter that was used by

roughly half of users. Based on analysis of Sober Badge metadata compared to the amount of sober time that individuals reported in posts, badge values were lower and significantly different from distributions of self-reported sobriety duration (e.g., badges not reliably reset after a lapse). Users also identified technical issues (e.g., unable to reset badge) and definitional challenges (i.e., sober versus abstinent) in using this feature. Despite sobriety being an ideal outcome to investigate in this research context, I concluded that badge values did not present reliable proxies of recovery outcomes that I could conscientiously defend in a follow-up study.

This led to a reappraisal of earlier proposed models and a step back to appreciate the broader conceptual framing and research questions that emerged in earlier chapters of this project. In particular, Chapter 2 demonstrates strong potential for digital MHGs to generate social recovery capital and foster development of recovery identities, to the extent that individuals regularly engage in support there. Chapter 3 provides evidence that the SD community presents a potentially rich source of social recovery capital and an opportunity to foster a recovery identity. To complement these findings, Chapter 4 was aligned to examine patterns sustained user engagement that may reflect commitment to change and access to recovery capital potentiated by this MHG.

As little is quantifiably known about patterns of new MHG user behavior in this realm, **Chapter 4** focused on a sample of new users who first engaged on SD from July 2018 through June 2019. Users were observed for 244 days with an objective to identify early contexts of SD engagement (i.e., first week activity) that predict longer term commitment to community participation (i.e., sustained weekly engagement) through 4- and 13-week follow-up windows (i.e., approximately one- and three-month recovery milestones). Making an introductory post within the first week was associated with patterns of sustained engagement. Based on prior literature, individuals who indicated alcohol-related problems (e.g., health concerns, cravings) or who were directly asking for support early-on, could be expected to have a greater commitment to digital MHG recovery efforts. To test this, the respective data annotated in Chapter 3 were used to train computational linguistic models to identify these contexts at scale. Classifiers performed reasonably well but these text features did not predict sustained SD engagement through recovery milestones. However, having above average commenting and posting frequency and setting up a Sober Badge within the first week predicted sustained engagement at both milestones. Sustained weekly engagement was found to be a fairly high standard in this MHG, as this was achieved by only 5% of users at 4-weeks and 1% of users at 13-weeks. Thus, this population should be understood in the context of exceptional users who joined and became quickly committed to engaging with SD. This level of commitment is particularly exceptional given that roughly half of users disengaged after only one day of activity.

While exceptional patterns of engagement early-on may offer an initial modicum of recovery capital, the relationship with sustained engagement is not assumed to be causal. These associations likely reflect some combination of underlying psychological constructs (e.g., motivation to change, recovery identity orientation, abstinence self-efficacy), which were unable to be observed in this context. An ideal follow up study design would include comprehensive baseline surveys and regular self-report prompts to identify and control for these individual differences over time. Future work should also consider the differences among MHG support accessed via asynchronous forums, synchronous chatrooms, private messaging, and video meetings separately. The landscape of digital MHGs has evolved substantially since the unidimensional Pathways Disclosure Model was conceptualized in 2004. Based on present findings, it will be useful to consider additional conceptual dimensions where distinct recovery identities and levels of disclosure co-exist across diverse MHG engagement contexts.

Summary: Digital MHGs for problematic alcohol use serve as convenient and generally acceptable sources of social support. While there is insufficient evidence supporting their effectiveness in improving alcohol use outcomes, regular engagement with digital MHGs is associated with the accumulation of recovery capital and the emergence of recovery identities. These contexts were qualitatively apparent in content posted to the SD forum. However, new users were unlikely to commit to regular engagement within this MHG. Within the first week of engagement, users who submitted an introductory post, posted and commented at above average frequency, and set up a Sober Badge were most likely to remain committed over initial months. Future research should model and control for individual differences that predict this type of committed digital MHG use. This will serve to better characterize recovery pathways and to identify populations that may benefit most from particular digital MHG formats. Ultimately, this should lead to appropriately scoped randomized trials, evidence-based recommendations, and best-practice frameworks for engaging with popularly used digital MHGs.

Appendix A – Bibliographic database searches

PubMed

(("Alcoholism"[Mesh] OR "Alcohol Abstinence"[Mesh] OR "Alcohol Drinking"[Mesh:NoExp] OR "Alcohol Drinking in College"[Mesh] OR "Binge Drinking"[Mesh] OR alcohol abuse*[Title/Abstract] OR alcohol use[Title/Abstract] OR alcoholism[Title/Abstract] OR alcohol misuse[Title/Abstract] OR alcohol addiction*[Title/Abstract] OR alcohol dependen*[Title/Abstract] OR alcohol problem*[Title/Abstract] OR problem drink*[Title/Abstract] OR heavy drink*[Title/Abstract] OR risky drink*[Title/Abstract] OR alcohol consumption[Title/Abstract] OR alcoholic*[Title/Abstract] OR "Alcohol-Related Disorders"[Mesh:NoExp])

AND ("Self-Help Groups"[Mesh:NoExp] OR "Community Participation"[Mesh:NoExp] OR "Self Care"[Mesh:NoExp] OR "Social Support"[Mesh:NoExp] OR mutual help[Title/Abstract] OR mutual aid[Title/Abstract] OR mutual support[Title/Abstract] OR recovery communit*[Title/Abstract] OR recovery group*[Title/Abstract] OR peer based[Title/Abstract] OR peer support*[Title/Abstract] OR supportive communit*[Title/Abstract] OR support group*[Title/Abstract] OR social support[Title/Abstract] OR social network*[Title/Abstract] OR self help[Title/Abstract])

AND (online[Title/Abstract] OR "Telemedicine"[Mesh:NoExp] OR internet[Title/Abstract] OR digital[Title/Abstract] OR mobile[Title/Abstract] OR web[Title/Abstract] OR A-CHESS[Title/Abstract])) OR (("Internet"[Mesh:NoExp] OR "Social Media"[Mesh] OR "Online Systems"[Mesh:NoExp] OR "Mobile Applications"[Mesh] OR "Online Social Networking"[Mesh] OR "Social Networking"[Mesh:NoExp] OR "Blogging"[Mesh] OR "Smartphone"[Mesh] OR "Cell Phone"[Mesh] OR online self help[Title/Abstract] OR online social network*[Title/Abstract] OR discussion forum*[Title/Abstract] OR Facebook[Title/Abstract] OR Reddit[Title/Abstract] OR mobile app*[Title/Abstract] OR mobile health[Title/Abstract] OR mHealth[Title/Abstract] OR e health[Title/Abstract] OR blog*[Title/Abstract] OR software app*[Title/Abstract] OR smartphone*[Title/Abstract])

AND ("Alcoholism"[Mesh] OR "Alcohol Abstinence"[Mesh] OR "Alcohol Drinking"[Mesh:NoExp] OR "Alcohol Drinking in College"[Mesh] OR "Binge Drinking"[Mesh] OR alcohol abuse*[Title/Abstract] OR alcohol use[Title/Abstract] OR alcoholism[Title/Abstract] OR alcohol misuse[Title/Abstract] OR alcohol addiction*[Title/Abstract] OR alcohol dependen*[Title/Abstract] OR alcohol problem*[Title/Abstract] OR problem drink*[Title/Abstract] OR heavy drink*[Title/Abstract] OR risky drink*[Title/Abstract] OR alcohol consumption[Title/Abstract] OR alcoholic*[Title/Abstract] OR "Alcohol-Related Disorders"[Mesh:NoExp]))

CINAHL

((MH "Alcoholism" OR MH "Alcohol Abuse" OR MH "Binge Drinking" OR MH "Alcohol Drinking" OR MH "Alcohol Drinking in College" OR MH "Alcoholic Intoxication" OR "alcoholism" OR "alcohol abuse*" OR "alcohol addiction" OR "alcohol dependen*" OR "alcohol use disorder" OR "alcohol misuse" OR "heavy drink*" OR "problem drink*" OR "risky drink*" OR "alcohol problem*")

AND (MH "Blogs" OR MH "Internet" OR MH "Social Media" OR MH "Telehealth" OR MH "Telemedicine" OR MH "Smartphone" OR "online communit*" OR "online support" OR "online forum*" OR "online peer*" OR "online self help" OR "online social" OR "discussion forum*" OR "e health" OR "hello sunday"))

OR

((MH "Alcoholism" OR MH "Alcohol Abuse" OR MH "Binge Drinking" OR MH "Alcohol Drinking" OR MH "Alcohol Drinking in College" OR MH "Alcoholic Intoxication" OR "alcoholism" OR "alcohol abuse*" OR "alcohol addiction" OR "alcohol dependen*" OR "alcohol use disorder" OR "alcohol misuse" OR "heavy drink*" OR "problem drink*" OR "risky drink*" OR "alcohol problem*")

AND (MH "Peer Group" OR MH "Support Groups" OR "mutual help" OR "peer support" OR "support forum*" OR "supportive community" OR "self help" OR "social network*" OR "recovery group*" OR "recovery community" OR "mutual aid")

AND (MH "World Wide Web" OR MH "Social Networking" OR MH "Online Systems" OR "blog*" OR "Internet" OR "mobile" OR "mhealth" OR "online" OR "smartphone*"))

PsycINFO

((("alcohol use disorder"/ OR Alcohol Abuse/ OR Alcoholism/ OR binge drinking/ OR Alcohol Drinking Patterns/ OR Alcohol Drinking Attitudes/ OR Sobriety/ OR Alcohol Intoxication/ OR Social Drinking/ OR "Recovery (Disorders)"/ OR alcoholism.ti,ab,id.) OR (alcohol adj2 (abuse* or addict* or dependen* or misuse or problem*)).ti,ab,id.)

AND (support groups/ OR (mutual aid OR mutual help OR mutual support OR self help OR recovery communit* OR peer support).ti,ab,id.)

AND (telemedicine/ OR Mobile Phones/ OR (digital OR discussion forum* OR Facebook or Reddit or Subreddit OR social media).ti,ab,id. OR (mobile adj2 (health or app*)).ti,ab,id. OR (website* or ((web adj2 site*) or based)).ti,ab,id.)) OR

((Online Social Networks/ OR Computer Mediated Communication/ OR Online Community/ OR Internet/ OR Blog/ OR Websites/ OR Social Media/ OR Online Therapy/ OR Mobile Health/ OR Smartphones/ OR Mobile Devices/ OR (online adj2 (communit* or platform* or support or group* or forum* or help or peer or social or network*)).ti,ab,id.)

AND (("alcohol use disorder"/ OR Alcohol Abuse/ OR Alcoholism/ OR binge drinking/ OR Alcohol Drinking Patterns/ OR Alcohol Drinking Attitudes/ OR Sobriety/ OR Alcohol Intoxication/ OR Social Drinking/ OR "Recovery (Disorders)"/ OR alcoholism.ti,ab,id.) OR (alcohol adj2 (abuse* or addict* or dependen* or misuse or problem*)).ti,ab,id.))

IEEE

(((((All Metadata:alcohol*) OR All Metadata:drinking) OR All Metadata:drinker*)))

ACM

[[All: "help group*"] OR [All: "support group*"] OR [All: "peer support"] OR [All: "community"] OR [All: "self care"] OR [All: "social support"] OR [All: "mutual aid"] OR [All: "peer based"] OR [All: "self help"]]

AND [[All: "alcohol*"] OR [All: "substance use"]]

AND [[All: "online"] OR [All: "forum"] OR [All: "facebook"] OR [All: "reddit"] OR [All: "application*"] OR [All: "software"] OR [All: "internet"] OR [All: "mobile"] OR [All: "social media"]]

ArXiV

("help group*" OR "support group*" OR "peer support" OR community OR "self care" OR "social support" OR "mutual aid" OR "peer based" OR "self help")

AND ("alcohol*" OR "substance use")

AND ("online" OR "forum" OR "facebook" OR "reddit" OR "application*" OR "software" OR "internet" OR "mobile" OR "social media")

Appendix B – Screening and abstraction forms

Screening form

posts of others. The primary analysis used Weighted Generalized Estimating

Equations.

ReflD: 19, A Digital Intervention Addressir Randomized Controlled Trial Tait, R. J.,Paz Castro, R.,Kirkman, J. J. L.,Mo	Actions Experimental Actions Actions Actions Actions Experimental				
Reference Label(s):					
Add Labels here					
BACKGROUND: <u>Alcohol</u> use is prevalent in many societies and has major adverse impacts on health, but	Submit Form and go to This Form - Next Reference				
the availability of effective interventions limits treatment options for those who want assistance in	or program that may include an MHG feature.				
changing their patterns of alcohol use.	1. Related to one or more <i>Mutual Help Groups</i> (MHGs).				
OBJECTIVE: This study evaluated the	Related or unsure				
new Daybreak program, which is accessible via mobile app and desktop and was developed by Hello Sunday	OUnrelated				
Morning to support high-risk drinking individuals looking to change their	MHGs - "also known as <i>self-help <u>groups</u> -</i> are groups of two or more people <i>who share an experience or problem</i> and who come together to provide <i>problem-specific</i> help and support to one another."				
relationship with alcohol. In particular, we compared the effect of adding online coaching via real-time chat messages (intervention group) to an otherwise self-guided program (control	"Coming together" can be in-person or virtual (e.g., online, text message, telephone). Do include apps, interventions, or programs which have an MHG feature (i.e., <i>peer-to-peer</i> support is facilitated, peer connections are made). Also include (i.e., "unsure") systematic reviews covering apps that might include MHG features. Do not include self-help apps or programs that lack peer-to-peer involvement.				
group).	2. MHG modality (i.e., how the group is accessed).				
METHODS: We designed the	◯ In-person or telephone				
trial, but as some people (n=48; 11.9%)	Online or mobile app				
in the control group were able to use the online coaching, the main analysis comprised all participants. We collected	⊖ Both or unsure				
online surveys at one-month and three- months follow-up. The primary	3. Directly related to alcohol use OR Broadly related to substance use (i.e., alcohol may be included/implied).				
outcome was change in alcohol risk	If specific to a topic other than alcohol, choose "Unrelated".				
(measured with the <u>alcohol</u> use disorders identification test-	Directly related (i.e., mentions alcohol specifically)				
consumption [AUDIT-C] score), but	\bigcirc Broadly related (i.e., mentions substance without specification)				
standard drinks per week, <u>alcohol</u> - related days out of role, psychological distress (Kessler-10), and quality of life (EUROHIS-QOL). Markers of engagement with the program included	○ Unrelated				
posts to the site and comments on the					

Abstraction form

- 1. Relevance
- Primary research on participation in OMHG-Au
- O Meta-analysis or systematic review of studies that include OMHG-Au
- O Commentary (e.g., editorial, book chapter) that specifically covers OMHG-Au, but no primary or secondary research was conducted
- O Something else related to OMHG-Au that should be evaluated further (e.g., app review, clinical trial protocol)
- Not directly relevant to OMHG-Au
- EXCLUDE (not an article; e.g., correction, retraction)
- FULL-TEXT NOT AVAILABLE

Definition: An "Online Mutual Help Group for Alcohol use" (OMHG-Au) is a mobile or web-based application that provides a framework for individuals with alcohol use concerns to engage in peer support.

"Peer support can be defined as the process of giving and receiving nonprofessional, nonclinical assistance from individuals with similar conditions or circumstances to achieve long-term recovery from psychiatric, alcohol, and/or other drug-related problems." (Tracy & Wallace, 2016)

Clarification: This does <u>not</u> include 1-on-1 peer counseling in a professional setting (e.g., peer treatment facilitators) but can include peer support groups that are moderated by health professionals (if online). It does <u>not</u> include basic telephone or text message communication. This does include ad-hoc peer support groups on social media platforms and in-person groups using supplemental online infrastructure (e.g., AA text/video chat). OMHG-Au studies might include broader substance use populations, in which case they can be considered relevant if they specifically assess alcohol use trajectories or outcomes.

2. Is a specific OMHG-Au identified? (Or a specific platform/app containing an OMHG-Au)

⊖No.	
• Yes, one:	
\bigcirc Yes, more than one:	

Clear Response

- 3. What is the goal of this group?
- O Cessation only: 12-step (e.g., AA)
- O Cessation only: Not 12-step

 \bigcirc Harm-reduction only (reducing alcohol use quantity or frequency; not cessation)

O Cessation and/or harm-reduction, or unclear

Clear Response

4. What is the modality of this group?

 \bigcirc Asynchronous post/response format (e.g., social media or blog type group)

- O Real-time: Live chat sessions (text)
- Real-time: Audio/visual chat (e.g., AA video meetings)
- Other or unclear

Clear Response

5. What type of platform is used to access this group?

- Online webpage
- O Mobile app

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Clear Response

Abstraction form (continued)

- 6. What methods were used?
- O Quantitative / Inferential
- \bigcirc Qualitative / Descriptive
- ⊖ Mixed-methods

Clear Response

- 7. Clinical population?
- \bigcirc No: General population (e.g., heavy alcohol users, community sample)
- Yes: Alcohol use disorders specifically
- Yes: Alcohol or other substance use disorders
- Yes: Other clinical population

- Clear Response
- 8. Sample size? (Number of participants enrolled)
 - If sample is not participants, clarify what it was (e.g., "2,581 messages")
 - ---
- 9. What were overall study findings, specific to OMHG-Au's? (Copy/paste or summarize)

Overall findings can typically be copied from the conclusion or discussion section for a primary research article that is specifically focused on OMHG-Au's.

In some cases, the MHG features are a minor part of a larger research protocol: then relevant information might be found in the results section (e.g., looking for mentions of *forum, board, messag* post, discuss*, support,* etc.). Note findings that are specific to MHG features, rather than related to the broader intervention, mobile app, etc.

Appendix C – Codebook

Variable types and descriptions:

[1] Dichotomous – presence (=1) or absence (=0 or blank) of a variable.

[2] Nominal – two or more levels or categories of a variable.

[D] Date interval –i.e., number of days (note pluralization)

- day = 1, days = 2, week = 7, weeks = 14, month = 30, months = 60, year = 365, years = 730.
- "a couple" (x2), "a few" (x3), "several" (x4), "many" (x5), "so many" or "too many" (x?)
- Leave blank if N/A or none; code as 0 if construct is present but date not specified Do the math... e.g.,
 - "I've been lurking." Construct present but date not specified = 0
 - "It feels like *days* since I've had a drink." *Days* = 2
 - "I've been lurking here for *weeks*." Weeks = 14
 - "Two weeks to go until my sober anniversary." Year is inferred so: 365 14 = 351

<u>Codes</u>

Exclude from analysis (DO NOT CODE FURTHER):

#	N/A	•	None of the other codes applied. OR The post was meant as an artistic contribution
			(e.g., poetry, lyrics), which might include other codes, but should not be interpreted
			literally. <u>OR</u>
		•	Community-themed posts that are meant for the broader community to engage with (e.g., "Daily Check-in", "Sunday Solutions")

Date frames

D	Sober	Specifying a current length of time that they have been alcohol abstinent.
D	Lurking	Noting that they had spent some time reading but not posting (i.e., lurking) within the
		SD community (e.g., "long time reader first time poster")

Locus of Control (LOC), identity, and support seeking (choose any that apply)

2	Internal LOC	1. General affirmation or common platitude to indicate commitment, e.g.,
	& recovery	"not drinking today", "I will not drink with you today" (iwndwyt)
	self-efficacy	2. Indicating that they are confident about their personal ability to recover
	("I" focused)	or to overcome challenges (e.g., "I know I can _", "I will _"). Or,
		mentioning purposeful engagement in specific activities or actions that
		support sobriety or displace drinking activities.
1	External LOC	Focus on events or circumstances outside of their control as a cause for current
	("me"	circumstances (e.g., "_ happened to me", "I am unlucky",
	focused)	someone made me feel/do something) or completely lacking control (e.g., "I
		can't stay sober", "I'm powerless over drinking")
1	Identifies with	Indicating reliance on a higher power (i.e., religious or spiritual context) for
	Higher Power	support or guidance.
1	Identifies with	Indicating reliance on the SD recovery group for support or guidance (e.g., "glad I
	recovery	have you", "thank you" (for past help, not thanks in advance), "SD changed my
	group	life"). Or offering unsolicited advice to the community.
		Or, salutations mentioning the group (e.g., "Hi all", "Hi SD").
1	Support	Clearly seeking informational support (e.g., advice) or emotional support (e.g.,
	seeking	relatable peer), or appraisal. Must include a clear "ask" (e.g., question to be
		answered or a request for feedback or support).

Current or past drinking commitments (choose any that apply)

	-	
1	Abstinence ¹	Clearly indicating that they have or want to quit drinking entirely, or that they have
		a goal to not drink for the foreseeable future (e.g., "I quit drinking"). Does <u>not</u>
		include "won't drink today" type sentiment (See Locus of Control) ²
		OR
		Demonstrating affiliation with an abstinent, non-drinking identity (e.g., "I don't
		drink anymore", "back when I was a drinker", "my sobriety").
1	Harm	Clearly indicating that they want(ed) to or tried to cut back on drinking, but not to
	reduction	stop drinking entirely. Or, indicating that they are committed to abstinence for a
		defined but temporary amount of time (greater than one day; e.g., Sober October,
		Dry January, "try it for a week", etc.).

<u>Notes:</u> (1) Simply keeping count of sober days doesn't necessarily infer one approach or the other. (2) "I won't drink today" sentiment is better suited for *Internal Locus of Control*
Current or past concerns that are possibly related to alcohol use (choose any that apply). Including mentions of positive life circumstances (e.g., "I'm back in shape", "my liver doesn't hurt") that were a past concern related to drinking.

Currently has or once had ______ concerns that are... [1] Generalized, or [2] Attributed to alcohol use

Physical	1. General physical health concerns, diet, health conditions, etc.
concerns	2. Mentioning physical concerns associated with drinking (e.g., medical
	history, digestive issues, physical restlessness, tremors, sweats, insomnia,
	sleep disturbance).*
	* DO include alcohol-related withdrawal symptoms. DO NOT include
	"hangover", unless other physical symptoms are specified.
Mental	1. General emotional concerns, mental illness, anxiety, distress.
concerns	2. Mentioning mental health conditions or emotional concerns that were
	caused or made worse by drinking (e.g., depression, anxiety) or mentioning
	memory loss / blackouts.
	E.g., feeling depressed, hopeless, unstable, "I feel like a bad person", etc.
<u>Social</u>	1. General social concerns, belonging, peer/family relationships, etc.
concerns	2. Mentioning interpersonal concerns that were caused or made worse by
	drinking (e.g., arguments, embarrassment, separation of family or friends,
	not following through on commitments, feeling left out, bored, lonely,
	unable to leave the house or attend to daily matters).
<u>Legal or</u>	1. General legal or financial concerns, income/expenses, debt, etc.
<u>financial</u>	2. Mentioning legal concerns that were caused or made worse by drinking
concerns	(e.g., DUI/DWI, citation, arrest, incarceration, probation or parole
	violation). Or, mentioning financial concerns that were caused or made
	worse by drinking (e.g., loss of job due to use, living expenses diverted to
	alcohol or other substance use, loss of valuable property like a phone or
	wallet).
Craving	Experiencing a <u>current or past</u> desire, craving, or trigger to use alcohol.
	Physical concerns Mental concerns Social concerns Legal or financial concerns

Clinical care related to alcohol or other mental illness

1	Clinical care:	Mentions needing or using prescribed medication for treating
	Medication	alcohol/substance use or other mental illness.
1	Clinical care:	Mentions needing or getting counselling / therapy for substance use and
	Counsel	associated problems or other mental illness. This includes inpatient (e.g.,
		rehab) or outpatient care (e.g., IOP clinic, therapist).
1	Clinical care:	Mentions interacting with a healthcare provider, receiving emergency services,
	Other	or other clinical care directly related to alcohol/substance use.

12-step, AA, or other in-person group orientation (choose any that apply)

_		
1	History of	Indicate going to AA or similar recovery "meetings" or "rooms" in the past or
	involvement	present. Also: "fellowship", "sponsor", "working the steps", "the program".
1	Future	SKIP IF History of Involvement = 1
	involvement	Indicating a plan or desire to engage in AA or similar in-person meetings.
1	Aversion or	Indicating reluctance, reservation, or aversion to engaging in AA or similar in-
	reservation	person meetings (could be negative past experiences or future concerns).

Appendix D - Data processing map for Chapters 3 & 4



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