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A computerised screening instrument for adolescent depression: population-based validation and application to a two-phase case-control study

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Abstract Computer-administered questionnaires have been little explored as a potentially effective and inexpensive alternative to pencil and paper screening tests. A self-administered computerised form of the revised Clinical Interview Schedule (CIS-R) was compared with the Composite International Diagnostic Interview (CIDI) in a two-phase study of 2032 Australian high school students (mean age 15.7 years) drawn from a stratified random sample of 44 schools in the state of Victoria, Australia. Prevalence, sensitivity and specificity were estimated using weighting to compensate for the two-phase sampling. Point prevalence estimates of depression using the CIS-R were 1.8% for males and 5.6% for females – an overall prevalence of 3.2%. Prevalence estimates for depression in the past 6 months using the CIDI were 5.2% for males and 16.9% for females – an overall estimate of 12.1%. The CIS-R had a positive predictive value (PPV) of 0.49 and negative predictive value (NPV) of 0.91 for CIDI depression in the past 6 months. Specificity was very high (0.97) but sensitivity low (0.18), indicating that a majority of those with a CIDI-defined depressive episode in the past 6 months were not recognised at a single screening using the CIS-R. Even so, the CIS-R has proved at least as good as any pencil and paper questionnaire in identifying cases for nested case-control studies of adolescent depression. Further exploration of strategies such as serial screening to enhance sensitivity is warranted.

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Introduction

Episodes of depression are common in adolescence. The study of these early episodes offers a prospect of distinguishing antecedents of disorder from either consequences of depression or determinants of its course. As yet, few population-based studies of adolescent depression have been reported [1–3]. Most studies have taken place within clinical samples, where the likelihood of referral bias renders interpretation of associations difficult [2, 4, 5].

Case identification remains difficult in population-based research into depression and other specific psychiatric syndromes in adolescents [6]. A strategy of interviewing all members of a population sample with a structured instrument demands very considerable resources [7–10]. Two-phase procedures, in which members of a population are initially screened and then subgroups later interviewed for diagnostic assessment, seem an attractive alternative [11–14]. In practice, the scope for utilising two-phase designs in the study of adolescent depression has been limited by the efficiency of first phase pencil and paper screening measures. Achieving both satisfactory sensitivity and specificity against diagnostic interview has proved elusive. As a result, the positive predictive value of questionnaire screens, i.e. the proportion of screen positives confirmed as cases in second phase interviews, has been low in previous studies. A majority of second phase interviews have therefore been with non-cases, limiting potential gains in efficiency from a two-phase design [15].

Computer-administered questionnaires have been little explored as an alternative first phase screen to pencil and paper screening tests [16]. They have a number of potential advantages in case identification beyond efficiencies in data collection and entry. Complex decision-trees can be incorporated within the branched questionnaire, and thus questions are posed on the basis of previous responses, bringing enhanced accuracy and savings in time [17]. The concurrent use of a

diagnostic algorithm offers a scoring system tailored to a particular disorder and study research criteria, rather than a global score typical of fixed self-report questionnaires. Such algorithms allow exclusion of symptoms with lesser value in discrimination [18].

The Revised Clinical Interview Schedule (CIS-R) was among the first structured psychiatric interviews to be computerised and has been used in both outpatient and general practice settings. It is an attractive screening option for early onset psychiatric disorder, as the Clinical Interview Schedule (CIS), from which the CIS-R was derived, has been used as a criterion measure of "caseness" in community studies of adolescents [19, 20]. In this paper, its screening potential in the identification of depression is examined in a community sample of older adolescents. Specifically, the computerised CIS-R is compared with the Composite International Diagnostic Interview (CIDI), a widely used structured interview for community surveys.

Subjects and methods

The computerised version of the Revised Clinical Interview Schedule (CIS-R) [19, 21] is a branched questionnaire designed for assessing symptoms of depression and anxiety in non-clinical populations. Its 14 subscales delineate the frequency, severity, persistence and intrusiveness of common symptoms. The CIS-R has an ease of reading consistent with its suitability for a teenage group (Flesch Reading Ease 78.5, Flesch Grade Level 7.1). The depression and hypomania modules of the Composite International Diagnostic Interview (CIDI), a structured diagnostic interview devised for use by non-medical professionals after a standardised training, was used for second phase diagnosis [22]. The Core Version 1.1 used in this study generated diagnoses according to the ICD-10 classification system [23]. A research psychologist, trained in the use of the CIDI and blind to first phase CIS-R scores or risk status, conducted the second phase interviews.

Adjusting the screening algorithm

The CIS-R algorithm for ICD-10 depressive disorder, as defined in the CIS-R manual, was examined in a preliminary calibration study before testing it in a larger sample [21]. The calibration sample derived from four schools selected as typical of schools found across the state of Victoria: a Catholic boys' secondary, an Independent private girls' secondary and a rural and a metropolitan comprehensive. One year 9 and one year 10 class were selected at each comprehensive school and a year 10 class at the Catholic and Independent schools. The computerised Clinical Interview Schedule (CIS-R) was administered in the first phase. Subjects who fulfilled the diagnostic algorithm for ICD-10 major depression, based on the manual of the CIS-R, were all selected for a second phase interview [21]. An approximately one-in-three sample of subjects who fulfilled two or three of the provisional criteria for major depression and a one-in-five sample of those with either zero or one criterion fulfilled were selected randomly for second phase interview. The second phase interview (CIDI) took place within 3 weeks of screening. Depression caseness on the CIDI was defined as reporting a depressive episode in the past 6 months. There is evidence that recall beyond this point is prone to error in younger samples [24], and the 6-month definition minimised a problem of discrepancies arising from a resolution of a depressive episode where the second phase interview was delayed. Agreement between the CIS-R and CIDI were compared in the interviewed sample on each of the ten individual criteria for ICD-10. The algorithm for each criterion for depressive episode in the CIS-R was modified by adjusting the thresholds for frequency, severity, persistence and intrusiveness of individual symptoms to give greatest agreement (i.e. highest kappas) with the definition for each criterion given by the CIDI. The resulting algorithm was tested for its capacity to identify subjects for second phase interview in the main study.

The main study sample

The main study used a cross-section of participants in a multiwave cohort study of adolescent health in Victoria, Australia. The sample was defined in a two-stage cluster sampling procedure in 1992. At stage one, 45 schools were selected from a stratified sampling frame of Government, Catholic and Independent schools, with a probability proportional to the number of year 9 students (age 14–15 years) in schools in each stratum in the state (total number 60,905). The state has a population of 4.4 million, of whom 63% live in the capital city Melbourne [25]. At stage two, two single intact classes were selected at random, one at the first wave of data collection and the other 6 months later at the second wave, when the sampling frame had moved into year 10. One school from the initial sample was unavailable for the cohort study, leaving a total sample of 44 schools. Of these, 24 were Government, 11 Catholic and 9 Independent private. Subjects completed a computerised questionnaire at intervals of 6 months. The assessments in this report took place between April and September 1993.

Assessment procedure

Phase 1

The Revised Clinical Interview Schedule (CIS-R) [19, 21] was the phase one screening measure. Subjects who completed the first phase of the study were classified into high (CIS-R+) or low risk (CIS-R−) categories according to whether they fulfilled criteria of ICD-10 depressive disorder using the adjusted algorithm. All CIS-R+ subjects were invited to second phase interview. For each CIS-R+ subject, two CIS-R− subjects were selected at random for interview from the same school.

Phase 2

The second phase interviews took place at a subject's school, using the depression and hypomania modules of the CIDI within 3 weeks of completion of at least 70% of first phase assessments in that particular school.

Analysis

Data analysis was carried out using Stata [26]. All analyses used weights calculated to approximate the inverse probability of selection into the final (second phase) sample. Stata's "survey estimation" commands provided weighted estimates for both simple proportions and ratios, such as required for estimating sensitivity and specificity, and for logistic regression models. Standard errors are based on Taylor-series approximations [27]. For those positive on the CIS-R criterion ("first phase cases"), weights were calculated as the inverse of the participation rate at phase two. For CIS-R negatives ("first phase non-cases"), weights were estimated separately in tertiles determined by the likelihood of selection as a putative control, taking account of the fact that two controls were selected per case within each school from which a case arose. Within each tertile the weight applied to each CIS-R negative was the inverse of the ratio of the total number of CIS-R positives to twice the number of available control subjects. It needs to be remembered that a small number of CIS-R negatives were found positive at the second phase, and these carried high weights in the analysis.

Results

Adjustment of the CIS-R algorithm for depressive disorder

Participants in the preliminary calibration study were 157 (96%) of 164 students on the class rolls. Of these, 38% ($n = 60$) were in year 9 and 62% ($n = 97$) in year 10. Mean age was 14.6 years (SD 0.6), and 52% of the subjects were male. Of the 157 subjects, 9 fulfilled the provisional criteria for ICD-10 depression and were selected for second phase interview. Fourteen out of 43 subjects who fulfilled criteria for depressive symptoms and 18 out of 105 subjects with minimal or no depressive symptoms were seen for second phase interview. All those selected for second phase interview were assessed.

Initial validity coefficients were estimated using inverse probability weighting, and were as follows: sensitivity 0.49, specificity 0.97 and positive predictive value (PPV) 56%. The diagnostic algorithm was revised by adjusting thresholds for individual criteria to provide maximum agreement within the interviewed sample between the CIS-R and the CIDI. Validity coefficients for the revised algorithms were re-estimated: sensitivity 0.30, specificity 0.99 and PPV 75%. The higher PPV was in keeping with the aim of identifying a group for interview with a high likelihood of caseness and the modified algorithm was therefore used for case selection in the case-control study.

The study sample

From the total selected sample at outset of 2032 students, 1729 subjects completed the first phase questionnaire – a response rate of 85% of the population selected for participation. The gender ratio of the achieved sample (47% males) was similar to that in Victorian schools at the time of sampling [28]. The mean age of the achieved sample was 15.7 years (SD 0.5). A comparison of participants with 218 non-participants in the first phase indicated higher rates of maleness (47% vs 58%, $\chi^2 = 8.2$, $P = 0.004$), parental divorce (15% vs 26%, $\chi^2 = 14.7$, $P < 0.001$) and languages other than English being spoken at home (9% vs 16%, $\chi^2 = 5.1$, $P < 0.024$) in the non-participants.

Comparison of CIS-R and CIDI diagnoses

Sixty-five subjects fulfilled the criteria for current ICD-10 depression on the CIS-R using the revised algorithm – a prevalence of 3.8% (95%CI 2.9–4.7). Prevalence estimates were substantially higher in females than males (5.6% vs 1.7%, $\chi^2_1 = 18.05$, $P < 0.001$). Fifty-three (82%) of the 65 subjects fulfilling criteria for depression on the CIS-R were assessed at phase two; 105 controls drawn from the same schools as cases also completed the second phase interviews. Second phase interviews took place between 2 and 9 weeks from initial screening, delays arising from the requirement to complete 70% of first phase screens before drawing of controls.

Table 1 compares the CIS-R against three CIDI definitions of major depression reflecting recency of symptoms at the time of the CIDI interview. Given a delay of up to 9 weeks in the second phase assessment, depression in the past 6 months was taken as the principal criterion index. Specificity was very high but sensitivity low, with an estimated one in five of all subjects with CIDI-defined depression classified as such by the CIS-R. PPV was reasonably satisfactory in that around one-half of those identified by the Revised Clinical Interview Schedule as high risk were confirmed with the CIDI. Validity coefficients for original CIS-R algorithm, previously examined in the calibration study, were estimated using the same inverse probability weights. Compared with the revised algorithm, it had a lower specificity (0.92, 0.87–0.97) for CIDI depression in the past 6 months, somewhat higher sensitivity (0.33, 0.07–0.6), lower PPV (0.36, 0.14–0.58) and similar NPV (0.91, 0.83–0.98).

Prevalence of major depression

Prevalence estimates derived from the CIS-R and the CIDI are shown in Table 2. The CIS-R measures

Table 1 Validity coefficients [a] (with 95% confidence intervals) of the computerised Revised Clinical Interview Schedule (CIS-R) definition of ICD-10 depression compared with diagnosis of depressive episode in the past 6 months obtained at interview with the Comprehensive International Diagnostic Interview (CIDI) (*PPV* Positive predictive value, *NPV* negative predictive value)

First phase assessment	Second phase assessment (CIDI)			
	Depressive episode	No depressive episode	Total	
CIS-R positive	26	27	53	PPV 0.49 (0.35–0.63)
CIS-R negative	9	96	105	NPV 0.91 (0.82–0.97)
Total	35	123		
	Sensitivity 0.18 (0.05–0.32)	Specificity 0.97 (0.96–0.99)		

[a] Estimates for sensitivity and specificity obtained using inverse probability weighting as described in Subjects and methods

Table 2 Prevalence estimates (95% confidence intervals) for ICD-10 depression in males and females using the CIS-R and the CIDI respectively

	Male	Females	Total	Gender ratio
CIS-R – Current major depression	1.8 (0.9–2.7)	5.6 (4.1–7.1)	3.8 (2.9–4.7)	3.2 (1.8–5.7)
CIDI – Current major depression	0.6 (0–1.4)	9.8 (0.3–19.3)	6.2 (0.3–11.8)	17.3 (3.5–85)
CIDI – Depression in past 6 months	5.2 (0–11.5)	16.9 (5.8–28)	12.1 (5.0–19.3)	3.7 (0.8–16)
CIDI – Depression ever	8.1 (0–16)	18.4 (7.1–30)	14.2 (6.6–22)	2.6 (0.7–9.7)

symptoms present in the previous 7 days, and is therefore viewed as giving a measure of current depression. The weighted CIDI prevalence estimate for major depression in the past 6 months was 12.1% (5.0–19.3). The female to male ratio for depression in the past 6 months was 3.7. The gender ratio for CIDI-defined depression decreased substantially from estimates of current to lifetime depression.

Associations with major depression (Table 3)

The pattern of demographic associations with depression was examined for CIS and CIDI definitions respectively. For CIDI-defined depression in the past 6 months, the analysis was carried out both as a simple unweighted case-control analysis and using inverse probability weighting, as described in the Subjects and methods section, to illustrate the potential extent of bias in the unweighted analysis.

Gender had a clear and consistent association with depression, the strength of which varied little across definitions and analysis methods. Parental divorce similarly showed a consistent robust association. Australian place of birth, which had a more extreme frequency in this sample (87%), showed a less consistent pattern of association across the three analyses. The weighted analysis, indicating a stronger link with Australian birth, was influenced by cases among the CIS negatives receiving high weighting.

Discussion

This paper reports the use of a computerised screen in a population-based study of early onset depression. Specifically it compares the Revised Clinical Interview Schedule (CIS-R) with an established structured interview for administration by trained interviewers. Participation rates in the first phase of the study compare favourably with those obtained using other screens and suggest that the computerised screen is acceptable in this age group.

A PPV of 0.49 for a depressive episode in the past 6 months suggests that it is a useful tool for identifying subjects with a high likelihood of caseness. Conversely, the NPV of 0.91 indicates the great majority of putative non-cases will prove to be negative at interview. Such findings suggest that the computerised CIS-R has practical utility as a first phase screen for adolescent depression. However, its sensitivity was low, in that only one in five estimated cases of depression were identified. An explanation may have been the different time frame for symptom definition used in the two phases of the study, since the CIS-R used a current definition in contrast to the lifetime diagnosis generated by the CIDI. However, sensitivity varied little when alternative definitions of current depression and depression ever were used, suggesting that this is not an adequate explanation. An alternative possibility, that the second phase measure had a different threshold for diagnosis, also seems unlikely as the prevalence estimates for current depression using the CIS-R and CIDI were similar. These in turn were similar to recent estimates for current depression and past depression in older adolescent and young adult samples [29, 30]. A plausible explanation for the low sensitivity of the CIS-R is short-term variation in subject response. Despite being a highly standardised assessment instrument, Lewis et al. [31] noted considerable variation in CIS-R responses even when the interval between testing was only a few minutes. It is therefore possible that variations in subject response as well as actual changes in symptoms may have contributed to the rates of false-negatives and, therefore, low sensitivity estimates.

Direct comparison of the screening effectiveness of the CIS-R with early pencil and paper questionnaires is limited by the different age of samples and different second phase assessments. Garrison et al. [15] compared the CES-D with second phase interview using the Present Episode version of the Schedule for Affective Disorders and Schizophrenia in School Aged Children

Table 3 Associations between ICD-10 depression and demographic factors, estimated using multivariate logistic regression, for CIS-R-defined major depression and for CIDI-defined depression in the last 6 months

	CIS-R-defined major depression (n = 1729)	CIDI-defined depression [a] (n = 187)	
		Unweighted analysis	Weighted analysis
Gender	3.2 (1.8–5.7)	3.8 (1.4–9.8)	3.7 (0.8–16)
Metropolitan residence	1.1 (0.6–2.1)	0.9 (0.4–2.2)	1.8 (0.5–6.2)
Parental divorce	2.2 (1.3–4.0)	2.8 (1.1–7.2)	3.1 (0.7–13)
Australian birth	1.8 (0.7–4.5)	1.3 (0.2–6.7)	7.6 (1.1–52)

[a] Depressive episode in the past 6 months used as dependent variable

(K-SADS) in a younger adolescent population and found optimal PPVs for major depression of 25% in females and 13% in males. The younger age of the sample and lower prevalence of depression in this study may explain the lower PPVs. The study of Roberts et al. [32] is more comparable with the present one. They examined both the CES-D and Beck Depression Inventory (BDI) as screens for detecting DSM-IIIR major depression using a second phase interview with the Kiddie SADS in an older adolescent school sample. PPVs were 0.25 for the CES-D and 0.30 for the BDI for depression ever, which had a prevalence of 16%. For current major depression with a prevalence of 2.5%, PPVs were 0.08 and 0.1 respectively. Olsson and von Knorring [6] reported a more recent study using the BDI in Swedish students aged 16–17 years in one high school. The BDI at a cut-off of 16 had a PPV of 0.49 and NPV of 0.94 against a criterion of depressive episode in the past year diagnosed on the DICA-R-A, a structured psychiatric interview. Sensitivity and specificity were not reported, but the comment was made that sensitivity was probably very low. It was also not clear that second phase interviews were conducted blind to first phase status. In this context, the computerised CIS-R has performed at least as well as the best pencil and paper questionnaire screens, achieving a PPV of 0.49 for depression in the past 6 months, a criterion with an estimated prevalence of 12.1%.

This study has noteworthy methodological strengths in comparison to previous reports. The procedure for case identification was tested in a calibration sample before an independent assessment in a large representative population-based sample. The time to second phase assessment was controlled and limited to 2 months, a shorter period than used in most earlier studies using a two-phase design. Nevertheless, there are some limitations, which are recognised. The calibration study was carried out in a small sample and the development of the diagnostic algorithm used in the main sample was based on reports from the second phase subjects in the calibration study – a group with higher rates of depressive symptomatology than in the main sample. This raises a possibility of mis-specification of validity coefficients, but estimates derived from the main sample suggest that the revised algorithm continued to have both a higher PPV and specificity and lower sensitivity than the original CIS-R algorithm.

The cohort sample, on which this study was based, was derived from a representative group of Victorian secondary schools, but some sampling limitations are noted. Early school leavers, not included in the sampling frame, probably do have higher levels of psychiatric morbidity [33]. However, school retention rates of 98% to year 9 for Victoria in the year of initial sampling should have minimised this bias [34]. Non-participation of the targeted sample is a further consideration. Response rates of 85% at the first phase were high, but comparison of responders with non-responders revealed differences on demographic characteristics associated with depression. This raised the possibility of response bias leading to mis-specification of prevalence estimates and patterns of association. The inverse weighting procedures used in this study took into account second phase participation rates, but assume that non-participants were similar to participants – an assumption that may not be warranted. Achieving high first phase response rates brought a cost in delaying some second phase interviews up to 2 months, and may in part explain the rate of false-negatives found. If the course of episodes of depression differs in males from females, this may also be one reason why the gender ratio found for current depression on the CIDI was so skewed.

This paper illustrates the use of inverse probability weighting in the analysis of a two phase case control study with a school sampling frame. This approach provided a means to estimate prevalence from second phase data, to calculate validity coefficients for the first phase screen and allow adjustment in the case-control analyses for bias arising from a two-phase identification of cases and the drawing of controls from the same schools as cases. This strategy has recently been employed in a general practice sampling frame, and our report demonstrates its scope in a school-based study [35]. Appropriately weighted analysis is even more important where a substantial proportion of cases in the base population are not included in the second phase study because of low sensitivity of the screening instrument. Even so, it is clear that for the estimation of associations with risk factors with lower prevalences, precision in estimation requires screening of large samples in the first phase.

The CIS-R and other self-administered computerised assessments appear to have great potential as screening instruments for population-based studies. The CIS-R itself was not designed as a screening instrument and includes many items that are common symptoms of disorder, but not specific for major depression. There appears to be scope for modification of items and an overall reduction in the length of the questionnaire leading to a more economical screening instrument with similar or even better screening properties than the CIS-R. On the basis of this study, further exploration and development of the screening potential of computer-administered screening questionnaires seem warranted. Short-term variability in symptoms is likely to continue to present a major challenge in gaining satisfactory sensitivity. Extending the time for reporting symptoms may offer one way to improve instrument sensitivity. However, it is also clear that recall error for reporting psychopathology rises sharply in this young age group [36]. Strategies of parallel screening, using other informants or measures, or alternatively serial screening may prove beneficial depending on the purpose of the investigation. If marked short variation in depressive symptoms levels is found in adolescents, serial screening strategies in which a population is studied on multiple occasions may ultimately prove the best way to identify a more complete and representative sample of cases for case-control study.

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Appendix

Derived algorithm for screening for ICD-10-defined depressive Episode based on questions from the CIS-R

Criterion A The depressive episode should last for at least 2 weeks
> 2 weeks since onset

Criterion B At least two of the following symptoms

(1) depressed mood:
4 or more days in past week
AND
for at least 3 h on one occasion
AND
did not cheer up on one or more occasions
(2) loss of interest or pleasure in activities that are normally pleasurable:
in the past week
AND
for at least 3 h on one occasion
(3) decreased energy or increased fatigability
4 days or more in last week
AND
for more than 3 h

Criterion C Additional symptom/s from the following list to give a total of at least four:

(1) loss of confidence or self-esteem
within past week
(2) unreasonable feelings of self-reproach or excessive and inappropriate guilt
within past week
(3) recurrent thoughts of suicide or death or any suicidal behaviour
within past week
(4) complaints or evidence of diminished ability to think or concentrate
4 days or more in the past week
(5) change in psychomotor activity
talking or moving more slowly than is usual OR pacing up and down and unable to sit still
4 days or more within the past week
AND
3 h or more
(6) sleep disturbance
4 nights or more in the past week
(7) change in appetite with corresponding weight change
poor appetite in past week
AND
unintended > 3 kg weight loss within past few weeks or months

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