The Genetic Epidemiology of Bulimia Nervosa

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Objective: The authors seek to clarify, from both an epidemiologic and genetic perspective, the major risk factors for bulimia nervosa and to understand the relationship between narrowly defined bulimia and bulimia-like syndromes. Method: Personal structured psychiatric interviews were conducted with 2,163 female twins from a population-based register. Psychiatric disorders were assessed using DSM-III-R criteria. Results: Lifetime prevalence and risk for narrowly defined bulimia were 2.8% and 4.2%, respectively. Including bulimia-like syndromes increased these estimates to 5.7% and 8.0%, respectively. Risk factors for bulimia included 1) birth after 1960, 2) low paternal care, 3) a history of wide weight fluctuation, dieting, or frequent exercise, 4) a slim ideal body image, 5) low self-esteem, 6) an external locus of control, and 7) high levels of neuroticism. Significant comorbidity was found between bulimia and anorexia nervosa, alcoholism, panic disorder, generalized anxiety disorder, phobia, and major depression. Probanded concordance for narrowly defined bulimia was 22.9% in monozygotic and 8.7% in dizygotic twins. The best-fitting model indicated that familial aggregation was due solely to genetic factors with a heritability of liability of 55%. A multiple threshold model indicated that narrowly defined bulimia nervosa and bulimia-like syndromes represented different levels of severity on the same continuum of liability. Conclusions: The liability to fully syndromal bulimia nervosa, which affects around one in 25 women at some point in their lives, is substantially influenced by both epidemiologic and genetic risk factors. The same factors that influence the risk for narrowly defined bulimia also influence the risk for less severe bulimia-like syndromes.


Bulimia nervosa, first delineated as a clinical syndrome in 1979 (1), has become a major focus of psychiatric practice and research. However, relatively little is known about its epidemiology; even less is known about the role of familial factors in the etiology of bulimia.

THE EPIDEMIOLOGY OF BULIMIA

Most studies of the epidemiology of bulimia have examined point prevalence on the basis of self-report questionnaires, often in select populations such as college students (2). Averaged across published studies, the frequency of current binge eating in women has been
estimated at 35%, while 8% report self-induced vomiting and 5.8% laxative abuse (2). On the basis of studies using self-report, the point prevalence of bulimia averages 9.0% for the DSM-III definition and 2.6% for the DSM-III-R definition. Far fewer studies have used face-to-face interviews, and in only two of those was the entire sample interviewed (3, 4). However, in those two studies the samples were limited to normal-weight volunteers (3) or college students (4). The interview-based studies produced lower estimates for the point prevalence of bulimia in women than the questionnaire-based studies: 1.5% using DSM-III and 0.9% using DSM-III-R criteria (2).

Two studies have recently reported lifetime prevalence rates for DSM-III bulimia nervosa. In a general population sample from New Zealand, assessed by lay interviewers, the lifetime prevalence of bulimia in women aged 18-44 was 2.6% (5). However, on the basis of clinician interviews of a subset of this sample, the estimated lifetime prevalence of bulimia in the same sample was lower (1.7%) (5). Using two-stage screening with high school students from New Jersey, Whitaker et al. (6) found that the lifetime prevalence of bulimia was 4.2% in girls. One epidemiologic study of bulimia ascertained subjects through treatment facilities and found, using DSM-III criteria, a 2-year prevalence of treated bulimia in females aged 16-24 of 0.4% (7). These results, consistent with those found by others (4, 6, 8, 9), indicate that a minority of subjects with bulimia seek treatment.

Studies of the epidemiology of bulimia frequently note that, in the general population, the syndrome is more a spectrum of pathology than a discrete disease entity (2-5, 8, 10, 11). For example, in a general practice survey in London, patients with “partial-syndrome eating disorder” outnumbered patients with classic cases of bulimia by more than two to one (11). A recent review recommended “a shift in emphasis away from studies of the distribution of the disorder toward studies of the determinants of the whole spectrum of the disturbance that exists in the community” (2).

FAMILY/GENETIC STUDIES OF BULIMIA

While a number of studies have examined the risk of affective illness in relatives of patients with bulimia (12, 13), only four published reports have examined whether bulimia itself aggregates in families. Using DSM-III criteria, Hudson et al. (14), in an uncontrolled family history study, found that the prevalence of bulimia in relatives of bulimic probands was 3.4%. In a later controlled family history study, the same group found that the risk for bulimia was 2.2% in relatives of bulimic probands; this prevalence was nonsignificantly higher than the 0% risk in relatives of control subjects (15). Logue et al. (16) found no case of bulimia in interviewed relatives of bulimic probands who were ascertained through treatment facilities. By contrast, Kassett et al. (13), using direct interviews with relatives, found that the risk for bulimia in relatives of hospitalized bulimic probands was 9.6%, versus 3.5% in relatives of normal control subjects (p<0.05).

Of the four published reports, only one (13) provides robust evidence for the familial aggregation of bulimia. These reports suffer from several methodologic limitations. Risk for bulimia is not reported separately for female and male relatives. Two of the studies relied on family history information only, which may have only modest sensitivity. All reports ascertained probands through psychiatric treatment facilities, which may produce a proband sample that lacks the milder cases of bulimia commonly seen in the community or in primary care settings.

We are aware of two published twin studies of bulimia. Hsu et al. (17) examined 11 twin probands with bulimia who were referred to an eating disorders clinic. The co-twin was personally interviewed in six pairs. Two of the six monozygotic female-female pairs (33%) were concordant for bulimia, compared to none of the five dizygotic pairs (two female-female and three male-female pairs). Fichter and Noegele (18) ascertained 27 twin pairs with bulimia from volunteers to a press survey (17 pairs) and two clinical services (10 pairs). Diagnosis was made using DSM-III-R criteria applied to a self-report measure. Excluding the one male monozygotic pair and the five opposite-sex dizygotic pairs, they reported pairwise concordance for bulimia nervosa in five of six female monozygotic pairs (83%) and in four of 15 female dizygotic pairs (27%).

In this report, we examine the epidemiology and genetics of bulimia in 2,163 female twins from a population-based registry in which bulimia and bulimic-like syndromes were assessed by personal interview.

METHOD

Sample

Data for this report come from an ongoing study of genetic and environmental risk factors for common psychiatric disorders in Caucasian female same-sex twin pairs from the Virginia Twin Registry. The Virginia Twin Registry is a population-based register formed from a systematic review of all birth records in the Commonwealth of Virginia. Current addresses are obtained by a variety of means, including matching with state records.

Twins were eligible to participate in this study if both members of the pair had previously responded to a mailed questionnaire, the individual response rate to which was 64%. This is certainly an underestimate of the cooperation rate, as an unknown proportion of the twins did not receive the questionnaire because of lack of correct addresses. In a total of 1,176 twin pairs, both members returned questionnaires and thus were eligible for the personal interview phase of the study. In 46 pairs, neither twin was successfully interviewed. In 97 pairs, one twin was interviewed and the other refused.
In 1,033 pairs, both twins were interviewed. During the personal interview phase of the project, therefore, the individual response rate was 91.8%. Of the completed interviews, 89.3% were performed face to face, usually in the twin’s home, and 10.7% (primarily twins residing outside Virginia) were interviewed by telephone. The mean±SD age of the sample at interview was 30.1±7.6 years (range=17-55).

Determination of Zygosity

Information on zygosity for each twin pair in which both members participated in the interview was reviewed by two experienced twin researchers who were blind to all information about the psychiatric status of the twins. This information included the response to questions about physical similarity and frequency of confusion as children (which have been shown to be able to identify zygosity in twins with over 95% accuracy) (19) and, in over 80% of cases, photographs of both twins. Twin pairs were divided into five groups: definitely monozygotic, definitely dizygotic, probably monozygotic, probably dizygotic, and uncertain. Disagreement between the two raters was resolved by consensus. We attempted to obtain blood samples from both members of the pairs in the final three categories and were successful in 119 of the 186 pairs so classified. Zygosity was determined by DNA analysis using eight highly polymorphic probes (20). The probability of monozygosity for twins identical at all eight loci was 0.9997. Final determination of zygosity, which used DNA results when available and otherwise a diagnosis of definite or probable zygosity, yielded 590 monozygotic twin pairs, 440 dizygotic twin pairs, and three pairs classified as uncertain. In 105 twins with a diagnosis of probable zygosity, DNA methods validated our assignment in 87 of the cases (83%). DNA or protein polymorphism zygosity information was available for 26 twins with a diagnosis of definite zygosity and validated our assignment in all cases.

Measures and Interviewers

Lifetime psychiatric illness was diagnosed with an adapted version of the Structured Clinical Interview for DSM-III-R (21). All interviewers, who had at least a master's degree in social work or a bachelor's degree and 2 years of social work or counseling experience, were initially trained for 80 hours and received bimonthly review sessions over the course of the study, which was completed between September 1987 and July 1989. The same interviewer never interviewed both members of a twin pair.

To assess the similarity of childhood environment, twins were asked how often, as children, they 1) shared the same room, 2) had the same playmates, 3) were dressed alike, and 4) were in the same classes. Answers to these questions were summed to form a single index of childhood similarity. Twins were also asked how frequently they were in current contact with their co-

twins, with response options ranging from “living together” to “once a year or less.”

Personality was assessed by the short version of Eysenck’s Personality Questionnaire (22), self-esteem by the Rosenberg Self-Esteem scale (23), and locus of control by a modified form of the Attributional Styles Questionnaire (24). Maternal and paternal care and overprotectiveness were assessed by seven items selected from the Parental Bonding Instrument (25).

In part of our sample (N=1,375), the twins returned, 1 to 3 years before interview, a questionnaire providing further information about weight, level of exercise, and body image as assessed by body silhouettes (26). The twins were asked which silhouettes were “closest to the usual appearance” (“usual silhouette”) of themselves, their mother, and their father and which silhouette they would “like to look like” (“ideal” silhouette).

Diagnostic Review

Final project diagnoses were based on a blind review of the entire interview by one of us (K.S.K.), an experienced psychiatric diagnostician. Diagnoses were made at three levels of certainty—definite, probable, and possible—using DSM-III-R criteria. For a definite diagnosis, all diagnostic criteria had to be met with sufficient severity or certainty that the individual, if seen in a clinical setting, would definitely be considered a “case.” A probable diagnosis meant that the diagnostic criteria were met, but the severity or certainty of these symptoms was less impressive. A possible diagnosis was given when most but not all of the diagnostic criteria were met and the syndrome was considered to be clinically significant.

Statistical Analysis

The analysis of epidemiologic risk factors for bulimia nervosa was performed using logistic regression (27) in two different ways (results available on request). First, analyses were conducted treating each twin as a separate observation; the dependent variable was the affection status of the twin. Second, analyses were repeated in which each complete twin pair was a single observation. The independent variables were the mean values of the two members; the dependent variable became ordinal: 0=neither twin affected, 1=one twin affected, and 2=both twins affected. When the dependent variable is modestly correlated in pairs of observations, the former method should be slightly statistically liberal, while the latter method should be quite conservative. These methods differed in assigning significance (at the 5% level) in three of the 23 regression analyses reported here. In two of these, the results were significant only by the presumably more conservative second method. We therefore present results from the first method, which treats the twins as separate observations.

In all regression analyses, age was included as a control variable and the statistical significance of the independent variable was determined by a chi-square test with one degree of freedom. To test the “equal environ-
ment assumption," the impact of childhood similarity or frequency of contact on twin similarity for bulimia was assessed by logistic regression in which the dependent variable coded zero if the twins were concordant (i.e., both or neither twin had a diagnosis of bulimia) or one if they were discordant.

Given that the risk for bulimia is correlated in twins, if bulimic individuals are less likely to cooperate with personal interviews, then the risk for bulimia should be higher in twins whose co-twin was not versus was successfully interviewed. This can be assessed by logistic regression using a dummy independent variable for interview status of co-twin.

Body mass index was calculated as weight divided by height squared. The magnitude of comorbidity in possible versus definite and probable cases of bulimia was compared by examining the difference in odds ratios (28). Lifetime risk was calculated by life table analysis. The statistical test between survival curves was conducted using Cox's proportional hazard model (27).

The analysis of the twin data is based on a "liability-threshold" model which assumes that underlying the observed dichotomous distribution of "unaffected/affected," there exists a continuous, normally distributed latent liability (29). The observed discontinuous distribution is assumed to emerge from the imposition of a threshold on the normally distributed latent liability. This model assumes that the genetic and environmental factors contributing to the liability to bulimia act additively and are relatively numerous and small in magnitude. Although this model basically assumes a large number of genes, a normal distribution of liability can be closely approximated by a quite small number of genes (30).

When the discrete distribution contains only two categories (e.g., unaffected/affected), a correlation in liability (or, more technically, a tetrachoric correlation) is calculated from the 2x2 contingency table of twin 1's and twin 2's affection status. This statistic is superior to the traditional concordance rate calculated in twin studies because it takes into account both concordance for affection and concordance for nonaffection.

A tetrachoric correlation fit to a 2x2 table is a "perfect fit" and provides no test of the model. However, in testing whether possible, probable, and definite cases of bulimia can be assumed to represent different levels of severity in the same liability continuum, a polytropic correlation is calculated from the 4x4 table, cross-tabulating the diagnoses of the two twins (unaffected and the three levels of diagnostic certainty). A chi-square goodness of fit test is then available for testing the distributional assumptions made in calculating the polytropic correlation.

The tetra- or polytropic correlations for twin 1 and twin 2 were separately computed for monozygotic and dizygotic twins using the computer program PRELIS (31). Results were fit to these correlations using the computer program LISREL (32-34). The goal of these analyses was to obtain estimates for the proportion of variance in the underlying liability to bulimia that was due to additive genetic factors (A), family or "common" environment (C), environmental factors shared by both members of a twin pair such as rearing environment, social class, and school), and individual specific environment (E; environmental influences unique to each member of a twin pair, including any unreliability of measurement). We began by fitting an ACE model that included additive genes, family environment, and individual specific environment. The fit of this model was assessed by a goodness of fit chi-square test. We then fitted two simpler models that postulate markedly different causes for any observed familial aggregation of bulimia. The AE model assumes that all familial aggregation results from additive genetic effects, while the CE model assumes that all observed familial aggregation is the result of shared environmental influences. The fit of each of these models was compared, by a likelihood ratio chi-square test with one degree of freedom, with that found for the ACE model. The best-fitting model was chosen using Akaike's information criterion (35), which reflects both the goodness of fit and the parsimony of the competing models.

RESULTS

Lifetime Prevalence, Risk, and Sampling Bias

Of the 2,163 interviewed twins, 32 were diagnosed as having definite, 28 probable, and 63 possible bulimia nervosa. Because of the limited sample size, and because subjects with both definite and probable bulimia met DSM-III-R criteria for the following analyses we divided our affected twins into two categories: definite and probable cases (sometimes termed "narrowly defined bulimia") and possible cases. We use the term "broadly defined bulimia" to refer to definite, probable, or possible cases of bulimia. The lifetime prevalence (the proportion of individuals who received the diagnosis at any time in their life) for definite and probable and for possible cases of bulimia was 2.8% (95% confidence interval of 2.1%-3.5%), and 2.9% (95% confidence interval of 2.2%-3.6%), respectively. The lifetime risks (the proportion of individuals who would be expected to receive the diagnosis if they completed their age at risk, here defined as age 50) for diagnoses of narrowly and broadly defined bulimia were, respectively, 4.2% and 8.0%.

No evidence was found in the twins for sampling bias with respect to bulimia, as the interview status of the co-twin did not significantly predict risk for broadly defined bulimia nervosa ($\chi^2=0.08$, n.s.). Mode of interview (face to face versus telephone) also did not significantly predict risk for a diagnosis of broadly defined bulimia ($\chi^2=2.10$, n.s.).

Method of Preventing Weight Gain

The methods used to prevent weight gain for twins with definite and probable versus possible bulimia are seen in table 1. Although all methods were more common in the twins with definite and probable bulimia.
than in those with possible bulimia, the patterns of methods used to prevent weight gain were similar (i.e., exercise was the most common, followed by strict dieting and vomiting). Self-induced vomiting was used to control weight gain in 40% of the twins with definite and probable bulimia and nearly 22% of the twins with possible bulimia. A review of the remaining DSM-III-R criteria for bulimia indicated that the greatest difference between the twins with definite and probable versus possible bulimia was in criterion D ("a minimum average of two binge eating episodes a week for at least three months"). While nearly all subjects with definite and probable bulimia endorsed this criterion, only one-third of the subjects with possible bulimia reported binges at least twice a week for 3 months.

Age at Onset and Cohort Effect

The mean±SD age at onset for subjects with definite and probable bulimia (20.9±6.5 years) was similar to that for the subjects with possible bulimia (20.5±5.3 years) (t=0.43, df=121, n.s.). Current age was negatively, although nonsignificantly, related to lifetime prevalence of bulimia (χ²=1.41, df=1, n.s.). This result, which is not explicable by a standard model of cumulative incidence, would be expected if individuals born more recently were at higher risk for the disorder.

To assess the presence of a cohort effect, we divided the sample into twins born before 1950 (N=367, mean age at interview=42.3 years), between 1950 and 1959 (N=761, mean age=33.0 years), and after 1959 (N=1,035, mean age=23.6 years). As seen in figure 1, the survival curves were significantly different across birth cohorts for subjects with both definite and probable bulimia (χ²=14.05, df=1, p=0.0002) and possible bulimia (χ²=4.07, df=1, p=0.04). The life table curves for definite and probable versus possible bulimia did not significantly differ (z=1.61, n.s.).

Comorbidity

The 123 subjects with broadly defined bulimia had the following additional lifetime psychiatric disorders: major depression, 63 (51.2%); phobia, 52 (42.3%); alcoholism, 19 (15.5%); generalized anxiety disorder, 14 (11.4%); anorexia nervosa, 12 (9.8%); and panic disorder, 11 (8.9%). Only 28 of the 123 subjects (22.8%) had no other lifetime psychiatric diagnosis.

The odds ratios for psychiatric disorders in subjects with definite and probable versus possible bulimia are seen in table 2. For subjects with definite and probable bulimia, all the odds ratios were statistically significant and ranged from 2.20 for major depression to 8.23 for anorexia nervosa. The pattern of results for subjects with possible bulimia was similar. The magnitude of comorbidity as assessed by the odds ratios did not differ for any of the disorders in the subjects with definite and probable versus possible bulimia.

Because of particular interest in the etiologic relationship between bulimia and depression (36-39), we ex-
BULIMIA NERVOSA

TABLE 2. Odds Ratios for Psychiatric Disorders in Female Twins With Definite and Probable Versus Possible Bulimia

<table>
<thead>
<tr>
<th>DSM-III-R Disorder</th>
<th>Definite and Probable Cases</th>
<th>Possible Cases</th>
<th>( \chi^2 ) for Homogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>95% Confidence Interval</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>Major depression</td>
<td>2.20</td>
<td>1.32–5.69</td>
<td>2.44</td>
</tr>
<tr>
<td>Phobia</td>
<td>2.37</td>
<td>1.41–3.97</td>
<td>1.65</td>
</tr>
<tr>
<td>Generalized anxiety disorder</td>
<td>2.61</td>
<td>1.21–5.62</td>
<td>1.75</td>
</tr>
<tr>
<td>Panic</td>
<td>3.00</td>
<td>1.25–7.20</td>
<td>2.30</td>
</tr>
<tr>
<td>Alcoholism</td>
<td>3.23</td>
<td>1.55–6.73</td>
<td>3.48</td>
</tr>
<tr>
<td>Anorexia nervosa</td>
<td>8.23</td>
<td>3.27–20.70</td>
<td>7.79</td>
</tr>
</tbody>
</table>

TABLE 3. Concordance Rate and Correlations of Liability for Broadly and Narrowly Defined Bulimia in Monozygotic and Dizygotic Female Twins

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Zygosity</th>
<th>N</th>
<th>%</th>
<th>Correlation of Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad</td>
<td>Monozygotic</td>
<td>18/69</td>
<td>26.1</td>
<td>0.30</td>
</tr>
<tr>
<td>Broad</td>
<td>Dizygotic</td>
<td>8/50</td>
<td>16.0</td>
<td>0.31</td>
</tr>
<tr>
<td>Narrow</td>
<td>Monozygotic</td>
<td>8/35</td>
<td>22.9</td>
<td>0.55</td>
</tr>
<tr>
<td>Narrow</td>
<td>Dizygotic</td>
<td>2/23</td>
<td>8.7</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Based on the order of ages at onset of the two disorders in the 63 subjects with both diagnoses, seven subjects (11.1%) reported onset of both disorders at the same age. Of the remaining 56 subjects, far more reported onset of depression before bulimia (N=45) than bulimia before depression (N=11) (\( \chi^2 = 20.6, df = 1, p = 0.0000 \)). The pattern of results was seen when only subjects with narrowly defined bulimia were considered.

Social Class, Personality Traits, and Rearing Environment

No significant relationship was found between risk for broadly defined bulimia and social class as indexed by years of education (\( \chi^2 = 1.57, n.s. \)), income (\( \chi^2 = 0.04, n.s. \)), or occupation (\( \chi^2 = 2.39, n.s. \)). Having a college education did not predict risk for bulimia (\( \chi^2 = 0.38, n.s. \)). Neither parental years of education (\( \chi^2 = 1.40, n.s. \)) nor parental occupation (\( \chi^2 = 0.74, n.s. \)) significantly predicted risk for bulimia.

Risk for broadly defined bulimia was unrelated to levels of extraversion (\( \chi^2 = 0.02, df = 1, n.s. \)) but was significantly related to high levels of neuroticism (\( \chi^2 = 31.25, p < 0.0001 \)), low levels of self-esteem (\( \chi^2 = 26.27, p < 0.0001 \)), and an external locus of control (\( \chi^2 = 6.09, p = 0.01 \)).

The risk for broadly defined bulimia was unrelated to the level of maternal care (\( \chi^2 = 0.81, n.s. \)), maternal overprotectiveness (\( \chi^2 = 0.01, n.s. \)), or paternal overprotectiveness (\( \chi^2 = 0.00, n.s. \)), but was significantly and negatively related to reported levels of paternal care (\( \chi^2 = 5.32, p = 0.02 \)).

Weight, Dieting, Level of Exercise, and Body Image

Current weight (\( \chi^2 = 0.10, n.s. \)), body mass index (\( \chi^2 = 0.19, n.s. \)), previous minimum weight since age 18 (\( \chi^2 = 0.45, n.s. \)), and previous maximum weight (\( \chi^2 = 1.12, n.s. \)) were not significantly related to risk for broadly defined bulimia. However, as assessed on an earlier questionnaire, maximum weight fluctuation (maximum weight–minimum weight) (\( \chi^2 = 8.91, p = 0.0028 \)), current dieting (\( \chi^2 = 20.59, p < 0.0001 \)), and high levels of exercise (\( \chi^2 = 11.99, p = 0.0005 \)) predicted the diagnosis of bulimia made on subsequent interview.

As assessed on this same questionnaire, while the “usual” body image did not predict risk for bulimia (\( \chi^2 = 2.19, n.s. \)), risk for a subsequent diagnosis of bulimia was associated with a slim ideal body image (\( \chi^2 = 5.26, p = 0.02 \)). Neither the usual body image of the mother (\( \chi^2 = 0.95, n.s. \)) nor that of the father (\( \chi^2 = 0.34, n.s. \)) significantly predicted risk for bulimia.

Risk Factors for Definite and Probable Versus Possible Bulimia

None of the identified risk factors for broadly defined bulimia significantly discriminated between definite and probable versus possible bulimia. These risk factors included neuroticism (\( \chi^2 = 0.79, n.s. \)), self-esteem (\( \chi^2 = 0.29, n.s. \)), locus of control (\( \chi^2 = 1.73, n.s. \)), low paternal care (\( \chi^2 = 0.22, n.s. \)), weight fluctuation (\( \chi^2 = 0.01, n.s. \)), slim ideal body image (\( \chi^2 = 0.35, n.s. \)), exercise (\( \chi^2 = 1.50, n.s. \)), and dieting (\( \chi^2 = 0.04, n.s. \)).

Examination of Potential Biases in Twin Analysis

Zygosity in our sample was unrelated to risk for bulimia (\( \chi^2 = 0.00, n.s. \)). When age was controlled, monozygotic twins had more similar childhood environments (\( \chi^2 = 15.73, p < 0.0001 \)) and more frequent contact with one another as adults (\( \chi^2 = 77.43, p < 0.0001 \)) than dizygotic twins. When the effects of age and zygosity were controlled, however, twin similarity for bulimia was unrelated to either the similarity of childhood environment (\( \chi^2 = 1.08, n.s. \)) or the frequency of contact as adults (\( \chi^2 = 1.08, n.s. \)).

Twin Concordance and Correlation of Liability

The probandwise concordance and the correlation in liability for bulimia, broadly and narrowly defined, for monozygotic and dizygotic twins are seen in Table 3. When either the broad or narrow definition was used,
TABLE 4. Model Fitting for Broadly and Narrowly Defined Bulimia and the Multiple Threshold Model in Female Twins

<table>
<thead>
<tr>
<th>Definition of Bulimia</th>
<th>Fit in χ² Units</th>
<th>Parameter Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACE</td>
<td>CE</td>
</tr>
<tr>
<td>Broad</td>
<td>0.98</td>
<td>0.15</td>
</tr>
<tr>
<td>Narrow</td>
<td>0.99</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.87</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

|^a^Additive genetic factors, C=family or common environmental factors, E=individual specific environmental factors.
|^b^df=0.
|^c^df=1.
|^d^df=2.
|^e^Best-fitting model by Akaike's criterion (35).

Concordance in both twin types substantially exceeded the population risk, thus providing evidence for the familial aggregation of bulimia. For example, for narrowly defined bulimia, the risk in a monozygotic cotwin of an affected twin exceeded the population risk by over eight times.

When either the broad or narrow definition of illness was used, the concordance rate in monozygotic twins substantially exceeded that found in dizygotic twins (broad definition: 26.1% versus 16.0%; narrow definition: 22.9% versus 8.7%). This correlation in liability for bulimia in monozygotic twins was relatively high (about 0.50 for both definitions) and considerably exceeded that found in dizygotic twins (about 0.30 for both definitions).

Fit of the Multiple Threshold Model

The multiple threshold model provides a statistical test for the hypothesis that possible, probable, and definite cases of bulimia result from the same underlying vulnerability and hence can all be called part of a bulimia spectrum. If this model fits well, it supports the hypothesis that subjects with possible, probable, and definite bulimia, in terms of their disease vulnerability, differ quantitatively but not qualitatively. The multiple threshold model fit well in both monozygotic twins (χ² goodness of fit=6.80, df=8, p=0.558), producing an estimated correlation of liability of 0.54, and in dizygotic twins (χ² goodness of fit=10.95, df=8, p=0.204), producing an estimated correlation of liability of 0.38.

Twin Model Fitting

The results of model fitting applied to correlations of liability for broadly defined bulimia, narrowly defined bulimia, and bulimia spectrum (obtained with the multiple threshold model) are seen in table 4. The findings, which were similar for all three definitions of illness, can be summarized as follows: 1) the E only model (which predicts no familial resemblance) was strongly rejected; 2) the full ACE model produced estimates of A that exceeded those of C; 3) by Akaike's criterion, the AE model was preferable to the CE model, although the statistical superiority was modest; and 4) the best-fitting model, by Akaike's criterion, produced estimates of the heritability of the liability to bulimia of between 50% and 55%.

DISCUSSION

Prevalence and Risk

Studies using various assessment methods and diagnostic criteria have produced widely varying estimates for the point prevalence of bulimia nervosa in women (2). In studies using personal interviews with DSM-III-R criteria, the point prevalence averaged across studies is 9.0% (2). Estimates of lifetime prevalence for DSM-III bulimia nervosa in young women have ranged from 1.7% to 4.2% (5, 6). One study, based on clinician re-interviews of a subset of an epidemiologic sample, has estimated lifetime prevalence of DSM-III-R bulimia, in women aged 18-44, at 1.6% (5). In the present study, the first to our knowledge to assess lifetime prevalence using DSM-III-R criteria from personal interviews of an entire epidemiologic sample, 2.8% of female twins born in the Commonwealth of Virginia received a lifetime diagnosis of bulimia. Our results are within the general range of previous estimates using DSM-III and DSM-III-R criteria. (While several studies suggest that DSM-III criteria for bulimia are broader than DSM-III-R criteria [2, 10], others have found little difference in caseness defined by the two criteria sets [5, 40].) It is plausible that true differences exist in lifetime rates for bulimia across populations and/or age groups, but further research will be needed to demonstrate this conclusively. However, our estimate of lifetime risk for DSM-III-R bulimia in women of 4.2%, increasing to 8.0% if probable bulimia-like syndromes are included, supports the importance of this syndrome from a public health standpoint.

Methods of Weight Loss

In our epidemiologic sample of bulimic women, 40% of women with narrowly defined bulimia reported self-induced vomiting and 30% laxative abuse. These figures are considerably lower than those reported in clini-
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cal samples (41) but similar to those previously reported in nonclinical populations (5, 8). These results suggest that bulimics with deviant methods of weight control (i.e., vomiting or laxative abuse) are more likely to be seen in psychiatric settings than those who use normal weight control methods (i.e., dieting and exercise).

Age at Onset and Cohort Effect

In our population-based sample, the mean age at onset for bulimia was about 20 years, several years later than that reported in samples obtained from clinical settings (37, 41, 42). This discrepancy may result from a greater tendency for subjects with early-onset bulimia to seek treatment.

While it is often stated that bulimia is becoming more common, empirical support for this view is slight. Three studies found evidence for increasing (8), decreasing (43), or stable (44) rates of bulimia during the 1980s. When we divided our sample into three birth cohorts (before 1950, 1950–1959, and after 1960), we found that the later the cohort of birth the higher the risk for bulimia and the earlier the age at onset. These results are similar to those recently reported from a general population sample in New Zealand, where the lifetime prevalence for DSM-III bulimia nervosa in women was much higher in younger than in older age groups (5).

This pattern of results is consistent with a cohort or period effect for bulimia. However, because our data, as well as that of the New Zealand sample (5), were gathered retrospectively at one time, the pattern of findings could be explained by two artifacts: a cohort effect for greater awareness of bulimia as a “disorder” and time-dependent forgetting. Older women who experienced bulimia might be less likely to identify it as a “disorder,” and hence less likely to recall and report it, than similarly affected younger women. Alternatively, given that onset of bulimia is usually in young adult life, older women will, compared to younger women, have a longer time span in which to forget bulimia. Only prospectively gathered data can powerfully discriminate between real and artificial explanations of the cohort variations observed for bulimia.

Comorbidity

Most previous studies of comorbidity in bulimia have examined clinical samples. Because individuals with two disorders are more likely to present for treatment than individuals with one disorder, comorbidity may be exaggerated in clinical populations (45). In our nonclinical sample, we documented significant comorbidity between bulimia and a wide range of psychiatric disorders. Contrary to the opinion of some (37–39), our results were not consistent with a special etiologic relationship between bulimia and depression. While a large proportion of patients with bulimia had a history of major depression, this disorder also had a high base rate in the sample. The odds ratio between bulimia and depression was modest and lower than for most other psychiatric disorders examined. Contrary to most (36, 38) but not all (14) studies done in clinical settings, we found that in most subjects with lifetime diagnoses of both major depression and bulimia, the onset of bulimia followed rather than preceded that of major depression.

Consistent with previous reports (14, 38, 41), we found significant comorbidity between bulimia and both alcoholism and anxiety disorders. The highest odds ratio was found for anorexia nervosa, suggesting some shared etiologic features in these two eating disorders. Our results, however, are consistent with both clinical series (41) and population-based studies (5, 6, 8) in suggesting that only a small minority of patients with bulimia also have a history of anorexia nervosa.

Social Class

Preoccupation with weight and body image is positively associated with social class (46). It has been claimed that boarding schools and colleges may “breed” bulimia (47). However, in our population-based sample, we found no strong evidence for a relationship between bulimia and social class. College attendance was not associated with an increased risk for bulimia. These results are consistent with previous epidemiologic (3) and clinical (48) studies that also found no relationship between social class and bulimia or bulimic behaviors.

Personality

The level of extraversion of bulimic women did not differ from that of the overall sample, while they had, on average, a considerable elevation in neuroticism. These results are broadly consistent with previous clinical (49–51), psychometric (46), and epidemiologic (3) studies that report an association between personality dysfunction and bulimia or bulimic behavior. Given the reported association between avoidant personality disorder and bulimia (50, 51), we were surprised to find no association between levels of introversion and risk for bulimia in our subjects.

Self-Esteem, Body Size, and Image

Bulimia most often occurs in individuals with normal weight, but it is also seen in underweight and overweight individuals (37). Although several researchers have found an association between obesity and bulimia (52, 53), in our general population sample, current weight, body mass index, previous heaviest weight, and usual body silhouette were not related to risk for bulimia. However, bulimic twins had significantly greater previous weight fluctuations and rates of dieting. These results support previous findings that dieting may be a risk factor for bulimia (46, 54).

Level of exercise in our sample was strongly related to risk for bulimia. Eating disorders appear to cluster in certain occupational groups, including athletes (46). Ath-
letic activity in adolescents has been reported to be associated with dissatisfaction with body weight and image (55).

Consistent with results from both clinical (46, 56) and epidemiologic (4, 8) samples, bulimic twins in our sample had significantly slimmer ideal body images than nonbulimic twins. Risk for bulimia was also related to low levels of self-esteem and an external locus of control. These findings support previous research in women linking self-esteem to body image satisfaction (57–59) and bulimia to a high need for approval from others (60, 61).

Parents and Risk for Bulimia

Research based on clinical samples has often hypothesized that parental expectation and a disturbed parent-child relationship are critical etiologic factors in eating disorders (12, 62). Although limited in scope, results from our population-based sample provided little support for these hypotheses. Parental social class was unrelated to the risk for bulimia, suggesting that a greater parental demand for thinness, which is positively associated with social class (63), is unlikely to be of etiologic importance in this syndrome. Risk for bulimia was also unrelated to maternal or paternal body image as reported by the twin; it is therefore unlikely that bulimia is caused by either a reaction formation against parental obesity or a striving to match the body image of a thin parent (3, 46). Contrary to research that has emphasized the role of disturbed mother-child relationships in eating disorders (12, 62), of the four dimensions of parent-child behavior retrospectively reported by the twins, only paternal care correlated significantly with risk for bulimia.

The Role of Genes in the Etiology of Bulimia

Previous family studies have disagreed as to the presence or magnitude of familial aggregation for bulimia. Two small family twin studies reported substantially higher concordance rates for bulimia in monozygotic than dizygotic female twins (16, 17). Most previous family or twin studies of bulimia have been uncontrolled, have relied on only indirect or self-report information, or have ascertained their sample through treatment facilities or by advertisement. In the present population-based sample, all twins were personally interviewed by mental health professionals and no interviewer ever evaluated both members of a pair. We tested for bias in the twin method in several ways. The risk for bulimia was unrelated to zygosity, similarity of childhood environment, or frequency of contact as adults. Our results support the validity of the “equal environment assumption” of the twin method with respect to the risk for bulimia.

Consistent with previous reports (17, 18), probandwise concordance in our sample was substantially higher in monozygotic than in dizygotic twins for both narrowly and broadly defined bulimia. Model fitting was then applied to both definitions; the best-fitting model in each case suggested that about 50% of the variance in liability was due to additive gene action and 50% to individual-specific environment. However, because of the small number of affected twins, the statistical superiority of this model over a model in which twin resemblance was due to familial-environmental factors was modest. Model fitting results therefore need to be interpreted with caution. Although we do find evidence consistent with genetic influences on risk for bulimia, the evidence against an effect of familial-environmental factors is relatively weak. Given our sample size of affected twins, if genetic factors are significant, we have almost no statistical power to detect an additional modest familial-environmental effect (64).

Bulimia Nervosa and the Bulimia-Like Syndrome

Several epidemiologic investigations have observed a spectrum of bulimic behaviors in which “subsyndromal” cases are at least as common as cases meeting full diagnostic criteria for bulimia (2–5, 8, 11). Consistent with these findings, in our sample, cases of possible bulimia were slightly more common than cases judged to meet full DSM-III-R criteria for bulimia nervosa. These possible cases most frequently failed to meet criterion D; while the subjects had the clinical features of the bulimic syndrome, their binges were less frequent than two per week for 3 months.

A focus of this report was therefore to examine, from an epidemiologic and genetic perspective, the relationship between these bulimic-like syndromes and classic bulimia nervosa. Our results were clear-cut. All the epidemiologic risk factors that affected classic bulimia nervosa influenced the risk for the bulimic-like syndrome to a similar degree. The putative period or cohort effect was nearly identical for the two syndromes. A multiple threshold model which hypothesized that the two syndromes reflected different levels of severity on the same continuum of liability fit well in both monozygotic and dizygotic twins. These results consistently support the spectrum concept of bulimia. A bulimic-like syndrome with binge eating episodes less frequent than twice per week for 3 months may differ quantitatively but does not appear to differ qualitatively from the classic disorder of bulimia nervosa.

Limitations

The results of this report should be interpreted in the context of four potential limitations. First, twins may not be representative of the general population with respect to eating disorders. Although studies have suggested no differences in the overall rate of psychiatric disorder in twins and singletons (65, 66), no study has specifically compared rates of eating disorders in these two populations.

Second, selection of our sample may not be random with respect to bulimia. Although we began with a register of all twins born in Virginia, those who migrated
out of state or who did not return our initial questionnaires are not represented. However, the refusal rate at the personal interview stage was low and appeared to be unrelated to risk for bulimia.

Third, the associations reported between risk for bulimia and personality traits and weight history are correlated and may not be causal. While several of these measures were obtained years before the personal interview, in many cases this was still after the reported onset of bulimia. Poor self-esteem, neuroticism, or a history of weight fluctuations may predispose an individual to bulimia. Alternatively, bulimia may predispose an individual to poor self-esteem, neuroticism, and weight fluctuations.

Finally, the analyses presented are incomplete. Our goal here was to outline the major features of the epidemiology and genetics of bulimia in our sample. Many of our potential risk factors (e.g., neuroticism and low self-esteem) are probably highly correlated, and a full treatment of these relationships would require multiple regression techniques, as well as the addition of other potential risk factors on which we have information, including symptoms of anxiety and depression, coping behavior, alcohol intake, and parental history of psychiatric illness. Our genetic analyses are also incomplete. In particular, it will be of great interest to employ multivariate genetic analysis to examine the relationship between bulimia and the other major comorbid conditions, including depression, alcoholism, and anxiety disorders. If the sample size is sufficient, these methods will allow us not only to determine whether these disorders share familial risk factors, but also to estimate the degree to which such shared factors are the result of genes or family environment.

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