OBJECTIVES: To estimate associations between kindergarten readiness and academic, psychological, and health risks by end of high school.

METHODS: This study is based on 966 Canadian children. At age 5, trained examiners assessed child number knowledge and receptive vocabulary. Teachers reported kindergarten classroom engagement. At age 17, participants reported academic grades, school connectedness, anxiety sensitivity, substance abuse, physical activity involvement, and height and weight. High school dropout risk was also estimated for each participant on the basis of grades, school engagement, and grade retention.

RESULTS: Kindergarten math skills contributed to better end-of-high school grades ($\beta = .17, P < .01$) and lower dropout risk ($\beta = -.20, P < .001$), whereas receptive vocabulary predicted lower anxiety sensitivity ($\beta = -.11, P < .01$). Kindergarten classroom engagement predicted higher end of high school grades ($\beta = .17, P < .001$), lower dropout risk ($\beta = -.20, P < .01$), better school connectedness ($\beta = .15, P < .01$), lower risk of substance abuse ($\beta = -.21, P < .001$), and more physical activity involvement ($\beta = .09, P < .05$). Kindergarten classroom engagement was also associated with a 65% reduction (odds ratio = 0.35) in the odds of being overweight at age of 17. Analyses were adjusted for key child (sex, weight per gestational age, nonverbal IQ, and internalizing and externalizing behaviors) and family (parental involvement, maternal depression and immigrant status, family configuration, and socioeconomic status) characteristics.

CONCLUSIONS: Early childhood readiness forecasts a protective edge by emerging adulthood. With these findings, we build links between education and health indicators, suggesting that children who start school prepared gain a lifestyle advantage. Promoting kindergarten readiness could reduce the health burden generated by high school dropout.

WHAT’S KNOWN ON THIS SUBJECT: Researchers have shown that being ready to learn in kindergarten can forecast achievement in later elementary school. Furthermore, separate researchers have established a link between high school achievement, lifestyle choices, and productivity.

WHAT THIS STUDY ADDS: With our results, we suggest long-term protective associations between readiness to learn in kindergarten and personal success at age 17. With this study, we therefore reaffirm the importance of early childhood readiness and suggest that early interventions could benefit population productivity and health.
Many children begin kindergarten inadequately prepared to benefit from classroom instruction. Children who are unprepared risk struggling throughout their academic journey. Among physical wellbeing, general knowledge, and social emotional wellbeing characteristics, compelling evidence suggests that fundamental skills in math and vocabulary are invariably the most crucial predictors of academic success in later elementary. Kindergarten classroom engagement skills, which reflect the ability to successfully adjust to classroom demands, also appear to foster an academic edge throughout elementary school. Indeed, productive learning behaviors in kindergarten predict educational attainment by emerging adulthood.

In addition to academic success, school readiness has been linked to health and social outcomes. According to researchers of one study, students who began kindergarten with better vocabulary and math skills showed greater chances of healthy lifestyle behavior by the end of fourth grade. Kindergarten classroom engagement has also been found to forecast more optimal emotional adjustment, relationships with classmates, participation in physical activity, and BMI by the end of elementary school.

Educational attainment is closely intertwined with important health, wellbeing, and productivity outcomes for both individuals and society. However, to date, much of the work on school readiness has examined how school readiness contributes to success in later elementary school. A longer-term follow-up of school readiness on later indicators of vocational success can therefore afford crucial evidence of the importance of ensuring that all children are ready to learn at the time of school entry. The 20th century expression that all one really needs to know they learned in kindergarten appeals to us for its health, social, and economic implications. A compelling way to evaluate that adage would be to examine the extent to which cognitive and learning skills predict long-term outcomes and indicators of life success.

The objective with this study is to examine the extent to which kindergarten readiness skills, reflecting previous experiences and learning, forecast later mental and physical health risks by the end of high school, an important life course turning point for youth. As a result, we examine academic performance, dropout risk, school connectedness, anxiety sensitivity, substance abuse, physical activity, and healthy weight outcomes by age 17, which marks the end of high school in the province of Quebec. Given that development is presumably influenced by multiple individual and environmental factors across childhood, we adjust for child sex, birth weight per gestational age, kindergarten nonverbal IQ, and behavior problems as well as parental and family demographic characteristics as potential confounding variables. Furthermore, in regressions addressing links between school readiness and end of high school physical activity and BMI, we control for kindergarten BMI and physical fitness.

**METHODS**

**Sample**

We conducted secondary analyses using data from the Quebec Longitudinal Study of Child Development (QLSCD; 1998–2019). The QLSCD originates from a randomly selected, stratified potential sample of 2837 infants from the birth registry between 1997 and 1998 in Quebec, Canada. From these, 2120 children were retained for longitudinal follow-up from 5 months onward. The retained participants, representing 82% of the eligible target population, are considered representative of all singleton births that took place in the province between 1997 and 1998. Sex was equally represented, with 49% girls and 72% of parents described their child as being Canadian. Most parents (81%) reported that their spoken language was French. Finally, 21.7% of parents reported being under the poverty line cutoff for Canadian families. For complete sample description, see Supplemental Information.

**Main Predictors (Age 5, Kindergarten Entry)**

Math skills were assessed by using an abridged version of the Number Knowledge Test (NKT). The NKT measures the child’s degree of familiarity with basic notions of arithmetic such as counting, adding, and subtracting, as a function of age. For additional details on this measure see Supplemental Information.

Verbal skills were assessed by using the Peabody Picture Vocabulary Test, which was administered individually in French or English by a trained research assistant. This test comprises practice images, followed by 170 other images in order of increasing difficulty. The starting point depends on the child’s age. Scores are standardized as a function of tables of age-related normative criteria. The results of the Peabody Picture Vocabulary Test are strongly correlated with typical language subscales of most standardized intelligence tests.

Classroom engagement was reported by kindergarten teachers using a 7-item scale: works and plays cooperatively with other children, follows rules and instructions, follows directions, listens attentively, completes work on time, works autonomously, and works neatly and carefully (α = .94). Responses were made on a Likert scale and ranged from 1 (never) to 3 (always) for each item. Higher scores reflect better engagement. This classroom engagement...
engagement measure is empirically related with academic ability.\textsuperscript{5,6}

**Outcomes (Age 17, End of High School)**

**Academic Achievement**

Academic performance was based on student self-reported average marks in math and English and French language from the previous year. A global academic achievement variable reflecting mean marks in percentage across both disciplines was computed, sample mean (SD) = 75.62\% (10.29).

**Dropout Risk**

Dropout risk was assessed by creating an index comprising academic performance, school engagement, and previous grade retention.

**School Connectedness**

School connectedness was based on students answers to the following questions: I am proud I go to this school, I am happy to go to this school, I feel safe at my school, most mornings I look forward to going to school, I like my school (α = .86). Items were rated using the following scale: strongly disagree, disagree, unsure, agree, strongly agree.

**Anxiety Sensitivity**

Participants indicated the extent to which they agreed with the following statements from the substance use risk profile scale\textsuperscript{21}: it is frightening to feel dizzy or faint, it frightens me when I feel my heart beat change, I get scared when I am too nervous, I get scared when I experience unusual body sensations (feelings), it scares me when I am unable to focus on a task. All items were rated as either 1 (completely disagree), 2 (disagree), 3 (agree), or 4 (completely agree), α = .82.

**Substance Abuse**

Substance abuse was based on youth responses of yes (scored as 1) or no (scored as 0) to the following situations over the past 12 months: my alcohol or drug use has had negative psychological effects on me (anxiety, depression, problems concentrating, etc), my alcohol or drug use has had negative effects on my relationships with my family, my alcohol or drug use has had negative effects with my friends or in my love life, my alcohol or drug use has had negative effects on my school connectedness, I like my school, most mornings I look forward to going to school, I feel safe at my school, most mornings I look forward to going to school, I like my school (α = .86).

**Physical Activity**

Participants answered questions regarding their level of physical activity during their free time. Items included frequency of physical activity during a typical week, the amount of time they spent being physically active on a typical day, their level of effort during physical activities, and the amount of time spent surfing the Internet for school work and leisure, playing video games, watching television shows and movies, and reading for school work. For additional details, see Supplemental Information.

**BMI**

To derive BMI, participants self-reported weight and height. Weight status was classified as healthy or overweight and/or obese according to International Obesity Task Force cutoffs for BMI ([weight in kg]/[height in m\(^2\)]) specific for age and sex.

**Control Variables**

Child nonverbal IQ was directly assessed by trained professionals when children were in kindergarten by using the Wechsler Intelligence Scale for Children, Third Edition.\textsuperscript{22} This subtest, which assesses visual perception and organization and abstract reasoning, provides an estimate of nonverbal IQ.

Kindergarten teachers reported on child emotional distress and physical aggression using items derived from the Child Behavior Checklist and Preschool Behavior Questionnaire.\textsuperscript{23–25} Finally, weight for gestational age, child age, and sex were derived from medical records.

Parental involvement was measured by using the Home Observation for Measurement of the Environment, Infant version.\textsuperscript{26} Trained examiners made assessments after observing parent–child interactions for a period of 3 hours. The following 5 items were assessed: provides toys that challenge child to develop new skills, structures child’s play periods, interacts with her child while engaged in other tasks, encourages her child’s progress, and values educational toys (α = .85). These items were rated as 1 (never), 2 (rarely), 3 (sometimes), 4 (often), or 5 (always). When children were 5 months, mothers also self-reported depressive symptoms using the modified lifetime depression section of the Diagnostic Interview Schedule, and family configuration (2 parent = 1 and not = 0) and maternal immigration status (nonimmigrant or European immigrant = 0, non-European immigrant = 1). An index of socioeconomic status was derived from mother and father reports of income, level of education, and occupational prestige. Scores were standardized to a mean of 0. Details on this method have been published elsewhere.\textsuperscript{26,27}
Data Analytic Strategy

Our aim was to estimate prospective associations between kindergarten readiness skills (age 5) and educational and health outcomes by the end of high school (age 17). A series of multiple regressions were used to simultaneously estimate the respective and unique contribution of kindergarten number knowledge, receptive vocabulary, and classroom engagement to achievement, dropout risk, school connectedness, anxiety sensitivity, substance abuse, and physical activity. Logistic regressions were used to estimate associations between school readiness characteristics and odds of being overweight. Analyses were adjusted for key child and family contextual characteristics.

RESULTS

Descriptive Statistics

In Tables 1 and 2, we provide descriptive statistics on continuous and categorical variables. Boys scored significantly lower on classroom engagement than girls (mean = 2.76 vs 2.60, P < .001); however, there were no sex-based differences in number knowledge or receptive vocabulary scores. Boys also had lower academic averages at the end of high school (mean = 68.35 vs 74.38, P < .001).

Missing Data and Attrition Analysis

Given that it was possible to estimate incomplete data on outcome variables based on covariates, we conducted multiple imputation on outcome and control variables, assuming that data were missing at random.28 All regression analyses are based on pooled imputed data. A comparison of children with and without kindergarten reported data is available in Supplemental Information.

Predictive Statistics

Adjusted linear and logistic regression results are documented in Tables 3 and 4, respectively. To facilitate effect size comparisons across measures, we report standardized regression coefficients in Table 3. After holding all other variables constant, a 1-point increase on the number knowledge assessment corresponded to 0.518-U increase in academic grades (P = .001) and a 0.016-U decrease in high school dropout risk (P = .001). Each 1-point increase in kindergarten vocabulary scores was associated with 0.016-U decreases on our measure of anxiety (P = .001). Finally, a 1-point increase in classroom engagement scores predicted a 4.66-U increase in academic grades (P = .007), a 0.872-U increase in school connectedness (P = .005), a 0.406-U increase in physical activity (P = .047), a 0.138-U decrease in dropout risk (P = .002), and a 1.01-U decrease in substance abuse scores (P < .001). In terms of the logistic regression, each 1-point increase in classroom engagement scores was associated with a 65% reduction in the odds of being overweight (odds ratio = 0.35, 95% confidence interval, 0.16 to 0.74; P = .009).

<table>
<thead>
<tr>
<th>TABLE 1 Descriptive Statistics for Continuous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictors</strong></td>
</tr>
<tr>
<td>Number knowledge</td>
</tr>
<tr>
<td>13.26 (3.27)</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
</tr>
<tr>
<td>Classroom engagement</td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
</tr>
<tr>
<td>Global achievement</td>
</tr>
<tr>
<td>Dropout risk</td>
</tr>
<tr>
<td>School engagement</td>
</tr>
<tr>
<td>Anxiety sensitivity</td>
</tr>
<tr>
<td>Substance abuse</td>
</tr>
<tr>
<td>Physical activity</td>
</tr>
<tr>
<td><strong>Control variables (kindergarten)</strong></td>
</tr>
<tr>
<td>Nonverbal IQ</td>
</tr>
<tr>
<td>Emotional distress</td>
</tr>
<tr>
<td>Physical aggression</td>
</tr>
<tr>
<td>Child BMI</td>
</tr>
<tr>
<td>Child fitness (sit up test)</td>
</tr>
<tr>
<td><strong>Control variables (preschool)</strong></td>
</tr>
<tr>
<td>Parental involvement</td>
</tr>
<tr>
<td>Maternal depression</td>
</tr>
<tr>
<td>Socioeconomic status</td>
</tr>
<tr>
<td><strong>Control variables (kindergarten)</strong></td>
</tr>
<tr>
<td>Nonverbal IQ</td>
</tr>
<tr>
<td>Emotional distress</td>
</tr>
<tr>
<td>Physical aggression</td>
</tr>
<tr>
<td>Child BMI</td>
</tr>
<tr>
<td>Child fitness (sit up test)</td>
</tr>
<tr>
<td><strong>Control variables (preschool)</strong></td>
</tr>
<tr>
<td>Parental involvement</td>
</tr>
<tr>
<td>Maternal depression</td>
</tr>
<tr>
<td>Socioeconomic status</td>
</tr>
</tbody>
</table>

All regression analyses are based on pooled imputed data. A comparison of children with and without kindergarten reported data is available in Supplemental Information.

<table>
<thead>
<tr>
<th>TABLE 2 Frequency Distribution for Categorical Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percentage</strong></td>
</tr>
<tr>
<td><strong>BMI (age 17)</strong></td>
</tr>
<tr>
<td>Overweight</td>
</tr>
<tr>
<td>Sex (5 mo)</td>
</tr>
<tr>
<td>Boys</td>
</tr>
<tr>
<td>Birth weight</td>
</tr>
<tr>
<td>Low birth weight</td>
</tr>
<tr>
<td>Immigrant (5 mo)</td>
</tr>
<tr>
<td>Non-European immigrant</td>
</tr>
<tr>
<td>Family configuration (5 mo)</td>
</tr>
<tr>
<td>Nonintact</td>
</tr>
</tbody>
</table>

—, not applicable.
engagement scores by 1 point was associated with an additional 4.66 percentage points in academic grades as well as a full-scale point decrease in substance abuse risk, which can both be interpreted as clinically significant effects. To further contextualize these results, we found small to moderate effect sizes for models predicting academic achievement and dropout, explaining 30% and 35% of the variance, whereas models predicting anxiety (10%), physical activity (10%), substance abuse (6%), and school connectedness (5%) were smaller.

**DISCUSSION**

At a time when youth obesity and mental health risks have increased, 29,30 with the current study we provide timely evidence that early readiness for school sets the stage for population increases in wellbeing, health, and human capital formation. With these results, it is also suggested that early success begets continued success, which has been previously noted in education research. 31,32 Early math skills predicted academic achievement and was the strongest predictor of high school dropout risk. Previous work has revealed that kindergarten math competence is a key contributor to academic achievement in elementary school students. 3–5 Although vocabulary skills were not related to academic outcomes beyond math, they did predict subsequent decreases in self-reported anxiety sensitivity in adolescence. Large-scale population-based findings have shown that kindergarten math skills become more important than vocabulary, suggesting that the influence of language becomes indirect, as children transition from learning to read to reading to learn, over the course of elementary and high school. 33 With our findings, we also suggest that solid vocabulary skills promise an important edge for psychological adjustment and, ultimately, overall mental health.

Children’s kindergarten classroom engagement was a consistent predictor of high school outcomes predicting academic achievement, dropout risk, school connectedness, substance use, physical activity, and weight status. Previous researchers have found that being less invested in school is associated with underachievement, reduced academic motivation, less supportive relationships with teachers, more involvement with delinquent peers, and a higher frequency of problem behaviors including substance use. 34–36 Our results are consistent with this literature and suggest that the roots of less-effective engagement may be traceable to kindergarten.

Classroom engagement skills are also strongly reflective of impulse control, goal-directedness, and cognitive and attentional control. 37 Children need self-control to follow classroom rules, work cooperatively with other students, and remain focused in the face of distractions. As such, it is possible that classroom engagement represents an important mechanism through which self-control ultimately contributes to academic adjustment. 38 In line with this hypothesis, researchers have found that classroom behavior accounts for the association between executive functioning and achievement. 39 Furthermore, other researchers have linked preschool self-control to better economic, health, and interpersonal functioning in adulthood. 40 Children’s ability to learn at the time of school entry reflects the quality of their experiences and relationships during the preschool years. Sensitive caregiving, linguistically and cognitively stimulating environments, and protection from chronic adversity and stress support optimal brain development and capacity for lifelong learning, wellbeing, and health. 41 In contrast, there is evidence that growing up in poverty is associated with developmental risks for regional gray matter deficits in the frontal and temporal lobes and hippocampi,

**TABLE 3 Adjusted Standardized Regression Coefficients Depicting Associations Between Kindergarten School Readiness Skills and Outcomes at Age 17**

<table>
<thead>
<tr>
<th>Skill</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. knowledge</td>
<td>.17</td>
<td>.01</td>
<td>.20</td>
<td>&lt;.001</td>
<td>.01</td>
<td>.76</td>
<td>.024</td>
<td>.337</td>
<td>.06</td>
<td>.206</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.04</td>
<td>.834</td>
<td>.03</td>
<td>.162</td>
<td>.06</td>
<td>.264</td>
<td>.11</td>
<td>.907</td>
<td>.04</td>
<td>.445</td>
</tr>
<tr>
<td>Classroom engagement</td>
<td>.17</td>
<td>.004</td>
<td>.20</td>
<td>.002</td>
<td>.15</td>
<td>.005</td>
<td>.08</td>
<td>.998</td>
<td>.21</td>
<td>.001</td>
</tr>
</tbody>
</table>

Models are adjusted for child sex, low birth wt, kindergarten nonverbal IQ, emotional distress and physical aggression, parental involvement, maternal depression and immigrant status, family configuration, and socioeconomic status.

<table>
<thead>
<tr>
<th>Skill</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
<th>β</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight OR (95% CI)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number knowledge</td>
<td>1.01</td>
<td>.03</td>
<td>1.01</td>
<td>.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>1.01</td>
<td>.03</td>
<td>1.01</td>
<td>.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom engagement</td>
<td>0.35</td>
<td>.16</td>
<td>0.35</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Models are adjusted for child sex, low birth wt, kindergarten BMI, fitness, emotional distress and physical aggression, parental involvement, maternal depression and immigrant status, family configuration, and socioeconomic status.
which are critical factors in supporting the development school readiness skills. Children who grow up in socioeconomically disadvantaged families are therefore especially likely to begin school less well prepared than their more-advantaged peers.

Several interventions can help offset the significant burden experienced by vulnerable children. These include access to high quality universal preschool and community support systems such as home visitation and parental training programs. In addition to providing young children with experiences that are cognitively challenging, protection from toxic stress and adversity also represent essential components of impactful interventions.

Encouragingly, home visit programs have been found to have positive effects on child health and school readiness and offer mechanisms for intervening to reduce parent stress. Pediatricians can play a key role in promoting school readiness by helping ensure that children receive the nutrition, sleep, and developmental experiences they need to develop strong school readiness and learning skills. In addition, pediatricians can screen children for exposure to environmental threats including lead, toxins, and excessive screen time, as well as exposure to chronic adversity, which can take the form of housing or food insecurity, family violence, parental mental health problems, and the experience of discrimination and systemic racism. Finally, when needed, pediatricians can share information on community resources with parents.

The present research is not without limitations. First, in our study, we did not account for preschool attendance. As a result, it is possible that this unmeasured variable accounts for some of the variance in school readiness. Given the tremendous popularity of affordable day care policy implementation in the province of Quebec, we estimate that preschool participation is unlikely to represent an important confounding variable. Furthermore, the contextual variable most closely related to preschool participation in Quebec is socioeconomic status, which we statistically adjust for in our analyses. Second, our correlational design precludes us from making any causal attributions. It may be the case that important unmeasured child and family characteristics are responsible for the observed associations. Nevertheless, to reduce the possibility of confounding, we accounted for influential child (nonverbal IQ) and family (socioeconomic status, parental involvement) characteristics in our analyses. Third, the current study was based on secondary data, and as a result, direct assessments for outcome measures were nonexistent. Consequently, it is possible that social desirability motives or recall bias led to some of misclassification on the behalf of respondents. Nevertheless, the use of multiple measures, including direct assessments as well as teacher and self-reports, allows us to reduce the chances of shared measurement bias. The use of prospective longitudinal data, which allowed us to assess child school readiness long before they begin to develop dispositions toward health and productivity and to study the evolution of a large population-based group of children over the course of 17 years, represents compelling strengths.

High school dropout incurs high medical and social costs. In particular, dropout is associated with increased risk of poverty, nicotine dependence, low self-esteem, depression, underemployment, and involvement in criminal behavior. Given that high school dropout exacts a heavy cost on individuals and society, in the current study, we underscore that early interventions which aim to boost school readiness could translate into important economic savings across the life span. With our findings, we further highlight the usefulness of conceptualizing kindergarten readiness as a public health issue and indicate that the decreased quality of life experienced by youth who fail to complete high school may be rooted in early childhood risk.

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ABBREVIATIONS

NKT: Number Knowledge Test
QLSCD: Quebec Longitudinal Study of Child Development

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POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.
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**Kindergarten Readiness, Later Health, and Social Costs**  
Caroline Fitzpatrick, Elroy Boers and Linda S. Pagani  
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