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**NEVER LET GO! THE ETIOLOGY,
CLINICAL PRESENTATION AND
TREATMENT OF HOARDING DISORDER**

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NEVER LET GO! THE ETIOLOGY, CLINICAL
PRESENTATION AND TREATMENT OF HOARDING
DISORDER
THESIS FOR DOCTORAL DEGREE (Ph.D.)

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To my father, Z. Ivanov, 1949-2003. Смело вперед.

ABSTRACT

Background: Hoarding disorder (HD) is characterized by difficulties discarding possessions which results in clutter that is impeding and causes distress. Retrospective reports suggest HD debuts in childhood or adolescence but very little is known about the prevalence, presentation and etiology of hoarding in young people. Furthermore, although cognitive behavior therapy (CBT) for HD reduces hoarding symptoms, treatment engagement is generally low and many individuals with HD remain symptomatic after CBT.

Aims: The general aims of this thesis were to examine the prevalence, etiology and clinical presentation of hoarding symptoms in young people and to develop and test a novel treatment for adults with HD.

Results: In study I we analyzed data from a sample (n=3,974) of 15-year old twins from the Swedish Twin Registry and estimated the prevalence of clinically significant hoarding symptoms. Using twin methods, we also estimated the genetic and environmental effects on hoarding symptoms. We found that clinically significant hoarding symptoms occurred in 2.0% of the sample. In boys, the heritability was estimated to 32% and in girls to 2%. Non-shared environmental effects accounted for the remaining variance in boys. In girls, shared environmental effects accounted for 32% and non-shared environmental effects for the remaining variance.

In study II, we estimated the heritability of hoarding symptoms in three cohorts of twins aged 15 (n=7,905), 18 (n=2,495) and 20-28 (n=6,218). We also estimated the sources of stability and change of hoarding symptoms in a sample with available data at ages 15 and 18 (n=1,701). Heritability for hoarding symptoms at ages 15, 18 and 20-28 ranged from 41% (age 15) to 29% (age 20-28). Shared environmental effects were significant only in girls at age 15 and accounted for 22% of the variance at that age. Longitudinal bivariate analyses revealed a significant phenotypic correlation of hoarding symptoms between ages 15 and 18, and a genetic correlation. The bivariate heritability was estimated to 65%.

In study III, we conducted follow-up assessments of twins who screened positive for clinically significant hoarding symptoms 1-6 years after the survey in study I. None of the participants met full diagnostic criteria for HD. Twins who met diagnostic criteria A and B for HD, were compared to a group of twins who did not meet these criteria. Twins in the hoarding group were more psychiatrically burdened and the clinical presentation was similar to the presentation in adults with HD.

In study IV, we developed and tested a novel treatment for adults with HD which consisted of group CBT and online between-session therapist support. Twenty self- and clinically referred adults were treated. After treatment, we observed large reductions in hoarding symptoms. Treatment engagement and treatment acceptance were high and none of the participants dropped out from treatment. The treatment gains were maintained three months after treatment was completed.

Conclusions: Hoarding symptoms are common during adolescence and young adulthood and may cause distress and impairment. However, none of the participants that were followed up in clinical assessments met diagnostic criteria for HD. Hoarding symptoms are heritable in young people but non-shared environmental factors appear to have a larger effect. Group CBT combined with online between session therapist support is a feasible and efficacious treatment for adults with HD and might increase treatment adherence.

LIST OF SCIENTIFIC PAPERS

- I. Ivanov VZ, Mataix-Cols D, Serlachius E, Lichtenstein P, Anckarsäter H, Chang Z, Hellner Gumpert C, Lundström S, Långström N, Rück C. (2013). Prevalence, Comorbidity and Heritability of Hoarding Symptoms in Adolescence: A Population Based Twin Study in 15-Year Olds. *PLoS ONE*, 8(7): e69140.
- II. Ivanov VZ, Nordsletten A, Mataix-Cols D, Serlachius E, Lichtenstein P, Lundström S, Magnusson PKE, Kuja-Halkola, R, Rück C. (2017). Heritability of hoarding symptoms across adolescence and young adulthood: A longitudinal twin study. *PLoS ONE*, 12(6): e0179541.
- III. Ivanov VZ, Mataix-Cols D, Serlachius E, Lichtenstein P, Lundström S, Brander G, Elmquist A, Enander J, Rück C. The origins of hoarding in adolescence: a clinical interview study following an epidemiological survey. *Manuscript*.
- IV. Ivanov VZ, Enander J, Mataix-Cols D, Serlachius E, Månsson KNT, Andersson G, Flygare O, Tolin D, Rück C. Internet-supported cognitive-behavioral therapy for hoarding disorder: a feasibility study. *Manuscript*.

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LIST OF ABBREVIATIONS

ADHD	Attention deficit/hyperactivity disorder
ASD	Autism spectrum disorder
AQ	Adult Autism Spectrum Quotient
BADDS	Brown Attention-Deficit Disorder Scales
BDD	Body dysmorphic disorder
CATSS	Child and Adolescent Twin Study in Sweden
CBT	Cognitive behavior therapy
CI	Confidence interval
CIR	Clutter Image Rating
CSI	Children's Saving Inventory
CSQ-8	Client Satisfaction Questionnaire
DSM	Diagnostic and Statistical Manual of Mental Disorders
DZ	Dizygotic
EQ-5D	EuroQol-5D – Health Related Quality of Life Scale
ERP	Exposure and response prevention
FISH	Family Impact Scale for Hoarding
GAD	Generalized anxiety disorder
GAF	Global Assessment of Functioning Scale
HD	Hoarding disorder
HRS-SR	Hoarding Rating Scale-Self Report
K-SADS-PL	Schedule for Affective Disorders and Schizophrenia for School-Age Children Present and Lifetime Version
MDD	Major depressive disorder
MZ	Monozygotic
OCD	Obsessive-compulsive disorder
RCT	Randomized controlled trial
SCI	Saving Cognitions Inventory
SI-R	Saving Inventory-Revised
SSRI	Selective serotonin-reuptake inhibitors
YATSS 20-28	Young Adult Twins in Sweden Study

1 INTRODUCTION

Just like most people, before starting my dissertation, I mostly knew about hoarding from TV-shows such as *Hoarders* and *Hoarding: Buried Alive*. Typically, these shows portray individuals with heavily cluttered homes who undergo a clean out with support (and pressure) from relatives, a TV-team, and sometimes, a therapist. Through the miraculous wonders of television, the possessions that congest these homes vanish rapidly within just a few weeks. Critical viewers of these shows are left with lingering questions about the consequences of these “interventions”: What happened to these people after the TV-show? Did they accumulate new things? Did they ever get better? Many of us who have met individuals with hoarding disorder are righteously skeptical of the apparent success of such a simple solution to an immensely complex problem.

While the questions about the consequences of a cleanout are paramount, when watching these shows, I was equally intrigued by another set of questions: How did all this start? What happened before the TV shows? Did the hoarding behaviors appear suddenly or was the clutter rather the result of accumulation that started a long time ago? If that would be the case, could hoarding actually be detected already during childhood? Also, as a practicing clinical psychologist, the itch to do something to help people with hoarding had also begun to grow in me. Could we actually do something to help these people using psychological treatment (and maybe adding a bit of technology) rather than coercing them to throw away their stuff on television?

The work on this dissertation started in Stockholm 2011 and took me on a journey throughout Sweden, to the United Kingdom and the United States and ended back in Stockholm, where I now believe, a seed of help for this population is starting to grow. But before we come to that, I would like to start by taking on those nagging questions about what might have happened long before the clutter reached levels that TV loves to show us.

Buttle; August, 2017

1.1 CLINICAL FEATURES

Hoarding has been a part of the psychiatric nosology for a long time and has historically been mentioned as a symptom of obsessive-compulsive disorder or a symptom of obsessive-compulsive personality disorder (1). In 2013, hoarding was included as a separate disorder

(hoarding disorder; HD) in the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (2).

The cardinal feature of HD is the persistent difficulty letting go of possessions (2).

Individuals with HD experience a need to keep their possessions and are often strongly distressed when attempting to discard or by other means let go of their possessions. Strong emotional attachment to the possessions is also common (3) and domains of cognitive performance such as decision making can be impaired, further complicating the process of letting go of possessions (4).

With time, the difficulties parting with possessions result in obstructive clutter, which precludes everyday use of living spaces. Although not all individuals with HD are distressed by their hoarding, they often experience impairment in their daily activities due to the clutter. Normal activities such as cooking, sitting in the sofa or using the bathroom can only be performed with difficulty or not at all in the homes of individuals with HD. The clutter usually consists of a plethora of items, as individuals with HD tend to save a wide variety of items, both valuable and of limited value. Typically saved objects are clothes, books, sentimental objects, letters and magazines (5, 6). Commonly reported reasons for saving the possessions are due to a perceived sentimental value of the possessions, saving them for future use and saving in order to avoid waste (6, 7).

In addition to the difficulties discarding possessions, roughly 80 to 95% of people with HD also exhibit excessive acquisition of items, most commonly by ways of buying or acquiring free things (8-10). Approximately 7-25% of those with excessive acquisition also report stealing (10, 11). As excessive acquisition is not present among everyone with difficulties discarding, it is included as a diagnostic specifier and not a criterion for HD in DSM-5 (2).

Despite the impairment and/or distress caused by the hoarding, insight into the consequences of the hoarding behaviors among individuals with HD varies from good to delusional, but is generally regarded as poor by clinicians (12, 13) and family members (14). One clue to the cause of this is the nature of the thoughts in HD. In contrast to the anxiety provoking and recurrent obsessions typical for obsessive-compulsive disorder (OCD), generally the thoughts in HD tend to be ego-syntonic, i.e. considered to be a part of the normal thought process and not experienced as obtrusive or unwanted. Similarly, the acquisition of items is more correctly conceptualized as a preoccupation rather than a compulsion (15). The notion that individuals with HD have poor insight is however likely to be more complex than simply not acknowledging that one has a psychiatric disorder. Poor insight might also represent

defensiveness to forced treatment attempts such as cleanouts (16). Moreover, the poor insight reported by relatives to people with HD tends to be affected by the relatives' negative attitudes toward the individual with HD (17). Similar to excessive acquisition, the level of insight is a diagnostic specifier for HD in DSM-5 (2).

Table 1. DSM-5 diagnostic criteria for hoarding disorder.

Criterion	
A	Persistent difficulty discarding or parting with possessions, regardless of their actual value.
B	This difficulty is due to a perceived need to save the items and to distress associated with discarding them.
C	The difficulty discarding possessions results in the accumulation of possessions that congest and clutter active living areas and substantially compromises their intended use. If living areas are uncluttered, it is only because of the interventions of third parties (e.g., family members, cleaners, authorities).
D	The hoarding causes clinically significant distress or impairment in social, occupational, or other important areas of functioning (including maintaining a safe environment for self and others).
E	The hoarding is not attributable to another medical condition (e.g., brain injury, cerebrovascular disease, Prader-Willi syndrome).
F	The hoarding is not better explained by the symptoms of another mental disorder (e.g., obsessions in obsessive-compulsive disorder, decreased energy in major depressive disorder, delusions in schizophrenia or another psychotic disorder, cognitive deficits in major neurocognitive disorder, restricted interests in autism spectrum disorder).
Specifier	
Specify if:	

With excessive acquisition	If difficulty discarding possessions is accompanied by excessive acquisition of items that are not needed or for which there is no available space.
Specify if:	
With good or fair insight	The individual recognizes that hoarding-related beliefs and behaviors (pertaining to difficulty discarding items, clutter, or excessive acquisition) are problematic.
With poor insight	The individual is mostly convinced that hoarding-related beliefs and behaviors (pertaining to difficulty discarding items, clutter, or excessive acquisition) are not problematic despite evidence to the contrary.
With absent insight/delusional beliefs	The individual is completely convinced that hoarding-related beliefs and behaviors (pertaining to difficulty discarding items, clutter, or excessive acquisition) are not problematic despite evidence to the contrary.

Reprinted with permission from the diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, (Copyright © 2013). American Psychiatric Association.

1.2 CONSEQUENCES

HD is associated with distress and also has a negative impact on occupational and psychosocial domains (18-20). For instance, individuals with hoarding reported 7 psychiatric work impairment days during the past month (20). Individuals with HD are also more likely to be unmarried or widowed and have financial difficulties compared to healthy controls (21). More extreme consequences of hoarding involve an increased risk for eviction and homelessness (22), fire hazards, and in some rare instances, even death caused by the fire hazards or so called “clutter avalanches” (23).

Hoarding also poses serious strain on family and caretakers (24). Relatives to individuals with HD experience burden comparable to care givers of individuals with dementia (24) and children who grow up with someone who hoarded report distressed childhoods (14).

Unfortunately, hoarding can also have a negative impact on animals. In some cases, a large number of animals are accumulated and kept by an individual who fails to provide adequate care for the animals. This behavior can result in highly squalid environments and even in the death of the animals (25, 26).

1.3 PREVALENCE

Estimates of the occurrence of hoarding difficulties in the community suggest that hoarding might be surprisingly common. One early estimate of the prevalence of hoarding in adults indicated that as many as 14.4% of US adults had hoarding symptoms (27). This estimate was however based on two questions probing compulsions and obsessions related to hoarding and does not correspond to the current conceptualization of HD but rather hoarding symptoms typical for OCD (28). Later prevalence estimates have relied on two self-report questionnaires specifically developed to measure HD-symptoms; the Saving Inventory-Revised (SI-R) (29) and the Hoarding Rating Scale-Self Report (HRS-SR) (30). Based on established cut-offs on these scales, the prevalence of clinically significant hoarding symptoms has been estimated to 5.8% in Germany (11), 2.5% in New Zealand (31), 2.6% in Australia (32), 6.0% in Italy (33) and 6.8% in the Netherlands (34). It is likely that the most accurate prevalence estimate comes from a study in the United Kingdom. In this study, Nordsletten and colleagues (2013) (21) screened individuals for hoarding difficulties in the community and followed up this survey by conducting clinical assessments in order to examine how many individuals actually met full diagnostic criteria for HD (such as having impairing levels of clutter in their homes). Using this method, the authors estimated the prevalence of HD to be 1.5% in the community. The literature is inconclusive with regard to gender differences in the prevalence of HD. Some studies suggest HD is more common in men (34, 35), one study found that HD was more common in women (31), while the majority of studies have not found any gender differences (11, 21, 32, 33).

1.4 ONSET AND COURSE

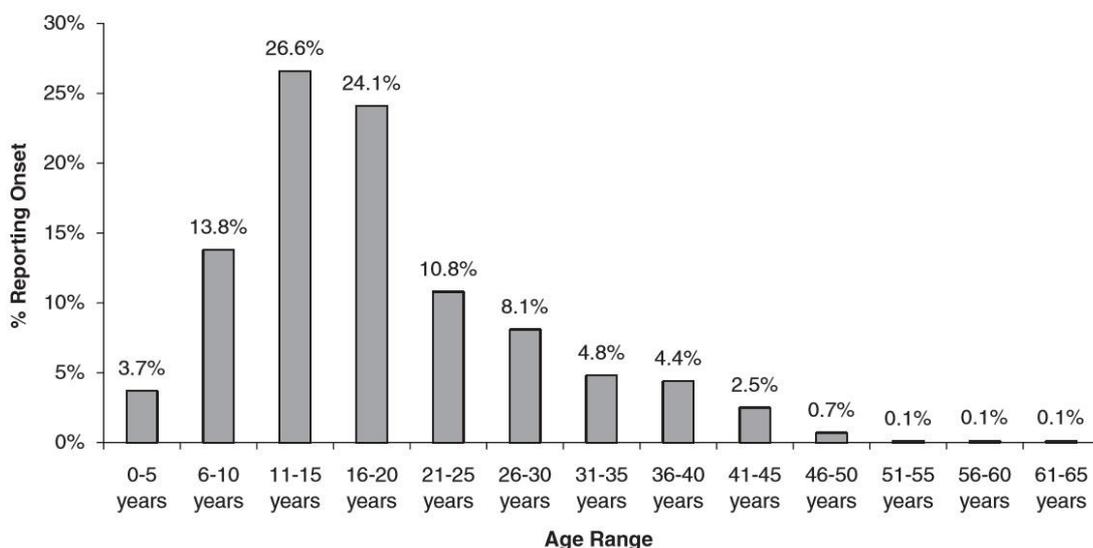
Although individuals with HD who come to the attention of clinical services and research tend to be older (i.e. above the age of 50), in most people with HD, the origins of the disorder are likely to be found decades earlier. Several studies have attempted to trace the trajectory of HD by asking sufferers to retrospectively report the course of their difficulties throughout their lives. In a study by Grisham, Frost, Steketee, Kim, and Hood (2006) (36), 51 participants (age range 26-71) with hoarding difficulties were asked to recall the age of onset and severity of their difficulty discarding, clutter and excessive acquisition. In this sample, the mean age of onset of any symptom of hoarding was 13 years and at age 18, hoarding difficulties had debuted in 80% of the sample. The symptoms became moderate at age 24 and severe at age 34. Furthermore, the onset of difficulties discarding and clutter were reported to occur before excessive acquisition had debuted. After onset, the hoarding symptoms remained chronic in 86% of the sample.

Using a web-survey, Tolin et al. (2010) (37), also examined the course of hoarding difficulties in a large sample (N=751) and found that onset between ages 11 and 20 was reported by 70% of the sample. Difficulties became moderate for half of the sample after the age of 30. As in the aforementioned Grisham study (38), after their onset, the hoarding difficulties remained chronic in a majority (73%) of the sample.

Finally, Landau et al. (2011) (39) interviewed 44 participants with hoarding and found that the mean self-reported age of onset was 16 for difficulties discarding, 18 for excessive acquisition and 21 for clutter. However, these hoarding difficulties became impairing only when the participants reached their 30s.

Taken together, these studies suggest that hoarding debuts during childhood, adolescence or young adulthood and follows an unremitting, and possibly, deteriorating course. However, all prior studies of onset and course have relied on retrospective recall, a method which is known to be susceptible to bias (40, 41). Thus, in order to detect whether hoarding symptoms indeed occur in childhood or adolescence and if so, how common they are, there is a need to assess hoarding behaviors directly in younger samples.

Figure 1. Self-reported age of onset of hoarding difficulties.



Published in: Tolin DF, Meunier SA, Frost RO, Steketee G. Course of compulsive hoarding and its relationship to life events. *Depression and Anxiety*. 2010, 27:829–838. Reprinted with permission from John Wiley & Sons, Inc.

1.5 PSYCHIATRIC COMORBIDITY

Psychiatric comorbidity in HD appears to be the rule rather than the exception and might occur in as many as 9/10 individuals with HD (8). Despite the historical link to OCD and the

high occurrence of hoarding in treatment seeking OCD-samples (42, 43) and in community samples with OCD (44), other disorders than OCD appear to be more common among people with HD. The most commonly reported psychiatric comorbidity is major depressive disorder (MDD) which occurs in roughly 25-50 % of those with HD (8, 21, 39). HD has also commonly been reported to co-occur with anxiety disorders, of which generalized anxiety disorder (GAD) and social anxiety disorder (SAD) seem to be most common and occur in 20-25% of individuals with HD. Interestingly, fewer than 20% of people with HD also have comorbid OCD (8, 39). Comorbidity with neuropsychiatric disorders is also common. Attention-deficit/hyperactivity disorder (ADHD) is estimated to occur in approximately 30% of those with HD (8) whereas autistic traits are somewhat more common in people with HD than in healthy individuals but not more prevalent than in patients with OCD (45).

Due to the lack of longitudinal assessments of psychiatric comorbidity in HD, it is not possible to draw any conclusion about the course and onset of comorbidities and whether they precede, or rather are the consequence of HD.

1.6 ETIOLOGY

Family studies show that 40-80% of people with hoarding difficulties report that they have a first-grade relative with hoarding (6, 76-79). Despite the large variability in these estimates, when compared to prevalence estimates in the general population (11, 21, 35), these studies clearly suggest that hoarding clusters in families.

Twin studies have confirmed that hoarding is transmitted in families and extended this finding by showing that the familial similarity is largely due to the influence of genes. Twin studies to date have been based on data from continuous measures of hoarding symptoms rather than from twins who meet diagnostic criteria for HD. This is a common approach in behavior genetics which is based on the assumption that the same genes underlie the distribution of a trait in the population and that psychiatric disorders lie at the extreme end of the distribution (80, 81). Furthermore, a dimensional distribution of hoarding symptoms in the population has previously been supported (82).

Heritability estimates from twin studies using this methodological approach have ranged between 0.33-0.49% (34, 35, 83, 84) and the rest of the variation has been attributed to non-shared environmental factors and measurement error. Shared environmental factors have been found to be negligible across all twin studies.

In the only study to detect sex-differences in the etiology of hoarding symptoms, the authors analyzed a sample of Australian Twins (mean age=34; n=2,495), and found that the heritability for self-reported hoarding symptoms in females was 39% and 25% in males (32). There is also evidence to support that hoarding shares an etiologic genetic link to OCD and body-dysmorphic disorder (BDD) (85).

Very little is known about specific genetic or environmental risk factors that underlie the development of HD. Genetic studies have so far failed to identify specific genetic underpinnings of HD (86) (87). A high occurrence of traumatic events among individuals with HD has been reported across studies (37-39), but there is a need for more sound methodological study designs that control for genetic influences in order to determine causality of traumatic events in the etiology of HD.

In summary, twin studies to date represent initial steps in unravelling the etiology of hoarding but have not addressed several crucial aspects. First, since all previous twin studies have been comprised of adult samples, the genetic and environmental effects on hoarding symptoms at different ages, are not known. As childhood and adolescence are the suggested earliest stages of HD, it seems particularly important to examine what causes hoarding symptoms then. Second, the heritability estimates in all twin studies have been based on cross-sectional data, and it is therefore not possible to determine whether the genetic and environmental risk factors that influence hoarding symptoms are stable or rather change over the course of development. Knowledge about the developmental structure of genetic and environmental risk factors for hoarding in young people could thus potentially further our understanding of a possible dynamic etiological nature during a crucial phase of the development of hoarding symptoms.

1.7 HOARDING IN CHILDREN AND ADOLESCENTS

Although hoarding difficulties seem to debut early in life, very little is known about these symptoms in children and adolescents. Despite lack of conclusive evidence, it is probable that hoarding in children and adolescents presents differently than in adults (46). Generally, children and adolescents will not have the means to acquire items to the same degree as adults due to limitations in economic means and freedom. Furthermore, it is likely that levels of clutter are milder and restricted to the young person's room. Evidence from case reports of children with hoarding symptoms also indicate that difficulties discarding occur before excessive acquisition and clutter (47). To date, insight into the occurrence, phenomenology

and clinical correlates of hoarding in young people has exclusively been provided by studies of hoarding symptoms in clinical samples with other primary disorders.

Mataix-Cols et al. (2008) (48) examined the structure of OCD symptoms in a large clinical sample (n=238) of children and adolescents (mean age: 14 years) and found that hoarding symptoms were prevalent in 53% of the girls and 36% of the boys. Study participants with OCD and hoarding symptoms were also more likely to have more symptoms of depression as well as emotional problems.

Storch and colleagues (2007) (49) reported that children (aged 7-17) with OCD and hoarding symptoms had lower insight and higher levels of externalizing and internalizing problems than those without hoarding symptoms. Comparing younger children (aged 4-10) with OCD with and without hoarding symptoms Frank et al. (2014) (50) showed that hoarding symptomatology was associated with earlier onset of primary diagnosis as well as a higher proportion of ADHD and anxiety disorders. Samuels et al. (2014) (51) found that among 641 children with OCD aged 6-17, children with clinically significant hoarding symptoms had earlier age of onset, and more severe obsessive-compulsive symptoms, as well as a greater prevalence of panic disorder, specific phobia, and Tourette disorder (52).

In a study which included youth and adult patients with childhood-onset OCD, hoarding symptoms occurred in 21% of their sample and were strongly associated with ADHD (53). The association between ADHD and hoarding symptoms was further explored in 99 youth with ADHD (age 8-17) of which 29% had clinically significant hoarding symptoms and compared to non-hoarding participants, exhibited greater ADHD symptom severity (52). Attention problems were also found to predict hoarding severity after controlling for anxiety and obsessive-compulsive symptoms in a sample of 109 children with anxiety disorders (54).

Although providing some preliminary insight, studies of hoarding in children and adolescents to date have generally been limited by their methodological inconsistencies. Most importantly, the studies have relied on clinical samples, with another primary disorder, such as OCD. This is problematic since HD in adults can be present as a separate disorder despite high levels of comorbidity. Another problematic aspect in the current literature of clinical samples is that hoarding symptoms in young might not be severe enough to warrant clinical attention. Furthermore, the instruments that have been used to measure hoarding symptoms have not been consistent with current definitions of hoarding but for OCD.

Thus, many basic questions about hoarding in children and adolescents remain largely unanswered (55, 56). The prevalence and clinical presentation of hoarding symptoms in non-

clinical samples are not known. One further question is whether young people with hoarding symptoms would meet criteria for HD or if the criteria are in need of adaptation.

1.8 TREATMENT

Despite the detrimental outcomes HD has on the individual, family and community, very few people with HD receive treatment for their condition. An epidemiological study showed that only a third of individuals with HD had received treatment for any mental health condition during the past year (21). Nevertheless, most individuals with HD report that they actually would be interested in treatment, if such treatment was available to them (20). However, due to the previous conceptualization of hoarding as a subtype of OCD, the evidence based treatments offered to individuals with hoarding difficulties have historically been treatments developed for OCD, namely exposure with response prevention (ERP) and selective serotonin reuptake inhibitors (SSRIs) (57-60). The effects of these treatments for individuals with OCD and hoarding symptoms have generally been discouraging (59). Moreover, since the majority of these studies were conducted before criteria for HD were published, the definitions of hoarding in this part of the literature vary widely and it is not known to what extent the findings can be extended to the current conceptualization of HD.

1.8.1 CBT for HD

The modest effect of OCD-treatments for hoarding difficulties has spurred the development of cognitive behavior therapy (CBT), specialized for HD. CBT for HD builds on the cognitive behavioral model for hoarding (61) and generally entails building skills for better decision-making and categorization of possessions, exposure to negative emotions when discarding, and cognitive restructuring of dysfunctional beliefs related to saving and acquiring (62). In the past decade, there has been an upsurge of treatment studies of CBT for hoarding (63, 64). The effects of CBT for HD are encouraging, and comparable when the treatment is delivered individually (65), in a group setting (66) and when facilitated by peers (individuals with experience of HD) (67). Individual CBT reduces hoarding symptoms with between 15-40% (65, 68-70), while symptom reductions after group CBT are between 14-30% (66, 71, 72).

A recent meta-analysis of CBT for HD concluded that across studies and ways of delivery, CBT produces large effect sizes (Hedges $g=0.82$) for hoarding symptoms. However, 65% of participants remain in the clinical range after completing CBT (63). Nonetheless, a systematic review of different treatment modalities for HD published in 2017, concluded that CBT is the intervention with the most reliable evidence base (64).

1.8.2 Long-term efficacy of CBT

Considering that HD is likely to be a chronic disorder, surprisingly few studies have investigated the long-term effects of treatments for HD. In one of the few published studies of long-term outcomes, Muroff et al. (73) followed up participants from the first wait-list controlled RCT for individual CBT for HD (65). Follow-up assessments at 3-12 months after completed CBT showed that the treatment gains were maintained but further treatment improvements after completed CBT were rare. In a recent study (74), Ayers and colleagues showed that the effects of a combined treatment consisting of cognitive rehabilitation and exposure/sorting therapy as well as of case management alone, were maintained 6 months after treatment. Thus, although the evidence base for CBT is steadily increasing, there remains much to be learned about the long-term effects of this treatment.

1.8.3 Treatment barriers and limitations to CBT

The most evident limitation to CBT for HD is that the majority of individuals with HD remain highly symptomatic after treatment. One suggested reason for this discouraging outcome is the treatment drop-out and low level of patient compliance during treatment (65, 68, 69). For instance, homework completion has been found to have a strong association with treatment outcome (69). Moreover, CBT for HD is highly time consuming, typically including 16-35 in-clinic and home-based sessions (65, 68, 69, 75). Another limiting factor is that access to therapists who can deliver specialized CBT for HD is still very limited, especially in other settings than those in which the treatment was initially developed. To date, there are no published studies of CBT coming from Europe, and in Sweden, clinicians with expertise in CBT for HD are extremely rare.

Figure 2. Reliable change and clinically significant change in studies of CBT for HD.

Outcome	Reliable change	Clinically significant change	Reliable and clinically significant change
Total HD severity	98.85% (2.49)	35.38% (10.22)	35.28% (10.14)
Clutter	98.25% (2.74)	25.44% (9.62) ^a	25.44% (9.62) ^a
Difficulty discarding	96.65% (4.47)	34.04% (12.07)	34.04% (12.07)
Acquiring	96.35% (5.37)	40.95% (12.41) ^b	39.81% (12.49) ^b
Impairment	89.62% (28.36)	43.30% (11.59) ^b	40.12% (15.10)
$F_{4,50}$	0.94	4.02 ^{**}	2.68 [*]
* $P < .05$; ** $P < .01$.			
Within each column, values with different superscripts are significantly different ($P < .05$).			

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1.9 THESIS AIMS

The general aims of this thesis were to examine the prevalence, etiology and clinical presentation of hoarding symptoms in young people and to develop and test a novel treatment for adults with HD.

The specific aims of each study are presented below:

Study I: The aims of Study I were to (a) estimate the prevalence of clinically significant hoarding symptoms and (b) the relative effects of genes and environment on hoarding symptoms at age 15.

Study II: The aims of Study II were to extend the findings from study I and to (a) estimate the relative effects of genes and environment on hoarding symptoms in three large twin cohorts (ages 15, 18, and 20-28) and to (b) estimate the relative contribution of genetic and environmental effects on the stability and change of hoarding symptoms in twins who provided data at both age 15 and 18.

Study III: The aims of this study were to follow up twins from study I and to (a) examine what proportion of adolescents who screened positive for clinically significant hoarding symptoms at age 15 would meet diagnostic criteria for HD 1-6 years later and to (b) compare

twins with prominent hoarding symptoms to a group of twins without prominent hoarding symptoms over a range of demographic and clinical variables.

Study IV: The aims of this study were to (a) test the feasibility and (b) efficacy of a novel treatment for HD in which group CBT was combined with online therapist support between group sessions.

2 METHODS

2.1 PARTICIPANTS

Studies I-III used data from twins and their parents from the Swedish Twin Registry (88). Data was included from the ongoing longitudinal cohort the Child and Adolescent Twin Study in Sweden (CATSS) (89) and from the Young Adult Twins in Sweden Study (YATSS) (90).

Study IV was an uncontrolled clinical trial carried out at Psykiatri Nordväst and Psykiatri Sydväst, Stockholm County Council and the Department of Clinical Neuroscience, Centre for Psychiatry Research, Karolinska Institutet.

2.1.1 Studies I-II

In study I, we used data from 3,974 15-year old twins recruited from the Child and Adolescent Twin Study in Sweden (CATSS-15), a population-based nationwide twin cohort. In this sample we also estimated the genetic and environmental effects on the variation of hoarding symptoms in those with known zygosity ($n=3,110$).

In study II, we assessed participants from CATSS-15 which included data from several new waves of twins ($n=7,905$), as well as a sample of 18-year old twins from the same cohort (CATSS-18; $n=2,495$). In addition, data on twins ($n=6,218$) from another population-based nationwide twin cohort (Young Adult Twins in Sweden Study; YATSS 20-28), mean age 23.8 years ($SD=2.0$, range=20-28) were also included. In total, 16,618 twins (of which 15,381 had known zygosity) were included in study II. Response rates for the samples were as follows cohorts: CATSS-15: 51%; CATSS-18 48%; YATSS 20-28; 38%.

2.1.2 Study III

In study III we contacted all twins from CATSS-15 who participated in study I and were screen positive for clinically significant hoarding symptoms at age 15 ($n=79$; 2% of the screened sample), their co-twins and parents and a group of screen-negative controls.

2.1.3 Study IV

Study IV included 20, self- or clinically referred adult participants with a diagnosis of HD according to DSM-5. Most participants were female (90%), 75% had a college or university degree) and 65% were either unemployed or on sick leave. Generalized anxiety disorder (GAD) was the most common comorbidity and occurred in 30% of the sample and major

depressive disorder (MDD), the second most common disorder, occurred in 25% of the participants. Half of the sample was using psychotropic medication during the study.

2.2 MEASURES

2.2.1 Studies I-II

In study I and II, hoarding symptoms were measured with the Hoarding Rating Scale-Self Report (HRS-SR) (30). The HRS-SR consists of five items measured on a 9-point Likert type scale ranging from 0 (none) to 8 (extreme). The HRS-SR items reflect the proposed DSM-5 criteria for HD: clutter in the rooms of one's home, difficulty discarding possessions, excessive acquisition and perceived distress and impairment. To address adolescents' limited control over their entire homes and parental control, we rephrased the clutter item in the questionnaire to refer solely to clutter in the young person's own room (rather than the entire home). In study I we estimated the prevalence of clinically significant hoarding symptoms (defined as scoring >3 on HRS-SR items measuring difficulty discarding, clutter and distress and/or impairment).

2.2.2 Study III

We assessed diagnostic criteria for HD with the Structured Interview for Hoarding Disorder (SIHD) (91, 92). The SIHD examines the six core criteria for HD and the two specifiers (excessive acquisition and level of insight). Assessors were blind to the self-report measures at the time of the diagnostic assessments. The SIHD was complemented with a short interview including a list of items and reasons for saving them (6). Clutter levels were measured with the Clutter Image Rating (CIR) (93). The CIR is a visual assessment of the clutter dimension of hoarding and consists of nine photographs depicting increasing levels of clutter in a bedroom, kitchen and living room, rated on a scale from 1 to 9. Psychiatric disorders were assessed with the Schedule for Affective Disorders and Schizophrenia for School-Age Children Present and Lifetime Version (K-SADS-PL) (94).

We also included several self-report measures of hoarding symptoms: the SI-R (29), the HRS-SR (14, 30) and the Saving Cognitions Inventory (SCI) (95) and symptoms of autism (Adult Autism Spectrum Quotient; (96)) and ADHD (Brown Attention-Deficit Disorder Scales; (97)). Parents were asked to rate their twins' hoarding symptoms with the Children's Saving Inventory (CSI) (98) and their own levels of accommodation and burden with the Family Impact Scale for Hoarding (FISH) (99). Parents also answered the ADHD and ASD sections of the K-SADS-PL.

2.2.3 Study IV

The main outcome measure was the SI-R which is considered to be the gold standard instrument in treatment studies of HD (29). Secondary outcome measures consisted of self-report measures including the Saving Cognitions Inventory (SCI) (95), HRS-SR (30) and Euroqol (EQ-5D) (100) as well as clinician rated measures including Clinical Global Impression (CGI) (101), Global Assessment of Functioning (GAF) (102) and the CIR (93). Participants also reported on compliance with homework. Treatment satisfaction was assessed with the Client Satisfaction Questionnaire (CSQ-8) (103). Participants' experiences of using the online therapist support were evaluated with a questionnaire, specifically designed for this study, comprised of qualitative questions regarding the strengths and weaknesses of the online support. The participants were also rated the level of difficulty of learning how to use the online support.

2.3 INTERVENTIONS STUDY IV

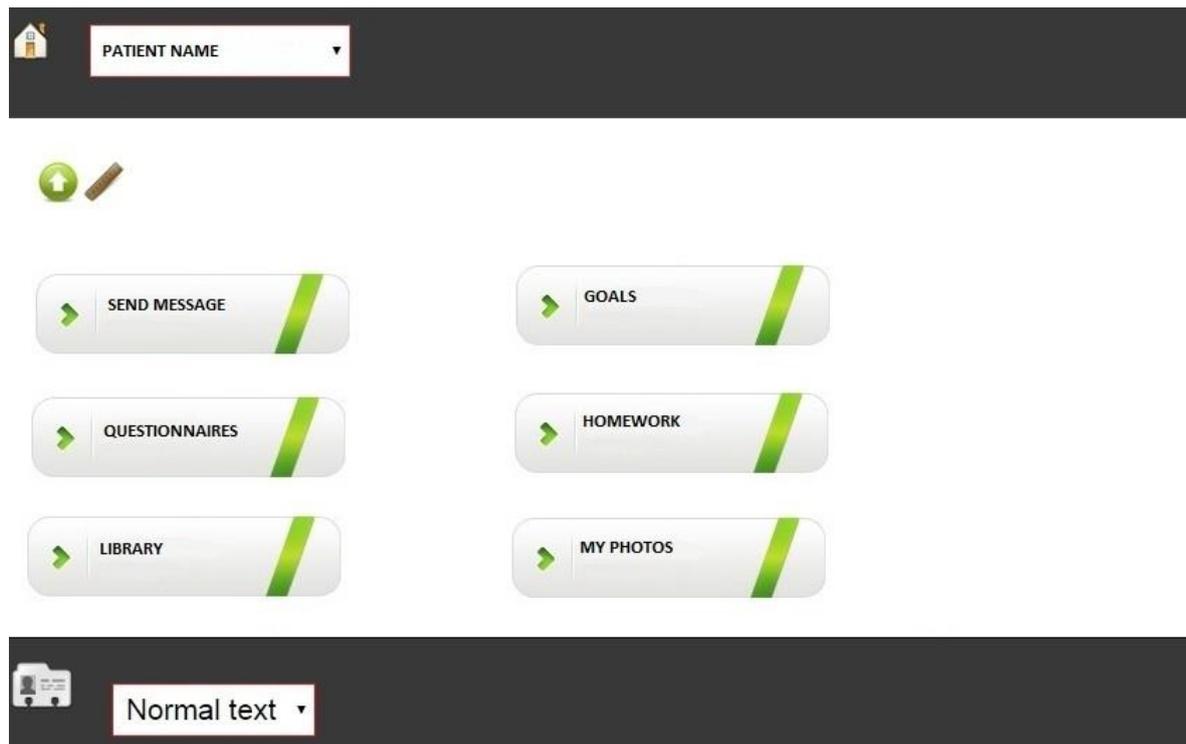
2.3.1 Group CBT

Group CBT consisted of 16 weekly, 2.5-hour long sessions at two psychiatric units led by 2 psychologists. Group CBT followed a recently published manual and included psychoeducation, goal-setting, strategies for motivation enhancement, executive skills training, restructuring of dysfunctional cognitions, skills to accept and tolerate emotions and relapse prevention (107).

2.3.2 Internet-support

Group CBT was combined with the Internet support-system COMMIT (108). The system enabled the participants to send messages to their therapist in order to receive motivational support and practical guidance between group sessions. The treatment manual, and the participants' goals and homework assignments were also contained in the system.

Figure 3. Screenshot of the COMMIT interface.



2.4 STATISTICAL ANALYSIS

2.4.1 Studies I-II

Nature has provided us with twins which can help us disentangle the causes of familial similarity on a trait or a disorder (also called a phenotype). The twin design makes use of the two types of twins that appear in nature; monozygotic (MZ), who share 100% of their co-segregating alleles, and dizygotic (DZ), who on average share 50% of their co-segregating alleles. The twin design rests on the assumption that both types of twins share their common environment. Based on this assumption, by comparing twin similarity on a given phenotype (also called a univariate analysis) the twin design can be used to partition the etiological influences on a phenotype into 3 sources: (A) additive genetic effects, also referred to as heritability, (C) shared- and (E) non-shared environmental factors. Shared environmental factors refer to factors in the environment that are common to both members of a twin pair and contribute to their similarity. Typically, family environment such as parenting and socio-economic status are considered to be sources of shared environment. If peer relations and school environment are shared within a twin pair, their influence will also contribute to *C*. Non-shared environmental influences on the other hand, are factors that contribute to the dissimilarity within twin pairs. These factors can for example encompass traumatic events, being bullied or being exposed to different peers or school environments. Measurement error is also included in *E* (104).

It is also possible to estimate the influence of *A*, *C* and *E* on a phenotype separately in males and females in order to examine etiological sex differences. There are two types of sex differences. Qualitative sex differences refer to differences in the sets of genes affecting a phenotype. In short, these are estimated by allowing the genetic correlation between opposite sex twins to be lower than the expected (0.50). In the other type of sex differences (quantitative), the magnitude of the genetic effect varies but the same set of genes are affecting the phenotype in both sexes. Estimating the quantitative sex-difference is achieved by restraining the genetic correlation between the opposite sex twins to 0.5.

Longitudinal twin analysis is a variant of a multivariate twin analysis and is used to examine to what extent genetic and environmental influences contribute to the correlation of a phenotype that is measured at several time points (also called the phenotypic correlation). First, the cross-twin cross-time correlations on a phenotype for MZ and DZ twins are estimated. Subsequently, and following similar logic as in the univariate twin analysis, if the cross-twin cross-time correlation in MZ twins is larger than the equivalent in DZ twins, genetic factors are likely contributing to the phenotypic correlation between the traits. In the longitudinal analyses, we thus estimated to what extent the phenotypic correlation of hoarding symptoms between age 15 and 18 was explained by shared genetic factors, shared environmental factors and non-shared environmental factors.

In order to gain power in our twin analyses, we used continuous data on self-reported hoarding symptoms on the HRS-SR. This approach is commonly used in twin methodology (105) and is well-suited for hoarding symptoms (82).

2.4.2 Studies III-IV

T-tests were carried out to examine differences on continuous variables. Categorical data were compared with chi-square tests and Fisher's exact test. Analysis in study IV was by intention to treat and the effects of time on the SI-R were analyzed with linear mixed effects models (106). In study IV, pairwise comparisons were performed to test if the effect of time was maintained 3 months after treatment was completed. Within-group effect sizes for change were calculated using Cohen's *d*. All statistical tests in studies III and IV were two-tailed and the significance level was set to $p < 0.05$.

3 RESULTS

3.1 STUDY I – EPIDEMIOLOGY AND HERITABILITY OF HOARDING SYMPTOMS IN ADOLESCENCE

3.1.1 Prevalence

We found that the prevalence of clinically significant hoarding symptoms at age 15 was 2.6% in girls, 1.2% in boys and 2.0% combined in both sexes. Among those with clinically significant hoarding symptoms, 38% reported excessive acquisition. OCD occurred in 2.9%, ASD in 2.9% and ADHD in 10.0% of twins with clinically significant hoarding symptoms. There were no statistically significant differences in the occurrence of these co-occurring symptoms/disorders in twins with and without clinically significant hoarding symptoms.

3.1.2 Heritability

Model-fitting analyses indicated quantitative sex differences in the etiology of hoarding symptoms. In boys, the genetic effects accounted for 32% (95% CI: 13-44%) of the variance and non-shared environmental effects for most of the remaining variance. In girls, genetic effects accounted for only 2% (95% CI: 0-24%) of the variance while shared environmental effects accounted for 32% (95% CI 14-41%) of the variance and non-shared environmental effects for the remaining variance.

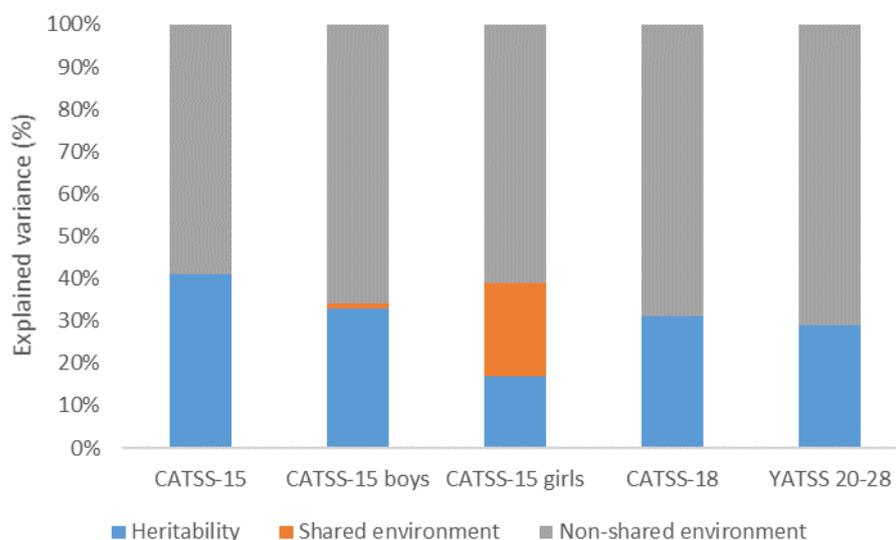
3.2 STUDY II – HERITABILITY OF HOARDING SYMPTOMS ACROSS ADOLESCENCE AND YOUNG ADULTHOOD

Univariate model-fitting analyses were performed separately at age 15, 18 and in 20-28 to estimate the genetic and environmental effects on hoarding symptoms at every time point. CATSS-15 was the only cohort in which the correlational pattern indicated possible sex differences and thus sex-limitation models were only fitted to the data from this cohort.

3.2.1 Univariate analyses

Hoarding symptoms were heritable in all samples, but the heritability appeared to decrease over time. Heritability estimates for hoarding symptoms at ages 15, 18 and 20-28 were 41% (95% CI: 36-45%), 31% (95% CI: 22-39%) and 29% (95% CI: 24-34%). Quantitative sex-differences emerged at age 15 and at this age, the heritability in boys was 33% (95% CI: 22-41%) and 17% (95% CI: 0-36%) in girls. Shared environmental effects influenced hoarding symptoms only in girls at age 15 (22%; 95% CI: 6-36%).

Figure 4. Genetic and environmental influences on hoarding symptoms in Swedish Twins at ages 15, 18 and 20-28.



3.2.2 Longitudinal analysis

We found a moderate phenotypic correlation in hoarding symptoms between ages 15 and 18 (0.40; 95% CI: 0.36-0.44) and a strong genetic correlation (0.75; 95% CI: 0.57-0.94). The bivariate heritability was estimated to 65% (95% CI: 50-79%).

3.3 STUDY III – CLINICAL INTERVIEWS WITH ADOLESCENTS

3.3.1 Screening

A total of 51.4% of the screen positive participants and 64.5% of the screen negative participants from study I chose to partake in study III. Full criteria for HD was not met by any of the assessed twins in study III. A total of 17 of 42 twins were however judged to meet criteria A (difficulties discarding) and B (the difficulties are due to a perceived need to save and distress when discarding). However, significant levels of clutter were not present in any of the living areas of the twins and thus no one met the criterion for significant clutter (criterion C).

3.3.2 Group comparisons

Regardless of screening status at age 15, twins who met criteria A and B (hoarding group; n=28), were compared to a comparison group of twins who did not meet both criteria (comparison group; n=46). The results showed that psychiatric disorders were more common in the hoarding group, and an anxiety disorder was the most common co-occurring psychopathology. Participants in the hoarding group also had significantly higher scores on

all self- and parent reported measures of hoarding symptoms and on measures of symptoms of ADHD and ASD.

Both groups saved similar items. Books, tickets and letters/postcards were the most frequently saved items in both groups. However, participants in the hoarding group reported saving significantly more types of items and more reasons for saving these items.

When examining the diagnostic specifiers for HD, 35.3% in the hoarding group had excessive acquisition and 5.8% had poor insight (all other twins had good or fair insight).

3.4 STUDY IV – PILOT TRIAL OF GROUP CBT COMBINED WITH INTERNET-SUPPORT

3.4.1 Treatment feasibility

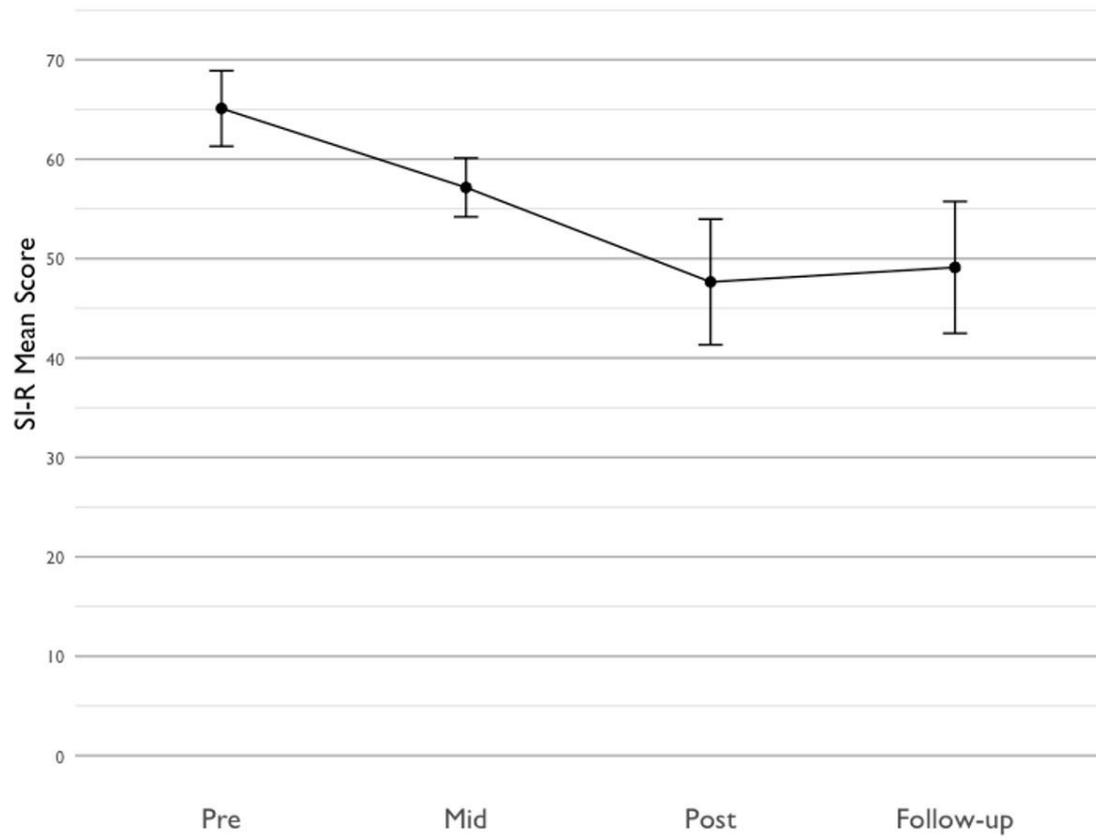
During treatment, group attendance was high. The participants attended 14 of 16 group sessions on average. No participants discontinued the treatment prematurely. Treatment satisfaction was high and between-session motivational support from the therapist was most frequently mentioned as the main strength of COMMIT. Reported weaknesses were primarily associated with the technical aspects of COMMIT, such as not being able to log in to the system or to upload photographs and being dissatisfied with the interface of COMMIT.

3.4.2 Efficacy

The treatment was associated with a significant reduction on the SI-R total scores and a large effect size was found at post-treatment, Cohen's $d = 1.57$ (95% CI 0.85 to 2.27). At post-treatment, 25% ($n=5$) of the participants did not meet criteria for HD. Treatment gains were maintained at the 3-month follow-up.

Time accessing COMMIT was correlated with time spent on homework ($r=0.46$; $p<0.05$) but not with change on any of the outcomes from pre- to post-treatment.

Figure 5. Means on the SI-R, including 95% CIs.



4 DISCUSSION

4.1 HOW COMMON ARE HOARDING SYMPTOMS IN ADOLESCENTS AND YOUNG ADULTS?

The prevalence of clinically significant hoarding symptoms was estimated in studies I and II. In study I, 2.0% of the participants screened positive for clinically significant hoarding symptoms at age 15, while results from study II, which included a considerably larger sample, indicated that hoarding symptoms occurred in 1.5% of the twins at age 15, in 0.9% at age 18 and in 0.8% in the oldest sample (mean age=24 years). In study I, we also examined whether the prevalence of hoarding symptoms differed by gender and found that hoarding symptoms were significantly more common in girls (2.6% vs. 1.2 in boys). We also found that 38% of the twins with clinically significant hoarding symptoms reported excessive acquisition at age 15.

Our prevalence estimates are consistent with results from a recently published study by Cath and colleagues (2016), in which the HRS-SR was sent out to 1,637 participants, aged 15 – 19 years, sampled from the Netherlands Twins Register (109). In this study, hoarding symptoms occurred among approximately 1% of the sample (the exact figure is not disclosed in the study). Our prevalence estimates were however considerably lower than the prevalence reported in a recent study including a sample of 16,718 youth (ages 6-18), in which hoarding symptoms occurred in 8.9% of the participants (110). This estimate was however based on two items (“collects useless objects” and “has difficulty throwing things away”) from the Toronto Obsessive-Compulsive Scale (111) and does not correspond to the current definition of HD.

With regard to gender differences in prevalence, the Cath et al. study did not detect that hoarding status differed between boys and girls, while Burton and colleagues found that hoarding symptoms were more prevalent in girls. Considering that the Cath et al. study used a substantially smaller sample of 15-year olds than we used in our study, and that the definition of hoarding in the Burton et al. study is problematic, the results from study I appear to represent the most robust finding of the distribution of hoarding symptoms across sexes in adolescents to date.

One unanswered question is whether hoarding symptoms are more common in adults or in younger samples. Cath and colleagues also examined whether the prevalence of hoarding symptoms increases with age and found that the risk of a probable diagnosis of HD increased with 20% for every 5 years (109). This estimate was however largely driven by the increase

in prevalence that occurs after age 35, since the prevalence was relatively constant around 1% before that. Based on this study and on the results from studies I-III, it seems highly likely that the prevalence of hoarding symptoms increases with age.

The frequency of excessive acquisition has not been estimated in previous studies of youth samples but in comparison to adult samples with HD in which excessive acquisition occurs among 80-95% (8-10), excessive acquisition appears to be far less common in 15-year olds. This finding was expected, given the limited resources and freedom 15-year olds have and is also in line with the retrospective reports of adults with HD which suggest that the onset of excessive acquisition occurs after the difficulties discarding debut (46, 47).

In summary, the results from studies I and II indicate that clinically significant hoarding symptoms occur in 0.9-1.5% of young people (age 15-28) and cause distress and impairment. However, what proportion of these would meet full criteria for HD according to DSM-5 is less straightforward and discussed more in detail further below.

4.2 WHAT CAUSES HOARDING SYMPTOMS IN ADOLESCENCE AND YOUNG ADULTHOOD?

In study I and II we aimed to estimate the causes of hoarding symptoms in young people, using twin methodology. Taken together, our results from the twin analyses showed that the variation of hoarding symptoms in young people is clearly influenced by genes, with heritability estimates ranging from 29-41%. These estimates are largely consistent with previous twin studies in adult samples (34, 83, 84). The only marked exception is a twin study conducted in the United Kingdom in which the heritability was estimated to 49% (35). It is worth noting that the mean age (55.5 years) in that twin sample is the highest in the twin literature. Thus, our results suggest the heritability of hoarding symptoms might increase considerably from young adulthood to middle age.

Relating our results to the twin literature in general, the heritability of hoarding symptoms in young people appears to be somewhat lower than the heritability of the majority of human traits (49%) (112). This suggests that the unravelling of specific environmental influences on hoarding symptoms will be especially important for understanding their etiology.

In contrast to prior twin studies which examined etiological sex-differences, and failed to find any (32, 34, 83), we found that genes affected hoarding symptoms to a larger degree in boys than in girls in one of our samples (age 15). This sex-difference was quantitative, suggesting that the same set of genes influence hoarding symptoms in both sexes but that the magnitude of the effect of these genes, differs between boys and girls. One possible explanation of this

contrasting finding is that these sex-differences reflect that boys and girls in Sweden interpret the HRS-SR differently from samples in other countries. However, considering that our twin sample was substantially larger than the sample in the Cath et al. study, another possibility is that we had sufficient power to detect a true sex-difference at age 15.

4.3 WHAT CAUSES THE STABILITY OF HOARDING SYMPTOMS DURING ADOLESCENCE?

One of the aims in study II was to analyze twins with repeated measures of hoarding symptoms (at both age 15 and 18) in order to examine to what extent these symptoms were stable during adolescence, and by applying bivariate twin methods, to estimate the sources of their stability and change. We found that the phenotypical correlation of hoarding symptoms between ages 15 and 18 was modest ($r= 0.40$), which although consistent with findings in obsessive-compulsive symptoms in adolescence (113), is surprisingly low considering how stable hoarding difficulties appear to be in older age groups (36, 37, 39). Although to date, no studies have included longitudinal assessments of hoarding symptoms or HD in adults, our finding suggests that hoarding symptoms might be less temporally stable during adolescence than in adulthood.

In study II, we also examined the sources of stability and change in hoarding symptoms between ages 15 and 18 and found that the stability was largely explained by genetic factors, while non-shared environmental factors primarily had a time-specific effect, and thus, contributed to the stability to a lesser degree. The finding that age-to-age stability is primarily due to the same genes, whereas change is largely due to environmental factors, has emerged in regard to obsessive compulsive symptoms (113), borderline personality symptoms (114) and has also been described as one of the 10 most replicated findings in behavioral genetics (115). One implication of this finding is that attempts to identify specific genes that increase the risk for hoarding symptoms in adolescence could include both 15 and 18 year olds but that identification of environmental risk factors will require studying 15 and 18 year olds separately.

4.3.1 Limitations and methodological considerations studies I-II:

Although the definition of clinically significant hoarding symptoms in studies I-II was based on a cut-off with empirical support (20, 116), the HRS-SR has not been validated for young populations. The clutter item in the HRS-SR was however modified to refer to the twins' rooms rather than their homes, which might have increased the validity of the clutter item.

A further limitation is that the psychometrical properties of the HRS-SR were not optimal in the studies. Since it is not practically feasible to include the lengthy Children Saving Inventory, a 23-item questionnaire developed specifically for hoarding in younger samples, to an extensive questionnaire battery, more adequate scales are sorely needed for future epidemiological studies.

One further methodological consideration is whether clutter should be included in the hoarding phenotype in adolescence at all. The decision to retain the clutter item in study II was motivated by the results from the clinical assessments in study III. These suggested that although clutter levels among twins with prominent hoarding symptoms were low compared to what is typical for adult HD, they were nevertheless slightly elevated compared to levels of clutter in the non-hoarding participants, and thus assumed to reflect an important aspect in hoarding during adolescence.

A limitation in studies I-II is that the response rates were $\approx 40-50\%$, which is slightly below what has been suggested as an acceptable threshold for epidemiological studies (117). However, these response rates are comparable to the Cath et al. study (45%) (109) and it should also be noted that the rates apply to the entire population of twins in Sweden and not merely a volunteer sample as is typical in other studies of hoarding symptoms (32, 35).

General methodological consideration for studies I and II also consist of certain assumptions that twin studies are based on. One of these assumptions is the equal environment assumption, which implies that MZ and DZ twins are equally exposed to environmental factors (but not genetic factors). A violation of this assumption would for instance occur if MZ twins would be treated more similarly than DZ twins by their parents. This would in turn result in an overestimation of the heritability of hoarding symptoms since the increased similarity would in part be explained by the more similar shared environment in MZ twins. Although the validity of this assumption remains to be tested for HD and related disorders, it has been shown to be valid for other psychiatric disorders such as MDD and GAD (118).

One assumption that, if violated, could lead to an underestimation of heritability, is the random mating assumption (i.e. that mating occurs randomly in the population and that DZ twins thus share 50% of their genes). It was recently shown that non-random mating does indeed occur in individuals with psychiatric disorders (119) suggesting that the heritability estimates in studies I and II could be deflated if non-random mating occurs in parents with hoarding symptoms. Further studies are needed to conclude whether these assumptions are valid for HD and for hoarding symptoms.

4.4 CAN WE IDENTIFY YOUNG TWINS WITH HD?

By following up the young twins that were screened with the HRS-SR in study I, in study III, we aimed to determine what proportion those with clinically significant hoarding symptoms would meet DSM-5 criteria for HD when assessed more thoroughly.

The clinical assessments in study III showed that 40.5% of the twins who screened positive in study I did express profound difficulties parting with possessions due to a desire to keep these and distress when attempting to discard. However, none of the assessed participants endorsed full criteria for HD since the levels of clutter were not judged to be impairing in any of the cases (and this was not explained by parental interventions). Thus, based on a strict interpretation of the HD criteria, we were not able to validate a diagnosis of HD after screening with the HRS-SR. This finding raised the interesting questions of how HD should be defined in adolescence and whether it exists at all. These questions are discussed below.

4.5 HOW DOES HD PRESENT IN ADOLESCENCE?

In study II, twins who met criteria A and B (difficulties discarding due to a desire to keep the possessions and associated distress) for HD according to DSM-5, were also compared to a group who did not endorse these criteria. Based on this definition of prominent hoarding, the main findings from study III were that difficulties discarding possessions due to typical “hoarding”-reasons, and even distress and impairment caused by the hoarding, can be present during adolescence. Moreover, levels of clutter are mild and not impairing as they are in adults with HD.

Additionally, several previous claims about the presentation of hoarding in young people (46, 47) were not supported by the group comparisons in study III. First, parents are not actively limiting clutter in older adolescents. Second, adolescents do not exclusively save useless objects but rather save a combination of valuable and sentimental objects, similar to saving patterns observed in adults with HD (6, 7). Third, a majority of young people with prominent hoarding present with good or fair insight into their hoarding behaviors.

Taken together, the results from study III indicate that HD, as defined currently in DSM-5, might not be present during adolescence. However, the similarities between the presentation of hoarding symptoms during adolescence and the presentation of HD in adults suggest that we might have captured a sub-threshold form of hoarding that could be a precursor to later life HD. This finding could potentially have important implications for detection and prediction of individuals at risk for developing HD. Considering the modest effects of treatments for HD (64), there is a need to define the initial clinical stages of HD. The idea that

sub-threshold disorders can be considered as risk factors for full-threshold disorders (120) is likely to be applicable to HD which develops gradually (37, 38) and appears on a continuum of severity (82). The hoarding phenotype that we found in the twins in study III might thus be interpreted within the theoretical framework for clinical staging in psychiatry (121). This theory proposes that current diagnostic boundaries should include an “extended phenotype” which encompasses sub-clinical stages in the development of a psychiatric disorder. This extended phenotype can be used to predict who develops a disorder and to develop treatments or preventive strategies, that are matched to the different stages of the disorder.

4.5.1 Limitations and methodological considerations study III

The main methodological consideration in study III is that the definition of the hoarding phenotype (i.e. meeting DSM-5 criteria A and B) was not based on an established definition but rather on previous case studies and convenience. However, since this is the first study to make use of these criteria in young people, this definition was deemed to be the most meaningful in order to explore important developmental aspects of prominent hoarding.

Another limitation is the relatively high rate of participant attrition between studies I and III. However, hoarding symptoms were higher among twins in study I who chose to participate in study III. This suggests that we were able to capture young people who were most likely to meet criteria for HD and thereby to examine a phenotype that is more likely to resemble HD.

4.6 IS GROUP CBT COMBINED WITH INTERNET-SUPPORT A FEASIBLE AND EFFICACIOUS TREATMENT FOR HD?

The feasibility and efficacy of group CBT is well documented, however, treatment effects are modest and attrition can be problematically high. The aim of study IV was to inform us about the feasibility of a novel treatment consisting of group CBT with added between-session therapist support. One of the questions we aimed to answer with this study was whether adding online support to group CBT would work for a portion of people with HD. Difficulties in domains of executive functioning (124), high age and a paucity of prior studies investigating online treatments for HD, raised several questions in our research group. Would we be able to recruit patients with HD with computers and Internet access and would they be able to use a technological online solution independently? Our results (study IV) were positive and indicated that the online support was used frequently and perceived as easy to learn despite that only a brief introduction to the system was given. The positive finding of the feasibility of the online support also suggests that some individuals with hoarding difficulties might benefit from less intensive treatment approaches such as pure online CBT.

Overall, we found that participants were highly satisfied with the treatment, group attendance was high and the online support was used frequently. This result aligns well with recent findings by Rodriguez and colleagues (125) who investigated what types of treatments individuals with HD find acceptable. Although they found that group CBT was not perceived as an overall acceptable treatment option, the social support that group CBT provides, was perceived as an acceptable domain of treatment. Moreover, this study found that the personalization of a treatment and “being held accountable” were treatment aspects found to increase the acceptability of an intervention among people with HD. Although the Rodriguez et al. study was not yet published at the time of the development of the treatment in study IV, based on our prior clinical experience of working with people with HD, these were two of the aspects we sought to encompass when combining group CBT with COMMIT.

Another noteworthy finding from this study was that none of the participants dropped out of treatment. Considering the fluctuating motivation and high dropout rates in HD, this finding is very encouraging. Although no firm conclusions can be drawn about the cause of the lack of drop-out, the between-session therapist support was most frequently reported to be the main strength of the system.

Our results also suggest that the combined treatment was efficacious and treatment outcomes were largely in line with other studies of group GBT. In fact, the treatment effect on the SI-R is among the largest observed in the literature (63, 64) and comparable to effects obtained after 20 sessions of group CBT combined with 8 home visits (66). Additionally, as the effects of CBT conducted in naturalistic settings tend to be smaller than in research settings ($d=0.80-0.92$) (122, 123), the treatment effects in study IV are even more encouraging. Furthermore, all treatment gains were maintained at follow-up 3 months after treatment, suggesting that the treatment might have an enduring effect on hoarding symptomatology.

4.6.1 Limitations and methodological considerations study IV

One major limitation of the study was that it was uncontrolled and it is thus not possible to conclude if the treatment caused the observed improvements or if these were merely the result of the passage of time or non-specific treatment effects. Pilot studies are not suited to answer questions about efficacy but to primarily assess the feasibility and acceptability of an intervention (126), which was the main aim of study I. The suggested chronicity and symptom stability in adult HD (36, 37) also supports the association between the treatment and the improvements.

A further limitation pertains to the treatment sample. The participants in study IV had good or fair insight and were well educated and relatively few suffered from depression. Although we made deliberate efforts to recruit participants from various settings (psychiatric clinics, social services and through self-referral) our sample may not be representative of the entire HD-population. This might affect the interpretation of feasibility of the online support. It is for instance reasonable to assume that the treatment might not be feasible for individuals with higher functional impairment and with lower insight.

A final limitation is the interpretation of the treatment effect on clutter in the participants' homes. Although data loss in study IV was minimal on most measures, only 50% of the participants provided pictures that could be rated properly with the CIR. The treatment effects on clutter, as measured with the CIR, should therefore be interpreted cautiously.

5 FUTURE DIRECTIONS

5.1.1 Studies I-II

Although the twin design can not be used to identify the exact cause of a trait or a disorder, twin studies tell us where to look for the causes of mental illness. Identification of specific genes or a specific environmental factor that influences the variation of hoarding symptoms might lead to a greater understanding of the etiological mechanisms involved in hoarding. Such an improved understanding could potentially lead to new, and improved treatments. A previous genome wide association (GWAS) study of hoarding traits in a sample of UK twins (n=3,304) failed to identify genetic variants that increased the risk for hoarding (87). It is thus likely that identification of specific genetic variants that increase the risk for hoarding would require considerably larger samples, as has been the case for successful studies in schizophrenia (127, 128), depression (129) and ADHD (130).

Findings from studies I and II inform us that the environmental influences on hoarding symptoms in adolescents and young adults are even stronger than the genetic effects. There is thus a clear need to understand the specific environmental factors involved in hoarding. As noted previously, traumatic events have been proposed as risk factors for developing hoarding but lack confirmation from methodologically sound prospective studies. It is also worth considering perinatal risk factors such as maternal smoking. Such risk factors have recently been identified for OCD (131) and are in need of investigation in HD. The inclusion of HD in the forthcoming edition of the International Statistical Classification of Diseases and Related Health Problems (ICD) will mean that patients with HD in Sweden can be identified

through the National Patient Register in the future. This will potentially enable important studies that can lead to the identification of specific environmental risk factors for HD.

5.1.2 Study III

More research is clearly needed to understand the clinical presentation of prominent hoarding in young people. Future studies will benefit from assessing HD with similar methods as we used in study III and also investigate whether young people who seek treatment for hoarding difficulties meet criteria for HD.

The utility of the proposed hoarding phenotype in adolescents found in study III, might be an important step in order to understand who is at risk for developing HD in the future. Thus, following up the twins from study II over the life-span is crucial. Recently, Nelson et al. (2017) (132) highlighted the importance of using models for predicting onset of mental disorders that can model gradual, rather than abrupt onset, in order to improve prediction. Such a framework involves moving from cross-sectional sampling to longitudinal assessments with repeated measures on a day-to-day basis or month/year basis in order to improve the understanding of how subthreshold-level states emerge into full-threshold psychopathology. To further the understanding of the mechanisms involved in the development of HD it will also be important to include multi-level assessments such as neuropsychological assessments, imaging and clinical data. Such an ambitious model for prediction does indeed seem challenging but the ongoing data collection from the CATSS cohort may prove to be a highly valuable asset in pursuing this cause.

5.1.3 Study IV

The next necessary step for the treatment developed in study IV will be to conduct an RCT in which the specific treatment effect of adding COMMIT to group CBT is tested against a credible control condition.

Although it is clear that some of individuals with HD will benefit from CBT, a remaining challenge is that the majority of people with HD do not receive or seek treatment at all. For this reason, it is important to explore alternative ways of engaging individuals with HD in treatment. I have devoted a considerable part of my PhD working with the social services in Stockholm. One result of this collaboration is the newly formed multi-profession hoarding task force in Stockholm, which aims to share knowledge and help people with HD access treatment. Another encouraging trend is the formation of several specialized teams for HD in different parts of Sweden.

The conclusion from this thesis with regards to treatment for HD is thus that promising treatment options are becoming available, at least to a minority of people with HD in Sweden. However, the major challenge ahead lies in the dissemination of these treatments to as many as possible while simultaneously acknowledging that a one-size-fits-all approach to treatment will not be the way to go.

An alternative treatment avenue is to develop low-threshold treatment interventions for people with hoarding difficulties who do not meet full criteria for HD. Such treatments can be designed to target key aspects of hoarding (e.g. difficulties discarding). Pure online CBT approaches show great promise in the treatment of OCD (133) and BDD (134) and warrant further investigation in people with difficulties discarding who do not yet have impairing clutter.

6 CONCLUSIONS

- Hoarding symptoms are relatively prevalent in adolescence and young adulthood and may cause distress and impairment.
- Adolescents who screen positive for clinically significant hoarding symptoms do not meet full criteria for HD, as clutter levels are not impairing.
- Prominent hoarding difficulties have a similar clinical presentation in adolescence and young adulthood as HD in adults but clutter levels are milder.
- Hoarding symptoms are heritable in adolescence and young adulthood and the genetic effects explain 29-41% of the variance in the population.
- Non-shared environmental effects on hoarding symptoms are larger than the genetic effects.
- The stability of hoarding symptoms between ages 15 and 18 is mainly due to genetic influence and non-shared environmental influences have a time-specific effect.
- Preliminary results suggest that group CBT combined with online between-session support is a feasible and efficacious treatment for HD.

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