

Lifetime prevalence of non-suicidal self-injury in patients with eating disorders: a systematic review and meta-analysis

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Background. Against a backdrop of increasing research, clinical and taxonomic attention in non-suicidal self-injury (NSSI), evidence suggests a link between NSSI and eating disorders (ED). The frequency estimates of NSSI in ED vary widely. Little is known about the sources of this variation, and no meta-analysis has quantified the association between ED and NSSI.

Method. Using random-effects meta-analyses, meta-regression analyses, and 1816–6466 unique participants with various ED, we estimated the weighted average percentage of individuals with ED, those with anorexia nervosa (AN) and those with bulimia nervosa (BN) who are reported to have a lifetime history of NSSI across studies. We further examined predictors of NSSI in ED.

Results. The weighted average percentage of patients with a lifetime history of NSSI was 27.3% [95% confidence interval (CI) 23.8–31.0%] for ED, 21.8% (95% CI 18.5–25.6%) for AN, and 32.7% (95% CI 26.9–39.1%) for BN. The difference between BN and AN was statistically significant [odds ratio (OR) 1.77, 95% CI 1.14–2.77, $p=0.013$]. The odds of NSSI increased by 24% for every 10% increase in the percentage of participants with histories of suicide attempts (OR 1.24, 95% CI 1.04–1.48, $p=0.020$) and decreased by 26% for every 10% increase in the percentage of participants with histories of substance abuse (OR 0.74, 95% CI 0.58–0.95, $p=0.023$).

Conclusions. In the specific context of ED, NSSI is highly prevalent and correlates positively with attempted suicide, urging for NSSI-focused treatments. A novel finding is that NSSI is potentially antagonized by substance abuse.

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Introduction

Non-suicidal self-injury (NSSI) is the intentional destruction of body tissue without suicidal intent and for purposes not socially sanctioned (Klonsky & Muehlenkamp, 2007). Examples of NSSI include 'impulsive' acts (preceded by increasing tension, and followed by pleasure, gratification, or relief), such as skin cutting/burning, and 'compulsive' acts (repetitive, seemingly driven, but non-functional motor behaviour

acts), such as hair pulling or skin picking (Favazza & Simeon, 1995; Klonsky & Muehlenkamp, 2007). NSSI has received increasing research, clinical and taxonomic attention in recent years, culminating in the addition of 'non-suicidal self-injury' in the new Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5; American Psychiatric Association, 2013) in the category of 'Conditions for Further Study'. The growing momentum in the scientific discourse on NSSI reflects its high clinical importance, reported association with a range of psychiatric disorders, and the imperative to better characterize an – as yet – poorly understood phenomenon (Klonsky & Muehlenkamp, 2007).

Empirical evidence and clinical observations suggest a strong link between NSSI and eating disorders (ED). NSSI is reported to occur in 4–18% of the general

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population, in 14–68% of individuals with anorexia nervosa (AN), and in 25–55% of individuals with bulimia nervosa (BN), while 54–61% of people with self-injurious behaviours report current or past ED (Sansone & Levitt, 2002; Jacobson & Gould, 2007; Klonsky & Muehlenkamp, 2007; Kostro *et al.* 2014). The observed link is set against a background of established similarities in epidemiology, underlying mechanisms, and correlates between the two psychopathologies. Specifically, ED and NSSI both have an onset in adolescence or early adulthood, and a female preponderance (American Psychiatric Association, 1994; Suyemoto, 1998; Paul *et al.* 2002; Mitchison & Hay, 2014); they share psychosocial risk factors, such as childhood adversity and sexual abuse (Chen *et al.* 2010; Maniglio, 2011); are proposed to share underlying neurobiological and psychological mechanisms, including noradrenergic dysfunction (Oquendo & Mann, 2000; Schmidt, 2003), impulsivity, obsessive-compulsive characteristics, affect dysregulation, dissociation, self-criticizing cognitive style, and need for control (Svirko & Hawton, 2007); and show similar psychiatric co-morbidities, including depression, anxiety, suicidality and substance abuse (Schmidt, 2003; Harrop & Marlatt, 2010; Hawton *et al.* 2013; Moller *et al.* 2013).

To date, epidemiological data on the occurrence of NSSI in the context of ED have been scarce; NSSI estimates across ED studies have varied widely; and all reviews on the topic have been narrative (Sansone & Levitt, 2002; Svirko & Hawton, 2007; Kostro *et al.* 2014). These limitations translate into a complete lack of aggregate and weighted quantitative data on NSSI in ED, which highlights the absence of a confident estimate of the true prevalence of NSSI among individuals with ED. To address this gap in the evidence, we have undertaken the first meta-analysis of NSSI in ED. The first aim of our study was to estimate the weighted average proportion of adolescents and young adults with ED who are reported to have a lifetime history of NSSI across studies. Addressing this aim can powerfully advance scientific knowledge by making a unique contribution to the existing evidence base, with important implications for health care, since identifying the true extent of NSSI in ED can inform treatment plans for this clinical population.

The second aim of our study was to identify factors that are associated with higher or lower frequency of NSSI among ED patients. Although we examined a variety of potential predictors of NSSI, we were particularly interested in the roles of: (a) diagnosis (anorexia *v.* bulimia) and diagnostic subtype within anorexia (eating-purging *v.* restrictive), in line with evidence that NSSI is more prevalent in individuals with binge and purge behaviours, i.e. patients with

BN or those with the binge eating-purging subtype of AN (Svirko & Hawton, 2007); (b) history of attempted suicide, in line with evidence that NSSI shows a positive association with suicide risk in various unselected and clinical populations (Jacobson & Gould, 2007; Turner *et al.* 2013; Kostro *et al.* 2014); and (c) history of substance abuse, in line with evidence that individuals with substance disorders are more likely to self-injure (Klonsky & Muehlenkamp, 2007). Quantifying, for the first time, the association of NSSI with each of the above predictors makes a valuable contribution to the evidence base, which is again limited by the lack of weighted aggregate data. This contribution is both novel and clinically important, since identifying correlates of NSSI in the context of ED can inform risk assessments, and individualized, focused treatment plans (Wilkinson & Goodyer, 2011).

Method

Study selection

We conducted literature searches in the bibliographic databases MEDLINE, PsycINFO, EMBASE, BIOSIS Previews, Health Management Information Consortium (HMIC) and International Pharmaceutical Abstracts using the Ovid and Web of Knowledge search interfaces (1946–June 2014). We used combinations of search terms for ED (bulim*, anorexia, eating disorder*) and self-injury (self-harm*, self-injury, self-injurious, self-mutilation, self-mutilating, self-destruct*, parasuicide, parasuicidal, self-wound*, cut*, self-cut*, head-bang*, nail-biting, hair-pull*, hitting, picking, skin-pick*, scratch*, bruise, bruising), limiting our search to publications in English. We also perused the bibliographies of the identified articles for additional references. Study eligibility was assessed by five authors (A.C., D.R., E.K., G.K., S.S.), who discussed in pairs and reached a consensus based on two *a priori* inclusion criteria: (1) studies reporting on independent (non-overlapping) samples of patients with ED, diagnosed using International Classification of Diseases (ICD) diagnostic criteria, or DSM diagnostic criteria, or other diagnostic criteria accepted as valid at the time of publication; and (2) studies reporting on the number of ED participants with a lifetime history of NSSI. Where two or more studies had overlapping participant samples, we included the largest sample, or the one with the highest informational value (e.g. the article reporting on NSSI in both AN and BN). On one occasion, this choice was not straightforward (Solano *et al.* 2005; Bueno *et al.* 2014). Bueno *et al.* (2014) reported on a substantially larger sample ($n=798$) than the overlapping sample ($n=109$) in Solano *et al.* (2005), but only the latter study provided

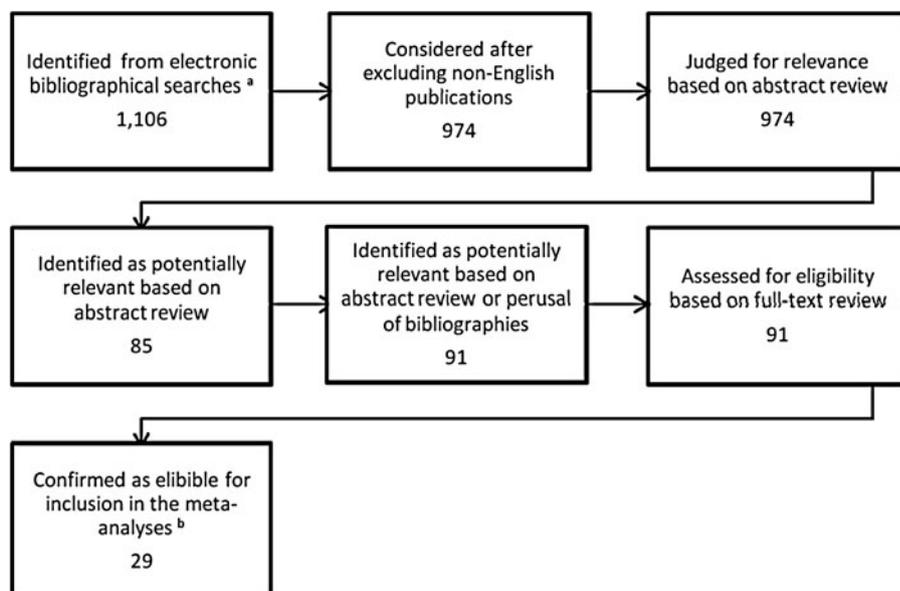


Fig. 1. Study identification and selection. ^a Electronic searches were conducted in MEDLINE, PsycINFO, EMBASE, BIOSIS Previews, Health Management Information Consortium (HMIC) and International Pharmaceutical Abstracts (1946–June 2014), using combinations of eating disorder terms and self-harm terms: (bulim* OR anorexia OR eating disorder*) AND (self-harm* OR self-injury OR self-injurious OR self-mutilation OR self-mutilating OR self-destruct* OR parasuicide OR parasuicidal OR self-wound* OR cut* OR self-cut* OR head-bang* OR nail-biting OR hair-pull* OR hitting OR picking OR skin-pick* OR scratch* OR bruise OR bruising). ^b In all, 17 studies were not relevant; 13 studies shared participants with studies that were included in the meta-analyses; 10 studies included intention to self-harm and/or suicidal self-harm in the definition of self-injury; 10 studies showed selection bias towards self-harming or ‘multi-impulsive’ patients; two studies did not assess lifetime history of self-injury; two studies assessed a single form of self-injury (wrist-cutting); four studies did not mention the total number of self-harmers; three studies did not define self-injury or self-harm; one study did not clarify the reference period of self-injury.

a breakdown of NSSI figures for AN and BN. We resolved this dilemma by including Bueno *et al.* (2014) in the meta-analysis of ED, and Solano *et al.* (2005) in the meta-analyses and comparison of AN and BN. A systematic attempt was made to address information gaps in relation to key questions by contacting the corresponding authors. Where this was not possible, the respective publications were excluded. We further excluded studies with an ascertainment bias towards self-injuring participants (to avoid inflated estimates of NSSI proportions), and a small number of studies that assessed a single type of self-injury. The latter strategy was adopted to ensure that the meta-analysed studies used comparable (i.e. relatively broad) definitions of self-injury. The step-by-step process of study selection and elimination is shown diagrammatically in Fig. 1. The definitions and methods of assessing self-injury in the meta-analysed studies are summarized in online Supplementary Table S1.

Data extraction

Four authors (A.C., D.R., E.K. and S.S.) independently extracted data from eligible articles (each article was

assigned to two authors), using a data extraction template, which was developed and refined through piloting on 10 randomly selected eligible studies. Where available, the following information was extracted: author; publication year; region of study; care frame (e.g. in-patients, out-patients, etc.); diagnostic criteria; range of diagnoses; sample size, number of males/females, mean age (total sample and/or diagnostic subgroups); definition of self-injury; number of participants with a lifetime history of NSSI (total sample and/or diagnostic subgroups); number of AN participants with restrictive *v.* binge eating/purging AN; and number of participants with a history of attempted suicide or substance abuse (total sample). Although information on co-morbid diagnoses of interest (e.g. depression and personality disorders) and on histories of alcohol abuse and child sexual abuse was also extracted, this was not reported in a consistent manner or in a sufficient number of studies (≥ 10 studies) to enable inclusion in our meta-regression analyses. Inconsistencies in data extraction were resolved in consensus meetings, and, where possible, corresponding authors were contacted to provide additional information and clarifications.

Data analysis

Meta-analyses: pooled NSSI proportion estimates

Meta-analyses were performed using the program STATA 11.0 (USA). To estimate the average weighted proportion (p) of participants with (1) ED, (2) AN and (3) BN who were reported to have a lifetime history of NSSI across published studies, we first used the immediate `cii` command in STATA to generate 95% binomial confidence intervals (CIs) for the proportions of NSSI, which were estimated based on the reported sample size and number of participants with a history of NSSI in each study. As the CIs are not necessarily symmetric, we transformed the proportions and their CIs onto the log-odds scale using the log-odds function $\ln[p/(1-p)]$, and conducted all meta-analyses on this new continuous scale, where we could more realistically assume normally distributed (log-odds) estimates. STATA's `metan` command was used to calculate the average weighted log-odds of patients with a history of NSSI in samples with (1) ED (grouping together all diagnoses of ED), (2) AN and (3) BN, using three separate meta-analyses. These weighted average estimates and their CIs were then back-transformed into proportions using the logistic (or inverse log-odds) function $e^x/(1+e^x)$.

Heterogeneity across studies was assessed using the I^2 index. Because significant heterogeneity was present in all analyses according to Cochran's Q -test, we used random-effects estimates meta-analyses and present here the respective pooled estimates. The weighted proportions of the meta-analysed studies and their CIs were visualized in forest plots, using the log-odds scale to produce symmetric CIs about the estimated proportions. The presence of publication bias was examined using tests for asymmetry proposed by Begg & Mazumdar (1994).

Meta-regression analyses: examining potential predictors of NSSI

We used a series of meta-regression analyses and STATA's `metareg` command to examine the effect of various study sample characteristics on the proportion of participants with a history of NSSI. The examined predictors included: mean age; care frame (1 = 'clinical ED setting/residential treatment; 0 = 'general practice/community'); attempted suicide (percentage of participants with a history of); substance abuse (percentage of participants with a history of); diagnosis (1 = 'BN'; 0 = 'AN'), and binge eating/purging subtype within AN samples (percentage of AN participants with). The selected predictors were examined using different sets or subsets of samples, including a minimum of 10 samples per predictor (to reduce the risk of insufficient

statistical power). The effects of the selected predictors were examined in study samples with any combination of ED, except for diagnosis, which was examined in the AN and BN samples, as well as diagnostic subtype within AN, which was examined in the AN samples. All predictors were addressed one at a time in simple linear meta-regression models, which looked at the effect of each predictor on the proportion of participants with NSSI, transformed onto the log-odds scale. Coefficients and 95% CIs were then exponentiated to express each effect as an odds ratio (OR) (reflecting change in odds of NSSI – for example, per 10% increase in the percentage of individuals with histories of attempted suicide). When appropriate (at least 10 studies reporting on the predictor), the meta-regression analyses were repeated separately for AN and BN, as well as after excluding studies with a small or unspecified number of males. To enable the interpretation of findings, the correlation matrix of the selected predictors is presented in online Supplementary Table S2.

Sensitivity analysis: addressing heterogeneity in the operationalization/characterization or assessment of NSSI, in diagnosis of ED and in gender composition

Most studies elaborated on the definition of NSSI by using operational examples of 'impulsive' acts, or characterized NSSI as 'impulsive' behaviour, and most assessed impulsive NSSI. However, a small number of studies had a mixed (impulsive and compulsive) or unspecified focus on NSSI in terms of operationalization/characterization or assessment (Results; Table 1; online Supplementary Table S1). In addition, most studies used DSM-IV diagnostic criteria, but a small number used other diagnostic criteria (Results; Table 1). Finally, most studies included exclusively female samples, but some did not specify the gender composition of their samples or included a small number of males (Table 1). We therefore assessed the sensitivity of our findings first to excluding studies with a mixed or unspecified focus on NSSI (both in terms of operationalization/characterization and in terms of assessment), second to excluding studies using diagnostic criteria other than DSM-IV, and third to excluding studies with a small or unspecified number of males.

Results

Search results

The descriptive characteristics of the 29 publications that contributed analytic samples to the three meta-analyses are summarized in Table 1. Of the studies, 28 comprised 6466 unique participants from 11

Table 1. Descriptive characteristics of the 29 publications that were included in the meta-analyses^a

Study	Country	Sample size	Percentage		Diagnostic criteria	Care frame	Mean age, years	Percentage			
			NSSI ^{b,c,d,e}	Diagnoses				Male ^b	Binge eating/ purging ^f	Suic. att. ^b	Subs. abu. ^b
1 Ahren-Moonga <i>et al.</i> (2008)	Sweden	38	36.8 ^c	AN, BN	DSM-IV	IN	30.4	0.0	25.0	26.3	–
2 Anderson <i>et al.</i> (2002)	USA	124	15.3 ^e	BN	DSM-III-R	GP, COM	26.0	0.0	N.A.	0.0	19.4
3 Bueno <i>et al.</i> (2014)	Spain	798	32.0 ^d	AN, BN, EDNOS	DSM-IV	–	26.2	0.0	–	23.2	22.6
4 Bulik <i>et al.</i> (2008)	USA	412	23.3 ^c	AN	DSM-IV	–	30.4	5.1	–	16.7	25.7
5 Corstorphine <i>et al.</i> (2007)	UK	102	31.4 ^c	AN, BN, EDNOS	DSM-IV	OUT	29.3	1.0	–	3.9	–
6 Dohm <i>et al.</i> (2002)	USA	215	12.6 ^c	BN, BED	DSM-IV	COM	30.3	0.0	N.A.	–	37.2
7 Favaro & Santonastaso (1997)	Italy	495	19.2 ^c	AN, BN, BED, EDNOS	DSM-IV	OUT	–	–	37.1	13.1	–
8 Favaro & Santonastaso (1998)	Italy	125	21.6 ^c	BN	DSM-IV	OUT	23.7	–	N.A.	18.4	16.0
9 Favaro & Santonastaso (2000)	Italy	236	17.8 ^c	AN	DSM-IV	OUT	22.0	–	34.3	6.4	–
10 Fichter <i>et al.</i> (2008)	Germany	264	43.9 ^c	BN, BED	DSM-IV	IN	26.6	0.0	N.A.	–	–
11 Garner <i>et al.</i> (1985)	Canada	177	14.1 ^e	AN, BN	G&G ^g	–	22.3	0.0	50.0	17.5	36.7
12 Gleaves & Eberenz (1993)	USA	535	27.3 ^c	AN, BN, EDNOS	DSM-III-R	RES	24.3	0.0	–	20.6	–
13 Iannaccone <i>et al.</i> (2013)	Italy	58	50.0 ^c	AN, BN, BED	DSM-IV	IN, OUT	27.5	0.0	–	–	10.3
14 Liang & Meg Tseng (2011)	Taiwan	316	32.6 ^e	AN, BN, EDNOS	DSM-IV	OUT	22.9	0.0	60.9	18.0	1.6
15 Mitchell <i>et al.</i> (1986)	USA	273	34.4 ^c	BN	DSM-III	OUT	24.8	0.0	N.A.	18.7	–
16 Muehlenkamp <i>et al.</i> (2009)	USA	131	14.5 ^c	BN	DSM-IV	COM	25.3	0.0	N.A.	–	–
17 Nagata <i>et al.</i> (2000a)	Japan	236	25.4 ^c	AN, BN	DSM-IV	OUT	23.7	0.0	50.8	28.4	3.0
18 Paul <i>et al.</i> (2002)	Germany	376	34.6 ^c	AN, BN, EDNOS	DSM-IV	IN	24.3	0.0	50.4	–	–
19 Peebles <i>et al.</i> (2011)	USA	612	40.8 ^e	AN, BN, EDNOS	DSM-IV	–	15.6	7.7	45.4	–	–
20 Pryor <i>et al.</i> (1996)	USA	171	17.0 ^c	AN	DSM-IV	OUT	22.7	0.0	–	14.6	–
21 Ruuska <i>et al.</i> (2005)	Finland	55	23.6 ^e	AN, BN	ICD-10	OUT	16.9	0.0	–	3.6	–
22 Solano <i>et al.</i> (2005)	Spain	109	37.3 ^d	AN, BN	DSM-IV	OUT	22.9	0.0	41.2	28.4	3.7
23 Steiger <i>et al.</i> (2001)	Canada	40	72.5 ^e	BN	DSM-IV	OUT	23.9	0.0	N.A.	–	–
24 Stein <i>et al.</i> (2004)	USA	150	24.7 ^c	AN, BN, BED, EDNOS	DSM-IV	OUT	26.6	3.3	–	20.7	14.7

Table 1 (cont.)

Study	Country	Sample size	Percentage				Percentage				
			NSSI ^{b,c,d,e}	Diagnoses	Diagnostic criteria	Care frame	Mean age, years	Male ^b	Binge eating/purging ^f	Suic. att. ^b	Subs. abu. ^b
25 Tobin & Griffing (1996)	USA	103	39.8 ^e	AN, BN, BED, EDNOS	DSM-IV	OUT	29.4	5.8	–	39.8	–
26 Vansteelandt <i>et al.</i> (2013)	Belgium	58	27.6 ^e	AN, BN	DSM-IV	IN	21.3	0.0	44.7	–	–
27 Wiederman & Pryor (1996a)	USA	117	22.2 ^c	AN, BN	DSM-III-R	OUT	15.4	0.0	22.0	20.5	–
28 Wiederman & Pryor (1996b)	USA	217	30.9 ^c	BN	DSM-III-R	OUT	25.1	0.0	N.A.	30.0	10.1
29 Yellowlees (1985)	UK	32	15.6 ^e	AN	DSM-III	IN, OUT	22.9	3.1	46.9	34.4	–

NSSI, Non-suicidal self injury (history of); Suic. att, suicide attempt (history of); Subs. abu., substance abuse (history of); AN, anorexia nervosa; BN, bulimia nervosa; DSM, Diagnostic and Statistical Manual of Mental Disorders (R: revised); IN, in-patients; GP, general practice (referrals); COM, community; N.A., not applicable; EDNOS, eating disorder not otherwise specified; OUT, out-patients; BED, binge eating disorder; RES, residential treatment; ICD, International Classification of Diseases.

^a The meta-analysis for eating disorders included studies 1–21 and 23–29, for anorexia nervosa studies 1, 4, 7, 9, 11, 13, 14, 17–22, 26, 27 and 29, and for bulimia nervosa studies 1, 2, 6–8, 10, 11, 13–19, 21–23 and 26–28.

^b Percentage of all study participants.

^c The study assessed: impulsive NSSI.

^d The study assessed: both impulsive and compulsive NSSI.

^e The study assessed: unspecified NSSI.

^f Percentage of participants with anorexia nervosa.

^g Diagnostic criteria by Garfinkel & Garner (1982).

countries (Garner *et al.* 1985; Yellowlees, 1985; Mitchell *et al.* 1986; Gleaves & Eberenz, 1993; Pryor *et al.* 1996; Tobin & Griffing, 1996; Wiederman & Pryor, 1996a, b; Favaro & Santonastaso, 1997, 1998, 2000; Nagata *et al.* 2000a; Steiger *et al.* 2001; Anderson *et al.* 2002; Dohm *et al.* 2002; Paul *et al.* 2002; Stein *et al.* 2004; Ruuska *et al.* 2005; Corstorphine *et al.* 2007; Ahren-Moonga *et al.* 2008; Bulik *et al.* 2008; Fichter *et al.* 2008; Muehlenkamp *et al.* 2009; Liang & Meg Tseng, 2011; Peebles *et al.* 2011; Iannaccone *et al.* 2013; Vansteelandt *et al.* 2013; Bueno *et al.* 2014). The 29th publication (Solano *et al.* 2005) shared participants with the sample in Bueno *et al.* (2014). As explained above, Solano *et al.* (2005) was only included in the meta-analyses and comparison of AN and BN, and Bueno *et al.* (2014) only in the meta-analysis of ED.

The diagnostic criteria used in the 29 publications included DSM-IV (21 studies), DSM-III-R (four studies), DSM-III (two studies), ICD-10 (one study) and diagnostic criteria described by Garfinkel & Garner (1982) (one study) (Table 1). In 21 publications, NSSI was defined using operational examples of impulsive self-injurious acts, or was explicitly referred to as 'impulsive' behaviour. Two studies included examples of both impulsive and compulsive acts in the definition of NSSI, and six studies used common definitions of self-injury without providing operational examples (online Supplementary Table S1). As operational examples do not necessarily reflect the actual range of NSSI acts assessed, where available, the authors relied on additional information to determine the type of NSSI assessed, e.g. the NSSI questionnaire items used, or the breakdown of participants per NSSI subtype. Based on such information, 18 studies (62%) assessed impulsive NSSI, nine (31%) assessed unspecified NSSI and two (7%) assessed both impulsive and compulsive types of NSSI (Table 1 and online Supplementary Table S1).

The diagnostic range of ED in the 28 independent studies that contributed analytic samples to the meta-analysis for ED included BN (3046 patients, 47.1%), AN (2138 patients, 33.1%), ED not otherwise specified (EDNOS) (871 patients, 13.5%) and binge ED (298 patients, 4.6%), while the diagnostic umbrella of 'eating disorders' was not broken down into specific diagnoses for 113 patients (1.7%). Of the 28 independent publications, 14 included out-patients ($n=2636$, 40.8%), four included in-patients ($n=736$, 11.4%), two focused on community samples ($n=346$, 5.4%), one examined 535 (8.3%) patients from a residential treatment facility, three drew participants from a variety of in-patient, out-patient, general practice or community settings ($n=214$, 3.3%), and four did not specify their care frames ($n=1999$, 30.9%). The mean age of the total analytic sample was 24.4 ± 4.0 years (mean

ages ranged from 15.4 to 30.4 years across studies). Of the studies, 19 included exclusively female patients ($n=4199$, 64.9%), six studies combined a majority of female patients ($n=1330$, 20.6%) with a minority of male patients ($n=81$, 1.3%), and three studies did not specify the gender composition of their participants ($n=856$, 13.2%). Of the studies, 20 reported on history of attempted suicide in their samples, which was present in 0–39.8% of participants, and 11 studies reported on history of substance abuse, which was present in 1.6–37.2% of subjects. Twelve ($n=12$) studies reported on the percentage of AN participants with the binge eating/purging diagnostic subtype, which ranged from 2.0% to 60.9%. The reader should refer to Table 1 for more information regarding participant characteristics.

Meta-analyses: pooled NSSI proportion estimates

The number of independent publications that assessed history of NSSI in individuals with any ED, in samples/subsamples of participants with AN, and in samples/subsamples of subjects with BN, were 28, 16 and 20, respectively, based on combined samples of 6466, 1816 and 2160 individuals, respectively.

Table 2 includes the results of the three meta-analyses. Figs 2 and 3 show the forest plots of the pooled weighted (log-odds transformed) proportions of NSSI and 95% CIs in ED (Fig. 2), and in AN *v.* BN (Fig. 3). The weighted mean percentage of participants with a lifetime history of NSSI was 27.3% (95% CI 23.8–31.0%) in the 28 ED samples, 21.8% (95% CI 18.5–25.6%) in the 16 AN samples and 32.7% (95% CI 26.9–39.1%) in the 20 BN samples, with statistically significant heterogeneity across studies (Table 2). The Begg test of asymmetry (publication bias) was uniformly non-significant (ED: $z = -0.71$, $p = 0.47$; AN: $z = 0.54$, $p = 0.589$; BN: $z = 0.00$, $p = 1.000$).

Meta-regression analyses: predictors of NSSI

The results of the meta-regression analyses are presented in Table 2.

Across samples with any ED, substance abuse, attempted suicide and care frame (but not mean age) emerged as statistically significant predictors of NSSI, explaining 48, 37 and 33% of variance in NSSI, respectively (Table 2). Specifically, the odds of NSSI decreased by 26% for every 10% increase in the percentage of participants with histories of substance abuse (OR 0.74, 95% CI 0.58–0.95, $p = 0.023$) and increased by 24% for every 10% increase in the percentage of participants with histories of suicide attempts (OR 1.24, 95% CI 1.04–1.48, $p = 0.020$) (Table 2 and online Supplementary Figs S1 and S2). Participants recruited from specialist ED or residential treatment settings were 2.6 times more

Table 2. Lifetime history and predictors of NSSI in participants with anorexia nervosa, bulimia nervosa and eating disorders: meta-analyses and meta-regression analyses

Diagnostic group	No. of samples	No. of patients	Predictor ^a	Percentage ^b	OR	95% CI		I ² , %	p ≤	Adjusted R ² , %
						LL	UL			
Meta-analyses: lifetime history of NSSI										
Any eating disorder ^c	28	6466		27.3		23.8%	31.0%	88.7	0.001	
Anorexia nervosa	16	1816		21.8		18.5%	25.6%	58.3	0.010	
Bulimia nervosa	20	2160		32.7		26.9%	39.1%	85.3	0.001	
Meta-regression analyses: predictors of NSSI										
Any eating disorder ^c	27	5971	Mean age		1.01	0.95	1.07		0.797	−5.4
Any eating disorder ^c	24	4409	Care frame ('clinical ED setting/residential treatment' v. 'GP/community')		2.58	1.29	5.19		0.010	33.1
Any eating disorder ^c	20	4712	History of attempted suicide (% of all participants with)		1.24 ^d	1.04	1.48		0.020	37.2
Any eating disorder ^c	11	2828	History of substance abuse (% of all participants with)		0.74 ^d	0.58	0.95		0.023	48.2
AN, BN	36	3976	Diagnosis ('bulimia nervosa' v. 'anorexia nervosa')		1.77	1.14	2.77		0.013	18.7
Anorexia nervosa	12	1179	Binge eating/purging subtype (% of AN participants with)		1.19 ^d	0.88	1.60		0.230	13.7

NSSI, Non-suicidal self injury; OR, odds ratio; CI, confidence interval; LL/UL, lower limit/upper limit of 95% CI; ED, eating disorders; GP, general practice; AN, anorexia nervosa; BN, bulimia nervosa.

^a Only predictors examined in a minimum of 10 studies have been analysed. Predictors were examined one at a time in simple linear meta-regression models, each examining the effect of the predictor on the proportion of patients with a lifetime history of NSSI, transformed onto the log-odds scale. The resulting coefficient and 95% CI were then exponentiated to express each effect as an OR reflecting change in odds of NSSI per factor change.

^b Percentage of patients with a history of NSSI across samples. The proportions of patients with NSSI and 95% CI in the individual samples were transformed onto the log-odds scale for each meta-analysis. The resulting effect and 95% CI were then back-transformed into proportions using the logistic (or inverse log-odds) function.

^c Including patients with diagnoses of anorexia nervosa, bulimia nervosa, eating disorder not otherwise specified and binge eating disorder.

^d The OR reflects change in odds of NSSI per 10% increase in the percentage of patients with a positive value ('present') for the predictor (the percentage was divided by 10).

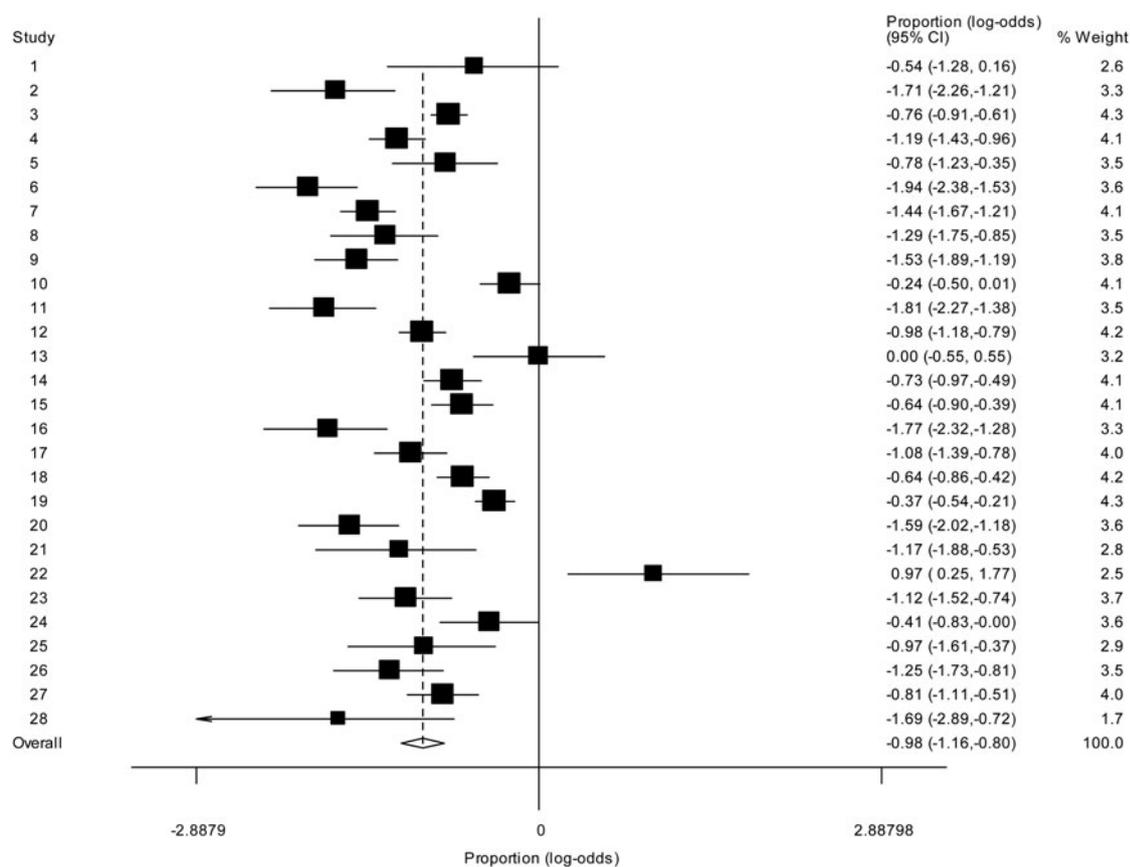


Fig. 2. Forest plot of pooled weighted (log-odds transformed) proportions and 95% confidence intervals (CIs) of lifetime history of non-suicidal self-injury in eating disorders. 1. Ahren-Moonga *et al.* (2008); 2. Anderson *et al.* (2002); 3. Bueno *et al.* (2014); 4. Bulik *et al.* (2008); 5. Corstorphine *et al.* (2007); 6. Dohm *et al.* (2002); 7. Favaro & Santonastaso (1997); 8. Favaro & Santonastaso (1998); 9. Favaro & Santonastaso (2000); 10. Fichter *et al.* (2008); 11. Garner *et al.* (1985); 12. Gleaves & Eberenz (1993); 13. Iannaccone *et al.* (2013); 14. Liang & Meg Tseng (2011); 15. Mitchell *et al.* (1986); 16. Muehlenkamp *et al.* (2009); 17. Nagata *et al.* (2000a); 18. Paul *et al.* (2002); 19. Peebles *et al.* (2011); 20. Pryor *et al.* (1996); 21. Ruuska *et al.* (2005); 22. Steiger *et al.* (2001); 23. Stein *et al.* (2004); 24. Tobin & Griffin (1996); 25. Vansteelandt *et al.* (2013); 26. Wiederman & Pryor (1996a); 27. Wiederman & Pryor (1996b); 28. Yellowlees (1985).

likely to report NSSI than participants from general practice/community settings (OR 2.58, 95% CI 1.29–5.19, $p < 0.010$). After limiting the meta-regression analyses to all-female samples, there was little change in the pattern of findings, except for ‘history of attempted suicide’, which was reduced to a statistical trend (online Supplementary Table S4).

Diagnosis explained 19% of variance in NSSI estimates across the 36 AN and BN samples, with bulimia showing a statistically significant increase (77%) in odds of NSSI compared with anorexia (OR 1.77, 95% CI 1.14–2.77, $p = 0.013$) (Table 2). None of the predictors examined separately in the AN or BN samples was statistically significant (most likely suggesting insufficient power) (Table 2 and online Supplementary Table S5), with the exception of care frame in BN (online Supplementary Table S5).

Sensitivity analysis: addressing heterogeneity in the operationalization/characterization or assessment of NSSI, in diagnosis of ED and in gender composition

After excluding studies with a mixed or unspecified focus on NSSI (both in terms of operationalization/characterization and in terms of assessment), studies using diagnostic criteria other than DSM-IV, and studies with a small or unspecified number of males, there was little change in the prevalence estimates of NSSI, which ranged within 0 to 3 points of the respective estimates in the total analytic sample (online Supplementary Table S3).

Discussion

In the context of growing scientific interest in NSSI, our meta-analyses provide aggregate, weighted and

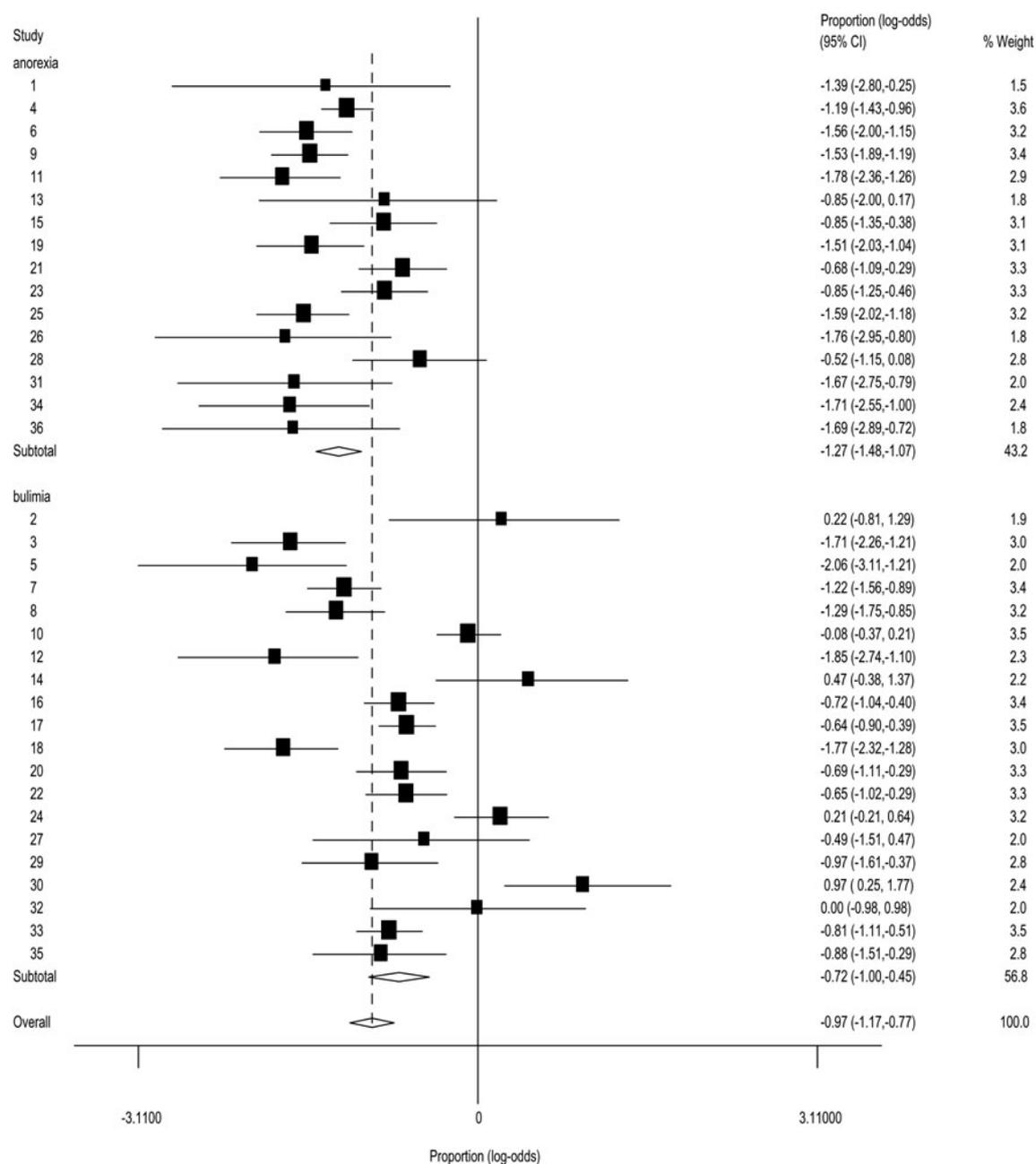


Fig. 3. Forest plot of pooled weighted (log-odds transformed) proportions and 95% confidence intervals (CIs) of lifetime history of non-suicidal self-injury in anorexia nervosa *v.* bulimia nervosa. Anorexia samples: 1. Ahren-Moonga *et al.* (2008); 4. Bulik *et al.* (2008); 6. Favaro & Santonastaso (1997); 9. Favaro & Santonastaso (2000); 11. Garner *et al.* (1985); 13. Iannaccone *et al.* (2013); 15. Liang & Meg Tseng (2011); 19. Nagata *et al.* (2000a); 21. Paul *et al.* (2002); 23. Peebles *et al.* (2011); 25. Pryor *et al.* (1996); 26. Ruuska *et al.* (2005); 28. Solano *et al.* (2005); 31. Vansteelandt *et al.* (2013); 34. Wiederman & Pryor (1996b); 16. Yellowlees (1985). Bulimia samples: 2. Ahren-Moonga *et al.* (2008); 3. Anderson *et al.* (2002); 5. Dohm *et al.* (2002); 7. Favaro & Santonastaso (1997); 8. Favaro & Santonastaso (1998); 10. Fichter *et al.* (2008); 12. Garner *et al.* (1985); 14. Iannaccone *et al.* (2013); 16. Liang & Meg Tseng (2011); 17. Mitchell *et al.* (1986); 18. Muehlenkamp *et al.* (2009); 20. Nagata *et al.* (2000a); 22. Paul *et al.* (2002); 24. Peebles *et al.* (2011); 27. Ruuska *et al.* (2005); 29. Solano *et al.* (2005); 30. Steiger *et al.* (2001); 32. Vansteelandt *et al.* (2013); 33. Wiederman & Pryor (1996a); 35. Wiederman & Pryor (1996b).

clinically important data on the prevalence and correlates of NSSI among individuals with ED. Using a multinational sample of 1816–6466 unique participants from 16–28 studies, 11 countries, and a variety of

settings (mainly clinical, but also community-based), we found that 27% of adolescents and young adults with ED, 22% of those with AN and 33% of those with BN are reported to have engaged in intentional,

self-inflicted destruction of body tissue without suicidal intent and for purposes not socially sanctioned.

In line with our hypothesis and earlier observations (Kostro *et al.* 2014), our findings confirm the higher salience of BN (as compared with AN) phenomenology in the profiles of individuals with ED and a history of NSSI. The broader hypothesis that NSSI is more prevalent in ED types that include binge or purge behaviours (Kostro *et al.* 2014) received only partial support by the present analysis, as the percentage of AN individuals diagnosed with the binge eating/purging subtype did not predict history of NSSI. The latter finding requires exploration in future meta-analyses, as our meta-regression of diagnostic subtype within AN was statistically less powered than that of diagnosis within ED.

Care frame emerged as a significant predictor of NSSI, explaining 33% of variance in NSSI. Participants presenting to specialist ED settings were approximately three times more likely to report a history of NSSI compared with those recruited from general practice/community settings. This finding suggests important differences in the prevalence of NSSI between clinical and community samples of ED sufferers. In addition, confirming our hypothesis, history of attempted suicide significantly predicted higher occurrence of NSSI, explaining 37% of the variability in the proportions of participants with histories of NSSI across studies. This is not surprising, as recurring NSSI has been argued to reflect impaired behavioural inhibition during states of acute negative emotionality, reducing sensitivity to punishing outcomes, and signalling a critical crossing of boundaries between ideas of self-injury and suicidal acts (Wilkinson & Goodyer, 2011).

Contrary to our hypothesis, history of substance abuse significantly predicted lower rather than higher occurrence of NSSI, explaining 48% of the variability in the proportions of participants with a history of NSSI. This result is difficult to interpret, particularly as studies varied widely in their reporting of substance abuse (some referred broadly to 'drug abuse', while others provided a detailed breakdown of frequencies by illicit substance, including cannabis, cocaine/crack, hallucinogens, opioids, sedative-hypnotics, stimulants and other illicit drugs; the percentage of participants with a history of substance abuse ranged from 2% to 37%, which largely overlaps, but is somewhat lower than, the percentage of 17–46% reported in a review by Harrop & Marlatt, 2010). A number of factors could have influenced the magnitude and direction of this association, including bias, variability in ED subtypes, and differences in the association between history of substance abuse and impulsive *v.* compulsive NSSI.

The strong negative correlation between NSSI and substance abuse seems to contradict evidence that

both features belong to a constellation of behaviours (NSSI, suicide attempts, substance abuse, alcohol abuse, shoplifting and sexual disinhibition), which reflect impaired impulse control beyond that inherent in ED, and which co-occur in a 'multi-impulsive' subgroup of ED patients (Fahy & Eisler, 1993; Wiederman & Pryor, 1996b; Matsunaga *et al.* 2000; Nagata *et al.* 2000a, b; Fichter *et al.* 1994). However, displaying more than two of the above behaviours characterizes a minority of ED patients (for example, 18% of participants in Wiederman & Pryor, 1996b reported at least three impulsive behaviours), while expressing only one appears to be more typical of this population (for example, 44% of participants in Fahy & Eisler, 1993 reported one impulsive behaviour) (Fahy & Eisler, 1993; Wiederman & Pryor, 1996b; Matsunaga *et al.* 2000; Nagata *et al.* 2000a, b). Our finding is in agreement with the interpretation of 'multi-impulsivity' by Lacey & Evans (1986), who propose that within ED there is a poor-prognosis group characterized not only by the specific presenting symptom, but also by one or more impulsive behaviours that are interchangeable (Lacey & Evans, 1986). As both NSSI and substance abuse are proposed to regulate affect by increasing endogenous opioids (Trigo *et al.* 2010; Bresin & Gordon, 2013), it is plausible that exhibiting either behaviour reduces the need and desire to engage in the other, explaining the present findings.

Taken together, our findings in relation to history of suicide attempt and history of substance abuse (which predicted higher and lower occurrence of NSSI, respectively) raise the possibility that impulsive behaviours in ED separate into distinct factors. This possibility has also been raised in previous reports. For example, in an AN sample studied by Favaro & Santonastaso (2000), skin cutting/burning and suicide attempts loaded on the same factor ('impulsive self-injurious behaviour'), whereas substance abuse did not load on any of three factors ('impulsive self-injurious behaviour', 'compulsive self-injurious behaviour' and 'purging behaviour'). In addition, in a medical prison sample of females with ED in Japan, none of the patients who had been convicted for shoplifting had a history of conviction for other crimes, and none of the patients who had committed drug offences had an incarceration history for shoplifting (Asami *et al.* 2014).

Our findings have important treatment, clinical and research implications. The high prevalence of NSSI and its positive correlation with attempted suicide suggest that the treatment and prevention of self-injury in ED should form primary targets for researchers and clinicians. Structured psychotherapeutic approaches focusing on collaborative therapeutic relationships,

motivation for change, family skills training (e.g. family communication and problem solving), and individual skills training (e.g. emotion regulation, problem solving, self-monitoring, communication skills) seem to be most effective in reducing NSSI (Turner *et al.* 2014; Glenn *et al.* 2015). Medications targeting the serotonergic, dopaminergic and opioid systems also have demonstrated some benefits (Turner *et al.* 2014). Future research should focus on replicating studies of promising treatments, examining mediators and moderators of treatment effects, and developing brief interventions for high-risk periods (e.g. following hospital discharge) (Turner *et al.* 2014; Glenn *et al.* 2015). In addition, our interesting finding that attempted suicide and substance abuse correlate with NSSI in opposite ways highlights a need for well-designed factor-analytic studies of impulsive features in ED.

Our findings must be viewed in the context of some limitations. Most (62%) studies included in the present meta-analyses assessed impulsive NSSI, but a significant minority (31%) did not specify the type of NSSI assessed and only two (7%) studies explicitly included compulsive acts in the assessment of NSSI. It is therefore unclear whether our results can be generalized to compulsive NSSI. In addition, some established or possible correlates of NSSI in ED, e.g. illness duration, diagnostic shifts (cross-over from AN to BN and vice-versa), co-morbid anxiety or depression, personality disorders, and child sexual abuse, could not be explored in our analysis, due to the low number of relevant studies, or inconsistencies in reporting.

Like all aggregate analyses, our study could only look at relationships at the level of study, for example, between proportion of participants with a history of NSSI and proportion of those with a history of substance abuse. Such associations can be confounded by other – measured or unmeasured – study-level variables, or may even go in the opposite direction at the individual level. Mitigating this risk, the examined predictors in our meta-regression analyses showed reasonable variability and mostly weak correlations with each other. Finally, most of the meta-regression analyses performed separately for AN and BN failed to yield statistically significant findings, most probably suggesting suboptimal statistical power, which may have concealed diagnosis-specific patterns.

In conclusion, a lifetime history of NSSI is highly prevalent among adolescents and young adults with ED, and correlates positively with a history of attempted suicide, while potentially being antagonized by a history of substance abuse. Our study provides valuable insights into the predictors of NSSI in the context of ED, which should be extended in future studies. Our aggregate, weighted and clinically important

evidence can inform guidance and practice in relation to risk assessment and treatment in ED.

Supplementary material

For supplementary material accompanying this paper visit <http://dx.doi.org/10.1017/S0033291716000027>

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Declaration of Interest

None.

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