Social decline in the psychosis prodrome: Predictor potential and heterogeneity of outcome

Ricardo E. Carrión [a,b,c], Andrea M. Auther [a,c], Danielle McLaughlin [a], Jean Addington [e], Carrie E. Bearden [f], Kristin S. Cadenhead [g], Tyrone D. Cannon [h,i], Matcheri Keshavan [l], Daniel H. Mathalon [j], Thomas H. McGlashan [i], Diana O. Perkins [k], Larry Seidman [l], William Stone [l], Ming Tsuang [l], Elaine F. Walker [m], Scott W. Woods [i], John Torous [l], Barbara A. Cornblatt [a,b,c,d,*]

[a] Division of Psychiatry Research, The Zucker Hillside Hospital, Northwell Health, Glen Oaks, NY, United States
[b] Institute of Behavioral Science, Feinstein Institute for Medical Research, Northwell Health, Manhasset, NY, United States
[c] Department of Psychiatry, Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, New York 11549, United States
[d] Department of Molecular Medicine, Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, New York 11549, United States
[e] Hotchkiss Brain Institute, Department of Psychiatry, University of Calgary, Calgary, Alberta, Canada
[f] Semel Institute for Neuroscience and Human Behavior and Department of Psychology, University of California, Los Angeles, Los Angeles, CA, United States
[g] Department of Psychiatry, University of California, San Diego, La Jolla, CA, United States
[h] Department of Psychology, Yale University, School of Medicine, New Haven, CT, United States
[i] Department of Psychiatry, Yale University, School of Medicine, New Haven, CT, United States
[j] Department of Psychiatry, University of California, San Francisco, United States
[k] Department of Psychiatry, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[l] Department of Psychiatry, Harvard Medical School at Beth Israel Deaconess Medical Center and Massachusetts Mental Health Center, Boston, MA, United States
[m] Department of Psychology, Emory University, Atlanta, GA, United States

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ABSTRACT

Background: While an established clinical outcome of high importance, social functioning has been emerging as possibly having a broader significance to the evolution of psychosis and long term disability. In the current study we explored the association between social decline, conversion to psychosis, and functional outcome in individuals at clinical high risk (CHR) for psychosis.
Methods: 585 subjects collected in the North American Prodrome Longitudinal Study (NAPLS2) were divided into 236 Healthy Controls (HCs), and CHR subjects that developed psychosis (CHR + C, $N = 79$), or those that did not (Non-Converters, CHR-NC, $N = 270$). CHR + C subjects were further divided into those that experienced an atypical decline in social functioning prior to baseline (beyond typical impairment levels) when in min-to-late adolescence (CHR + C-SD, $N = 39$) or those that did not undergoing a decline (CHR + C-NSD, $N = 40$).
Results: Patterns of poor functional outcomes varied across the CHR subgroups: CHR-NC (Poor Social 36.3%, Role 42.2%) through CHR + C-NSD (Poor Social 50%, Poor Role 67.5%) to CHR + C-SD (Poor Social 76.9%, Poor Role 89.7%) functioning. The two Converter subgroups had comparable positive symptoms at baseline. At 12 months, the CHR + C-SD group stabilized, but social functioning levels remained significantly lower than the other two subgroups.
Conclusions: The current study demonstrates that pre-baseline social decline in mid-to-late adolescence predicts psychosis. In addition, we found that this social decline in converters is strongly associated with especially poor functional outcome and overall poorer prognosis. Role functioning, in contrast, has not shown similar predictor potential, and rather appears to be an illness indicator that worsens over time.

1. Introduction

Functioning in society involves such activities as having social support networks, forming healthy marital/family relationships, completing school, maintaining employment and achieving financial independence as an adult. Although independent from clinical symptoms, functioning is especially relevant for mental health in being a

* Corresponding author at: Zucker Hillside Hospital, Psychiatry Research, 75-59 263rd Street, Glen Oaks, New York 11004, United States.
E-mail address: BCornblatt@northwell.edu (B.A. Cornblatt).

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critical determinant of independence and quality of life. In patients with schizophrenia, impaired functioning is highly treatment resistant. Even with positive symptom improvement with treatment, functioning, especially the ability to perform standard everyday activities, typically remains problematic (Robinson et al., 2004; Tohen et al., 2000; Ventura et al., 2011) and accounts for the large financial burden associated with psychosis.

The Recognition and Prevention (RAP) program at the Zucker Hillside Hospital in New York has long focused on understanding how problematic functioning interacts with psychosis risk over time and is interconnected with the onset of psychosis (Cornblatt, 2002; Cornblatt et al., 2015; Cornblatt et al., 2003). Although there are a variety of definitions of functioning throughout the field, the RAP program has contributed to the operationalizing of constructs specific to the psychosis risk period by developing the two parallel Global Functioning scales, one for the social domain (GF:Social) and the other for role, (GF:Role) scale (Carrión et al., 2019; Cornblatt et al., 2007). Social functioning involves meaningful interpersonal connections and role functioning refers to independence in the community, specifically successful adaptation to school or work. Substantial evidence suggests that individuals at clinical high-risk (CHR) for psychosis display large impairments in social and role functioning, relative to healthy controls that affect many aspects of life (Addington et al., 2011; Addington et al., 2017; Carrión et al., 2019; Carrión et al., 2013; Cornblatt et al., 2007; Fusar-Poli et al., 2010; Lo Cascio et al., 2016; Olvet et al., 2015).

Findings from the RAP program have consistently demonstrated larger social functioning deficits in individuals at CHR who later develop psychosis (i.e., converters) compared to those who do not. These impairments are stable over time and independent of increasing attenuated positive symptom severity and emerging psychosis (Cornblatt et al., 2015). Moreover, recent data from the second phase of the North American Prodrome Longitudinal Study (NAPLS2) demonstrated that an atypical worsening of already impaired social functioning over mid-to-late adolescence identifies those individuals at the highest risk of conversion to psychosis. In fact, a decline in social functioning in the year before entering the study, when subjects were in mid-to-late adolescence, was included in the NAPLS Psychosis Risk Calculator and was reported to be one of the leading predictors of psychosis, second only to attenuated positive symptoms (Cannon et al., 2016; Carrión et al., 2016a). In contrast with social, a decline in role functioning was not predictive of psychosis, underscoring the independence of the social and role domains and strongly suggesting different domain etiologies (rather than supporting a general functioning construct) (Cornblatt et al., 2012). As suggested by findings from adult patients, poor role functioning may be more susceptible to environmental determinants, such as economic factors and access to educational resources (Green et al., 2008; Gupta et al., 2012; Harvey, 2014a, 2014b).

Emerging evidence further suggests that the CHR population overall is characterized by significant heterogeneity in social functioning. First, those CHR subjects who do not convert to psychosis, display a consistent moderate level of functional impairment that appears to be quite stable across early development and follow up. Secondly, among those CHR individuals who do convert, about half the group displays a marked decline in social skills beyond the typical level, in mid to late adolescence, while the remaining converters do not experience a comparable decline (Carrión et al., 2019). Therefore, the subsample of converters that undergoes a further deterioration of already impaired social skills could possibly represent different biological mechanisms underlying the development of psychosis. We propose that CHR heterogeneity can be used to refine risk profiles, point to false positive identifications, and potentially provide additional information about long-term functioning in addition to conversion to psychosis (Cornblatt and Carrión, 2016).

In the current study we expanded on our previous findings and explored the heterogeneity of social decline in mid-to-late adolescence within a large sample of CHR individuals from NAPLS2. We identified two subgroups of converters, specifically those who did and did not evidence a decline in social functioning in the year prior to the baseline assessment when they were 16–18 years old on average. First, we explored baseline differences on critical clinical variables in addition to functioning, such as attenuated positive and negative symptoms, and intellectual performance. Second, longitudinal patterns were examined in order to establish the stability of social functioning after baseline and after emergence of psychosis. Whether or not mid-to-late adolescent social decline is specific to high-risk individuals about to develop psychosis was assessed by determining if similar decline was displayed by either CHR non-converters or healthy controls. Finally, we examined the predictive potential of pre-illness social decline for functioning at study outcome in addition to psychosis. From a longitudinal perspective, functional outcome appears to be a general barometer of overall prognosis, and is useful in understanding, and possibly preventing, long-term disability in CHR individuals. Since global functioning can represent ability to operate as an independent member of the community, changing levels can be a metric for the success of various treatments, and a predictor of an individual's future dependence or independence.

2. Methods

2.1. Participants

Data was collected as part of NAPLS 2 ($N = 1042$), a multi-site prospective CHR study funded by the National Institute of Mental Health (Addington et al., 2012). The NAPLS2 sample consists of 764 CHR subjects and 278 Healthy Control (HC) participants collected at Emory University, Harvard University, University of Calgary, UCLA, UCSD, UNC at Chapel Hill, Yale University, and the Zucker Hillside Hospital in New York. Seven hundred and fifty-five CHR individuals and 277 HCs completed the functional measures at baseline. Recruitment efforts primarily resulted from direct referrals, referrals from community professionals, and advertising in the community and the internet (Addington et al., 2012).

Subjects met criteria for one of the three CHR syndromes derived from the Structured Interview for Psychosis-Risk Syndromes (SIPS) and the companion SOPS (McGlashan et al., 2010): 1. Attenuated positive symptom syndrome: the presence of one or more moderate, moderately severe, or severe attenuated positive symptoms; 2. Genetic risk and deterioration syndrome: genetic risk for psychosis coupled with deterioration in functioning; or 3. Brief intermittent psychosis syndrome: intermittent psychotic symptoms that are recent, brief in duration, and not seriously disorganizing or dangerous. CHR and HCs between the ages of 12–35 were eligible to participate.

Exclusion criteria for all participants included: 1. Any Axis I Schizophrenia-spectrum diagnosis; 2. Non-English speaking; 3. A medical or neurological disorder; 4. Estimated IQ < 70; 5. significant head injury; or 6. Severe substance abuse. HCs were additionally excluded if they had a first-degree relative with a diagnosed Axis I psychotic disorder. All procedures were approved by the Institutional Review Board (IRB) at each site. Written informed consent (with assent from participants <18) was obtained from all participants.

Details of the comprehensive baseline clinical assessment have been reported previously (Addington et al., 2012; Addington et al., 2015). Axis I diagnoses were assessed by the Structured Clinical Interview for DSM-IV (SCID-I) (First et al., 1995). Psychosis-risk symptoms were assessed by the Scale of Psychosis-Risk Symptoms (SOPS) (McGlashan et al., 2010).

Social and role functioning was measured with the Global Functioning:Social and Global Functioning:Role scales (Cornblatt et al., 2007). The GF:Social scale rates peer relationships, peer conflict, age-appropriate intimate relationships, and family involvement. The GF: Role scale assess performance and amount of support needed in one's

specific role (i.e., school/work) (Cornblatt et al., 2007). These rater-scored measures were provide brief and easy to use clinician ratings, account for age and phase of illness, detect changes over time, avoid confounding with psychiatric symptoms, and disentangle the social and role functional domains (Cornblatt et al., 2007). Each scale is anchored to reflect comparable success/failure, so that, for example, a score of 6 (scale from 1 to 10, 10 = superior functioning to 1 = extreme dysfunction) indicates the same level of impairment on both scales. Each GF scale generates 3 scores: 1. Current level, 2. Highest, and, 3. Lowest level of functioning in the past year prior to the assessment (Carrión et al., 2019). Decline in social functioning was defined as having a 1 point or greater drop on the GF:Social scale from the Highest level to the Current (baseline) level of functioning (Cannon et al., 2016; Carrión et al., 2016a; Cornblatt et al., 2007).

The current study included 79 CHR subjects who transitioned to psychosis out of a total of 92. Thirteen converters were excluded for not having a post-psychosis onset GF assessment. There was no significant difference between the converters included and excluded in the present analyses on relevant baseline variables (including age, time to conversion to psychosis, IQ level, social functioning, and total attenuated positive symptoms, $P > 0.05$ for all). In addition to the two groups of CHR Converters, the present study included a group of CHR subjects who had been followed at least 24 months without developing psychosis (CHR-NC, $N = 270$) (Carrión et al., 2019; McLaughlin et al., 2016). Healthy controls with at least one follow-up visit were also included for comparison purposes (HCs, $N = 236$). CHR Converter subjects were divided into two groups based on the presence or absence of a decline in social functioning in the year prior to the baseline assessment: 1. Converters with no social decline prior to baseline (CHR + C-NSD, $N = 40$); and 2. Converters with social decline prior to baseline (CHR + C-SD, $N = 39$).

2.2. Statistical analyses

All analyses were conducted using SPSS 16.0 (SPSS Inc., Chicago, Illinois). Comparisons of demographic and clinical characteristics were performed with Student's *t*-tests for continuous variables, Pearson Chi-Square for categorical variables (Two-tailed, $P < 0.05$).

Linear mixed-effects models for repeated measures were used to evaluate group differences between the four subgroups in social functioning (Gueorguieva and Krystal, 2004; Mallinckrodt et al., 2001; McCulloch and Searle, 2001; Verbeke and Molenberghs, 2000). Three GF:Social scores were used: 1. highest level of functioning in the past year prior to the baseline assessment, 2. current functioning score at baseline, and 3. current functioning score at the last follow-up visit. For Converters, the last follow-up assessment was the rating done as close as possible following transition to psychosis. For Non-Converters, the 12-month follow-up assessment was used. Fixed effects were group (CHR + C-SD, CHR + C-NSD, CHR-NC, HCs), social functioning score over time (Highest in the past year prior to baseline, Current at baseline, Last Visit/Conversion) and the interaction between group and social functioning score over time. The subjects were entered as a random effect. Restricted maximum likelihood estimation and Type III tests of fixed effects were used, with a heterogeneous auto-regressive covariance structure.

In order to examine functioning patterns at study outcome, functioning was assessed at the 24 month follow-up visit for non-converters and at the conversion assessment for converters. Good functional outcome was defined as current functioning scores of 7 and higher, indicating mild impairments to superior functioning. Poor functional outcome was defined as current functioning scores of 6 and lower (moderate impairments to extreme dysfunction) (Carrión et al., 2013). Differences between the subgroups in functional outcome patterns were evaluated with chi-square analyses. Comparisons between the three CHR subgroups were considered significant when *P*-value<0.017 (0.05/3).

3. Results

3.1. Baseline characteristics

Table 1summarizes baseline demographic and clinical characteristics for the four subgroups. As shown in Table 1, Healthy Controls were significantly older, had more education, and higher IQs when compared to the three CHR subgroups. There were no differences between the Healthy Controls and three CHR subgroups on gender ratio, race, or ethnicity.

All three CHR subgroups were approximately 18 years of age (mid-to-late adolescence) and 2/3rds male. In addition, there were no differences among the three groups in race, ethnicity, or years of education.

Attenuated positive and negative symptoms significantly differed across all between-group comparisons. The Healthy Controls were significantly different from all three CHR subgroups, with lower SOPS positive and negative symptom levels. The Healthy Control group had significantly better functioning, assessed with the GAF, when compared to all three CHR subgroups.

In contrast, there were significant differences in symptom levels between the three CHR subgroups. The two CHR Converter subgroups had comparable levels of positive symptoms at baseline, but, as expected, had higher positive symptom levels compared to the Non-Converter group. By contrast, CHR Converters with Social Decline had more severe baseline negative symptoms and lower GAF scores when compared to the Non-Converters and Converters with No Social Decline. Healthy controls did not carry any DSM-IV clinical diagnoses. Rates of mood and anxiety disorder diagnoses were comparable across the three CHR subgroups. There was no significant difference in time to conversion between the two CHR Converter subgroups (CHR + C-SD: M = 32.36 weeks, SD = 27.795; CHR + C-NSD: M = 40.78, SD = 38.295, $t = 1.214$, $p = 0.23$).

3.2. Heterogeneity of social decline

As shown in Fig. 1, by definition the CHR + C-SD group showed a marked change from the highest to the current level of social functioning at baseline. After the initial decline, social functioning levels stabilized but remained lower than the CHR + C-NSD and CHR-NC groups at 12 month follow up. In contrast, the CHR-NCs showed a relatively small decline in social functioning from the highest to the current level of functioning and showed less impaired social functioning by the follow-up visit. Interestingly, the CHR + C-NSD group closely resembled the CHR-NCs and both groups had comparable levels of social functioning by the follow-visit.

The linear mixed-models for repeated measures revealed significant group ($F = 195.98$, $df = 3, 579.61$, $P < 0.001$) and time effects ($F = 55.91$, $df = 3, 862.38$, $P < 0.001$), as well as group x time interactions ($F = 35.68$, $df = 6, 862.53$, $P < 0.001$). Post-hoc comparisons showed that compared to the HCs, the CHR + C-SD group showed consistently lower social functioning ($P < 0.001$). The CHR + C-NSD and CHR-NC groups had comparable levels of social functioning ($P = 0.997$), however, the CHR + C-SD were significantly more impaired on social functioning compared to the other two CHR groups ($P < 0.01$), indicating that social decline prior to baseline has lasting consequences.

3.3. Social decline and functioning at study outcome

The functional outcome patterns for the three CHR subgroups and Healthy Control groups are displayed in Fig. 2. For the overall CHR group, 54.4% had a poor social outcome, whereas 45.6% were classified as having a good social outcome. For, role functioning at study outcome, 66.5% had a poor role functioning, whereas 33.5% were classified as having a good role functioning. There was a large difference between the

Table 1
Demographic and Clinical Characteristics of Participants at Baseline.

Characteristic	HC ($N = 236$)	CHR-NC ($N = 270$)	CHR + C-NSD ($N = 40$)	CHR + C-SD ($N = 39$)	*P* Value	Post-hoc
Age, mean (SD)	19.64 (4.77)	18.69 (4.29)	17.91 (4.26)	18.18 (2.84)	0.019	HCs > All 3 CHR subgroups
Years of education, mean (SD)	12.65 (2.38)	11.38 (2.76)	10.70 (2.91)	11.36 (2.07)	<0.001	HCs > All 3 CHR subgroups
Gender, No. (%)						
Male	120 (50.8)	148 (55.0)	25 (62.5)	23 (59.0)	0.46	–
Race, No. (%)						
White	133 (56.4)	148 (55.0)	22 (55.0)	19 (48.7)	0.85	–
Ethnic origin						
Hispanic, No. (%)	40 (16.9)	48 (17.8)	5 (12.5)	8 (20.5)	0.80	–
Estimated current IQ, mean (SD)	111.19 (14.35)	104.35 (15.49)	104.65 (15.07)	100.40 (14.19)	<0.001	HCs > All 3 CHR subgroups
Total SOPS score, mean (SD)						
Positive	1.07 (1.66)	11.74 (4.11)	13.00 (3.73)	13.77 (3.41)	<0.001	HCs < All 3 CHR subgroups; CHR + C-NSD and CHR + C-SD > CHR-NC
Negative	1.40 (2.08)	11.85 (5.94)	10.42(6.42)	14.03 (6.34)	<0.001	HCs < All 3 CHR subgroups; CHR + C-SD > CHR + C-NSD and CHR-NC
Modified negative	0.75 (1.33)	6.63 (3.94)	6.16 (4.52)	7.87 (4.22)	<0.001	HCs < All 3 CHR subgroups; CHR + C-SD > CHR + C-NSD and CHR-NC
GAF, mean (SD)	83.74 (10.15)	49.00 (10.72)	50.03(11.37)	44.74(8.80)	<0.001	HCs > All 3 CHR subgroups; CHR + C-SD < CHR + C-NSD and CHR-NC
DSM-IV diagnoses, No. (%)						
Mood[a]	–	138 (51.3)	21 (52.5)	21 (53.8)		–
Anxiety[b]	–	138 (51.3)	18 (45.0)	18 (46.2)		–

Note: SOPS=Scale of Psychosis-Risk Symptoms; GAF = Global Assessment of Functioning.
[a] DSM-IV defined diagnosis of major depressive disorder, dysthymic disorder, mood disorder NOS, or depressive disorder NOS.
[b] DSM-IV defined diagnosis of panic disorder, posttraumatic stress disorder (PTSD), obsessive-compulsive disorder (OCD), generalized anxiety disorder, anxiety disorder NOS, or phobias including simple phobias and social phobia.

HCs and the overall CHR group ($P < 0.001$), with almost the entire HCs group having a good social (98.7%) and role (97.5%) functioning at study outcome.

As shown in Fig. 3, different patterns of functional outcomes were revealed when the overall CHR group was divided into the three CHR subgroups (see Fig. 3). There was a stepwise progression pattern in

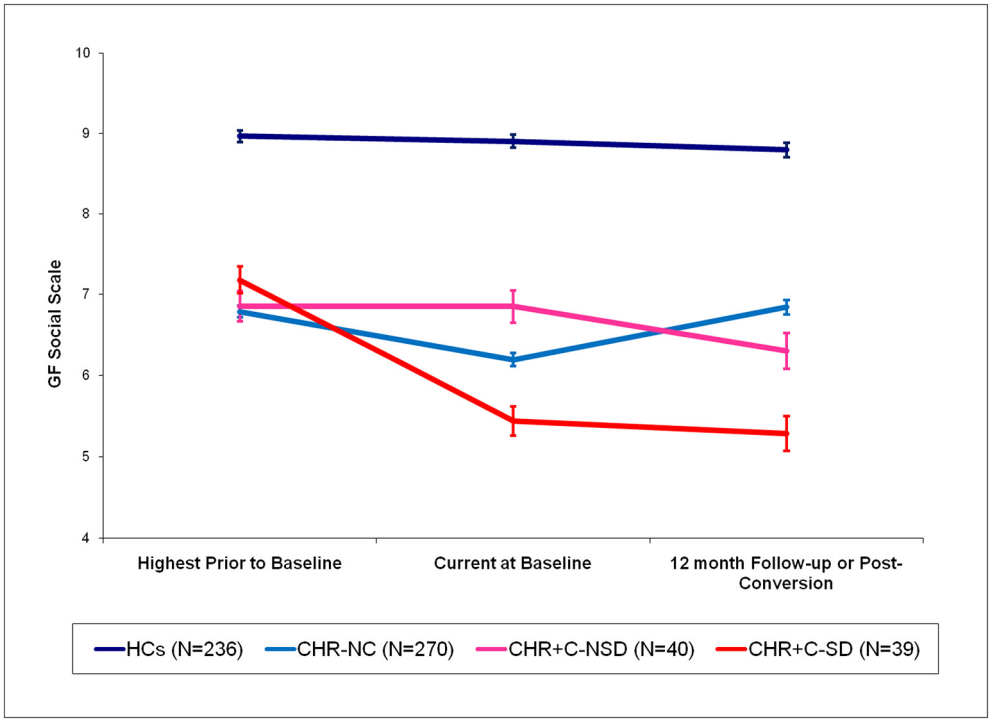

Fig. 1. Global functioning: social scores for CHR-converters with social decline prior to baseline (CHR + C-SD, N = 39), CHR-converters with no social decline prior to baseline (CHR + C-NSD, N = 40), CHR non-converters (CHR-NC, N = 270), and healthy controls (N = 236). Group effect: F = 195.98, df = 3, 579.61, $P < 0.001$. Time effect: F = 55.91, df = 3, 862.38, P < 0.001. Group x time: F = 35.68, df = 6, 862.53, P < 0.001.

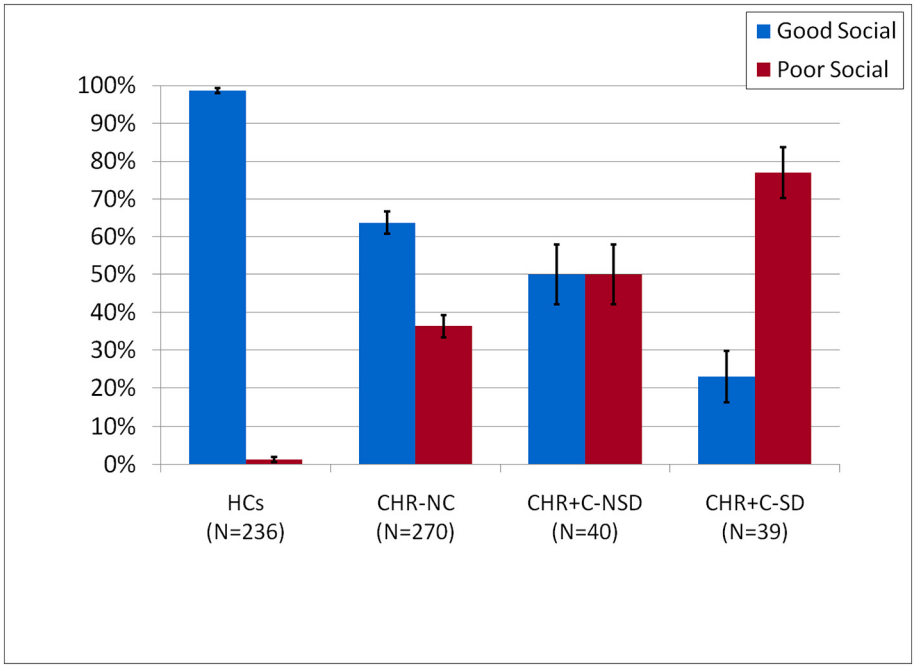

Fig. 2. Distribution of social functioning at study outcome for CHR-converters with social decline prior to baseline (CHR + C-SD, $N = 39$), CHR-converters with no social decline prior to baseline (CHR + C-NSD, $N = 40$), CHR non-converters (CHR-NC, $N = 270$), and healthy controls ($N = 236$).

terms of poor outcomes across the subgroups (CHR-NC → CHR + C-NSD → CHR + C-SD).

First, in terms of the progressive pattern among the three CHR subgroups, the CHR subjects that did not develop psychosis showed the highest rates of good functioning at outcome. Specifically for the CHR-NC subgroup, almost two-thirds experienced good social (63.7%) or role functioning (57.8%) at study outcome. Next, compared to the non-converters, the CHR + C-NSD group had worse social and role functioning at study outcome. While the CHR + C-NSD group had statistically comparable levels to the CHR-NC group on social ($P = 0.096$) and role ($P = 0.033$), 50% percent of the CHR + C-NSD group had poor social outcome and 67.5% had poor role outcomes. There was a significant difference between the CHR + C-SD and each of the other two CHR subgroups ($P < 0.017$). Finally, a large majority of CHR + C-SD group have either poor social (76.9%) or poor role (89.7%) functioning at outcome. Only a small proportion of the CHR Converters with pre-baseline social decline were classified as having good social (23.1%) or role (10.3%) outcome, demonstrating a strong association between developing psychosis after experiencing a social decline and poor functional outcomes.

4. Discussion

The ability to function in society is a multidimensional, non-specific construct that ranges from well above average through very impaired, and can be parsed into specific and separate components. While good

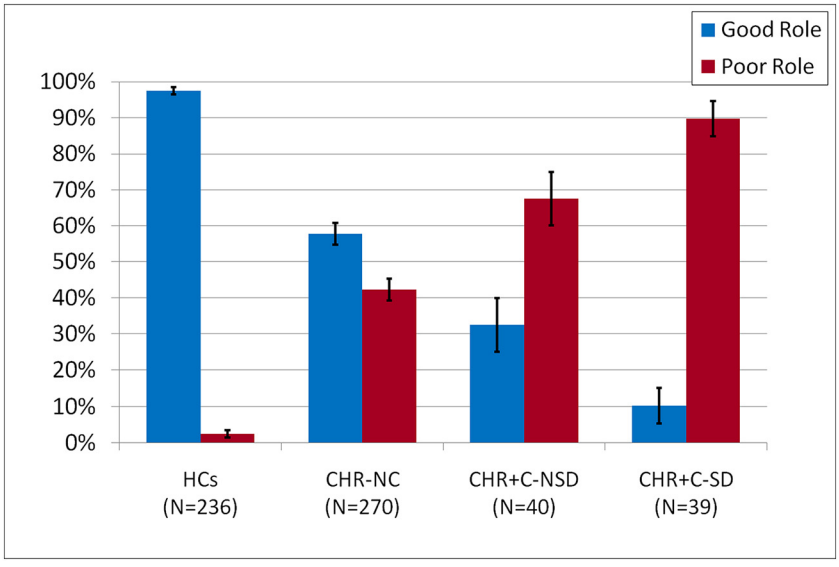

Fig. 3. Distribution of role functioning at study outcome for CHR-converters with social decline prior to baseline (CHR + C-SD, N = 39), CHR-converters with no social decline prior to baseline (CHR + C-NSD, N = 40), CHR non-converters (CHR-NC, N = 270), and healthy controls (N = 236).

functioning helps to identify individual exceptionality, poor functioning is often most notable for identifying individuals with mental illness who may need government or medical resources and family support. A great deal of research has assessed various types of functional difficulties as a major outcome of having a psychotic disorder, and have documented the toll functional disability exacts from patients and their families (Harvey, 2013, 2014a). Functional problems have been also reported widely in CHR individuals prior to illness (Addington et al., 2019b; Addington et al., 2017; Cannon et al., 2008; Cannon et al., 2016; Carrión et al., 2016a; Cornblatt et al., 2015; Velthorst et al., 2013; Velthorst et al., 2010; Velthorst et al., 2018). This encompasses difficulties in social skills and academic/work performance. However, in the current report we have focused on a different aspect of functioning in CHR: a decline in typically moderately impaired social skills during early pre-illness, (mid-to-late adolescence) that appears to be a specific predictor of future psychosis. There is further indication that, in general, both social and role functioning during pre-illness also are harbingers of latter chronic disability that is independent of the emergence psychosis and leads to poor prognosis regardless of the presence psychosis. Since adolescence also is a developmental phase psychosis (Häfner et al., 2013; Häfner et al., 2003), which coincides with extensive maturational changes in brain anatomy, chemistry, and circuitry (Cao et al., 2019a; Cao et al., 2019b; Chung et al., 2019), there may be a biological basis to the unusual decline in the CHR subgroup. Given that this only appears in approximately half of the converters, this decline may signal a heterogeneity of etiology among the overall CHR population.

4.1. Social decline as a potential biobehavioral marker

The current findings are an integration and expansion of several previous findings reported from the RAP and NAPLS groups (Addington et al., 2011; Carrión et al., 2019; Cornblatt et al., 2012; Cornblatt et al., 2015). In the current paper, our analyses target pre-illness functional decline, performance levels at study presentation and levels of stability at short-term follow-up. Our data extend the predictive range of pre-illness social decline in CHR by showing for the first time that it predicts functional outcome as well as psychosis. As in earlier reports, there is a significantly large, stable distance between healthy controls (typically at a GF level of around 9) and CHR subjects (characteristically around a GF score of 6) (Carrión et al., 2019). While several studies have shown that the overall CHR group improves modestly over time in both social and role domains (Addington et al., 2011; Carrión et al., 2019), our findings reinforce that functioning levels remain impaired after several years of follow-up and never reach levels typical for healthy controls. In this study, our results indicate that, in the short term, converters without social decline resemble non-converters, emphasizing the possible etiological differences associated with atypical social decline that is not associated with other factors such as IQ and positive symptoms. These findings strongly suggest that early social decline may be a type of biobehavioral marker since deficits precede psychosis (Carrión et al., 2016a) and have been shown to be independent from positive symptoms (Cornblatt et al., 2012). Biological roots are also indicated by the association with more proximal biological processes, including neuropsychological processing speed deficits (Carrión et al., 2011), a connection with auditory information processing as measured by the Mismatch Negativity (MMN) of the auditory event-related potential (Carrión et al., 2015), and an association with cerebral white matter integrity dysfunction (Karlsgodt et al., 2009).

4.2. Poor functioning as clinical outcome measure

The additional component of this study is to evaluate the impact of functioning as a clinical outcome measure, which in turn, contributes to the understanding of the way the CHR syndrome evolves in the long term. As reported in previous studies from the RAP group, functional outcome was defined as having either good (GF Social or Role score ≥ 7) and poor (score ≤ 6) functioning (Carrión et al., 2016b; Carrión et al., 2013). Compared to healthy controls, a substantial portion of the overall CHR group in the NAPLS2 sample had poor social (54%) and role (66%) functioning at their last visit (on average 58.95 weeks). Although not part of the formal criteria for defining clinical high risk, impaired social functioning appears integral to the CHR syndrome and to increase "riskness" of outcome. In terms of research feasibility, this data also suggests that functional difficulties among CHR individuals are considerably higher than most recently reported transition rates to psychosis of 23% (Malda et al., 2019) and in our view warrants more widespread treatment attention across high risk studies than is currently the case. Functional difficulties in vulnerable CHR individuals may become entrenched in adulthood, even in the absence of full-blown schizophrenia (Addington et al., 2019a; Cornblatt et al., 2007). Thus, early intervention efforts can potentially be developed to, on one hand, prevent psychosis, and, on the other, temper long-term chronic disability.

4.3. Functional outcome for CHR non-converters vs. converters with and without pre-illness social decline

The three CHR subgroups showed a step-wise progressive worsening in both social and role functioning at study outcome. Beginning with non-converters, a majority of the subjects showed good social (64%) and role (58%) functioning at outcome. Stably good social and role functioning during pre-illness may provide major clues helping to eliminate false positives from the CHR syndrome. Next, comparing the two subgroups of converters (with and without social decline), a fairly large proportion of the converters with no social decline had both poor social (50%) and poor role (68%) functioning at outcome. The two converter subgroups (i.e., with and without social decline at baseline) had similar levels of attenuated positive symptoms and IQ levels at baseline, highlighting that the differences in between the two subgroups are specifically related to dynamics involving social skills. The social decline converter subgroup showed no improvement after the initial pre-baseline worsening and a large majority had poor social (77%) and role (90%) functioning at outcome. While we expected pre-illness social decline to lead to worse impairment in the social domain in the long term, we did not necessarily expect role to follow suit; thus, our findings have implications for overall prognosis (i.e., involves both conversion to psychosis and globally poorer functioning) in the decline subgroup.

5. Conclusion

Taken together, the findings presented in this paper reinforce previous reports that social skills are enduring traits with their own trajectory and not simply secondary to positive symptoms (Cornblatt et al., 2012). Investigating social functioning as a potential biobehavioral construct has major implications for early interventions designed to change the developmental course of functional outcome (Addington et al., 2019a; Devoe et al., 2019). For example, clinicians can monitor CHR individuals for social interactions and apply tailored intervention when a marked social decline begins to emerge. It should be noted that role, the other major functional domain, has not shown similar predictor potential for psychosis, possibly being an illness indicator instead. Thus, role functioning appears to worsen as psychosis emerges and progresses with intervention perhaps best targeting role later on in the illness process.

5.1. Limitations

Our findings should be interpreted in light of the following potential limitations. First, CHR participants in the second phase of NAPLS received a range of treatments that were not included in the current analyses. While past findings have demonstrated a lack of relationship

between pharmacological treatments and functioning, nevertheless, future studies should include an examination of the relationship between medication treatment and social decline. Second, future analyses should explore the trajectories of non-functioning related variables (e.g., neurocognition) within each outcome group. Finally, social decline is currently defined as a worsening at some point in the year prior to the baseline assessment. This is partially based on the properties of the GF scale, an index which measures highest functioning in the prior year to baseline levels, making the exact timing of the decline imprecise. A second factor, includes the age of the NAPLS2 sample which is older than many other CHR samples. For example, CHR subjects in the RAP study had a younger age compared to NAPLS2 and social decline (ages 16–18, same as NAPLS pre-baseline) was measured as a change from baseline levels to follow-up (Cornblatt et al., 2015).

5.2. Future directions

The present study utilized a measure of social decline, which was dependent on assessing the highest level of social functioning in the year prior to baseline. The metric is a unique feature of the GF scales. Future studies should adopt a multimodal extension of our current findings by adding digital phenotyping methodology. Smartphone-based digital phenotyping can specially offer unique advantages for studying functioning in individuals at CHR. For example, bluetooth sensors on smartphones can automatically quantify social networks based on proximity data (Boonstra et al., 2017) and anonymized call/text logs can inform dynamic changes in personal social interactions (Torous et al., 2018). These data would be of considerable interest to digitally document the trajectory of social decline in mid-to-late adolescence and to determine if a similar change is shown in other domains.

CRediT authorship contribution statement

All authors contributed to this work; all authors contributed to the content, reviewed and revised drafts of the work, and approved the final version.

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Declaration of competing interest

The authors have declared that there are no conflicts of interests in relation to the subject of this study.

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