The Behavior and Mind Health (BeMIND) study: Methods, design and baseline sample characteristics of a cohort study among adolescents and young adults

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Abstract

Objectives: The Behavior and Mind Health (BeMIND) study is a population-based cohort study of adolescents and young adults from Dresden, Germany. The aim is to investigate psychological and behavioral factors linked to a range of mental disorders and health behaviors and their interaction with social-environmental and genetic/biologic factors.

Methods: A random sample of 14–21 year olds was drawn from the population registry in 2015. The baseline investigation was completed 11/2015–12/2016 (N = 1,180). Assessments include standardized diagnostic interview, cognitive-affective tasks, questionnaires, biosamples, and ecologic momentary assessment in real life with combined actigraphic/geographic monitoring. In the family study component, parents completed similar assessments and provided information on child’s early development.

Results: The participation rate (minimum response proportion) was 21.7%; the cooperation rate was 43.4%. Acceptance and completion of study components were high. General health data indicate that more than 80% reported no or only mild impairment due to mental or somatic health problems in the past year; about 20% ever sought treatment for mental health problems or chronic somatic illnesses, respectively.

Conclusions: Data from BeMIND baseline and follow-up investigations will provide novel insights into contributors to health and disease as adolescents grow into adulthood.

Keywords
cohort study, epidemiology, etiology, health behavior, psychopathology

1 | INTRODUCTION

Mental and behavioral disorders have been shown to be jointly responsible for the largest proportion of disability burden worldwide (Erskine et al., 2015; Kessler et al., 2011; Whiteford, Ferrari, Degenhardt, Feigin, & Vos, 2015; Wittchen et al., 2011). A wealth of epidemiological data shows a high prevalence in the general population (Beesdo-Baum & Wittchen, 2015; Polanczyk, Salum, Sugaya,
mental factors in the maintenance of health and the critical processes and their interaction with genetic/biological and environmental and dysfunctional psychological and behavioral factors and overarching aim is to contribute to an improved understanding of the and in controlled (experimental-laboratory) environments. The study's and objective measures of subjects' health and behavior in real life as well as a range of individual, familial, and social-environmental study focusing on mental disorders and health risk behaviors in ado-
targeted interventions suitable for changing disease trajectories.

The behavioral and psychological determinants, including cognitive-affective factors and decision-making processes, in the evolution of mental disorders and health risk behaviors contributing to somatic disease, and the interplay of these factors with genetic/biological and environmental factors, may improve etiopathogenetic models and targeted interventions suitable for changing disease trajectories.

We therefore launched a prospective-longitudinal epidemiological study focusing on mental disorders and health risk behaviors in adolescents and young adults, in which traditional subjective, retrospective assessments of mental and behavioral health and disorders, as well as a range of individual, familial, and social-environmental risk/protective factors, are complemented by more ecologically valid and objective measures of subjects' health and behavior in real life and in controlled (experimental-laboratory) environments. The study's overarching aim is to contribute to an improved understanding of the functional and dysfunctional psychological and behavioral factors and processes and their interaction with genetic/biological and environmental factors in the maintenance of health and the critical trajectories into mental disorders and health risk behaviors linked to noncommunicable somatic disease. Specific objectives are (a) to assess mental disorders and health behaviors in a population-based sample of adolescents and young adults both cross-sectionally and longitudinally; (b) to monitor changes in mental health symptoms and health behaviors, both on a microlevel in daily life using ecological momentary assessment and prospectively from baseline to one and 3-year follow-up; (c) to identify etiological pathways considering distal and proximal individual (psychological/behavioral) risk and protective factors as well as their interactions with social-environmental and biologic/genetic factors; and (d) to identify predictors for changes in mental health status and health behaviors.

2 | METHODS

2.1 | Study design

The Behavior and Mind Health (BeMIND) study is designed as a cohort study in a general population sample of adolescents and young adults from Dresden, a major city in the eastern part of Germany. The study comprises a baseline investigation and 1- and 3-year follow-up investigations to examine developmental trajectories of mental disorders and health risk behaviors related to noncommunicable somatic disease (Figure 1). In addition, the study includes a family study component.

To increase the overall sample size and to allow for replications of exploratory findings, a second smaller baseline-cohort has been independently sampled approximately 2 years after the original baseline-cohort (not detailed herein). The study protocol and its amendments were approved by the ethics committee of the Technische Universität Dresden (TUD; EK38110214).

2.2 | Sampling

The 14- to 21-year-old population living in Dresden, Germany, represents the study's target population. An age- and sex-stratified random sample of 14–21 year olds was drawn from the population registry of the city of Dresden in 2015 with the aim to recruit ~1,000 adolescents and young adults to become part of the prospective-longitudinal BeMIND study. Because it was deemed more important to ensure a sufficient sample size for each age group than to resemble the age/sex distribution of the target population (considerably more young adults than adolescents live in Dresden due to two large higher education institutions), younger individuals were oversampled. Sample size was determined based on a priori power calculation; Data S1A provides for select core research questions the power based on the final baseline sample size.

Eligibility to participate in the BeMIND study required living in a household in Dresden during the time of the field work and being between ages 14 and 21. Exclusion criteria were institutionalization and insufficient German language skills. Besides the 14–21 year olds, all parents willing and able to participate in the family study component were assessed at baseline with similar procedures. A smaller
scale 1-year and a large-scale 3-year follow-up investigations are conducted in which all baseline participants are approached again.

2.3 | Field work and procedures

Address lists of randomly selected adolescents and young adults with primary living address in Dresden were provided by the city’s resident registry office. In case of minors, names and address of the legal guardians were also provided. A personal invitation letter was sent by the BeMIND study team with information about the study, a response sheet, and a postage-paid return envelope. In the case of minors, letters were addressed to both subjects and parents. The information covered aims, approach, and comprehensiveness of the BeMIND study program; 50€ were offered for participating in all baseline study components (overall 6–10 hr on two assessment days and during 4 days in real life; details below); parents were offered 30€. Individuals/families indicated their interest to participate and contact information or the reasons for nonparticipation on the response sheet. A maximum of two reminder letters was sent to subjects/families if there had been no response after 3–4 weeks. No initiating personal or telephone contact could be made by study staff after nonresponse due to legal regulations. Nonparticipants were asked to return a brief nonresponder questionnaire.

With subjects who indicated interest to participate, a personal appointment was made in order to provide detailed study information and to obtain written informed consent/assent. In minors, all legal guardians provided written informed consent. Assessments were then conducted at the Center for Clinical Epidemiology and Longitudinal Studies at TUD. When participation at the research facility was not possible or desired by the subject, subjects’ own residences were used.

At baseline, subjects participated in a clinical-diagnostic assessment (Day 1), in a laboratory assessment approximately 1 week later (Day 2), and in an Ecological Momentary Assessment (EMA) during 4 days in real life and an online questionnaire assessment in between these personal appointments. Biological/physiological data were collected during the EMA period (saliva and heart rate) and at the second personal appointment (blood/buccal, hair, anthropometric measures, and blood pressure).

For the supplementary family study, parents of minors were invited simultaneously to the index subjects because the contact information was provided by the resident registry office; parents of 18+ year olds were invited by written invitation letter if contact information was provided by the index participant on site. Assessments and procedures for parents were similar to those of the index subjects. If a full assessment of parents was not possible (e.g., distant residence), parents were invited to complete a web-based assessment focusing on early developmental factors of the index child.

2.4 | Assessments and measures

An overview of the BeMIND baseline assessments is provided in Table 1. Measures were chosen to cover constructs of mental health/disorders and health behaviors (outcomes) as well as putative risk and protective factors (exposures) based on literature and utility/feasibility (psychometric properties, coverage, and brevity).

2.4.1 | Standardized assessment of mental disorders

Diagnostic status of index subjects was determined using an updated version of the Munich Composite International Diagnostic Interview (DIA-X/M-CIDI; Wittchen & Pfister, 1997). The DIA-X/M-CIDI provides lifetime and 12-month diagnoses for a wide range of mental disorders including anxiety, depressive, bipolar, substance use, somatic symptom/somatoform, psychotic disorders, and eating disorders and was originally designed to assess DSM-IV (APA, 2000) and ICD-10 (WHO, 1993) criteria. The updated version was created to assess diagnoses according to DSM-5 (APA, 2013) and a broader range of
| Category/construct | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure |
|--------------------|-------------------|----------------|----------------|----------------------|---------|
| **Sociodemographic variables** | | | | | |
| Sex | A; P | D1 | I | Current | DIA-X-5 Section A/family tree chart |
| Age | A; P | D1 | I | Current | DIA-X-5 Section A/family tree chart |
| Education | A; P | D1; O | I; Q | Lifetime/current | DIA-X-5 Section A |
| Financial situation | A; P | D1 | I; Q | Current | DIA-X-5 Section A |
| Employment | A; P | D1 | I; Q | Current | DIA-X-5 Section A |
| Marital status | A; P | D1 | I; Q | Current | DIA-X-5 Section A |
| Living situation | A; P | D1 | I; Q | Current | DIA-X-5 Section A |
| Age of parents at index’s birth | P | D1; O | Q | Past | Items used in EDSP |
| Index’s familial and financial situation during childhood | A; P | D1; O | Q | Past | Items used in BELLA/EDSP |
| Index’s educational trajectory | P | D1; O | Q | Past | Items used in EDSP |
| Family composition | A; P | D1 | I | Current | Family tree chart |
| **Health and health behavior** | | | | | |
| Psychopathology—categorical | | | | | |
| Symptoms, syndromes, and diagnoses of mental disorders (anxiety, depressive, bipolar, substance use, eating, stress-related, obsessive-compulsive spectrum, psychotic, somatic symptom, attention-deficit/hyperactivity, intermittent explosive, and disruptive/antisocial behavior disorders) | A; P | D1 | I; Q | Lifetime; past 12 months | DIA-X-5; self-administered questionnaire for parents |
| Index’s symptoms, syndromes, and diagnoses of childhood mental disorders (attention deficit/hyperactivity, conduct, oppositional defiant, intermittent explosive, separation anxiety, generalized anxiety, depressive, and disruptive mood dysregulation disorder) | P | D1; O | Q | Lifetime | Items based on DIA-X-5 |
| Diagnosed mental disorders | A; P | O | Q | Lifetime; past 12 months | Adapted items from DEGS |
| Index’s diagnosed mental disorders | P | D1; O | Q | Lifetime; past 12 months | Items used in EDSP |
| Self-harm behavior | A; P | D1 | Q | Lifetime; past 12 months | Adapted items of the self-injurious thoughts and behaviors interview for self-harming behavior (SITB) and Functional Assessment of Self-Mutilation (FASM) |
| Suicidal behavior | A; P | D1 | I; Q | Lifetime; past 12 months | DIA-X-5; adapted version of the Questionnaire on Suicidal attempts |
| Symptoms, syndromes, and diagnoses of relatives’ mental disorders (index’s parents and | A; P | D1 | I; Q | Lifetime; past 12 months | Items within DIA-X-5; self-administered questionnaire for adolescents and parents |

(Continues)
| Category/construct                                      | Target population | Assessment time | Assessment mode | Coverage (time frame)   | Measure                                                                 |
|-------------------------------------------------------|-------------------|-----------------|-----------------|-------------------------|------------------------------------------------------------------------|
| their partners, grandparents, and siblings)           |                   |                 |                 |                         |                                                                        |
| Psychopathology—dimensional                            |                   |                 |                 |                         |                                                                        |
| Risk for autism spectrum disorders (ASD)              | P                 | D1              | Q               | Age 2                   | Short Version of the Modified Checklist for Autism in Toddlers (M-Chat) |
| Mental health of parents                              | P                 | D1; O           | Q               | Ages 0 to 5             | Items used in EDSP                                                     |
| Alcohol consumption                                   | F-A               | D1              | Q               | Past 12 months          | Alcohol Use Disorders Identification Test (AUDIT-G-L)                  |
| Premenstrual symptoms                                 | F-A               | D1              | Q               | Past 12 months          | Shortened Version of the Premenstrual Symptom Scale                   |
| Anxiety                                               | A                 | D1              | Q               | Past 4 weeks            | Cross-cutting Dimensional Severity Measure for Anxiety (Cross-D)       |
| Agoraphobia                                           | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Disorder-Specific Severity Measure for Agoraphobia (AG-D)        |
| Generalized anxiety                                   | F-A               | D1              | Q               | Past 4 weeks            | Generalized Anxiety Disorder Dimensional Scale (GAD-D)                |
| Illness anxiety                                        | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Level 2 Cross-Cutting Symptom Measure—Illness Anxiety Disorder (IA-D) |
| Panic                                                 | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Disorder-Specific Severity Measure for Panic Disorder (PD-D)     |
| Separation anxiety                                     | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Disorder-Specific Severity Measure for Separation Anxiety Disorder (SepA-D) |
| Social anxiety                                         | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Disorder-Specific Severity Measure for Social Anxiety Disorder (SAD-D) |
| Specific phobia                                        | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Disorder-Specific Severity Measure for Specific Phobia (SP-D)    |
| Depression                                             | A                 | D1              | Q               | Past 2 weeks            | Patient Health Questionnaire-9 (PHQ-9)                                 |
| Repetitive thoughts and behaviors                     | F-A               | D1              | Q               | Past 4 weeks            | DSM-5 Level 2 Cross-Cutting Severity Measure—Repetitive Thoughts and Behaviors-Adult (adapted from the Florida Obsessive–Compulsive Inventory (FOCI) Severity Scale [Part B]) |
| Irritability                                           | A                 | D1              | Q               | Past week               | DSM-5 Level 2 Cross-Cutting Symptom Measure—Irritability, Child Age 11–17 (Affective Reactivity Index (ARI)) |
| Mania                                                 | A                 | D2; DL          | Q; EMA          | Past week; since last beep | DSM-5 Level 2 Cross-Cutting Symptom Measure—Mania (Altman Self-Rating Mania Scale [ASMR, adapted items in EMA]) |
| Mental health problems                                 | A; P              | D2              | Q               | Past week               | DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure                |
| Index's mental health problems                        | P                 | D1; O           | Q               | Past 6 months           | Strength and Difficulties Questionnaire extended (SDQ)                |

(Continues)
| Category/construct | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure |
|--------------------|-------------------|----------------|----------------|----------------------|---------|
| Emotional distress—anger | A; P | D2; DL; DL-N | Q; EMA | Past week; since last beep; past day | DSM-5 Level 2 Cross-Cutting Symptom Measure - Anger (PROMIS Emotional Distress - Anger - short-form) |
| Emotional distress—anxiety | A; P | D2; DL; DL-N | Q; EMA | Past week; since last beep; past day | DSM-5 Level 2 Cross-Cutting Symptom measure - Anxiety (PROMIS Emotional Distress - Anxiety - short-form) |
| Emotional distress—depression | A; P | D2; DL; DL-N | Q; EMA | Past week; since last beep; past day | DSM-5 Level 2 Cross-Cutting Symptom Measure - Depression (PROMIS Emotional Distress - Depression - short-form) |
| Compulsive internet use | F-A | O | Q | General | Compulsive Internet Use Scale (CIUS) |
| Video game dependency | F-A | O | Q | General | Video Game Dependency Scale (KFN-CSAS-II) |
| Physical health | | | | | |
| Natal complications | P | D1; O | O | past | Items used in EDSP |
| Physical health of parents | P | D1; O | Q | Past (ages 0 to 5) | Items used in EDSP |
| Somatic symptoms, sensory symptoms, and physical disabilities | P | D1; O | O | Lifetime | Items used in EDSP |
| Chronic physical diseases (allergies, asthma, cardiovascular diseases, etc.) | A; P | O | Q | Lifetime, past 12 months | Items adapted from KIGGs and DEGS |
| Chronic disease | A; P | O | Q | Current | Item of the Minimum European Health Module (MEHM) |
| Illness | A; P | D2 | BP | Past 3 months | Hair sample protocol |
| Physical health problems | A; P | DL; DL-N | EMA | Since last beep; past day | Self-developed item |
| Disability | A; P | O | Q | Past month | World Health Organization Disability Assessment Schedule II (WHODAS 2.0) |
| Impairment days (complete and partial) due to physical and mental health problems | A; P | D1 | I; Q | Past 4 weeks | DIA-X-5 Section Q |
| Physical and mental health impairment | A; P | D1 | Q | Past 12 months | Adapted Sheehan Disability Scale (SDS) |
| Sick days | A | O | Q | Past 12 months | Item used in DEGS |
| Pain intensity | A; P | D2 | Q | Past week | PROMIS-29 Profile v2.0 (pain intensity) |
| Pain tolerance | A | D2 | Q | General | Items of the Capability for Suicide Questionnaire (CSQ) |
| Pubertal stage | F-A | O | Q | Current | Tanner Stages Test |
| Puberty: acne, hair growth, vocal change in boys, age of first menstruation, and regular menstruation | A | O | Q | Lifetime; current | Self-developed items and item of Pubertal Developmental Scale (PDS) and item used in KIGGS survey |
| Reproductive health: sexual contact, use of birth control, and pregnancy in girls | A | O | Q | Lifetime; current | Items used in HBSC Survey and in DEGS |
| Sight or hearing problems | A; P | D1; O | Q | Current | Self-developed items |
| Category/construct                  | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure                                                                 |
|------------------------------------|-------------------|-----------------|-----------------|-----------------------|--------------------------------------------------------------------------|
| **Anthropometry**                  |                   |                 |                 |                       |                                                                          |
|Height                              | A; P              | D2              | AM              | Current               | Without shoes using a standard stadiometer                               |
|Weight                              | A; P              | D2              | AM              | Current               | Without shoes and heavy clothing using a standard digital scale          |
|Hip circumference                   | A; P              | D2              | AM              | Current               | Standard linear measure                                                  |
|Waist circumference                 | A; P              | D2              | AM              | Current               | Between the lower rib margin and the iliac crest in the horizontal plane using a standard linear measure |
|Head circumference                  | A                 | D2              | AM              | Current               | Standard linear measure                                                  |
|**General health**                  |                   |                 |                 |                       |                                                                          |
|Early developmental stages          | P                 | D1; O           | Q               | Early childhood       | Early Development & Home Background (EDHB) Form                          |
|Subjective general health           | A; P              | O               | Q               | General               | Items of the Short Form Health Survey (SF-36)                             |
|Subjective mental and physical health| A; P              | O               | Q               | General               | Self-developed items                                                     |
|**Service utilization and treatment**|                   |                 |                 |                       |                                                                          |
|Help-seeking behavior in infancy and childhood | P | D1; O | Q | Past | Item used in EDSP |
|Mental health care use              | A; P              | D1              | I; Q            | Lifetime              | DIA-X/5 Section Q                                                        |
|Treatment for mental health problems with psychotherapy/medication           | A; P              | D1              | I; Q            | Lifetime              | DIA-X/5 Section Q                                                        |
|Emergency care visits               | A                 | O               | Q               | Past 12 months        | Item used in DEGS                                                        |
|Health care use: practitioners      | A                 | O               | Q               | Past 12 months        | Adapted items used in DEGS                                               |
|Preventive service use              | A                 | O               | Q               | Past 12 months        | Adapted items used in DEGS                                               |
|Medication use                      | A; P              | D2              | D2              | Past 7 days           | Self-developed item                                                      |
|**Lifestyle**                       |                   |                 |                 |                       |                                                                          |
|Diet and substance use              |                   |                 |                 |                       |                                                                          |
|Diet—attitude towards diet         | A                 | D2              | Q               | General               | Items of the Eating Behavior and Weight Problems Inventory (EWI)         |
|Diet—habits and problems           | A; P              | O               | Q               | General               | Items used in HBSC Survey                                               |
|Diet—behavior                      | A                 | DL              | EMA             | Since last beep       | Self-developed item                                                      |
|Substance use—any, craving         | A; P              | DL; DL-N        | EMA             | Since last beep; past week | Items based on DIA-X-5                                                  |
|Substance use—alcohol              | A; P              | D1; D2          | I/Q; BP         | Lifetime; past 3 months | DIA-X-5 Section I; hair sample protocol                               |
|Substance use—psychoactive medicine and illicit drugs | A; P | D1; D2 | I/Q | Lifetime | DIA-X-5 Section L |
|Substance use—smoking (tobacco)     | A; P              | D1; D2          | I/Q; BP         | Lifetime; current     | DIA-X-5 Section B; hair sample protocol                                 |
|Substance use—alcohol, benzo diazepine, and cigarettes | A; P | DL | BP | Past day | Saliva sample protocol |
|Substance use—medication           | A; P              | DL              | BP              | Past 7 days           | Saliva sample protocol                                                   |
|**Activity**                        |                   |                 |                 |                       |                                                                          |
|Leisure time activities             | A; P              | O               | Q               | General               | Adapted items used in NCS-A                                               |
|Physical activity and its intensity | A; P              | D2              | BP              | General               | Hair sample protocol                                                     |

(Continues)
| Category/construct                              | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure                                                                 |
|-----------------------------------------------|-------------------|----------------|----------------|----------------------|-------------------------------------------------------------------------|
| Physical activity                             | A; P              | O              | Q              | Past 3 months        | Items used in DEGS and from the GPAQ                                    |
| Current activities                            | A; P              | DL; DL-N       | EMA            | Since last beep; past day | Self-developed item                                                     |
| Local position and environment                | A                 | DL             | EMA            | Since last beep      | Self-developed item                                                     |
| Physical activities                           | A; P              | DL; DL-N       | EMA            | Since last beep; past day | Self-developed item                                                     |
| Movement radius and points of interest        | A                 | DL             | EMA            | Current (continuous over 4 days) | GPS tracking in the smartphone with sampling frequency between 1 and 0.2 Hz |
| Sleep                                         |                   |                |                |                      |                                                                         |
| Sleep problems                                | A; P              | O              | Q              | Lifetime; past month | Self-developed questionnaire                                             |
| Sleep disturbance                              | A; P              | O; DL-M        | Q; EMA         | Past month; past night | DSM-5 Level 2 Cross-Cutting Symptom Measure - Sleep Disturbance (PROMIS Sleep Disturbance short-form) |
| Sleep duration                                | A; P              | O              | Q              | Past month           | Item used in DEGS                                                       |
| Day sleep                                     | A; P              | DL-N           | EMA            | Past day             | Self-developed item                                                     |
| Sleep quantity                                | A; P              | DL-M           | EMA            | Past night           | Self-developed items                                                    |
| Objective physical activity                   |                   |                |                |                      |                                                                         |
| Blood pressure (systole, diastole, and pulse)  | A; P              | D2             | Bio            | Current              | Oscillometric digital blood pressure monitor (705IT, OMRON)             |
| Blood/buccal sample                           | A; P              | D2             | Bio            | Current              | Two 9-ml blood samples by venipuncture (S-Monovettes; Sarstedt, Nümbrecht); or— alternatively—buccal swabs (Biozyme, Wien) for sampling buccal mucosa |
| Hair sample with standard hair protocol       | A; P              | D2             | Bio            | Past 3 months        | Two to three 3-cm-long, 3-mm-wide hair samples taken scalp-near from a posterior vertex position |
| Saliva samples with time recording            | A; P              | DL             | Bio            | Current (two subsequent weekdays) | Taken immediately after awakening, 30 min after the first sampling and 30 min before going to bed (Salivettes: Sarstedt, Nümbrecht, Germany; MEMSCAPS (MEMS 6 TrackCap container): Aardex Ltd., Switzerland) |
| Heart rate/heart rate variability (HRV)       | A                 | DL             | EMA            | Current (continuous over 4 days) | HRV in millisecond accuracy (Firstbeat Bodyguard 2)                     |
| Objective physical activity                   | A                 | DL             | EMA            | Current (continuous over 4 days) | Three-axis acceleration sensor system with a sampling frequency of 12.5 Hz (Firstbeat Bodyguard 2) |

Individual and environmental factors

Psychological factors

| Comparison of competencies                 | A                 | O              | Q              | General              | Extended scale for comparison of competencies (VK+)                    |
| Life satisfaction                          | A; P              | O              | Q              | General              | Cantril’s self-anchoring ladder rating of life                         |
| Dispositional optimism                     | A; P              | O              | Q              | General              | Life-Orientation-Test (LOT-R)                                          |
| Category/construct                  | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure                                                                 |
|------------------------------------|-------------------|----------------|----------------|-----------------------|-------------------------------------------------------------------------|
| Locus of control                   | A; P O; DL-N Q; EMA | General; past day | Internal-External-Locus of Control-4 (IE-4) |
| Sense of coherence                 | A; P O Q          | General         | Item of the Sense of Coherence Scale (SOC-L9) |
| Self-confidence, happiness, and mastery | A; P D2 Q          | General         | Self-developed items |
| Self-esteem                        | A; P O Q          | General         | Single-Item Self-Esteem Scale (SISE)         |
| Self-esteem                        | A; P DL-N EMA     | Past day        | Three items of the Rosenberg Self-Esteem Scale (RSES) |
| Daily meaning                      | A DL-N EMA        | Past day        | Daily Meaning Scale (MS)                     |
| Quality of life                    | A; P DL-N EMA     | Past day        | EUROHIS-QOL 8-item                            |
| Optimism/pessimism                 | A DL EMA          | Current         | Skala Optimismus-Pessimismus-2 (SOP2)         |

Social parameters

| Social situation of parents        | P D1; O Q         | Ages 0 to 5     | Items used in EDSP                            |
| Parental style                     | A O Q             | Childhood       | Measure of Parental Style (MOPS) and adapted items of the Parental Bonding Instrument used in NCS-A |
| Attachment                         | A; P O Q          | General         | Relationship Questionnaire (RQ)               |
| Burdensomeness                     | A; P D2 Q         | General         | Item of the Interpersonal Needs Questionnaire (INQ) |
| Loneliness and social exclusion    | A; P D2 Q         | General         | Self-developed items                           |
| Shyness                            | A; P D2 Q         | General         | Self-developed item                            |
| Stigma against mental illness      | A; P D2 Q         | General         | Self-developed item                            |
| Social support                     | A; P O Q          | General         | Short form of the social support questionnaire (F-SOZU) |
| Partnership and duration           | A O Q             | Lifetime        | Adapted items of KIGGS                         |
| Important relationships            | A D1 Q            | Past 6 months   | Items used in EDSP                            |
| Social interactions                | A; P DL; DL-N EMA | Since last beep; past night | Self-developed item                           |
| Social media use                   | A O Q             | Current         | Self-developed items                           |
| Social support                     | A; P O; DL-N Q; EMA | Past day       | Oslo 3 Support Scale extended (OSLO -3)        |

Cognition

| Volitional competencies            | A; P O Q          | General         | Short form of the Volitional Components Questionnaire (VCQ-S-SF) |
| Attributional style                | A; P O Q          | General         | Self-developed items                            |
| Approach and avoidance behavior    | A O; DL Q; EMA    | General; since last beep | Self-developed items                            |
| Volition                           | A; P DL; DL-N EMA | Since last beep; past day | Self-developed items                            |
| Advantageous and disadvantageous choices | A; P D2 ET          | Current         | Novel variant of an intertemporal choice task (ITC) |
| Context processing, goal maintenance, and updating | A; P D2 ET          | Current         | AX continuous performance task (AX-CP)          |
| Inhibition                         | A D2 ET           | Current         | Number Stroop task (Stroop)                     |
| Inhibition                         | A D2 ET           | Current         | Go–nogo task (Go–nogo)                         |
| Category/construct | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure |
|--------------------|-------------------|----------------|-----------------|-----------------------|---------|
| Reactions to emotional faces | A; P | D2 | ET | Current | Emotional face approach-avoidance task (Face AAT) |
| Speed of processing, visual search, scanning, flexibility, and executive functions | A; P | D2 | Test | Current | Trail-Making Test—A/B (TMT) |
| Speed of processing | A; P | D2 | Test | Current | Number Connection Test (Zahlenverbindungstest [ZVT]) |
| Working-memory’s number storage capacity | A; P | D2 | Test | Current | Digit Span Task—forward/backward (DSP) |
| Emotion | | | | | |
| Emotion regulation | A | O | Q | General | Emotion-Regulation Skills Questionnaire (SEK/ERSQ) |
| Emotional pain tolerance | A; P | D2 | Q | General | Self-developed item |
| Experiential avoidance | A; P | DL; DL-N | EMA | Since last beep; past day | Adapted items from another EMA study |
| Positive/negative mood | A; P | DL; DL-N | EMA | Since last beep; past day | Self-developed item |
| Mood | A | DL | EMA | Current | Six-item short form of the Multidimensional Mood Questionnaire (MDBF) |
| Temperament/personality | | | | | |
| Behavioral inhibition | P | D1 | Q | Ages 0 to 2 | Retrospective Infant Behavioral Inhibition Scale (RIBI) |
| Behavioral inhibition: social/school and fear/illness | A | O | Q | Ages 5 to 16 | Retrospective Self Report of Inhibition (RSRI) |
| Behavioral inhibition/activation | A; P | O | Q | General | Behavioural Inhibition System/Behavioural Activation System scales (BIS/BAS scales) |
| Big Five personality | A; P | O | Q | General | Short version of the Big Five Inventory (BFI-10) |
| Personality: negative affect, detachment, antagonism, disinhibition, and psychoticism | A; P | D1; D2 | Q | General | Personality Inventory for DSM-5—Brief Form (PID-5-BF) |
| Personality: harm avoidance, reward dependence, and sensation seeking | A; P | D2 | Q | General | Short form of the Tridimensional Personality Questionnaire (TPQ-44) |
| Willingness to take risks | A; P | O | Q | General | Kurzskala Risikobereitschaft-1 (R-1) |
| Intolerance of uncertainty | A | O | Q | General; past day | Short version of the German Intolerance of Uncertainty Scale (IUS-D) |
| Coping/resiliency | | | | | |
| Coping | A | O | Q | General | Extended Brief COPE |
| Resilience | A; P | O | Q | General | Connor-Davidson Resilience Scale (CD-RISC-10) |
| Resilience | A; P | O | Q | Past 3 months | Resilience Scale for Adolescents (READ); Resilience Scale for Adults (RSA) |
| Resilience | A; P | DL-N | EMA | Past day | Brief Resilient Coping Scale (BRCs) |
| Self-efficacy | A; P | O; DL-N | Q; EMA | General; past day | Short Scale for Measuring overall Self-efficacy Beliefs (ASKU) |

(Continues)
| Category/construct                                      | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure                                                                 |
|--------------------------------------------------------|-------------------|-----------------|-----------------|-----------------------|-------------------------------------------------------------------------|
| Stress                                                 |                   |                 |                 |                       |                                                                         |
| Discomfort intolerance                                  | A; P              | D2              | Q               | General               | Four items of the Discomfort Intolerance Scale (DIS)                    |
| Childhood trauma/adversity                             | A                 | D1              | Q               | Until age 18          | Child-Trauma Questionnaire extended (CTQ)                                |
| Violence against mother or father                      | A                 | D1              | Q               | Until age 18          | Adapted items of the Adverse Childhood Experiences Questionnaire (ACE)  |
| Trauma                                                 | A; P              | D1              | I; Q            | Lifetime              | DIA-X-5 Section N                                                       |
| Separation from parents                                | A; P              | D1              | Q               | Past                  | Items used in EDSP                                                      |
| Life events and conditions                             | A                 | O               | Q               | Past 5 years          | Munich Event list for each year (MEL)                                   |
| Assaults, aggressive behavior, bullying as victim and perpetrator in real life and social media | A                 | D1              | Q               | Past 12 months        | Self-developed questionnaire with items from DEGS                      |
| Burdensome events                                      | A; P              | D1              | I; Q            | Past 12 months        | DIA-X-5 Section AD                                                      |
| School performance                                     | A                 | O               | Q               | Past 12 months        | Self-developed items                                                   |
| Work and life conditions                               | A; P              | O               | Q               | Past 12 months        | Self-developed items                                                   |
| Stress—chronic                                         | A; P              | O               | Q               | Past 3 months         | Trier Inventory of the Assessment of Chronic Stress-Screening (TICS-SSCS) |
| Stress—load                                            | A; P              | D2              | BP              | Current; past 3 m     | Hair and cortisol sample protocols                                      |
| Stress—perceived                                       | A; P              | O               | Q               | Past month            | Perceived Stress Scale (PSS-4)                                          |
| Stress—perceived                                       | A; P              | DL-N            | EMA             | Past day              | Perceived Stress Scale (PSS-10)                                         |
| Stress—expected                                        | A; P              | DL-M            | EMA             | Past night            | Self-developed items                                                   |
| Daily hassles                                          | A                 | O               | Q               | Past 2 weeks          | Daily Hassles Scale (DH)                                               |
| Time urgency                                            | A                 | O               | Q               | Past 2 weeks          | Self-developed items                                                   |
| Bullying                                               | A; P              | DL-N            | EMA             | Past day              | Self-developed item                                                    |
| Mood changing events                                   | A; P              | DL              | EMA             | Since last beep       | Self-developed items                                                   |

| Biomaterials and physiological parameters              |                   |                 |                 |                       |                                                                         |
| Blood pressure (systole, diastole, and pulse)           | A; P              | D2              | Bio             | Current               | Oscillometric digital blood pressure monitor (705IT, OMRON)             |
| Blood/buccal sample                                    | A; P              | D2              | Bio             | Current               | Two 9-ml blood samples by venipuncture (5-Monovettes; Sarstedt, Nümbrecht); or— alternatively—buccal swabs (Biozyme, Wien) for sampling buccal mucosa |
| Hair sample with standard hair protocol                 | A; P              | D2              | Bio             | Past 3 months         | Two to three 3-cm-long, 3-mm-wide hair samples taken scalp-near from a posterior vertex position |
| Saliva samples with time recording                      | A; P              | DL              | Bio             | Current (two subsequent weekdays)                                   | Taken immediately after awakening, 30 min after the first sampling and 30 min before going to bed (Salivettes: Sarstedt, Nümbrecht, Germany; MEMSCAPS (MEMS 6 TrackCap container): Aardex Ltd., Switzerland) |

(Continues)
disorders (e.g., also disruptive behavior, attention-deficit/ hyperactivity, and impulse-control disorders; DIA-X-5; Hoyer et al., submitted). The fully standardized computer-assisted personal interviews were conducted face-to-face by trained clinical (psychology/medical) interviewers. Supporting lists and dimensional symptom scales were applied via tablet computers. Adjacent to each diagnostic section, index subject provided family history information on psychopathology of parents, grandparents, siblings, and—if relevant—one significant other person per DIA-X-5 stem screening question. The time for the standardized interview at baseline varied broadly depending on the amount of psychopathology reported and the speed in answering tablet-based questionnaires (1.5–8 hr). For interviews taking 3+ hours, scheduling a separate appointment was offered.

Parents completed a self-administered short form of the DIA-X-5 via tablet questionnaire providing data on own psychopathology. Additional family history information was assessed from participating parents and—whenever possible—also from the index subject using an extended family history module applied via tablet-questionnaire covering mental disorders of the index child’s grandparents (biological-/adoptive) parents, siblings, and—if relevant—one significant other person per DIA-X-5 stem screening question. The interview; EMA: ecological momentary assessment; AM: anthropometric measures; BP: biological sample protocol; ET: experimental tasks. BELLA: mental health module (BELLA study) within the German Health Interview and Examination Survey of Children and Adolescents; DEGS: German health interview and examination survey for adults; EDSP: Early Developmental Stages of Psychopathology study; HBSC: Health Behaviour in School-aged Children study; KIGGS: German Health Interview and Examination Survey of Children and Adolescents; NCS-A: National Comorbidity Survey Replication Adolescent Supplement. References for the Measures in Table 1 are available from the authors upon request.

### 2.4.2 Ecological momentary assessment

In the EMA assessment (Shiffman, Stone, & Hufford, 2008), index subjects answered questions presented via a self-developed study smartphone app on eight occasions per day over the course of four consecutive days (two weekdays and the weekend). Three survey sets were configured (one morning, six midday, and one evening assessment), each containing 203–248 items, most of which related to the time window since the previous assessment. Implemented branching rules allowed an adaptive answering of the questions so that the study load and time burden could be reduced (~3 min per assessment). The assessments covered current mood and emotions, perceived stress, substance use, daily activities, approach/avoidance behaviors, eating behavior, and physical activity (Table 1). Additionally, sleep behavior and quality during the last night were assessed in the morning and quality of life and subjective stress over the course of the day in the evening assessment. Using GPS tracking, the geographic position of the subject was continuously recorded to investigate the movement radius and points of interest. Furthermore, heart rate/heart rate variability (HRV) and objective movement data were continuously recorded via an integrated HRV and acceleration sensor system (Firstbeat Bodyguard 2; Parak & Korhonen, 2015).

Subjects were informed by trained staff about the EMA study procedures including a presentation of handling the smartphone and HRV sensor. In order to optimally tailor the EMA assessments to the subjects’ everyday life, sleep times and periods during which the subjects did not want to be disturbed were requested. An individual reminder scheme was created for each subject and transferred to the smartphone. Reminders were distributed symmetrically throughout the day, taking into account the "nondisturb" times to cover the entire day’s course. Participants were allowed to postpone each survey prompted by an acoustic signal three times by 5 min or omit the questionnaire if it was not possible to complete.

On the day before the first assessment, three questionnaire sets were presented in order to familiarize participants with the EMA modality. On the day after the last assessment, a postassessment questionnaire asked for specific impressions and difficulties during the assessment period.

Collected data were stored locally on the smartphone and HRV device and transferred to the study server after the participant returned the equipment to the study center. GPS data were recorded on the smartphone (sampling frequency 0.2 Hz), and HRV (in millisecond accuracy) and physical activity data (three-axis acceleration sensor motion data with a sampling frequency of 12.5 Hz) were recorded continuously over the 4-day period. Participants were asked to wear the HRV sensor over the entire EMA period (including the night),

### TABLE 1 (Continued)

| Category/construct         | Target population | Assessment time | Assessment mode | Coverage (time frame) | Measure                                                                 |
|---------------------------|-------------------|-----------------|-----------------|-----------------------|-------------------------------------------------------------------------|
| Heart rate/HRV            | A                 | DL              | EMA             | Current (continuous over 4 days) | HRV in millisecond accuracy (Firstbeat Bodyguard 2)                     |
| Objective physical activity| A                 | DL              | EMA             | Current (continuous over 4 days) | Three-axis acceleration sensor system with a sampling frequency of 12.5 Hz (Firstbeat Bodyguard 2) |

Note. Target population: A: adolescents and young adults (index subjects); F-A: filtered adolescents (i.e., by age, video game use); P: parents. Assessment time: D1: first assessment day; D2: second assessment day; DL: in daily life between D1 and D2; DL-M: morning assessment in daily life between D1 and D2; DL-N: night assessment in daily life between D1 and D2; O: Online-questionnaire between D1 and D2. Assessment mode: Q: questionnaire; I: interview; EMA: ecological momentary assessment; AM: anthropometric measures; BP: biological sample protocol; ET: experimental tasks. BELLA: mental health module (BELLA study) within the German Health Interview and Examination Survey of Children and Adolescents; DEGS: German health interview and examination survey for adults; EDSP: Early Developmental Stages of Psychopathology study; HBSC: Health Behaviour in School-aged Children study; KIGGS: German Health Interview and Examination Survey of Children and Adolescents; NCS-A: National Comorbidity Survey Replication Adolescent Supplement. References for the Measures in Table 1 are available from the authors upon request.
which was attached to the skin with electrodes on the upper body and only to be taken off before contact with water. Replacement electrodes were made available to the subjects in sufficient quantities.

On the two weekdays of the EMA period, the awakening reaction and the daily variation of cortisol levels was determined by collecting saliva samples immediately after awakening, 30 min later, and 30 min before bedtime. Subjects were shown how to provide the saliva samples using Salivettes (Sarstedt, Nümbrecht, Germany) and received reminders by the smartphone. The actual saliva sampling time was recorded with the use of MEMSCAPS (MEMS 6 TrackCap container, Aardex Ltd., Switzerland). Participants were asked to store the saliva samples immediately in their freezer before returning them at the second personal appointment to the study personnel, who immediately stored the samples in a laboratory freezer. After thawing, saliva samples were centrifuged for 10 min at 4,000 rpm and cortisol concentrations were determined using a commercially available chemiluminescence assay (CLIA, IBL-Hamburg, Germany).

Participating parents completed a paper-and-pencil-based EMA twice a day (morning and evening) over the course of 4 days (two weekdays and weekend) and also provided three saliva samples on the two weekdays.

### 2.4.3 Biosamples and anthropometric measurements

Besides saliva samples over the course of two EMA days for diurnal cortisol analyses, a hair sample was taken by trained study personnel for assessment of long-term cortisol secretion both from index subjects and participating parents (Kirschbaum, Tietze, Skoluda, & Dettenborn, 2009). Two to three 3-cm-long hair samples were collected, scalp-near from a posterior vertex position. The selected hair was about the diameter of a pencil (~3 mm) and stored in foil. After hair sample, participants filled in questions about hair treatments (e.g., dyeing), alcohol consumption, smoking, sporting activities, and recent illnesses or stressful situations (Stalder & Kirschbaum, 2012).

In addition, two 9-ml EDTA blood samples were collected by venipuncture from index subjects and participating parents using the vacuum method for DNA analyses (S-Monovettes; Sarstedt, Nümbrecht) and were stored at -80°C. For participants not concurring with the blood withdrawal, buccal swabs (Biozyme, Wien) for sampling buccal mucosa were offered.

Standard digital scales were used with index-subjects and participating parents for anthropometric measures (weight, height, and waist circumference). Systolic and diastolic blood pressure were measured after a resting period of at least 5 min, and three times on the arm without blood sampling of seated subjects using an oscillometric digital blood pressure monitor (705IT, OMRON).

### 2.4.4 Questionnaire assessments

Index subjects completed a range of questionnaires during the personal assessments in the study center and during a web-based online assessment between the two personal appointments. Questionnaires assessed putative distal and proximal individual and environmental risk and protective factors covering constructs from various domains (see Table 1). The total time for filling in the questionnaires was approximately 60–90 min online and 30–60 min on site.

Participating parents completed a shorter version of the questionnaire assessment and provided additional information on pregnancy, birth, and early development of the index child.

#### 2.4.5 Behavioral tests and tasks

Index subjects completed paper-and-pencil tests and computerized tasks on executive functioning, cognitive control, and decision making during the second personal appointment. The total time for this behavioral experimental assessment was ~70 min.

Three paper-and-pencil tests were conducted by trained examiners. For a nonlanguage-based measure of intelligence (“speed of processing”), the number connection test (German ZVT; Oswald & Roth, 1987) was conducted. The ZVT is comparable with the trail-making test (Reitan, 1955), which was also applied. To measure working-memory’s number storage capacity, a digit span task was used (Richardson, 2007).

The matlab-programmed task battery included five tasks that were presented in the same order to every subject and that started automatically. Subjects were introduced to the set up by trained study personnel. During task battery performance, subjects were alone in a quiet room and allowed to do self-paced breaks between the individual tasks. The tasks included the number Stroop task (Stroop, 1932) to measure inhibition (using a mouse-click version in contrast to common keyboard-based response), the emotional face approach-avoidance task (Face-AAT; Heuer, Rinck, & Becker, 2007) to investigate reactions to emotional faces, the AX continuous performance task (AX-CP; Cohen, Barch, Carter, & Servan-Schreiber, 1999) to measure context processing, goal maintenance and updating, a novel variant of an intertemporal choice task (ITC, Scherbaum, Dshemuchadse, Leiberg, & Goschke, 2013) to measure individually determined advantageous and disadvantageous choices, and a go–nogo task (Wolff et al., 2016) to measure inhibition.

Participating parents completed the same paper-and-pencil tests and a shortened task battery (Face-AAT, AX-CP, and ITC).

#### 2.5 Quality assurance

To ensure high data quality different steps were followed including (a) handing the operation manual with standard operating procedures for recruitment, assessments, and data management to every new staff member; (b) intensive recruitment, interviewer, and other assessment training and certification for new staff including supervision by scientific project members as long as required to ensure high data quality; (c) refreshment trainings for staff every 4–6 months; (d) systematic monitoring of assessments with spot checks throughout the field phase followed by individual feedback to staff members and—if
required—additional training; (e) supervisions with the study PI regarding the clinical interviews; and (f) systematic checks of data regarding completeness, consistency, and plausibility.

Prior to the study, all assessments and study procedures were tested for feasibility, practicability, and time requirements. Novel assessments were also checked for reliability and validity. The entire study procedure was piloted with 20 subjects from the general population. To avoid false or missing values and for a time-economic study, execution value ranges were defined and branching rules were applied. A comprehensive IT infrastructure has been developed for several study aspects such as recruitment, participant management, scheduling appointments, data entry, and integration.

3 | RESULTS

3.1 | Recruitment flow and study population

Invitation letters were subsequently sent to overall 6,321 sampled individuals/families. Of these, 14.1% were ineligible, mostly due to the fact that they were not residing under the provided address (Figure 2). Of the remaining 5,428 individuals, 1,180 were assessed resulting in a minimum response (participation) proportion of 21.7% (AAPOR, 2016: formula RR1). The cooperation rate among those with known eligibility was 43.4% (formula COOP1). The main reason for nonparticipation was refusal, mostly due to lack of time or interest, followed by failure to contact and arranging suitable appointments; 42.8% of all invited individuals/families did not answer the invitation letter, two reminder letters, and an anonymous non-responder questionnaire. Assuming that the proportion of eligible subjects in these cases with unknown eligibility is the same as the proportion of eligible subjects among those with known eligibility, the estimated overall response proportion was 24.8% (formula RR3) and the overall cooperation rate was 49.5% (formula COOP3).

Table 2 shows the sample and the total population of 14- to 21-year-old people in Dresden by age and sex. Participation was generally higher in females than males.

In order to improve representativeness of the sample, we apply sample weights. The sample is divided into 16 strata according to the 16 possible combinations of sex and age. The sample weights are calculated so that after weighting adjustment, the relative sample frequencies of these groups equal the corresponding relative frequencies of the strata in the population of the 14- to 21-year-old people of Dresden (the target population). Note that this accounts for (a) intended (sampling probabilities differing over age groups, by design) and (b) unintended discrepancies. The distribution of other determinants of participation is also adjusted for to an extent that these are associated with sex and age. The age and sex distribution of the target population were taken from the Registration Office of the city of Dresden (Landeshauptstadt Dresden-Kommunale Statistikstelle, 2016b) and can be considered highly accurate.

3.2 | Sample characteristics of index subjects

The mean age of the N = 1,180 index participants at baseline was 17.3 years (SD 2.3) and was similar for boys (17.1, SD 2.3) and girls (17.4, SD 2.2). As shown in Table 3, most participants had German Nationality (97.5%); 61.2% still went to school, 19.6% were university students; 99.3% of the index subjects had never been married, and 74.7% lived with a parent.

Table 4 shows demographic characteristics of participants and nonparticipants with returned nonresponder questionnaire and the 14–21 year olds living in Dresden as indicated by the German Microcensus 2014. The Microcensus subsample of 14- to 21-year-old participants from Dresden (N = 345) cannot be as representative for the target population as the whole Microcensus sample is representative for German households, but it is the most reliable source about key sociodemographic characteristics of this age group in Dresden. Table 4 reveals that the proportion of people with high education level is higher in the BeMIND cohort than in the Microcensus-sample for...
the 14- to 21-year-old Dresden population. Additional weighting procedures accounting for the overrepresentation of high education in the BeMIND sample will, therefore, be used for sensitivity analyses in the future. Furthermore, the proportion of people living with parents and the proportion of people attaining school is higher in the BeMIND cohort than in the Microcensus sample. To a certain extent, this just reflects the fact that at age 16–18, people attaining higher secondary education at school (assigned to the high education group) were more likely to participate in the BeMIND study than people already attaining job training (usually assigned to middle education level).

Table 5 shows general health indicators in the BeMIND participants and the nonparticipants with returned nonresponder questionnaire. Participants and nonparticipants are comparable indicating that over 80% show no or only mild interference due to somatic or mental/psychosomatic/substance use problems in the past 12 months. The BMI distribution was also similar. Yet, in the BeMIND cohort, a somewhat larger proportion indicated having had treatment for chronic somatic disease (22.6% vs. 17.4%) or mental health problems (20.7% vs. 11.9%) and reported to be a current smoker (20.7% vs. 11.9%).

### 3.3 Family study

Overall, 709 parents of 549 index participants were directly assessed with similar procedures. Further, 207 parents completed at least a minor assessment via online questionnaire. Thus, 916 parents of 677 index subjects provided data.

### 3.4 Completion of baseline study assessments

Data S1B provides an overview of the numbers of subjects who provided data to the individual baseline study components. Participation...
TABLE 3  Demographic sample characteristics of BeMIND index subjects at baseline (N = 1,180)

|                  | Total | Age 14-17 | Age 18-21 | Males | Females |
|------------------|-------|-----------|-----------|-------|---------|
|                  | N     | %         | %w        | N     | %       | %w     | N     | %         | %w     | N     | %         | %w     |
| **Age**          |       |           |           |       |         |        |       |           |         |       |           |         |
| 14-17 years      | 635   | 53.8      | 41.0      | 635   | 100.0   | 100.0  | 0     | 0.0       | 0.0     | 279   | 56.4      | 41.3    |
| 18-21 years      | 545   | 46.2      | 59.0      | 0     | 0.0      | 0.0    | 545   | 100.0     | 100.0   | 216   | 43.6      | 58.7    |
| **Sex**          |       |           |           |       |         |        |       |           |         |       |           |         |
| Male             | 495   | 41.9      | 51.7      | 279   | 43.9    | 52.1   | 216   | 39.6      | 51.5    | 495   | 100.0     | 100.0   |
| Female           | 685   | 58.1      | 48.3      | 356   | 56.1    | 47.9   | 329   | 60.4      | 48.5    | 0     | 0.0       | 0.0     |
| **German Nationality** |       |           |           |       |         |        |       |           |         |       |           |         |
| Yes              | 1,150 | 97.5      | 97.1      | 621   | 97.8    | 97.6   | 529   | 97.1      | 96.8    | 478   | 96.6      | 96.3    |
| No               | 30    | 2.5       | 2.9       | 14    | 2.2      | 2.4    | 16    | 2.9       | 3.2     | 17    | 3.4       | 3.7     |
| **Living arrangement** |       |           |           |       |         |        |       |           |         |       |           |         |
| With parents     | 881   | 74.7      | 65.1      | 623   | 98.1    | 98.0   | 258   | 47.3      | 42.1    | 383   | 77.4      | 66.7    |
| Alone            | 109   | 9.2       | 12.5      | 5     | 0.8      | 0.8    | 104   | 19.1      | 20.6    | 36    | 7.3       | 10.6    |
| With partner     | 50    | 4.2       | 5.4       | 2     | 0.3      | 0.3    | 48    | 8.8       | 8.9     | 10    | 2.0       | 3.0     |
| Other            | 140   | 11.9      | 17.1      | 5     | 0.8      | 0.9    | 135   | 24.8      | 28.4    | 66    | 13.3      | 19.7    |
| **Education**    |       |           |           |       |         |        |       |           |         |       |           |         |
| Low              | 25    | 2.1       | 2.3       | 12    | 1.9      | 1.9    | 13    | 2.4       | 2.6     | 15    | 3.0       | 3.2     |
| Middle           | 233   | 19.7      | 18.6      | 158   | 24.9    | 24.7   | 75    | 13.8      | 14.3    | 101   | 20.4      | 18.7    |
| High             | 881   | 74.7      | 76.4      | 433   | 68.2    | 68.4   | 448   | 82.2      | 82.0    | 362   | 73.1      | 75.7    |
| Other            | 41    | 3.5       | 2.8       | 32    | 5.0      | 5.0    | 9     | 1.7       | 1.2     | 17    | 3.4       | 2.3     |
| **Employment**   |       |           |           |       |         |        |       |           |         |       |           |         |
| School           | 722   | 61.2      | 48.7      | 604   | 95.1    | 94.6   | 118   | 21.7      | 16.8    | 316   | 63.8      | 49.0    |
| University       | 231   | 19.6      | 28.6      | 0     | 0.0      | 0.0    | 231   | 42.4      | 48.6    | 104   | 21.0      | 31.6    |
| Job training     | 99    | 8.4       | 10.0      | 16    | 2.5      | 2.9    | 83    | 15.2      | 15.0    | 33    | 6.7       | 8.8     |
| Employed         | 61    | 5.2       | 6.9       | 3     | 0.5      | 0.7    | 58    | 10.6      | 11.2    | 24    | 4.8       | 6.5     |
| Unemployed       | 19    | 1.6       | 1.6       | 5     | 0.8      | 0.8    | 14    | 2.6       | 2.2     | 4     | 0.8       | 0.8     |
| Other            | 48    | 4.1       | 4.1       | 7     | 1.1      | 1.1    | 41    | 7.5       | 6.2     | 14    | 2.8       | 3.3     |
| **Social class** |       |           |           |       |         |        |       |           |         |       |           |         |
| Lowest           | 23    | 2.0       | 2.6       | 6     | 1.0      | 1.1    | 17    | 3.1       | 3.6     | 10    | 2.1       | 2.8     |
| Lower middle     | 144   | 12.5      | 14.6      | 48    | 7.8      | 7.9    | 96    | 17.7      | 19.1    | 60    | 12.4      | 14.8    |
| Middle           | 710   | 61.5      | 60.6      | 391   | 63.7    | 63.8   | 319   | 59.0      | 58.4    | 300   | 62.0      | 60.8    |
| Upper middle     | 272   | 23.5      | 21.7      | 167   | 27.2    | 26.9   | 105   | 19.4      | 18.2    | 112   | 23.1      | 21.2    |
| Upper            | 6     | 0.5       | 0.5       | 2     | 0.3      | 0.4    | 4     | 0.7       | 0.6     | 2     | 0.4       | 0.5     |
| No information³  | 25    | 2.1       | –         | 21    | 3.3      | –      | 4     | 0.7       | –       | 11    | 2.2       | –       |

(Continues)
in each study component was high with around 90% or more of the subjects providing some or even complete data.

4 | DISCUSSION

The BeMIND study offers unique features to expand our knowledge on the complex developmental factors of mental disorders and health risk behaviors contributing to somatic diseases. The particular strength of the study is the assessment of psychological and behavioral factors both in real life (via EMA with combined actigraphic/geographic monitoring) and in the laboratory (via experimental tasks)—in addition to the more traditional assessments used in epidemiological research including clinical-diagnostic and questionnaire assessments relying on subjective retrospective self-report. Select biologic measures (DNA and stress markers) allow testing for critical interactions with behavioral, psychological, and/or environmental risk/protective factors.

For analysis and interpretation of BeMIND study data, several limitations need to be considered. First of all, the response rate is relatively low (AAPOR-RR1: 21.7%; RR3: 24.8%). The cooperation rate was more favorable, yet still below 50%. Decreasing participation is a general problem in epidemiologic study and survey research (Galea & Tracy, 2007), a trend that has been continuing in more recent health studies in Germany and other European countries (Loeffler et al., 2015; Scheidt-Nave et al., 2012; Scholtens et al., 2015; Volkert et al., 2017) with particularly low participation of adolescents and young adults (Keeble, Baxter, Barber, & Law, 2016; Lange et al., 2017). Several aspects may have prevented a more favorable participation rate in our study. First, in the invitation letter, participants were informed that no individual feedback on test results would be possible. Thus, the only incentive was the relatively low financial compensation. Second, due to legal regulations, standard epidemiological procedures such as home visits or telephone contacts for recruitment could not be carried out; the maximum allowed number of written contact attempts was three. Third, because of the prospective-longitudinal design, we emphasized to recruit individuals willing to become part of a cohort with follow-up investigations at irregular intervals. Subjects who might have participated in a cross-sectional but not longitudinal study might thus have refrained from enrollment. Fourth, the study procedures were comprehensive and time-consuming. To maximize chances for complete data, this information was given upfront in the invitation letter, which might have decreased participation. No time and no interest were the mostly provided reasons for nonparticipation.

A low response rate may not necessarily impair study validity (Morton, Bandara, Robinson, & Carr, 2012). The risk of bias needs to be carefully assessed for each individual research question under analysis. Representativeness may be limited by many factors that could have been related to participation beyond age and sex. In the BeMIND sample, subjects with a higher education appear overrepresented (76.4%w) when compared with Microcensus data (59.4%), which, however, are based on a much smaller sample size (actually
TABLE 4  Characteristics of BeMIND participants in comparison to nonparticipants and the German Microcensus subsample of 14- to 21-year-old people in Dresden

|                      | Participants  | Nonparticipants with returned short questionnaire | Microcensus 2014 (sample of 14- to 21-year-old people living in Dresden [n = 345]) |
|----------------------|---------------|----------------------------------------------------|---------------------------------------------------------------------------------|
|                      | (n = 1,180)   |                                                    |                                                                                 |
| **Age**              |               |                                                    |                                                                                 |
| 14–17 years          | 635 53.8 41.0 | 423 64.5 40.9                                       | 128 37.1                                                                        |
| 18–21 years          | 545 46.2 59.0 | 233 35.5 59.1                                       | 217 62.9                                                                        |
| Unknownb             | — — —         | 8 1.2 —                                             | — —                                                                              |
| **Sex**              |               |                                                    |                                                                                 |
| Male                 | 495 41.9 51.7 | 322 49.2 51.7                                       | 162 47.0                                                                        |
| Female               | 685 58.1 48.3 | 333 50.8 48.3                                       | 183 53.0                                                                        |
| Unknownb             | — — —         | 9 1.4 —                                             | — —                                                                              |
| **Living arrangement** |             |                                                    |                                                                                 |
| With parents         | 881 74.7 65.1 |                                                    | 179 51.9                                                                        |
| With partner         | 50 4.2 5.4    | Not assessed                                        | 19 5.5                                                                          |
| Alone/other          | 249 21.1 29.6 |                                                    | 147 42.6                                                                        |
| **Living with both (biological) parents (only for <18 years)** |               |                                                    |                                                                                 |
| No                   | 221 34.8 34.0 | 152 35.9 —                                          | 46 35.9                                                                         |
| Yes                  | 414 65.2 66.0 | 271 64.1 —                                          | 82 64.1                                                                         |
| **Having partner**   |               |                                                    |                                                                                 |
| No                   | 679 67.3 64.5 | 480 72.3 70.0                                       | —                                 |
| Yes                  | 330 32.7 35.5 | 123 18.5 21.5                                       | Not assessed                       |
| Others               | 0 0.0 0.0     | 15 2.3                                               | 3.5                               |
| Unknownb             | 171 14.5 —    | 46 6.9                                               | 5.0                               |
| **Education**        |               |                                                    |                                                                                 |
| Low                  | 25 2.1 2.3    |                                                    | 27 7.8                                                                          |
| Middle               | 233 19.7 18.6 | Not assessed                                        | 96 27.8                                                                         |
| High                 | 881 74.7 76.4 |                                                    | 205 59.4                                                                        |
| Other                | 41 3.5 2.8    |                                                    | 17 4.9                                                                          |
| **Employment**       |               |                                                    |                                                                                 |
| School/University    | 952 80.8 77.3 | 538 81.3 76.9                                       | 224 65.0                                                                        |
| School               | 722 61.2 48.7 | c                                                    | 132 38.3                                                                        |
| University           | 231 19.6 28.6 | c                                                    | 92 26.7                                                                         |
| Job training         | 99 8.4 10.0   | 82 12.4                                              | 76 22.0                                                                        |
| Employed             | 61 5.2 6.9    | 11 1.7                                               | 2.3 26                                                                           |
| Unemployed/Other     | 19 5.7 5.7    | 22 3.4                                               | 5.1 19                                                                           |
| Unknown              | — — —         | 11 1.7 —                                             | — —                                                                              |
| **Subjective financial situation** |               |                                                    |                                                                                 |
| Very bad, bad        | 80 6.9 8.1    | 67 11.0                                              | 12.6                                                                            |
| Neither good nor bad | 406 34.9 33.6 | 252 41.4 41.8                                       | Not assessed                       |
| Good                 | 532 45.8 45.8 | 205 33.7 33.6                                       | 33.6                              |
| Very good            | 144 12.4 12.4 | 85 14.0                                              | 12.1                              |
| Unknownb             | 18 1.5 —      | 55 8.3 —                                             | — —                                                                              |

**Note.** %w: weighted percentage.

*RDC of the Federal Statistical Office and Statistical Offices of the Federal States, Microcensus 2014, survey year 2014, own calculations. The German Microcensus provides official representative statistics of the population in Germany (covering almost completely 1% of German households).

bPercentages of main categories are percentages from those with available information and add up to 100% except for rounding residuals, percentage of category “unknown” is raw percentage from the complete sample.

cSchool and University are one category in nonresponder questionnaire.
below one third of the BeMIND sample size). Therefore, we decided to weight by default for age and sex as a consequence of our sampling scheme only and not additionally for education. However, we will use such a related weighting variable for sensitivity analysis. No comprehensive epidemiologic study can ever achieve complete representativeness, that is, a sample that represents the source or even target population in every aspect. However, bias due to selection strongly depends on the target parameter to be estimated (e.g., prevalence/incidence rate, association, and causal effect). This bias occurs only if determinants of participation are related to the target parameter (e.g., if education is a moderator of the association between an exposure such as a life event and an outcome such as depression). Then the amount of this bias depends on the sign and magnitude of that association and the difference of the determinant’s distribution between sample and target population. Roughly speaking, larger bias is more likely when estimating marginal parameters (prevalences/incidences) than when estimating associations or effects (Little, Lewitzky, Heeringa, Lepkowski, & Kessler, 1997); and bias might be further smaller when moderators of associations are investigated. This assumes that the individual variation in a parameter (heterogeneity) decreases with an increasing number of variables involved. In the BeMIND study, these determinants could include concern and experience of mental health issues (with exposed individuals expected to have higher participation rates).

| TABLE 5 | General health characteristics of the BeMIND participants vs. nonparticipants |
|----------|--------------------------------------------------------------------------------|
|          | **Participants (n = 1,180)** | **Nonparticipants with returned short questionnaire (n = 664)** |
|          | n  | %   | %w | n  | %   | %w |
| Past 12-month interference due to somatic health problems |
| None     | 522 | 45.8 | 46.1 | 348 | 53.3 | 49.7 |
| Mild     | 510 | 44.7 | 44.4 | 211 | 32.3 | 35.4 |
| Moderate | 96  | 8.4  | 8.4  | 65  | 10.0 | 10.0 |
| Severe   | 12  | 1.1  | 1.2  | 25  | 3.8  | 4.3  |
| Very severe | 0  | 0.0  | 0.0  | 4   | 0.6  | 0.7  |
| Unknown  | 40  | 3.4  | —    | 11  | 1.7  | —    |
| Past 12-month interference due to mental, psychosomatic, or substance use problems |
| None     | 609 | 53.3 | 54.6 | 446 | 68.2 | 63.9 |
| Mild     | 414 | 36.2 | 35.4 | 124 | 19.0 | 21.0 |
| Moderate | 113 | 9.9  | 9.4  | 60  | 9.2  | 11.2 |
| Severe   | 7   | 0.6  | 0.6  | 21  | 3.2  | 3.5  |
| Very severe | 0  | 0.0  | 0.0  | 3   | 0.5  | 0.4  |
| Unknown  | 37  | 3.1  | —    | 10  | 1.5  | —    |
| Ever in treatment due to chronic somatic disease |
| No       | 826 | 79.0 | 77.4 | 505 | 81.7 | 82.6 |
| Yes      | 220 | 21.0 | 22.6 | 113 | 18.3 | 17.4 |
| Unknown  | 134 | 11.4 | —    | 46  | 6.9  | —    |
| Ever in treatment due to mental, psychosomatic, or substance use problem |
| No       | 924 | 79.4 | 79.3 | 544 | 87.7 | 88.1 |
| Yes      | 240 | 20.6 | 20.7 | 76  | 12.3 | 11.9 |
| Unknown  | 16  | 1.4  | —    | 44  | 6.6  | —    |
| Current smoker |
| No       | 966 | 81.9 | 79.3 | 566 | 89.8 | 87.2 |
| Yes      | 214 | 18.1 | 20.7 | 64  | 10.2 | 12.8 |
| Unknown  | 0   | 0.0  | —    | 34  | 5.1  | —    |
| Body mass index (BMI) |
| Underweight (BMI < 18.5) | 176 | 15.4 | 13.4 | 117 | 19.0 | 16.3 |
| Normal weight (18.5 < BMI < 25.0) | 843 | 73.8 | 74.4 | 446 | 72.5 | 74.3 |
| Overweight (BMI > 25.0)   | 123 | 10.8 | 12.2 | 52  | 8.5  | 9.4  |
| Unknown  | 38  | 3.2  | —    | 49  | 7.4  | —    |

Note. %w: weighted percentage.

*Percentages of main categories are percentages from those with available information, percentage of category “unknown” is raw percentage from the complete sample.
Missing data within the sample is another limitation and source of potential bias. Among BeMIND study participants, completion of individual assessments was generally high. We will check types of missing data (at random/not at random) and apply appropriate methods (e.g., imputation techniques, sensitivity analyses; Pedersen et al., 2017).

Another limitation refers to generalization of the BeMIND results to adolescents and young adults in Germany (or other countries). Given the regionally restricted sample (Dresden, Germany), it is important to consider how Dresden compares with other German regions. The city of Dresden is the capital of one of the 16 states of Germany, located in the east of Germany. Dresden has a total population of 548,800 inhabitants (in 2015 when sampling occurred). In contrast to other, mostly rural areas in the eastern part of Germany, the mean age of the population is relatively low (mean: 42.9 years) and as such rather comparable with other large cities in eastern Germany (such as Berlin) and to most regions in western Germany. Similar applies to population density. Compared with other large German cities, there is a relatively low proportion of migrants (6.2%, Landeshauptstadt Dresden-Kommunale Statistikstelle, 2016b). The unemployment rate is in the medium range (7.4%, Landeshauptstadt Dresden-Kommunale Statistikstelle, 2016a). In eastern Germany, including the city of Dresden, there is relatively high population movement, particularly among young adults. For the large-scale follow-up assessment, resources for travel are therefore budgeted. The address information is kept up to date by reminding subjects during the regular newsletters to return their new living information to the study center. New addresses will also be obtained from other information sources as available contact persons and—if needed—from the population registry.

To contrast the limitations of the BeMIND study with the strengths, the EMA of mood, emotions, and behaviors in real life with combined objective measures of activity and stress, as well as the laboratory-based behavioral indicators of cognitive-affective functioning and decision making go beyond traditional assessments of epidemiological surveys on mental and behavioral health. They allow for novel insights into the dynamic networks of symptoms and behaviors (Borsboom, 2017; Bringmann et al., 2016) as well as their predictors and predictive potential. Thus, the BeMIND study will advance our knowledge on the behavioral and psychological factors contributing to health and disease as adolescents grow into adulthood and provide new avenues for early detection and personalized interventions.

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