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Background and enrollment characteristics of students with autism in higher education

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ABSTRACT

Background: The number of students with Autism Spectrum Disorder (ASD) entering Universities is growing. Recent studies show an increased understanding of students with ASD in higher education. Yet, current research generally relies on small samples, lacks information about student characteristics prior to enrollment, and does not compare students with ASD to other students.

Method: Background and enrollment characteristics of students with ASD (n = 97) were compared to students with other disabilities (OD; n = 2252) and students with no recorded disabilities (ND; n = 24,794) based on administrative data of first-year bachelor enrollments (n = 27,143).

Results: From 2010 to 2016 the proportion of students with ASD significantly increased from 0.20% to 0.45%. The characteristics of ASD students at enrollment were similar to other students, but it took ASD students more time to reach higher education compared to ND students, and they were at heightened risk of comorbidity compared to OD students. No difficulties were found with participation in preparatory activities, and goal setting.

Conclusions: These quantitative insights are a valuable addition to the more qualitative evidence so far. For parents of children with ASD and individuals with ASD, these findings could help to adjust lower expectations. As this kind of administrative data is available to most institutions in higher education in day-to-day information systems, this study is promising for institutions to gain better insights in the enrollment of their students with ASD, and improve transition support.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by qualitative impairments in social interaction, communication, and repetitive, stereotyped behavior (American Psychiatric Association [APA], 2013). Approximately 50% of individuals with ASD have average or above average intelligence (Anderson, Carter, & Stephenson, 2017), and a growing number are currently enrolling (Volkmar, Jackson, & Hart, 2017) and expected to enroll in higher education (Van Hees, Moyson, & Roeyers, 2015).

Because of their aptitude for special interests and academic pursuits, universities are likely to be appealing to individuals with ASD (Hamilton, Stevens, & Girdler, 2016). Yet, life transitions, such as the transition to college, are difficult for individuals with ASD (Lambe et al., 2018). As a result, they often need more preparation and support for their transition to higher education compared to their peers (VanBergeijk, Klin, & Volkmar, 2008), but transition planning is often not formalized or inadequate for students with ASD (Dymond, Meadan, & Pickens, 2017; Nuske et al., 2019). Difficulties in transition for students with ASD include problems with

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transition planning, disclosure, life on campus, social relationships, self-awareness, self-advocacy, appropriate support, and executive skills (Cai & Richdale, 2016; Lambe et al., 2018; Van Hees et al., 2015; VanBergeijk et al., 2008; Volkmar et al., 2017; Wagner, Newman, Cameto, Javitz, & Valdes, 2011; Zeedyk, Bolourian, & Blacher, 2019). Furthermore, college life can be very stressful for students with ASD (Pinder-Amaker, 2014), and they are at an increased risk of comorbidity, and personal and academic failure (Van Hees et al., 2015). Early diagnosis, transition planning, and goal-setting are found to be essential to improve enrollment into higher education and graduation outcomes, and institutions in higher education face challenges in improving the transition for these students (Anderson, Carter et al., 2017; Wei, Wagner, Hudson, & Yu, 2016; White et al., 2017; Zeedyk, Tipton, & Blacher, 2016).

Recent studies show an increased understanding of students with ASD in higher education (Gelbar, Smith, & Reichow, 2014), the importance of parental support, and understanding of students with ASD by academic staff (Dymond et al., 2017; Peña & Kocur, 2013; Van Hees, Roeyers, & De Mol, 2018; Zeedyk et al., 2019). Several longitudinal studies have collected data on special education services during high school and participation in post-secondary education (USA: National Longitudinal Transition Study-2 [NLTS2, 2009]; UK: Benchmarking Autism Service Efficacy; [BASE, 2015]). Involvement in transition planning, higher household income, and higher performances at high school were found to correlate positively with participation of students with ASD in post-secondary education (Chiang, Cheung, Hickson, Xiang, & Tsai, 2012; Dillenburger, Jordan, & McKerr, 2016; Griffin, Lounds Taylor, Urbano, & Hodapp, 2013; Shattuck, Narendorf, Cooper, & Sterzing, 2012). Yet, studies based on evidence from higher education itself are limited and fragmented (Cox et al., 2017; Schindler, Cajiga, Aaronson, & Salas, 2015; Wei et al., 2016; White et al., 2016). A systematic review of the literature on college students with ASD and their transition to higher education (Anderson, Stephenson, & Carter, 2017) found only 23 articles describing the experiences of, in total, no more than 378 unique college students diagnosed with ASD. Studies were primarily from the USA (10; 43%) and the UK (7; 30%). Quantitative studies were sparse (7; 30%) and sample sizes were small, with an average of 16 students per sample. Only three studies verified diagnoses of ASD (13%), and five studies extended the eligibility criteria to include students with no formal ASD diagnosis (22%). Most studies reported high academic achievements (14; 61%), but all found students with ASD to struggle with disclosure, non-academic, and academic challenges. Non-academic barriers most frequently reported were social interactions or isolation (23; 100%), mental health, anxiety, or depression (21; 91%), sensory challenges (14; 61%), student accommodation (14; 61%), and poor daily living skills (13; 57%). Academic barriers mentioned by most researchers were organizational or time management (20; 87%), abstract or ambiguous concepts (16; 70%), weak communication skills (16; 70%), and group work or presentations (13; 57%). More recent studies confirm these findings (Anderson, 2018; Nuske et al., 2019).

Frameworks regarding enrollment and transition of students with ASD are complementary, as they differ in outcomes. Transition frameworks, such as the Taxonomy for Transition Programming (Taxonomy; Haber et al., 2016; Kohler, 1993; Trainor, Morningstar, & Murray, 2016; Wei et al., 2016), take formal data on transition planning into account with enrollment as the dependent outcome. Student retention frameworks on the other hand, such as Input-throughput-output frameworks (Van Rooij et al., 2018, derived from Tinto, 1993 and Astin and Antonio, 2012; Braxton, Milem, & Sullivan, 2000), have student success as the dependent outcome.

Even though the body of research is growing, several fundamental issues remain. First, sample sizes of studies on college students are small, verified diagnoses of ASD and information on background characteristics are limited, and most studies are restricted to students with ASD, with no comparison to other students. It is essential to examine quantitative, comparative data to substantiate the reported difficulties of students with ASD, and, if so, to what extent these problems are unique to students with ASD. These insights can enable universities to develop appropriate support for often talented students. Second, educational background and academic capabilities of college students with ASD prior to enrollment are generally unreported. Essential information regarding their intellectual starting point and their pathway to higher education is unknown. Third, most studies are conducted after one or more years in college or even graduation. Studies on the actual preparatory actions of college students, their expectations on possible barriers, and academic capabilities *before* enrollment are absent. To address these issues, we aim to answer the following three questions:

(1) What are the prevalence and background characteristics of students with ASD, OD, and ND in higher education? We examined the number of enrollments for each group, field of study, age, sex, and reported disabilities (ADD/ADHD, ASD, chronic diseases, dyslexia, physical disabilities, psychological disabilities, and other disabilities such as language deficiency and deafness). Numbers of students with ASD were assumed to have grown, but prevalence still to be low because of existing problems with transitions (VanBergeijk et al., 2008) and because, once enrolled, the disclosure is still problematic (Anderson, Stephenson et al., 2017). We expected the majority of students to study in the field of Natural sciences / Science, Technology, Engineering and Mathematics (STEM) (Anderson, Carter et al., 2017; Shattuck et al., 2014; Wei, Yu, Shattuck, McCracken, & Blackorby, 2012), to be male (Loomes, Hull, & Mandy, 2017), and to show high comorbidity rates (Mattila et al., 2010; Simonoff et al., 2008): a combination of the aforementioned disabilities. Age differences were explored.
(2) What are the academic capabilities and pathways to higher education prior to enrollment of students with ASD, OD, and ND in higher education? As we had no previous literature to rely on, we explored history in secondary education, high school examination grades, language proficiency, and the actual transition to higher education. We expected overall higher levels of high school performance for students with ASD compared to OD and ND, as students with ASD with higher grades, especially in Math (Wei et al., 2013), more often transition to university.
(3) What are preparatory actions and expectations prior to enrollment of students with ASD, OD, and ND to higher education? We examined prospective activities and planning, application and enrollment, study context and support. Participation in prospective activities with large groups of students was likely to be low (Lambe et al., 2018) for students with ASD, due to limited socializing, transition planning and goal setting.

To answer these questions, we explore prevalence and background characteristics of students with ASD (n = 97), their academic capabilities and pathways to higher education prior to enrollment, and preparatory actions and expectations prior to enrollment from

secondary school to higher education in comparison to students with other disabilities (OD $n = 2252$) and students with no recorded disabilities (ND $n = 24{,}794$) of a representative, major Dutch University. The present study is an exploratory and comparative study of background and enrollment characteristics of students with ASD, OD, and ND that align with inputs from Input-throughput-output frameworks (Van Rooij et al., 2018), such as demographic factors, prior education, ability, personality, and motivational factors.

2. Methods

2.1. Study population

The dataset included 27,143 first-year students in 52 bachelor programs of the Vrije Universiteit Amsterdam, a major university in the Netherlands, from 2010 to 2016 (M = 19 years of age, 55.4% female). The university offers a wide range of full-time bachelor and master programs in Humanities, Natural sciences, Social sciences & Law, and Health & Life sciences. The dataset was created by the university from its student information and enrollment systems to enable researchers of VU Amsterdam to conduct research based on validated, uniform, and anonymized student data. Identifying characteristics, such as name, email address and student number, were removed. Ethical clearance was obtained from the Scientific and Ethical Review Board of the institution.

The study population consisted of three participant groups: (1) 97 students with a clinical diagnosis of ASD (0.36%), (2) 2252 students with other disabilities such as ADD/ADHD and dyslexia (OD; 8.30%), and (3) 24,794 students with no recorded disabilities (ND; 91.35%). All diagnoses were provided and formally signed by a qualified clinician, independently from this study before the introduction of DMS-5. In the Netherlands, the diagnostic classification of ASD is given by a psychiatrist according to established DSM-IV or DSM-5 criteria and based on an elaborate examination, including observations and parent interviews by multiple experienced clinicians (psychologists, psychiatrists, and educationalists). The diagnostic classification follows the guideline on the diagnostics and treatment of Autism Spectrum Disorders in children and adolescents (monodisciplinary ASD Guideline, the Dutch Psychiatry Association [NvvP], March 2009).

The data on ASD and other disabilities were initially recorded to provide academic accommodations to students with disabilities. Information on accommodations and application was easily accessible to students through several information channels, such as the website of the university, open days and college tours, the national website for online application for a study program in Higher Education (Studielink), the welcome package after enrollment, and personal appointments with student counselors. Students who applied for an accommodation had to present formally signed, medical proof of diagnosis for each disability. Student counselors and student psychologists verified both the authenticity of all documents, as well as the qualification of the medical staff in a national registry of qualified medical professionals, the Professions in the Individual Healthcare Act Registry (Wet Beroepen in de Individuele Gezondheidszorg register, 1997). When a student applied for an accommodation based on more than one disability (i.e., ASD as well as dyslexia), each disability was documented and recorded separately. Provision of the accommodation did not require further disclosure of the diagnosis to peers or staff. This procedure was the same for all cohorts. Data on requests not granted were absent from the dataset, and therefore the number of requests not granted was unknown.

Information was available on the presence of seven disabilities: ADD/ADHD, ASD, chronic diseases, dyslexia, physical disabilities, psychological disabilities, and other disabilities (such as language deficiency and deafness). To focus on students with ASD, and yet compare them to students with other disabilities, we collapsed the six non-ASD disability categories to one group. Then we created three mutually exclusive participant groups. We assigned students to ASD if they had one or more disabilities and at least one of them was labeled "diagnosed with ASD." Students were assigned to OD if they had one or more disabilities and none of them was labeled "diagnosed with ASD." All other students were assigned to ND. See Table 1 for descriptive statistics of students with ASD, OD, and ND on Sex, Age, and Field of Study.

2.2. Measures

See Appendix A for a list of all variables and their measurement scales.

(1) **Prevalence and background characteristics.**

Prevalence. *Cohort* was the academic year a student enrolled for the first time in the academic program of choice. Prevalence was based on the number of ASD, OD and ND students enrolled from 2010 until 2016.

Field of Study. *STEM* showed if a student was enrolled in a Science, Technology, Engineering, and Mathematics study program, based on the STEM Designated Degree Program List ("STEM Designated Degree Program List," 2016).

Table 1
Descriptives for the Three Participant Groups (N = 27,143).

	ASD N = 97	OD N = 2252	ND N = 24,794	*df*	χ^2	*p*	*V*	Group differences
Sex: Female	28 (28.9%)	1319 (58.6%)	13,698 (55.2%)	2	29.19	< 0.001	.04	ASD < OD and ND
Age (in years)	20.0 [18.0-21.0]	19.0 [18.0-21.0]	19.0 [18.0-20.0]	2	132.22	< 0.001	.09	ASD > ND; OD > ND
STEM	54 (55.7%)	706 (31.3%)	6954 (28.0%)	2	46.61	< 0.001	.04	ASD > OD and ND

ASD, students with ASD; OD, students with other disabilities; ND: students with no recorded disabilities.

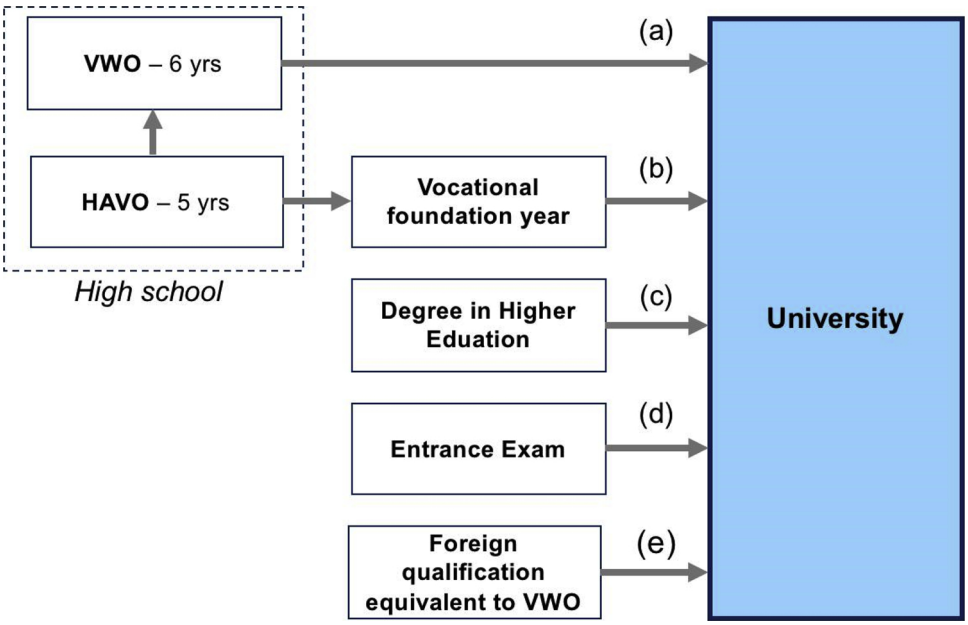

Fig. 1. Pathways to Higher Education.

Demographics. *Sex* was male or female. *Age (in years)* in Dutch higher education is recorded on October 1 in the year students enroll.

Disabilities. Each of the seven registered disabilities had a corresponding measure. *Comorbidity* was true when a student had more than one registered disability.

(2) **Academic capabilities and pathways to higher education prior to enrollment**.

Secondary Education and Secondary Education Examination Grades.

Highest Pre-education. There are five learning paths to higher education in the Netherlands: (a) high school VWO (Voorbereidend Wetenschappelijk Onderwijs, University Preparatory Education), (b) a vocational foundation year (high school HAVO [Hoger Algemeen Voortgezet Onderwijs, Senior General Secondary Education] with a first-year qualification from a University of Applied Sciences), (c) a qualification in Dutch higher education (academic or vocational), (d) other Dutch qualifications, such as a university entrance exam (Colloquium Doctum), or (e) a foreign qualification equivalent to VWO. Students with a foreign education (e) were excluded from the original data set, as many enrollment characteristics were unknown for these students. We included all other paths, to prevent bias towards students with a standard high school path (VWO). *Average Grade Secondary Education* is the average grade of all subjects chosen by a student to graduate in; grades range from 1 to 10. See Fig. 1 for an overview of these pathways.

Language Proficiency. A Dutch language test (LT) was taken after the first enrollment. The test was designed by the Vrije Universiteit Amsterdam to test the capabilities for academic writing (Yntema, Hannay, Van Gastel, Doeve, & Van Straalen, 2008). It consisted of five components that add up to a maximum score of 100%: (*LT Total Score*): (1) *LT Grammar* (22.6%), (2) *LT Phrasing* (14.5%), (3) *LT Spelling and Interpunction* (29.0%), (4) *LT Syntax* (9.0%), and (5) *LT Vocabulary and Choice of Words* (24.9%). LT data were available for 89.0% of the population.

Learning Path to Higher Education. *Gap Year* revealed if (a) a student enrolled directly from high school, without a gap year, (b) took one gap year or (c) neither. *Years of Higher Education* were the number of academic years a student had been enrolled in higher education including vocational programs, while *Years of Academic Education* were academics years of enrollment in academic programs only. If Gap Year was 'neither,' and Years of Higher Education was more than zero, this disclosed that the student enrolled in another program in higher education in the previous academic year.

(3) **Preparatory actions and expectations prior to enrollment**.

Prospective Activities. *Information Brochure*, *Bachelors Open Day*, *College Tour* and *Introduction Program* indicated whether a student downloaded a brochure from the university website, visited an open day for bachelor programs, attended a demonstration course of a specific program, or participated in a voluntary introductory program at the beginning of the academic year. The introductory program consisted of five days of activities to get to know life on campus and fellow students: an information market of facilities on campus, visits to student associations, excursions to the city, sports, introduction to the faculty and the first-year study program, and a closing party. The data on these activities was registered initially within the Customer Relationship Management system of the university.

Personal trust, Perceived Academic Qualities, and Study Conditions. Students who enroll for the first time in a program in Dutch higher education are entitled to get counseling on their choice of study before matriculation, called *Matching*. Part of this procedure was an online survey prior to enrollment for all first-year students since 2014, developed by NOA (Holtrop, 2016). This part of the data set was available for 34.1% of the population.

Personal trust contained measures on the beliefs of the student about his or her decision to enroll in an academic program: *Certainty of Program Choice* and *Confidence in Study Success*. They indicated whether the student hesitated about the decision to enroll in this program and if the student expected to be able to succeed in this program.
Perceived Academic Qualities expressed the required qualities the student expected to possess, including *Concentration*, *Pro-activeness*, *Study Planning*, *Analytical Skills*, *Goal Setting*, and *Self-discipline*. They conveyed executive skills necessary to succeed in an academic environment.
Study Conditions involved measures on support or impediments that could influence success: *Social Support* (student could ask people in his or her environment for social support), *Parents Attended University* (one or both parents attended university), *Additional Support Necessary* (student expected to rely on extra support). Three measures express expected time use and planning: *Study Load (in hours)* (lectures as well as self-study), *Work Load (in hours)* (job activities), *Extracurricular Activities (in hours)* (a second study program, sports, student board membership, student association membership).

2.3. Analytical strategy

R for statistical computing (R Core Team, 2017) was used for data wrangling and data analysis. Because the sample sizes were unequal, we did not assume homogeneity of the variance and applied appropriate tests: the chi-square test is a non-parametric test that does not make assumptions on the population and is, therefore, quite generally applicable (Sheskin, 2007). We performed pairwise comparisons for multiple testing using Bonferroni correction. We divided variables into those measures that applied to all three participant groups, and measures that only applied to ASD and OD e.i. the categorical measures on disabilities. We assessed the data quality for each variable by inspecting the number of zeros, missing values, and infinite values. Skewness and kurtosis were assessed through a graphic check on normality (Q-Q plot) and the Shapiro-Wilk test. Because none of the continuous variables were normally distributed, a Kruskal-Wallis test was conducted to compare these characteristics of the three research groups (median, 1st and 3rd quartiles; McKight & Najab, 2010). Effect sizes were measured using Cramer's V. We performed pairwise Wilcoxon rank sum tests for multiple testing. Categorical variables were compared using chi-square tests, as over 80% of the frequencies was over 5 (Bradley, Bradley, McGrath, & Cutcomb, 1979), and values are reported as absolute and relative frequencies. To calculate the difference in prevalence we took the proportions of 2010 as a baseline to assess the deviations of the baseline in 2016. Effect sizes were measured using Cramer's V. We performed pairwise comparisons for multiple testing, using paired chi-squared.

3. Results

See Appendix B for an overview of all descriptives for the three participant groups.

(1) **Prevalence and background characteristics**
Prevalence. From 2010–2016 the proportion of students with ASD increased significantly: 2010: ASD: 0.20%, OD: 4.76%, ND: 95.04%; 2016: ASD: 0.45%, OD: 10.22%, ND: 89.33%; χ^2 (2, N = 3308) = 228.39, p < .001, V = 1.19).
Field of Study. Students with ASD were significantly more often enrolled in STEM study programs compared to OD and ND (χ^2 (2, N = 27,143) = 46.61, p < .001, V = .04; ASD: 55.7%; OD: 31.3%; ND: 28.0%).
Demographics. Students with ASD were more often male (χ^2 (2, N = 27,143) = 29.19, p < .001, V = 0.04; ASD: 71.1%; OD: 41.4%; ND: 44.8%) and older compared to OD and ND (χ^2 (2, N = 27,143) = 132.22, p < .001, V = 0.09; ASD 20.0 [18.0–21.0]; OD 19.0 [18.0–21.0]; ND: 19.0 [18.0–20.0]).
Disabilities. Comorbidity was more common in students with ASD compared to OD (χ^2 (1, N = 2349) = 76,87, p < .001, V = 0.18; ASD: 24.7%; OD: 11.7%); most common combinations with ASD were dyslexia (7.2%) and ADD/ADHD (6.2%). We found no significant differences between students with ASD with comorbidity (n = 24) and students with ASD without comorbidity (n = 73).

(2) **Academic capabilities and pathways to higher education prior to enrollment**
Secondary Education and Secondary Education Examination Grades. Students with ASD more often had non-standard pre-education qualifications (χ^2 (6, N = 27,143) = 42.80, p < .001, V = .04; Vocational foundation year: ASD 12.4%; OD 13.5%; ND 10.3%; Other Dutch pre-education: ASD 9.3%; OD 2.8%; ND 2.6%). There were no differences between students with ASD and their peers in Average Examination Grades at High School. For specific topics, some differences were present. In English students with ASD outperformed OD and ND (χ^2 (2, N = 27,143) = 62.45, p < .001, V = .06). In Dutch students with ASD performed similarly to OD and ND, while ND outperformed OD. No group differences were found for Math Algebra and Math Calculus.
Years between High School and Higher Education. No differences were found for students with ASD in comparison to their peers in the distribution of Gap Year. The distribution of Years of Higher Education and Years of Academic Education of students with ASD was similar to those of ND, while OD had a higher score of one year in the third quartile of Years of Academic Education (Table 2).
Language Proficiency. Students with ASD outperformed both OD and ND on the Dutch Language Proficiency Test Scores (χ^2 (2, N = 24,163) = 315.84, p < .001, V = .14), while ND outperformed OD (Table 3).

(3) **Preparatory actions and expectations prior to enrollment**
Prospective activities. Students with ASD more often attended Open Days (χ^2 (2, N = 27,143) = 37.03, p < .001, V = .01; ASD: 55.7%; OD: 51.1%; ND: 51.7%). In other prospective activities no significant differences were found (Table 4).
Transition Planning, Perceived Academic Qualities, and Study Conditions. Regarding Transition Planning no differences were found between students with ASD and their peers in Certainty of Program Choice and Confidence in Study Success. As to

Table 2
Educational History and Academic Capabilities prior to Enrollment (N = 27,143).

	ASD N = 97	OD N = 2252	ND N = 24,794	*df*	χ^2	*p*	*V*	Group differences
Highest Pre-education:				6	42.80	< 0.001	.04	
High school VWO	74 (76.3%)	1792 (79.6%)	20,489 (82.6%)					ASD < OD < ND
Vocational foundation year	12 (12.4%)	304 (13.5%)	2548 (10.3%)					OD > ASD > ND
Degree in higher education	2 (2.1%)	92 (4.1%)	1122 (4.5%)					ASD < OD < ND
Other Dutch pre-education	9 (9.3%)	64 (2.8%)	635 (2.6%)					ASD > OD > ND
Average Grade SE	67.0 [65.0-72.0]	66.0 [63.0-70.0]	66.0 [63.0-70.0]	2	5.13	1.000	.07	n.s.
Grade Dutch SE	7.0 [6.0-7.0]	6.0 [6.0-7.0]	6.5 [6.0-7.0]	2	64.62	< 0.001	.06	OD < ND
Grade English SE	7.0 [6.0-8.0]	6.0 [6.0-7.0]	7.0 [6.0-7.0]	2	62.45	< 0.001	.06	ASD > OD and ND
Grade Math Algebra SE	6.0 [6.0-7.0]	7.0 [6.0-7.0]	6.5 [6.0-7.0]	2	3.41	1.000	.06	n.s.
Grade Math Calculus SE	6.0 [6.0-7.0]	6.0 [6.0-7.0]	6.0 [6.0-7.0]	2	0.27	1.000	.07	n.s.
Gap Year:				6	17.55	.276	.03	
Directly (no Gap year)	61 (62.9%)	1365 (60.6%)	15,897 (64.1%)					n.s.
1 Gap year	7 (7.2%)	228 (10.1%)	2246 (9.1%)					n.s.
Other	28 (28.9%)	656 (29.1%)	6619 (26.7%)					n.s.
Missing	1 (1.0%)	3 (0.1%)	32 (0.1%)					n.s.

SE: Secondary Education; ASD, students with ASD; OD, students with other disabilities; ND: students with no recorded disabilities; n.s., no significant group differences.

Perceived Academic Qualities, students with ASD reported lower scores on Concentration compared to ND. No significant differences were found between students with ASD and their peers in Pro-activeness, Analytical Skills, Goal Setting, Study Planning and Self-discipline. In the matter of Study Conditions, students with ASD reported higher scores on In Need of Support and lower scores on Social Support, Work Load and Extracurricular Activities (Table 5).

4. Discussion

The present study examined the enrollment characteristics of students with ASD from secondary school to higher education in comparison to OD and ND students at a major Dutch university. As expected, the prevalence of ASD students rose significantly between 2010 and 2016, most students with ASD were male, and comorbidity was more common compared to OD students. Contrary to our expectations, no differences were found in average examination grades in students with ASD, OD, and ND. Students with ASD more often had non-standard pre-education qualifications. Moreover, we did not find the expected difficulties with participation in prospective activities, transition planning, and goal setting.

Prevalence of ASD and OD students at the current university increased significantly over time in comparison to ND students (ASD: 0.4%; OD: 4.76%). As students with ASD in this study were restricted to those who are formally diagnosed and decided to disclose their disability, we expect the actual prevalence of students with ASD to be higher and more in agreement with estimations between 0.6% and 1.0% (Cai & Richdale, 2016; Van Hees et al., 2015). However, it is uncertain disclosure rates will ever reach these numbers, as students with ASD are reluctant to disclose and sign up for formal support services (Nuske et al., 2019; Van Hees et al., 2018). Reasons for non-disclosure are fear of stigmatization, prejudice, rejection or negative recommendations (Van Hees et al., 2015), lack of self-determination skills (Dymond et al., 2017; Peña & Kocur, 2013), and the wish to make a fresh start (Van Hees et al., 2018).

Most students with ASD were male (71.7%), which is close to recent findings of 75% (Loomes et al., 2017). As expected, we found students with ASD to be above average enrolled in STEM study programs (55.7%). These proportions substantiate previous findings that students with ASD do not necessarily fulfill common stereotypes of STEM majors (Cai & Richdale, 2016; Gelbar, Shefcyk, & Reichow, 2015; Zeedyk et al., 2019).

In accordance with our assumptions, we found comorbidity in students with ASD (25.3%) to be higher in comparison to OD students (11.7%); most common combinations were ASD with dyslexia (7.2%) or ADD/ADHD (6.2%). This is at the lower end of earlier reported

Table 3
Language Proficiency (N = 24,163).

	ASD N = 97	OD N = 2252	ND N = 24,794	df	χ^2	p	V	Group differences
LT Total Score	81.0 [76.0-85.0]	76.0 [71.0-81.0]	80.0 [75.0-84.0]	2	315.84	< 0.001	.14	ASD > OD and ND
LT Grammar	80.0 [74.0-86.0]	76.0 [68.0-82.0]	78.0 [72.0-84.0]	2	186.09	< 0.001	.11	ASD > OD; OD < ND
LT Spelling and Interpunction	80.5 [73.5-86.0]	73.0 [66.0-80.0]	78.0 [72.0-84.0]	2	430.50	< 0.001	.16	ASD > OD; OD < ND
LT Syntax	80.0 [75.0-90.0]	80.0 [70.0-85.0]	80.0 [75.0-90.0]	2	44.56	< 0.001	.06	OD < ND
LT Vocabulary and Word Choice	85.0 [82.0-89.0]	80.0 [75.0-85.0]	82.0 [76.0-87.0]	2	91.58	< 0.001	.08	ASD > OD and ND
LT Wording and Phrasing	81.0 [74.0-88.0]	81.0 [71.0-87.0]	81.0 [74.0-88.0]	2	77.82	< 0.001	.07	OD < ND

LT: Language Test; ASD, students with ASD; OD, students with other disabilities; ND: students with no recorded disabilities; n.s., no significant group differences; 11% missing.

Table 4
Preparatory Actions (N = 27,143).

	ASD N = 97	OD N = 2252	ND N = 24,794	df	χ^2	p	V	Group differences
Information Brochure	25 (25.8%)	638 (28.3%)	7636 (30.8%)	2	5.38	1.000	.02	n.s.
Bachelors Open Day	54 (55.7%)	1151 (51.1%)	12,828 (51.7%)	2	37.03	< 0.001	.01	ASD > OD and ND
College Tour	39 (40.2%)	755 (33.5%)	8865 (35.8%)	2	0.94	1.000	.01	n.s.
Introduction Program Attended	46 (47.4%)	1084 (48.1%)	11,432 (46.1%)	2	6.98	1.000	.01	n.s.

ASD, students with ASD; OD, students with other disabilities; ND: students with no recorded disabilities; n.s., no significant group differences.

Table 5
Personal trust, Perceived Academic Qualities, and Study Conditions (N = 9250).

	ASD N = 97	OD N = 2252	ND N = 24,794	df	χ^2	p	V	Group differences
Social Support:				10	156.40	< 0.001	.08	
Strongly disagree	4 (4.1%)	68 (3.0%)	447 (1.8%)					ASD > OD > ND
Disagree	11 (11.3%)	126 (5.6%)	939 (3.8%)					ASD > OD > ND
Neither	8 (8.2%)	211 (9.4%)	1863 (7.5%)					ND < ASD < OD
Agree	18 (18.6%)	371 (16.5%)	3101 (12.5%)					ASD > OD > ND
Strongly agree	5 (5.2%)	234 (10.4%)	1844 (7.4%)					ASD < ND < OD
Missing	51 (52.6%)	1242 (55.2%)	16,600 (67.0%)					ASD < OD < ND
Certainty of Program Choice	75.2 [62.9-93.8]	75.2 [56.7-93.8]	69.1 [50.5-93.8]	2	7.49	.876	.06	n.s.
Confidence in Study Success	81.2 [74.8-90.1]	84.2 [76.2-90.1]	84.2 [76.2-90.1]	2	1.06	1.000	.18	n.s.
Analytical Skills	61.7 [55.3-68.1]	64.9 [58.5-71.3]	64.9 [55.3-71.3]	2	8.94	.425	.17	n.s.
Concentration	62.5 [46.5-70.6]	65.2 [51.8-73.2]	65.2 [54.5-73.2]	2	25.99	< 0.001	.19	ASD and OD < ND
Pro-activeness	67.8 [55.5-77.7]	72.8 [65.4-80.2]	72.8 [65.4-80.2]	2	14.08	.032	.20	ASD < OD and ND
Goal Setting	75.2 [66.0-80.2]	75.2 [70.3-82.7]	75.2 [70.3-82.7]	2	3.02	1.000	.17	n.s.
Study Planning	70.3 [61.0-80.2]	72.8 [65.4-80.2]	75.2 [67.8-80.2]	2	14.88	.022	.21	OD < ND
Self-discipline	62.9 [53.6-78.3]	66.0 [53.6-72.2]	66.0 [56.7-75.2]	2	2.79	1.000	.15	n.s.
Parents Attended University	19 (19.6%)	508 (22.6%)	3398 (13.7%)	2	3.46	1.000	.06	n.s.
In Need of Support:				10	673.02	< 0.001	.16	
Strongly disagree	5 (5.2%)	305 (13.5%)	4114 (16.6%)					ASD < OD < ND
Disagree	9 (9.3%)	443 (19.7%)	2993 (12.1%)					ASD < ND < OD
Neither	16 (16.5%)	167 (7.4%)	856 (3.5%)					ASD > OD > ND
Agree	12 (12.4%)	77 (3.4%)	206 (0.8%)					ASD > OD > ND
Strongly agree	4 (4.1%)	18 (0.8%)	25 (0.1%)					ASD > OD > ND
Missing	51 (52.6%)	1242 (55.2%)	16,600 (67.0%)					ASD < OD < ND
Study Load (in hours)	40.0 [36.2-43.0]	40.0 [30.0-40.0]	40.0 [30.0-40.0]	2	7.57	.838	.20	n.s.
Work Load (in hours)	4.0 [0.0-9.5]	8.0 [5.0-10.0]	9.0 [6.0-12.0]	2	50.51	< 0.001	.13	ASD < OD and ND
Extracurricular Activities (in hours)	5.0 [2.0-9.2]	8.0 [5.0-10.0]	8.0 [5.0-10.0]	2	14.80	.023	.18	ASD < OD and ND

ASD, students with ASD; OD, students with other disabilities; ND: students with no recorded disabilities; n.s., no significant group differences; 66% missing.

values (26%–70%; Mattila et al., 2010; Simonoff et al., 2008), but note that these estimations were based on elevated levels on psychopathology questionnaires as part of a study, while we relied on full clinical diagnoses of comorbidity that ASD and OD students spontaneously disclosed. The small proportion of comorbidity in psychological disabilities (1.0%) is remarkable, as reports of problems with anxiety and depression are frequent (Anderson, Stephenson et al., 2017; Pinder-Amaker, 2014). Severe mental health issues could be absent at the beginning of the study career, disclosure of mental health problems could be more problematic, or a formal diagnosis of these disabilities might be lacking or categorized as 'Other disability' (ASD: 6.2%). More research is needed.

We found no differences between students with ASD and their peers in average examination grades, while scores on language proficiency were higher in students with ASD. Since most OD students had dyslexia (53.2%), it is not surprising that students with ASD outperformed them on almost every aspect of the test, and ND outperformed OD on every aspect of the test. But ASD students also had higher scores on vocabulary and word choice in comparison to ND students. These findings concur to some degree with earlier research, where individuals with ASD with average to above average intelligence (IQ > 85) were found to have well developed verbal communication (Reichow & Volkmar, 2010). It could be students with ASD require higher skills levels to finish high school and enroll in university (Wei et al., 2013). Another explanation could be they compensated a possible lack of social skills, by enhancing their verbal skills (Livingston, Colvert, the Social Relationships Study Team, Bolton, & Happé, 2018).

Students with ASD more often had non-standard pre-education qualifications than OD and ND students. It took these students additional time to take the non-direct route of a vocational foundation year (12.4%) or to follow non-standard education and take a university entrance exam (9.3%), reflected as well in the higher age of students with ASD in the year of enrollment. An explanation of this extended pathway to university could be that, compared to OD and ND students, at high school students with ASD excel in specific subjects, but have difficulty to succeed in general (Dente & Parkinson Coles, 2012). They might also start at a lower level of high school difficulty and follow a vocational learning path, or leave high school without certification, and catch up with additional training and entrance exams.

Contrary to our assumptions, difficulties with participation in prospective activities, and goal setting were not found. Preparatory actions and expectations prior to enrollment of students with ASD were similar to OD and ND students. Students with ASD show the same or even higher participation in preparatory activities, such as open days, college tours and introductory programs. It is likely students with ASD, or their parents, are aware of the benefits of these activities to reduce uncertainty and ease transition (Dymond et al., 2017; Peña & Kocur, 2013; Van Hees et al., 2018). Furthermore, all students with ASD in the current study applied for academic accommodations based on their ASD, which implicates they received a formal diagnosis with ASD and chose to disclose their disability. It is likely they have experienced earlier support and decided to disclose expecting a similar support structure at university. This pragmatic attitude is reflected by higher scores on questions related to support but does not necessarily mean students with ASD disclosed to peers or staff as well (Cox et al., 2017).

Combined with the preceding scores on examination grades and the language proficiency test, it is not likely academic content will be problematic for students with ASD. Concerning organization, time management, and study skills students with ASD report to expect issues with concentration. They seem to compensate for these self-observed shortcomings, as they expected to spend less time on work or extra-curricular activities in comparison to their peers (OD and ND).

4.1. Limitations and future directions

Several limitations of the current study need to be acknowledged. First, this research is based on data from one major university in the Netherlands. There is no evidence for differences between Dutch universities in the prevalence of students with disabilities and students with ASD in particular (Van den Broek, Muskens, & Winkels, 2013). Second, the dataset included students with ASD with a specific academic, cognitive, and intellectual profile, and most likely appropriate social and familial support. However, information on formal transition planning and support by teachers, coaches or parents during high school was not available, and potential preparatory visits to disability officers of the university were not recorded. Formal data on previous support systems would have been helpful to determine to what extent students with ASD rely on support systems to plan their transition to higher education and what barriers they face on a more personal level. Third, students in the current study decided to disclose their disability to the administration. As discussed, it is likely other students with ASD chose to conceal their disability or were not aware of it (Cox et al., 2017; Dymond et al., 2017; Peña & Kocur, 2013; Van Hees et al., 2015, 2018). It could be these students did not receive additional support before college and are at higher risk. The opposite could be true as well for students who learned to cope with their disability before college and therefore decided not to disclose. Finally, an additional level of analysis of students with ASD and students with different classifications of other disabilities could give more insights in additional differences, commonalities, and comorbidity. Extensive data on mental health was unavailable. Future studies on prevalence, transition planning, formal and social support of university students before enrollment, and reasons for disclosure are needed to provide a more detailed perspective.

4.2. Significance

The present study has charted enrollment characteristics of students with ASD of a Dutch university and has analyzed to what extent these are different or similar compared to students without ASD, using an innovative and appropriate mixed methods approach combining self-report and objective, administrative data. The results of this study show the prevalence of students with ASD has grown, but students with ASD have more difficulty to reach university and are older. As expected, they are at heightened risk of comorbidity, but not to the extent found in earlier studies. Data on preparatory actions demonstrate that students with ASD take part in activities to get to know university and life on campus. This finding is consistent with research on the transition of students with ASD to primary and secondary school, where school visits are an important strategy to reduce anxiety and uncertainty (Nuske et al., 2019). The lack of data on high school transition planning in our study could be an indication of insufficient coordination between secondary school and higher education.

Contrary to our assumptions, the enrollment characteristics of students with ASD to higher education were found to be most similar compared to ND students. Students with ASD demonstrate self-advocacy, intellectual and academic skills that could compensate for their disability. Some of these students may have compensatory skills, while others may have learned them in some way. So, programs in high school that are helping students with ASD prepare for higher education should focus on encouraging, developing, and support these skills. The continuous support for individuals with ASD, also in higher education, may be an important cause of their adequate skills reflected in this study.

These quantitative insights are a valuable addition to the more qualitative evidence so far. For parents of children with ASD and individuals with ASD, these findings could help to adjust lower expectations. As this kind of administrative data is available to most institutions in higher education in day-to-day information systems, this study is promising for institutions who wish to analyze similar data, gain better insights in the enrollment of their students with ASD, and improve transition support. This study has shown that transition paths with entrance exams are often crucial for students with ASD. Academic accommodations for this type of exams should be in place to improve admission and enrollment, and institutions should highlight information on the possibilities to apply for academic accommodations before admission. To enhance the confidence of both students with ASD and their parents, institutions should stress students with ASD do have a place in higher education by providing evidence from their institution.

Declaration of Competing Interest

Theo Bakker declares that he has no conflict of interest; Lydia Krabbendam declares that she has no conflict of interest; Sandjai Bhulai declares that he has no conflict of interest; Sander Begeer declares that he has no conflict of interest.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

Appendix A

See Table A1.

Table A1
Description of variables and measurement scales.

Category	Variables	Measurement scales
Prevalence	Cohort	2010, 2011, 2012, 2013, 2014, 2015, 2016
	STEM	FALSE = No, TRUE = Yes
Demographics	Gender	Female, Male
	Age (in years)	Age
Disabilities	ASD	FALSE = No, TRUE = Yes
	ADD ADHD	FALSE = No, TRUE = Yes
	Chronic Illness	FALSE = No, TRUE = Yes
	Dyslexia	FALSE = No, TRUE = Yes
	Physical disability	FALSE = No, TRUE = Yes
	Psychological disability	FALSE = No, TRUE = Yes
	Other disability	FALSE = No, TRUE = Yes
	Comorbidity	FALSE = No, TRUE = Yes
Secondary Education	Highest Pre-education	High school VWO, Vocational foundation year, Degree in higher education, Other pre-education, Foreign degree
Secondary Education Examination	Average Grade Secondary Education	1-10
Grades		
	Grade English Secondary Education	1-10
	Grade Dutch Secondary Education	1-10
	Grade Math Algebra Secondary Education	1-10
	Grade Math Calculus Secondary Education	1-10
Language Proficiency	Language Test Total Score	0-100%
	Language Test Grammar	0-100%
	Language Test Spelling and Interpunction	0-100%
	Language Test Syntax	0-100%
	Language Test Vocabulary and Word Choice	0-100%
	Language Test Wording and Phrasing	0-100%
Prospective activities	Information Brochure	FALSE = No, TRUE = Yes
	Bachelors Open Day	FALSE = No, TRUE = Yes
	College Tour	FALSE = No, TRUE = Yes
Introduction	Introduction Program Attended	FALSE = No, TRUE = Yes
History in Higher Education and Enrollment	Gap Year	Directly (No gap year), 1 Gap year, Other, Missing
	Years of Higher Education	0 or more
	Years of Academic Education	0 or more
Transition Planning (*self-reported*)	Certainty of Program Choice	1-100
	Confidence in Study Success	1-100
Academic Qualities (*self-reported*)	Analytical Skills	1-100
	Concentration	1-100
	Pro-activeness	1-100
	Goal Setting	1-100
	Study Planning	1-100
	Self-discipline	1-100
Study Conditions (*self-reported*)	Social Support	Strongly Disagree, Disagree, Neither, Agree, Strongly Agree
	In Need of Support	Strongly Disagree, Disagree, Neither, Agree, Strongly Agree
	Parents Attended University	FALSE = No, TRUE = Yes
	Extra-curricular Activities (in hours)	0-40
	Study Load (in hours)	0-40
	Work Load (in hours)	0-40

Appendix B

See Table B1.

Table B1
Descriptives for the Three Participant Groups.

	ASD	OD	ND
	N = 97	N = 2252	N = 24,794
Sex: Female	28 (28.9%)	1319 (58.6%)	13,698 (55.2%)
Age (in years)	20.0 [18.0-21.0]	19.0 [18.0-21.0]	19.0 [18.0-20.0]
LT Total Score	81.0 [76.0-85.0]	76.0 [71.0-81.0]	80.0 [75.0-84.0]
LT Grammar	80.0 [74.0-86.0]	76.0 [68.0-82.0]	78.0 [72.0-84.0]
LT Spelling and Interpunction	80.5 [73.5-86.0]	73.0 [66.0-80.0]	78.0 [72.0-84.0]
LT Syntax	80.0 [75.0-90.0]	80.0 [70.0-85.0]	80.0 [75.0-90.0]
LT Vocabulary and Word Choice	85.0 [82.0-89.0]	80.0 [75.0-85.0]	82.0 [76.0-87.0]
LT Wording and Phrasing	81.0 [74.0-88.0]	81.0 [71.0-87.0]	81.0 [74.0-88.0]
ADD ADHD	6 (6.2%)	316 (14.0%)	
Chronic Illness	1 (1.0%)	258 (11.5%)	
Dyslexia	7 (7.2%)	1198 (53.2%)	
Psychological Disability	1 (1.0%)	132 (5.9%)	
Physical Disability	3 (3.1%)	200 (8.9%)	
Other Disability	6 (6.2%)	308 (13.7%)	
Comorbidity	24 (24.7%)	264 (11.7%)	
Highest Pre-education:			
High school VWO	74 (76.3%)	1792 (79.6%)	20,489 (82.6%)
Vocational foundation year	12 (12.4%)	304 (13.5%)	2548 (10.3%)
Degree in higher education	2 (2.1%)	92 (4.1%)	1122 (4.5%)
Other Dutch pre-education	9 (9.3%)	64 (2.8%)	635 (2.6%)
Average Grade Secondary Education	67.0 [65.0-72.0]	66.0 [63.0-70.0]	66.0 [63.0-70.0]
Grade Dutch Secondary Education	7.0 [6.0-7.0]	6.0 [6.0-7.0]	6.5 [6.0-7.0]
Grade English Secondary Education	7.0 [6.0-8.0]	6.0 [6.0-7.0]	7.0 [6.0-7.0]
Grade Math Algebra Secondary Education	6.0 [6.0-7.0]	7.0 [6.0-7.0]	6.5 [6.0-7.0]
Grade Math Calculus Secondary Education	6.0 [6.0-7.0]	6.0 [6.0-7.0]	6.0 [6.0-7.0]
Information Brochure	25 (25.8%)	638 (28.3%)	7636 (30.8%)
Bachelors Open Day	54 (55.7%)	1151 (51.1%)	12,828 (51.7%)
College Tour	39 (40.2%)	755 (33.5%)	8865 (35.8%)
Introduction Program Attended	46 (47.4%)	1084 (48.1%)	11,432 (46.1%)
Gap Year:			
Directly (no Gap year)	61 (62.9%)	1365 (60.6%)	15,897 (64.1%)
1 Gap year	7 (7.2%)	228 (10.1%)	2246 (9.1%)
Other	28 (28.9%)	656 (29.1%)	6619 (26.7%)
Missing	1 (1.0%)	3 (0.1%)	32 (0.1%)
Years of Higher Education	0.0 [0.0-1.0]	0.0 [0.0-1.0]	0.0 [0.0-1.0]
Years of Academic Education	0.0 [0.0-0.0]	0.0 [0.0-1.0]	0.0 [0.0-0.0]
Cohort:			
2010	10 (10.3%)	233 (10.3%)	4652 (18.8%)
2011	21 (21.6%)	288 (12.8%)	3975 (16.0%)
2012	10 (10.3%)	287 (12.7%)	3525 (14.2%)
2013	6 (6.2%)	331 (14.7%)	3585 (14.5%)
2014	18 (18.6%)	401 (17.8%)	3311 (13.4%)
2015	17 (17.5%)	374 (16.6%)	2791 (11.3%)
2016	15 (15.5%)	338 (15.0%)	2955 (11.9%)
STEM	54 (55.7%)	706 (31.3%)	6954 (28.0%)
Certainty of Program Choice	75.2 [62.9-93.8]	75.2 [56.7-93.8]	69.1 [50.5-93.8]
Confidence in Study Success	81.2 [74.8-90.1]	84.2 [76.2-90.1]	84.2 [76.2-90.1]
Analytical Skills	61.7 [55.3-68.1]	64.9 [58.5-71.3]	64.9 [55.3-71.3]
Concentration	62.5 [46.5-70.6]	65.2 [51.8-73.2]	65.2 [54.5-73.2]
Pro-activeness	67.8 [55.5-77.7]	72.8 [65.4-80.2]	72.8 [65.4-80.2]
Goal Setting	75.2 [66.0-80.2]	75.2 [70.3-82.7]	75.2 [70.3-82.7]
Study Planning	70.3 [61.0-80.2]	72.8 [65.4-80.2]	75.2 [67.8-80.2]
Self-discipline	62.9 [53.6-78.3]	66.0 [53.6-72.2]	66.0 [56.7-75.2]
Social Support:			
Strongly disagree	4 (4.1%)	68 (3.0%)	447 (1.8%)
Disagree	11 (11.3%)	126 (5.6%)	939 (3.8%)
Neither	8 (8.2%)	211 (9.4%)	1863 (7.5%)
Agree	18 (18.6%)	371 (16.5%)	3101 (12.5%)
Strongly agree	5 (5.2%)	234 (10.4%)	1844 (7.4%)
Missing	51 (52.6%)	1242 (55.2%)	16,600 (67.0%)
Parents Attended University	19 (19.6%)	508 (22.6%)	3398 (13.7%)

(*continued on next page*)

Table B1 (*continued*)

In Need of Support:			
Strongly disagree	5 (5.2%)	305 (13.5%)	4114 (16.6%)
Disagree	9 (9.3%)	443 (19.7%)	2993 (12.1%)
Neither	16 (16.5%)	167 (7.4%)	856 (3.5%)
Agree	12 (12.4%)	77 (3.4%)	206 (0.8%)
Strongly agree	4 (4.1%)	18 (0.8%)	25 (0.1%)
Missing	51 (52.6%)	1242 (55.2%)	16,600 (67.0%)
Study Load (in hours)	40.0 [36.2-43.0]	40.0 [30.0-40.0]	40.0 [30.0-40.0]
Work Load (in hours)	4.0 [0.0-9.5]	8.0 [5.0-10.0]	9.0 [6.0-12.0]
Extracurricular Activities (in hours)	5.0 [2.0-9.2]	8.0 [5.0-10.0]	8.0 [5.0-10.0]

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