Children's Technology Time in Two US Cohorts

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Abstract
Over the last two decades, technologies available to children have accelerated with the advent of wireless internet and increasing portability and affordability of electronic devices. Children's technology use is a rapidly evolving challenge for families, organizin g their everyday lives and potentially resulting in social disparities in technology use and displacement of healthy behaviors. This study examined time spent on technology use, physical activity, play, and sleep by US children across early (ages 2-5) and middle (ages 6-11) childhood in two cohorts using time diary data with a focus on variation by class and race. Data came from the Panel Study of Income Dynamics Child Development Supplement in 1997 (N=2,193) and 2014-2016 (N=1,009). Multivariate regression models estimated total time spent engaged in technology use, physical activity, unstructured play, and sleep. Total time spent engaged with technology increased 32% since 1997 in early childhood and 23% in middle childhood. Technology use was lowest for children with the most highly educated parents. In the more recent cohort, technology use was associated with displacement of physical activity in middle childhood but with increased play in early childhood and increased sleep in middle childhood. Results suggest that changes over time in technology use have restructured children's everyday lives in ways that may be consequential for health and development, but co-occurring declines in physical activity and unstructured play cannot be attributed solely to technology time.

Keywords
Technology, media, early childhood, middle childhood, time diaries, CDS

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1 Introduction

Contemporary families face rapidly evolving challenges when managing children's extensive use of technologies in the mobile internet era. Children's time engaged with digital technology in the United States (US) has increased steadily over the last two decades as the expansion of devices and applications has created new opportunities to consume and produce content (Rideout 2015, 2017; Rideout et al. 2003, 2010). As technology use for media consumption, communication, education, and gaming consumes a growing share of children's time, the American Academy of Pediatrics has responded with recommended limits to children's and adolescents' "screen time" based on the expectation that technology use interferes with activities that are constructive for cognitive, physical, and social development such as reading, play, exercise and direct interaction with parents and peers (Moreno et al. 2016; Radesky and Christakis 2016). Yet we know little about how contemporary technology use fits in with or displaces children's other activities, or to what extent technology use is a key mechanism in reshaping how families organize children's time compared to cohorts growing up prior to the advent of the mobile technology era. Further, in the context of the US, where children's time use is largely patterned by social class (Hofferth and Sandberg 2001), we lack information about how variation in access to or use of technology may have contributed to growing or declining class-based disparities in time use among contemporary children compared to previous cohorts.

To better understand the distinctive role of the contemporary technology regime in the organization of children's time, we compare the relationship between technology use and time spent on other activities for two cohorts of US children growing up on either side of the digital revolution. Specifically, we compare the activity profiles of children aged 2-11 in an earlier (1997) and a more recent (2014-2016) cohort to address three research questions: (1) How is the frequency, format, and context of children's contemporary technology use similar to or different from children of the preceding generation? (2) Have class and race disparities in the time children spend engaged with technology emerged or diminished over time? (3) To what extent is increased technology use associated with changes in the amount of time contemporary children spend on other health behaviors including unstructured play, physical activity, and sleep, all of which are predictive of healthy physical, emotional, and cognitive development (Beebe 2011; Cappuccio et al. 2008; Ginsburg 2007; Janssen and LeBlanc 2010).

We use time diary data collected from two nationally representative cohorts of children in the Panel Study

of Income Dynamics (PSID) Child Development Supplement (CDS). These time diaries provide the only nationally representative source of data on children's time use and permit a relatively unbiased and comprehensive profile of how children's time is allocated, capturing behaviors, patterns, and tradeoffs that may be obscured in survey-based reports of usual activities (Hofferth and Sandberg 2001). Compared to other current survey-based estimates of children's media use, CDS time diary data also offer the advantages of minimizing the potential for overreporting by constraining all of a child's activities to occur in a 24-hour calendar; capturing children's media use both as a primary activity and as a secondary activity that occurred at the same time as a different primary activity; distinguishing weekday from weekend activity; and recording the full range of activities that occupy children's time.

2 Background

2.1 Changes in Technology Use over Time

Children's time engaged with technology has been a persistent concern for parents, educators, and health care providers, at least since movie theaters and broadcast radio became new sources of entertainment (Paik 2001; Wartella and Robb 2008). At the end of the 20th century, children's technology use included a variety of media and modalities, including broadcast and cable television; recorded visual media (e.g., video cassette recordings and DVDs); handheld, console, and computer gaming; and portable music devices. Population-based and clinical research, as well as public discourse from that period, were motivated by multiple concerns. The first was whether frequent media consumption and video game play contributed to children's poorer physical health, social isolation, poorer cognitive achievement, and increased aggressive behavior compared to earlier cohorts as a direct result of exposure to these technologies. The second concern was whether technology use compromised children's development indirectly as a result of time diverted out of activities like play, exercise, and sleep that are associated with healthy development (Wartella and Jennings 2000).

Over the last two decades, the stock of digital platforms and applications available to children from infancy through late adolescence has accelerated with the advent of wireless internet and innovations that have made electronic devices increasingly portable and affordable. Arguably, the profusion of digital platforms and applications has contributed to substantial increases in children's time spent using technology for entertainment, socializing, and learning. According to national retrospective survey estimates, children and teens in the late 1990s spent about one quarter of each day engaged with television, music and audio, computers, video games, and film (Rideout et al.

2010). Ten years later, this figure had increased to 7.5 daily hours (Rideout et al. 2010). Among contemporary youth, teens are estimated to spend more than one third of each day and younger school-aged children spend between three and six daily hours engaged with electronic entertainment media (Rideout 2015, 2017).

On one hand, the emergence of this new time-intensive technological regime has been met with optimism about children's access to new frontiers in creativity, problem solving, and human capital accumulation. Indeed, technological aptitude has been cited as an important factor associated with employment opportunities (Eisner 2010). On the other hand, concerns have been raised about children's increased sedentary time and the unknown consequences of new technologies for physical, cognitive, social, and emotional development (Plowman et al. 2009). Yet to date, we have little information about whether and how this profound change in children's home and learning environments has reshaped the organization of children's time, or how such change has influenced their well-being compared to earlier cohorts. Using nationally representative time diary data from two recent cohorts of US youth, we compare children's time spent in technology use before and after vast changes in the technology landscape. Additionally, we investigate whether any such changes have spilled over to change children's time in three health-related activities that historically have occupied a substantial fraction of children's days: play, physical activity, and sleep.

2.2 Social Disparities in Technology Use

Even prior to the emergence of portable and internet-dependent devices and applications, children's technology use was largely patterned by age, gender, race/ethnicity, and social class, but patterns varied by activity. With regard to television, national estimates of children's time use in 1997 demonstrated that family income and parents' educational attainment were negatively associated with children's time spent watching television and black children watched an estimated 2.6 more hours of television per week compared to white children. (Hofferth and Sandberg 2001). In contrast, Brodie and colleagues (2000) reported that during the same period, children from higher-SES families had access to computers and the internet nearly twice as often compared to children in lower-SES families, and racial gaps providing white children with more frequent home computer and internet access compared to black children were nearly as large.

How have socioeconomic and racial/ethnic disparities changed in the mobile internet era? We consider two possibilities. The first is that more advantaged parents may be curtailing children's technology use increasingly over

time. This expectation is rooted in fundamental cause theory (Link and Phelan 1995), which expects socioeconomically advantaged people to use their knowledge and resources to counteract perceived health threats when they arise. If technology use has become more prevalent in children's lives, advantaged parents may perceive that this increased use brings health risks or crowds out other health-promoting behaviors. We would expect this dynamic to be stronger in early childhood than in middle childhood because of expert recommendations that very young children should have little to no technology exposure (Moreno et al. 2016; Radesky and Christakis 2016). Alternatively, more advantaged parents may begin actively promoting technology use for their children at school age because of its relevance for their skill development in STEM (science, engineering, technology, and mathematics) fields and thus for their future socioeconomic attainment. This expectation originates from work on the role of socioeconomic advantage in parenting practices that are intended to produce future class advantages for children (Calarco 2014; King et al. 2014; Lareau 2011). Together, these possibilities suggest that children of higher-SES parents should use technology less frequently than others in early childhood, but their use could either be lower or higher than that of others in middle childhood. Racial advantage may result in similar patterns for white compared to other children, or these processes may be class-specific.

That said, a recent national survey of children's technology use (Rideout 2017) suggested that disparities in home access to technology are closing. As of 2017, nearly three-quarters of lower-income families with children between 0 and 8 years old had home internet and computer access, and 96% of such families had access to internet-connected mobile devices. Among higher-income families, home internet, computer, and mobile device access was nearly universal. The same study found that racial disparities in overall time engaged with technology had closed but that large disparities by family income remained, with children from lower-income families spending significantly more time with technology than those from higher-income families

2.3 Technology Use Displacing Health Behaviors

Broadly, research questions about the implications of technology use for children's well-being fall into three categories. The first considers whether a technological device or set of activities enabled by the device is in and of itself developmentally harmful or beneficial to children. Examples include assessments of how television viewing affects children's brain structure (Takeuchi et al. 2013) and neural activity (Cantlon and Li 2013), the influence of educational television compared to other types of programming on children's school achievement (Schmidt and

Vandewater 2008), and ongoing debates about whether mobile digital devices such as smartphones should be classified as potentially addictive (Chóliz 2010). A second area considers whether technology use degrades or enhances the quality of other activities occurring at the same time. For example, among students, multitasking with electronic devices while completing homework is associated with poorer academic performance (Junco and Cotten 2012). In families, Radesky and colleagues (2014) reported that parents who were absorbed by mobile digital devices during meal time were more likely to respond harshly to children's misbehavior compared to parents who were not using digital devices or whose attention was focused primarily on their child.

The third area, which we consider here, addresses whether children's time engaged in technology use displaces time in other activities that are beneficial or deleterious for child development. This approach considers technology use as an opportunity cost to other health-productive activity and provides a broad view of how families organize children's time in ways that may be more or less beneficial for development and well-being. Research conducted prior to the advent of mobile devices and broad access to wireless internet suggests that media consumption, and particularly television viewing, does substitute for time spent in activities that promote physical development and potentially compromises child health (Anderson et al. 2008; Hofferth 2010; Vandewater et al. 2004, 2006). We have little information from population-representative national samples about whether contemporary technology use, characterized by activity on a variety of mobile devices and performed as both a focal and background activity, detracts directly from time spent in other activities. We consider three types of health-promoting activity that earlier work suggests may be impinged upon by contemporary children's technology use: unstructured play, physical activity such as exercise or participation in organized sport, and sleep.

Unstructured play and physical activity. US children's time in physical activity and outdoor play has declined steadily over the last 50 years, with the exception of girls' participation in organized sports (Bassett et al. 2015). Increased time in sedentary activities, reduced time in housework and chores, and a shift from active to motorized transportation contributed to these long-term trends prior to the advent of the contemporary portable technology regime (Brownson et al. 2005). Research from the past decade considering whether contemporary young children's patterns of screen time, video game play, and other types of portable device use further displaces time in play or physical activity has yielded inconsistent results. In a US national study of children's usual media use, Rideout (2015) reported that children aged 8-12 years who were engaged in frequent screen time were less likely to be physically active at all compared to peers who had low or moderate amounts of screen time. But for children who

had any physical activity, those who also had high levels of screen time spent more time being active compared to peers with less screen time. In a national sample of Canadian children between 3 and 6 years old in 2012-13, time spent outdoors in physical activity was unrelated to children's sedentary time or screen time (Larouche et al. 2016). And in a community-based sample of preschool-aged Australian children in 2013-14, Hinkley and colleagues (2018) documented a modest positive association between children's time with computers, video games, or handheld devices and outdoor play time.

Sleep. Evidence of a negative relationship between technology use and sleep is more consistent. In a meta-review of 67 studies published between 1999 and 2014, Hale and Guan (2015) reported that most found a negative association between children's screen time with television, computers, and portable devices and sleep duration, timing, and quality, but were unable to establish the magnitude or clinical significance of this association because of variability in study populations and measurement. In a more recent pre-registered study, Przybylski (2019) found that caregiver-reported usual screen time explained less than 2% of variation in sleep time among children aged 6 months to 17 years, concluding that each additional hour of screen time reduced nightly sleep by 3 to 8 minutes (also see Xu et al. 2016).

2.4 Age Differences

In order to distinguish developmental periods in childhood, our analyses are stratified to consider early and middle childhood separately (ages 2-5 and 6-11, respectively). Although substantial cognitive development occurs during both periods (Centers for Disease Control and Prevention 2018), they are developmentally and socially distinct. Rideout and colleagues (2003) found, using survey reports, that children between the ages of 4 and 6 spent about two daily hours on average engaged with screen media, with slightly more than half of this time spent watching television. Additionally, they found that the majority of young children's time spent with technology occurred in the presence of a parent. Beyond time spent using technology, Hofferth and Sandberg (2001) found that children in this age group spend more time eating, sleeping, and playing than children in older age groups. The majority of children (61.3%) in this age group spend time in non-parental child care, with an average of 33 hours per week in either relative or non-relative child care (Laughlin 2013).

Middle childhood, on the other hand, is characterized by expanded social influences as children enter elementary school and become increasingly influenced by peers and teachers (Collins 1984). Middle childhood

represents a life stage when children begin to engage more actively with and explore their neighborhoods and develop autonomy in choices about how to spend their leisure time, unlike early childhood when children exhibit much less agency in time use (Perez-Brena et al. 2012; Smetana et al. 2004; Wray-Lake et al. 2010). During this period, time spent on play decreases and time in school increases substantially compared to early childhood (Hofferth 2010). Survey reports suggest that children in this age group spend approximately three hours per day using technology on average, with approximately two hours of this time devoted to television viewing and roughly 45 minutes spent playing video games (Rideout 2017).

3 Method

3.1 Data

The Panel Survey of Income Dynamics (PSID) is the world's longest-running multigenerational household panel study, having started in 1968 as a US-representative sample of families and following the descendants of original householders to the present day. A sample refresher in 1997 added families headed by foreign-born individuals who immigrated after 1968. Embedded within PSID, the Child Development Supplement (CDS) has collected survey information about children's family, school, and neighborhood contexts that may influence status attainment in adulthood, as well as time diary data about children's time use. CDS began in 1997 with a cohort of children (CDS-1997) who resided in families that participated in that year's PSID main interview. Up to two children between 0 and 12 years old per family were randomly selected for inclusion (N=3,563 children, 88% response rate). Children under 18 and their primary caregivers were re-interviewed in 2002 and 2007. From 2014 to 2016, a new round of CDS (CDS-2014) collected information on the well-being of children born since 1997. CDS-2014 included all eligible children 0-17 years old who were observed in a PSID family in the preceding year (N=4,333, 88% response rate).

Time diaries were collected for two randomly selected days (one weekday and one weekend day) from all children in CDS-1997 and from children in a randomly subsampled 50% of families in CDS-2014 (~80% response rate at each wave). Time use was not accounted for while children were in school. Time diaries for the CDS-1997 cohort were collected between March and December 1997 excluding summer months. Diaries in the more recent cohort were completed between November 2014 and February 2016, with a break during the summer months. As a result, time diary data were representative of children's time use during the traditional academic year. Our analytic

sample for early childhood included children 2-5 years old in CDS-1997 (N=922) or CDS-2014 (N=407). Children under two years of age were omitted due to small sample sizes in CDS-2014. The analytic sample for middle childhood included children 6-11 years old in CDS-1997 (N=1,271) or CDS-2014 (N=602). More than 99% of time diaries for children in the early childhood sample were completed by primary caregivers or other adults. In the middle childhood sample, approximately 95% of diaries were completed by primary caregivers or other adults. The mean age of children who completed their own diaries was 10.8 years.[1]

Collectively, time diary data characterize the distribution of time use in the target population over the course of a seven-day week. Time diaries from the CDS-1997 cohort have been used to describe the frequency of children's active leisure (Stafford and Chiteji 2012) and electronic media use (Hofferth 2010; Hofferth and Sandberg 2001; Vandewater et al. 2007), to document the correlation between television viewing time and obesity (Vandewater et al. 2004), and to describe time tradeoffs between passive and active leisure (Vandewater et al. 2015). However, ours is the first study to use nationally representative time diary data to compare children's comprehensive activity profiles under distinctive technology regimes and to investigate race/ethnic and social class variation in these changing activity profiles over time.

We note that a recent series of surveys reporting children's technology use during the day prior to interview (Rideout 2015, 2017; Rideout et al. 2010) have provided information about the frequency and content of US children's and adolescents' screen time as new platforms for electronic media have emerged. These survey-based reports have provided fine-grained measures of technology activity but are potentially problematic for a number of reasons: First, they allowed for overreporting of time in any given activity (i.e., total time can sum to more than 24 hours). Second, to date surveys have not distinguished between technology use as a primary activity, in which the activity was the main focus of a child's attention and energy (such as texting) or as a secondary activity in which the activity was done in the "background" to a primary activity (such as watching a television program while eating dinner). Further, to date, survey questionnaires have not routinely distinguished between weekday and weekend activities. Finally, they have not included information about time spent in other activities such as play, exercise, sleep, or time at school and lack a mechanism to ensure that total time in reported activities did not exceed a 24-hour day. Thus, they have not allowed for the assessment of time tradeoffs between technology and other activities. Time

[1] Robustness checks were performed to address differential reporter bias between parents and children. Specifically, all models were run while excluding cases in which children completed time diaries without parental assistance. Results were similar to models presented here. By retaining these cases, we are able to preserve generalizability and sample size.

diary data are uniquely equipped to overcome these limitations. In addition, compared to survey-based measures of time spent in usual activities, time diary data leave less leeway in question interpretation and are less subject to social desirability, or the tendency to provide responses that the study participant may perceive to be socially desirable rather than accurate (Hofferth 2006; Robinson 1985).

3.2 Measures

3.2.1 Technology Time Use

We classified technology use into six discrete categories: 1) watching television programming (on any type of device), 2) playing video games, 3) communication such as texting or talking by phone or video, 4) education-related activities including homework and research, 5) listening to music or other audio programming (e.g., radio, podcasts), and 6) recreation, including consuming and creating social media, surfing the Internet, and online shopping.

CDS time diary data distinguished between primary and secondary activities. Primary activities were recorded in response to the prompt, "What did you do?" Secondary activities were recorded in response to the prompt, "What else were you doing at the same time?" For the most part, when two activities co-occurred, the respondent determined which was primary and which was secondary. Exceptions included travel, in which travel was always the primary activity; and sleep, personal care, and time in school, for which no information about secondary activities was requested. We constructed separate measures for each type of technology use as a primary activity or as a secondary activity. Additionally, we constructed a measure of total time with technology. Since the distinction between primary and secondary activities can be arbitrary, this measure was constructed to reflect the sum of time in primary and secondary technology activities with periods of overlap between the two removed. For example, if a child spent one hour playing video games on a mobile device as a primary activity while also watching television as a secondary activity, this period was coded as one hour of total technology time. Following other time diary research (Hofferth 2010; Hofferth and Sandberg 2001; Vandewater et al. 2007; Williams et al. 2013), we constructed a synthetic week from reported weekday and weekend time use. Total time use during the week was calculated by multiplying the one reported weekday by five and adding it to the one weekend day multiplied by two to total seven synthetic days of time use (168 hours). Estimates of the number of total hours per week that children spent in each activity were derived from this synthetic week.

3.2.2 Unstructured Play, Physical Activity, and Sleep

In order to understand how increased time in technology use across cohorts may have impinged upon children's health behaviors, we constructed measures of weekly time spent in unstructured play, physical activity, and sleep at each wave. Unstructured play included a wide range of hobby and leisure activities (e.g., attending sports games), social (e.g., attending a party), and play activities (e.g., playing games). Physical activity included activities such as playing on the playground, leisure sports, and coached practice for organized sporting activities. Sleep included nighttime sleep, as well as naps throughout the day.

Sociodemographic Measures

To account for differences in time use by family social location in each historical period, regression models included indicators of child race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other) and family socioeconomic status (coded as a child's primary caregiver having at least a four-year college degree, some college, a high school degree but no college education, or less than a high school degree). Race/ethnicity and family SES were each interacted with period (CDS-1997=0, CDS-2014=1) to identify uneven change in children's time use over historical time. A dichotomous indicator of child gender was coded 1=male, 0=female. Child age at time diary completion was coded in years, averaging age at the date the weekday and the weekend daytime diaries were collected. Family structure was indicated by whether or not two parents co-resided with the child and by the number of other children in the home (not including the focal child). Descriptive statistics for all sociodemographic indicators are presented in Table 1.

[INSERT TABLE 1 HERE]

3.3 Analyses

Theory suggests that associations between sociodemographic indicators and technology use should differ between early and middle childhood beyond compositional differences. To confirm these differences empirically, we used seemingly unrelated estimation and Wald tests, which examined whether the relationships between the dependent and key independent variables differed in magnitude and/or direction across the two age groups. The tests of models for early and middle childhood groups were statistically significant, suggesting that associations between sociodemographic indicators and technology use differed between the two groups. Therefore, we stratified our samples by age group and performed analyses on each age group independently.

Descriptive analyses examined differences in technology use by activity across the two time periods and considered differences in total time engaged in technology use, unstructured play, physical activity, and sleep by race/ethnicity and social class in each cohort. Our multivariate models used negative binomial regression models to estimate total time engaged with technology as a function of cohort (CDS-1997 vs. CDS-2014), sociodemographic characteristics, and their interactions. Similarly, multivariate regression models estimated total time spent in physical activity, play, and sleep as a function of time spent using technology to describe the extent to which technology use displaced time in these activities. Due to their non-normal distributions, play and physical activity were modelled using negative binomial regression. Sleep, which was normally distributed, was modelled using ordinary least squares (OLS) regression. Simulation studies have suggested that negative binomial regression models (sometimes referred to as Poisson-gamma regression) are preferable to OLS and Tobit regression models for modeling time diary data when outcomes are not normally distributed (Brown and Dunn 2011).

Because data were missing for 4% of cases, we used multiple imputation to account for missing data in all analyses. Multiple imputation assumes that data are missing at random after conditioning on other observed variables in the data set, a more plausible assumption than those made by listwise deletion (Little and Rubin 2014). Fifteen data sets were imputed. Results were weighted to be representative of children contemporary to each cohort in families residing in the US since at least 1997. Additionally, construction of sampling weights differed between CDS-1997 and CDS-2014 (Institute for Social Research 1997, 2017). Therefore, these values were normed and trimmed to allow for consistent results across the two time periods. All analyses were completed using Stata 15 statistical software (StataCorp 2017).

4 Results

4.1 Changes in Technology Use over Time

Figure 1 summarizes the amount of time children were engaged in primary or secondary activities that required electronic or digital devices in the earlier and more recent cohorts for early (ages 2-5) and middle (ages 6-11) childhood. Table 2 shows that in the earlier cohort (1997), 2- to 5-year-old children spent 18.8 hours engaged in digital and electronic activities each week on average (combining primary and secondary technology use and removing overlap if both the primary and the secondary activity are technology use). In the more recent cohort (2014-16), this average rose to 24.9 hours, an increase of 6.1 hours or 32% ($p<.001$). Similarly, average time spent

using technology rose among 6- to 11-year-old children from 18.6 hours in the earlier cohort to 23.1 hours each week in the more recent cohort, an increase of 4.5 hours or 23% over the period ($p<.001$).

In both age groups, this upsurge was driven largely by increased technology use for secondary activities concurrently with other primary activities. Time with technology as a secondary activity rose by 7 hours per week on average in early childhood (3.4 hours in the earlier cohort vs. 10.4 hours in the more recent cohort, $p<.001$, Figure 1) and 5.5 hours in middle childhood (2.7 hours vs. 8.2 hours, $p<.001$). Changes in time spent with technology as a primary activity were not significant for either age group. In both age groups, increases in secondary time with technology occurred largely as the result of increased consumption during travel (results not shown). In early childhood, the share of travel time spent with technology use as a secondary activity increased from 5% in the earlier cohort to 38% in the more recent cohort ($p<.001$, not shown). Likewise, this share increased in middle childhood from 4% to 34% between cohorts ($p<.001$, not shown). We note that CDS time diary data are coded so that travel time (e.g., transit between home and school) is always treated as a primary activity. Thus, to some extent the increase in children's technology use as a secondary rather than as a primary activity may largely reflect changes in access to mobile internet-enabled devices.[2]

[INSERT FIGURE 1 AND TABLE 2 HERE]

A number of activities contributed to children's increased technology use (Figure 1). Total time spent with audio entertainment increased by 3.3 hours per week in early childhood (3.8 hours in the more recent cohort vs. 0.5 hours in the earlier cohort, $p<.001$) and 2.7 hours in middle childhood (3.4 hours vs. 0.7 hours, $p<.001$). Video game play increased by 1.8 hours in early childhood (2.6 hours in the more recent cohort vs. 0.8 hours in the earlier cohort, $p<0.01$) and 2.7 hours in middle childhood (4.9 hours vs. 2.2 hours, $p<.001$). Television viewing as a primary activity decreased over the period in both early childhood (12 hours in the more recent cohort vs. 14 hours in the earlier cohort, $p<0.01$) and middle childhood (10.8 hours vs. 13.1 hours, $p<.001$). However, television viewing increased as a secondary activity in early childhood by 3.4 hours (6.1 hours vs. 2.7 hours, $p<.001$) and 1.8 hours in middle childhood (3.6 hours vs. 1.8 hours, $p<.001$). As a result of the changes, there was a net increase of 1.5 hours per week of television viewing between the earlier and more recent cohorts in early childhood ($p<.05$) and

[2] Supplemental analyses using parent-reported survey responses in CDS (not shown) examined children's access to specific device types in early and middle childhood. In 2014, nearly 80% of children ages 2-5 had access to a smartphone or tablet. This percentage was slightly higher in middle childhood, with 86% of children having access to a smartphone or tablet. Although most children had access to a smartphone or tablet regardless of age, computer use was much more prevalent once children reached school age. Among young children, 33% had access to a computer, compared to 74% in middle childhood.

a net decrease of 0.4 hours in middle childhood (not significant).

Changes in both prevalence and duration have contributed to increases in children's time using technology (Table 2). The share of children playing video games has nearly doubled in early (37% in the more recent cohort vs. 18% in the earlier cohort, p<.001) and middle childhood (60% in the more recent cohort vs. 37% in the earlier cohort, p<.001). Among those who played video games, changes in time spent playing video games increased by 2.5 hours in early childhood (6.9 hours in the more recent cohort vs. 4.4 hours in the earlier cohort, p<.001) and 2.3 hours in middle childhood (8.2 hours vs. 5.9 hours, p<.001). The prevalence of engagement with audio entertainment increased from 17% in the earlier cohort to 70% in the more recent cohort for early childhood (p<.001) and from 24% to 67% in middle childhood (p<.001). Additionally, the numbers of hours spent listening to audio entertainment among listeners increased from 3 hours per week to 5.5 hours per week in early childhood (p<.001) and from 3 hours to 5 hours in middle childhood (p<.001).

4.2 Social Disparities in Technology Use

4.2.1 Socioeconomic Disparities

Figure 2 describes time spent using technology and other activities for the early childhood group in each cohort overall and by caregiver educational attainment. Here, all of the technology categories included in Figure 1 were summed into a single category of total time engaged with technology. Total time engaged with technology among 2- to 5-year-old children increased over the period for all primary caregiver education groups (Figure 2). Growth was greatest among children whose caregivers were high school graduates (10.1 hours or 53%), followed by children whose caregiver had some college but no bachelor's degree (9.4 hours or 53%), those whose caregiver lacked a high school diploma (4.4 hours or 20%), and those with a caregiver who was a college graduate (1.1 hours or 7%) over the period.

[INSERT FIGURE 2 HERE]

We used multivariate negative binomial regression to investigate whether patterns of change in technology use over historical time varied by socioeconomic status net of related sociodemographic characteristics. Primary caregiver educational attainment serves as an indicator of family socioeconomic status. Table 3 presents results stratified by CDS-1997 and CDS-2014 cohort, while Table 4 presents results with the two cohorts pooled. Models 1 and 2 in Table 4 present results for early childhood. Model 1 summarizes average socioeconomic disparities across

the two periods, while Model 2 introduces an interaction between socioeconomic status and cohort in order to assess whether group differences in the later cohort were significantly different compared to those in the earlier cohort. Model 1 shows that total technology time of children whose primary caregiver had some college was approximately 10% less ($1 - e^{-0.11} = 0.10$) than those whose caregivers had a high school diploma only ($p<.05$). Similarly, average total technology time of children with a primary caregiver who was a college graduate was approximately 24% less ($1 - e^{-0.28} = 0.24$) than those children whose primary caregiver was a high school graduate ($p<.001$). In post-hoc tests, all comparisons among the primary caregiver education levels were significantly different in Model 1 except for the comparison between high school graduate and less than high school (see footnotes to Table 4). Consistent with bivariate results, interaction terms in Model 2 show that, compared to children whose caregivers were high school graduates, increases in technology time between the two cohorts were significantly lower among those with caregivers who lacked a high school diploma ($p<.05$) and those who caregivers were college graduates ($p<.001$). Change in technology time between cohorts was statistically equivalent between those whose caregivers were high school graduates or had some college.

[INSERT TABLE 3 AND TABLE 4 HERE]

The lower panel of Figure 2 describes differences in time for each activity by primary caregiver education in middle childhood. Patterns were somewhat different in middle compared to early childhood. Increases in technology time among 6- to 11-year-old children from the earlier to the more recent cohort were greatest among those whose primary caregivers were college graduates (6.2 hours or 36%), followed by those whose caregivers were high school graduates (5.5 hours or 29%). Increases were smallest among those with caregivers having some college (3.6 hours or 20%) and those whose caregivers lacked a high school diploma (3.2 hours or 16%).

As in early childhood, a socioeconomic disparity in technology use was present in both cohorts. Table 3 presents results stratified by CDS-1997 and CDS-2014 cohort. Models 3 and 4 in Table 4 present results from negative binomial regression models examining total technology time for this group. Model 3 shows that for the pooled sample, total technology time among children with caregivers with a college degree was approximately 14% lower ($1 - e^{-0.15} = 0.14$) compared to those whose caregivers who had a high school diploma ($p<.01$). Technology time among children whose caregivers lacked a high school diploma and those with some college was not significantly different from those with a high school diploma. Post-hoc tests identified that college graduates were significantly different from all education levels except for some college, and no other differences were statistically

significant in Model 3 (see footnotes to Table 4).

Model 4 includes an interaction term between technology time and cohort. Increases in technology time between cohorts were significantly lower among children with caregivers who lacked a high school diploma ($p<.05$) and those whose caregivers had some college ($p<.05$) compared to those whose caregivers were high school graduates. There was no significant difference in change over time between children whose caregivers were college graduates and those whose parents were high school graduates.

4.2.2 Racial/Ethnic Disparities

The upper panel of Figure 3 summarizes changes in technology time by race/ethnicity among younger children in the two cohorts. Increases were largest among Hispanic children (8.6 hours or 51%) and similar between non-Hispanic white (5.5 hours or 30%) and non-Hispanic black (5.8 hours or 29%) children. Increases were smallest among children in the other race group (4.9 hours or 28%). Multivariate results presented in Model 1 of Table 4 reveal no significant differences in technology time by race/ethnicity across the two cohorts. Models testing interactions between race/ethnicity and cohort (not shown) were not significant, suggesting that increases were similar across race/ethnic groups.

[INSERT FIGURE 3 HERE]

Bivariate findings were somewhat different for middle childhood. The lower panel of Figure 3 illustrates that increases in technology time between the two cohorts were largest among non-Hispanic white (5.3 hours or 30%) and other race (5.4 hours or 29%) children, followed by non-Hispanic black (3.9 hours or 20%) and Hispanic (2.7 hours or 15%) children. Multivariate results presented in Model 3 of Table 4, however, show no significant differences in total technology time across race/ethnic groups once all controls were included in the model. An interaction model (shown in Model 4 of Table 4) identified no change in racial/ethnic disparities over time.

Overall, these findings demonstrate that socioeconomic disparities in technology time (with the most advantaged using technology the least) emerged in the more recent cohort in both early and middle childhood. In contrast, racial/ethnic disparities net of control variables were not identified at either time point.

4.3 Technology Use Displacing Other Activities

In Figures 2 and 3, three activity sets in addition to electronic activities are presented: sleep, physical activity, and

unstructured play. While time spent on technology increased by 6.1 hours in early childhood, time engaged in unstructured play decreased by more than 16 hours per week between the earlier and more recent cohorts in early childhood ($p<.01$) and total time engaged in physical activity decreased by 3 hours ($p<.001$). Sleep, on the other hand, increased by 2.3 hours ($p<.01$).

As with technology use, the decline in physical activity reflects change in both prevalence and duration (Table 2). The share of young children participating in physical activity decreased by 46% ($p<.001$). Among those engaged in any physical activity, weekly time decreased by 2.4 hours ($p<.001$). The substantial decline in unstructured play reflects changes in duration (23.2 hours in the more recent cohort vs. 39.9 hours in the earlier cohort, $p<.001$) rather than prevalence, which remained nearly universal.

Regression models examined time spent in unstructured play, physical activity, and sleep as a function of technology use and controls (not shown). Figure 4 presents estimated values from these models, showing differences by time point in the relationship between technology use and sleep (upper panel), physical activity (middle panel), and unstructured play (lower panel) with all covariates held at their respective means. Technology use was not significantly associated with sleep or physical activity time among young children in either cohort. However, it was associated with *increases* in unstructured play time in both the earlier cohort ($p<.001$) and the more recent cohort ($p<.01$), with no significant difference in the magnitude of the association between time points.

[INSERT FIGURE 4 HERE]

Table 2 shows that overall time spent engaged with technology increased by 4.5 hours ($p<.001$) across the two periods in middle childhood, while time in unstructured play decreased by nearly 13 hours per week ($p<.001$), and time in physical activity decreased by 3.1 hours ($p<.001$). Sleep increased by 3.2 hours over the period ($p<.001$). Similar to early childhood, decreases in physical activity were attributable to declines in both prevalence and duration (Table 2). The prevalence of physical activity decreased more than 36% ($p<.001$), while weekly time decreased by 2.1 hours among those engaged in any physical activity ($p<.001$). In contrast, prevalence of unstructured play was nearly universal in both time periods, while duration decreased substantially.

Figure 5 summarizes adjusted estimates for time in sleep, physical activity, and unstructured play by time spent using technology. Time with technology was not significantly associated with time in unstructured play (lower panel). However, total technology time was associated with a modest increase in sleep time ($p<.05$) in the more recent cohort. For instance, an increase in technology time from 0 to 10 weekly hours was associated with a 1%

increase in sleep (0.9 weekly hours). Although the direction of this association is at odds with prior work, it is consistent with work suggesting that the magnitude of any association is fairly small. In addition, there were important changes over time in the relationship between time with technology and physical activity (middle panel). In the earlier cohort there was no significant relationship between technology time and physical activity time, but in the more recent cohort technology time was strongly associated with decreases in physical activity ($p<.001$). For example, an increase in technology use from 0 to 10 hours per week was associated with a 2-hour, or 31%, decrease in physical activity. Cohort change over time in the relationship between technology and physical activity time was statistically significant. In sum, technology use "crowded out" physical activity for older children in the more recent cohort but facilitated unstructured play for younger children in both cohorts.

[INSERT FIGURE 5 HERE]

The sample did not provide enough statistical power to interact technology use with time period and sociodemographic characteristics simultaneously. However, we conducted supplemental analyses interacting technology use and sociodemographic characteristics to examine their relationship with play and activity time in cohort-stratified models. None of these interactions was significant, suggesting that offsets to play and activity by technology were similar across social groups in both historical periods.

5 Discussion

Moving beyond questions about the psychological and social effects of children's use of technology, this study adopted a time use approach that views technology use as a frequent activity that contributes to the organization of children's everyday lives, facilitating some types of activities and crowding out others. We used time diary data from US nationally representative samples of preschool- and school-aged children collected in 1997 and 2014-2016 to consider how the expanded variety of devices, platforms, and applications for electronic and digital activity over the last decade have shaped time use and whether class- and race-based patterning of children's technology use has persisted or changed over time in early and middle childhood.

We highlight three key findings. First, children's time spent with technology increased by about one third between the earlier and more recent cohorts in early childhood and one quarter in middle childhood. In the more recent cohort, both age groups spent more than three hours per day using technology. Much of this increase was attributable to technology time as a secondary activity. The nature of children's technology use also changed

compared to the earlier cohort. Television viewing remained the most frequent electronic activity, but time spent playing video games, communicating, and using digital devices for other forms of entertainment increased at a higher rate compared to television time.

Second, time engaged with technology was not racially patterned, but it was increasingly socioeconomically patterned. In early childhood, the increase in technology time between the earlier and more recent cohorts was lowest among children with the most highly educated caregivers. This may reflect increased awareness of recommendations regarding young children's technology use among the most socioeconomically advantaged parents (Radesky and Christakis 2016). Yet at the same time, children whose parents lacked a high school education also experienced lower increases in technology time relative to the middle education categories, despite having caught up in terms of device ownership (Rideout 2017). This surprising finding should be explored in future research. The pattern in middle childhood was somewhat different. Similar to early childhood, children of college-educated caregivers in this age group had the lowest levels of technology time in both the earlier and more recent cohorts. This was expected given socioeconomically advantaged parents' likelihood of curtailing child behaviors that reflect threats to health (Link and Phelan 1995). However, change in technology time across cohorts among children with college-educated caregivers were not significantly different compared to children whose caregivers had only a high school education, indicating that disparities in technology use did not expand between these groups. Between-cohort gains in technology time were less steep for children of caregivers with less than a high school degree or some college compared to a high school degree.

Third, the association between increased time using technology and the structure of children's days varied across age groups and cohorts. In early childhood, increased time using technology was not associated with changes in physical activity or sleep but was associated with increases in unstructured play. This is consistent with recent research conducted outside of the US (Hinkley et al. 2018; Larouche et al. 2016). We speculate that the positive association between technology and play time could be a result of underlying parenting approaches in which both technology and play are treated as unstructured time and vary together. Parenting that allows more unstructured time for the child, rather than scheduled activities or structured parent-child interaction, may result both in more unstructured play time and more technology time. In middle childhood, increased time using technology in the more recent cohort was associated with slight increases in sleep but greater decreases in physical activity compared to the earlier cohort. Although this "crowding out" of a healthful activity by technology use was an important finding, it

did not fully account for the observed continuation of a long-running decline in physical activity (Bassett et al. 2015). We stress that the offsetting of physical activity associated with total technology time should not be interpreted as causal; it may be the result of other changes in the organization of children's time.

This study has some limitations. First, children may have underreported some forms of technology use, particularly activities such as texting or consuming social media that typically occur in frequent short spells over the course of a day. This underreporting may be heightened when a caregiver is completing the diary on a child's behalf, as often occurs for younger children. To the extent that some forms of contemporary electronic and digital activity are underreported, we have provided a conservative estimate of technology use in early and middle childhood. Second, at both waves, PSID excluded families headed by immigrants who entered the US since 1997. While our profiles of children's time use excluded children residing in recent immigrant families, the comparison between the two historical periods captures the impacts of an evolving digital and electronic technology regime for compositionally similar cohorts. Finally, because the sample size in the more recent CDS cohort was smaller than in the earlier cohort, coefficients in multivariate regression models were estimated with lower precision, so potentially meaningful group differences were not statistically significant.

Despite these limitations, this study documented changes in children's daily time use that were associated with emergent technology changes and has set the stage for future research to consider related impacts on children's health behaviors and health status. We note that the primary ways in which children spend time on technology use—particularly watching television content, listening to audio, and playing video games—have not changed substantially over time, even as the amounts of time spent on these activities have changed and the technological platforms on which this time was spent have almost certainly evolved over time. In contrast, the rise of technology use as a secondary activity, particularly during travel and at meals, suggests paradigm-shifting changes in how children's technology use fits into the other ways they spend their time. In-depth observational research is needed to understand the emergence of secondary technology time and its implications for health, development, and social interaction. Qualitative observational and interview research could also shed light on changing socioeconomic disparities, and together with additional analyses of time use data could explore how gender plays out in technology use. Because children's technology use could have both negative and positive implications for their futures (e.g., potentially reducing face-to-face interaction but building skills that could be useful in technology-sector careers), these changing disparities are crucial to understand. Finally, the sharp decreases over time in unstructured play and

physical activity—and even in the proportion of children who engage in physical activity at all—cannot be fully accounted for by increases in technology use. Although outside the scope of the present study, an important goal for future research is to investigate these secular trends in unstructured play and physical activity as phenomena in their own right, and not simply as a function of rising technology use. This study, together with those that follow, can provide a nuanced picture of the organization of contemporary children's everyday lives and begin to point to potential implications for health and development.

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Table 1. Descriptive Means for Early and Middle Childhood Samples, CDS-1997 and CDS-2014

	Early Childhood			Middle Childhood		
	CDS-1997 Mean (SE)	CDS-2014 Mean (SE)	Total Mean (SE)	CDS-1997 Mean (SE)	CDS-2014 Mean (SE)	Total Mean (SE)
N	922	407	1329	1271	602	1873
Age	3.97	4.09	4.00	8.96	8.96	8.96
	(0.05)	(0.08)	(0.05)	(0.06)	(0.11)	(0.05)
Male	0.52	0.51	0.52	0.51	0.56	0.52
	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)	(0.01)
Race/Ethnicity						
Non-Hispanic White	0.68	0.71	0.69	0.67	0.61	0.65
	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)
Non-Hispanic Black	0.14	0.13	0.13	0.16	0.17	0.17
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Hispanic	0.10	0.15	0.11	0.11	0.21	0.14
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Other	0.08	0.02	0.06	0.06	0.01	0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Primary Caregiver Education						
Less than High School	0.14	0.06	0.12	0.14	0.10	0.13
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
High School Grad	0.34	0.21	0.30	0.37	0.25	0.33
	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Some College	0.29	0.32	0.30	0.28	0.32	0.29
	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)
College Grad	0.22	0.40	0.28	0.20	0.33	0.24
	(0.02)	(0.05)	(0.02)	(0.02)	(0.05)	(0.02)
2 Parents in Home	0.71	0.71	0.71	0.69	0.62	0.67
	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)	(0.02)
Other Kids in Home	2.17	1.27	1.90	2.46	1.64	2.20
	(0.05)	(0.10)	(0.04)	(0.03)	(0.10)	(0.05)

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries.

Table 2. Percent Participating, Overall Weekly Mean Hours, and Conditional Weekly Mean Hours for Selected Activities, CDS-1997 and CDS-2014

	Early Childhood			Middle Childhood		
	CDS-1997	CDS-2014	Diff.	CDS-1997	CDS-2014	Diff.
N	922	407		1,271	602	
Percent Participating						
Total Technology Time	99.0%	99.5%		98.0%	99.2%	
Total Tech (Excluding TV)	51.2%	86.2%	***	66.3%	91.2%	***
Tech Activities						
TV	98.0%	98.3%		96.1%	96.5%	
Videogames	17.5%	37.3%	***	37.2%	59.5%	***
Communication	4.0%	4.2%		11.1%	8.8%	
Education & Work	1.2%	2.9%	*	2.0%	6.5%	***
Listening	16.6%	69.5%	***	24.1%	67.4%	***
Recreation	32.6%	21.9%	***	27.2%	31.4%	
Sleep	100%	100%		99.9%	99.7%	
Physical Activity	65.3%	35.1%	***	69.2%	43.7%	***
Unstructured Play	99.8%	99.3%		98.8%	96.2%	***
Weekly Hour Means (Overall)						
Total Technology Time	18.78	24.88	***	18.60	23.14	***
Total Tech (Excluding TV)	2.25	7.10	***	3.97	9.59	***
Tech Activities						
TV	16.67	18.13	*	14.83	14.41	
Videogames	0.77	2.56	***	2.18	4.85	***
Communication	0.03	0.06		0.19	0.31	*
Education & Work	0.03	0.05		0.10	0.25	*
Listening	0.50	3.81	***	0.71	3.40	***
Recreation	0.93	0.64	**	0.82	1.06	*
Sleep	77.50	79.76	**	68.01	71.17	***
Physical Activity	4.63	1.64	***	5.83	2.75	***
Unstructured Play	39.83	23.24	***	29.79	17.13	***
Weekly Hour Means (Conditional on Use)						
Total Technology Time	18.97	25.00	***	18.99	23.33	***
Total Tech (Excluding TV)	4.40	8.23	***	5.99	10.51	***
Tech Activities						
TV	17.00	18.45	*	15.42	14.94	
Videogames	4.39	6.85	***	5.85	8.16	***
Communication	0.75	1.47		1.73	3.52	*
Education & Work	2.78	1.77		5.04	3.84	*
Listening	2.98	5.48	***	2.95	5.04	***
Recreation	2.86	2.91	**	3.03	3.37	*
Sleep	77.50	79.76	**	68.06	71.40	***
Physical Activity	7.09	4.67	***	8.44	6.30	***
Unstructured Play	39.91	23.42	***	30.14	17.81	***

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries.

Notes. All data are weighted. *** p<0.001, ** p<0.01, * p<0.05; t-tests comparing CDS-1997 to CDS-2014.

Table 3. Negative Binomial Regression Models Estimating Total Time Using Technology per Week, CDS-1997 and CDS-2014

	Early Childhood		Middle Childhood	
	CDS-1997	CDS-2014	CDS-1997	CDS-2014
Age	0.04*	-0.03	0.03	0.04*
	(0.02)	(0.03)	(0.02)	(0.02)
Male	0.07	0.19*	0.10*	0.07
	(0.05)	(0.09)	(0.05)	(0.05)
Race/Ethnicity [Non-Hispanic White]				
Non-Hispanic Black	0.14	0.09	0.12	0.04
	(0.08)	(0.10)	(0.07)	(0.08)
Hispanic	-0.17	0.02	-0.04	-0.05
	(0.09)	(0.10)	(0.09)	(0.08)
Other	-0.05	-0.12	0.05	0.03
	(0.09)	(0.42)	(0.10)	(0.17)
Primary Caregiver Education [High School Grad]				
Less than High School	0.17*	-0.16	0.12	-0.19
	(0.07)	(0.14)	(0.07)	(0.12)
Some College	-0.10	-0.16	-0.04	-0.24**
	(0.06)	(0.10)	(0.07)	(0.08)
4-Year College Grad	-0.07	-0.67***	-0.10	-0.28**
	(0.07)	(0.13)	(0.07)	(0.09)
2 Parents in Home	0.05	0.23*	0.00	-0.07
	(0.06)	(0.08)	(0.05)	(0.08)
Kids in Home	0.04	-0.04	-0.03	-0.01
	(0.03)	(0.04)	(0.02)	(0.02)
Constant	2.61***	3.38***	2.66***	3.00***
	(0.11)	(0.15)	(0.17)	(0.17)
ln(alpha)	-1.12***	-1.37***	-1.08***	-1.46***
	(0.07)	(0.14)	(0.08)	(0.11)
Observations	922	407	1,271	602

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries, CDS-1997 and CDS-2014.
Notes. Standard errors and reference categories in parentheses. *** p<0.001, ** p<0.01, * p<0.05.

Table 4. Negative Binomial Regression Models Estimating Total Time Using Technology per Week, Pooled Cohorts

	Early Childhood		Middle Childhood	
	Model 1	Model 2	Model 3	Model 4
Age	0.02	0.02	0.03*	0.03*
	(0.02)	(0.02)	(0.01)	(0.01)
Male	0.11*	0.11*	0.08*	0.09*
	(0.05)	(0.05)	(0.04)	(0.04)
Race/Ethnicity [Non-Hispanic White]				
Non-Hispanic Black	0.14	0.14*	0.10	0.08
	(0.08)	(0.06)	(0.07)	(0.05)
Hispanic	-0.16	-0.07	-0.03	-0.04
	(0.08)	(0.07)	(0.09)	(0.06)
Other	-0.03	-0.04	0.05	0.04
	(0.09)	(0.09)	(0.10)	(0.09)
Primary Caregiver Education [High School Grad]				
Less than High School	0.11	0.17*	0.04	0.12
	(0.06)	(0.07)	(0.06)	(0.06)
Some College	-0.11*	-0.12	-0.09	-0.04
	(0.05)	(0.07)	(0.05)	(0.07)
4-Year College Grad	-0.28***	-0.09	-0.15**	-0.10
	(0.07)	(0.07)	(0.06)	(0.07)
CDS-2014 Cohort	0.33***	0.56***	0.25***	0.38***
	(0.07)	(0.09)	(0.06)	(0.08)
Primary Caregiver Education x 2014				
Less than High School x 2014		-0.36*		-0.31*
		(0.16)		(0.13)
Some College x 2014		-0.04		-0.20*
		(0.12)		(0.10)
4-Year College Grad x 2014		-0.54***		-0.19
		(0.14)		(0.11)
2 Parents in Home	0.11*	0.11*	-0.03	-0.02
	(0.05)	(0.05)	(0.05)	(0.04)
Kids in Home	0.02	0.01	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Constant	2.72***	2.67***	2.68***	2.64***
	(0.10)	(0.10)	(0.15)	(0.15)
ln(alpha)	-1.14***	-1.17***	-1.18***	-1.19***
	(0.06)	(0.07)	(0.07)	(0.07)
Observations	1,329	1,329	1,873	1,873

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries, CDS-1997 and CDS-2014.
Notes. Standard errors and reference categories in parentheses. *** p<0.001, ** p<0.01, * p<0.05. Significant post-hoc tests in Model 1 and directions of association are as follows: less than high school > some college (p<.05); less than high school > college graduate (p<.001); high school graduate > college graduate (p<.001); some college > college graduate (p<.05). Significant post-hoc tests in Model 3 are as follows: less than high school > college graduate (p<.01); high school graduate > college graduate (p<.01).

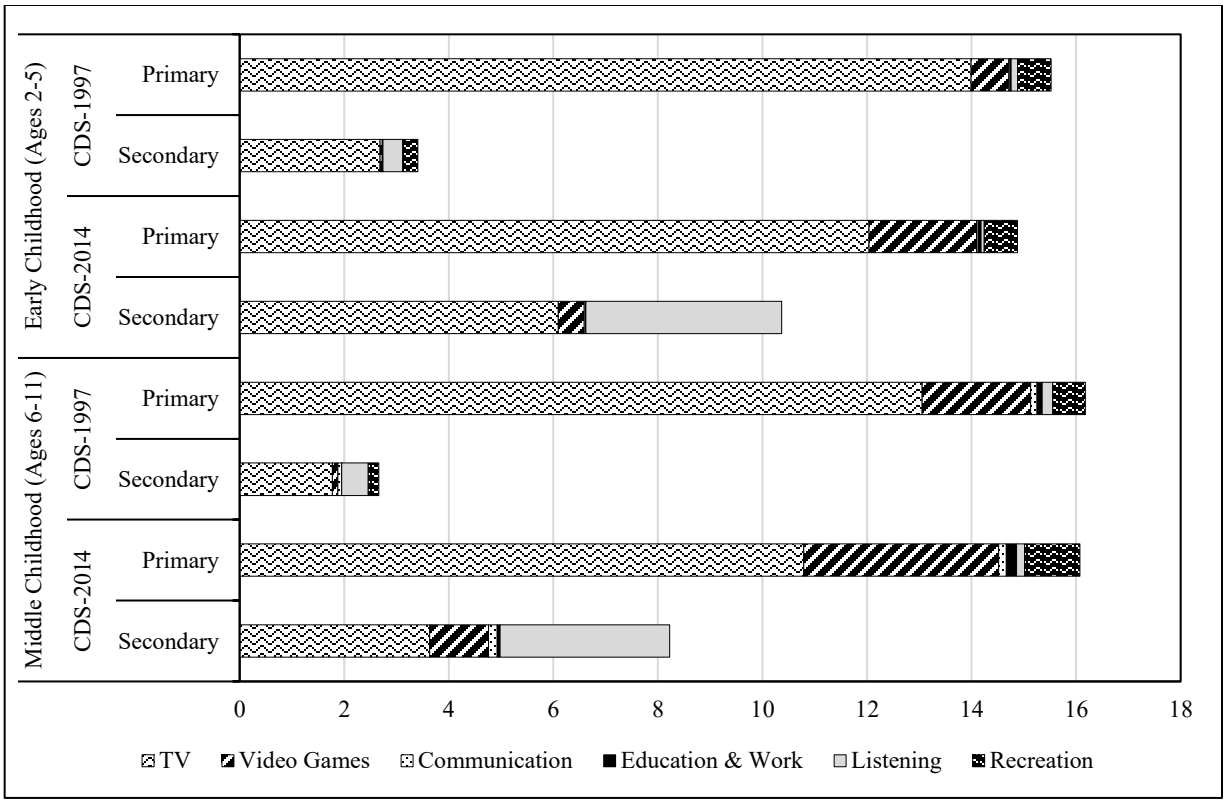

Figure 1. Children's Primary and Secondary Technology Time by Activity, CDS-1997 and CDS-2014
Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries. N = 1,329 for early childhood; N = 1,873 for middle childhood.

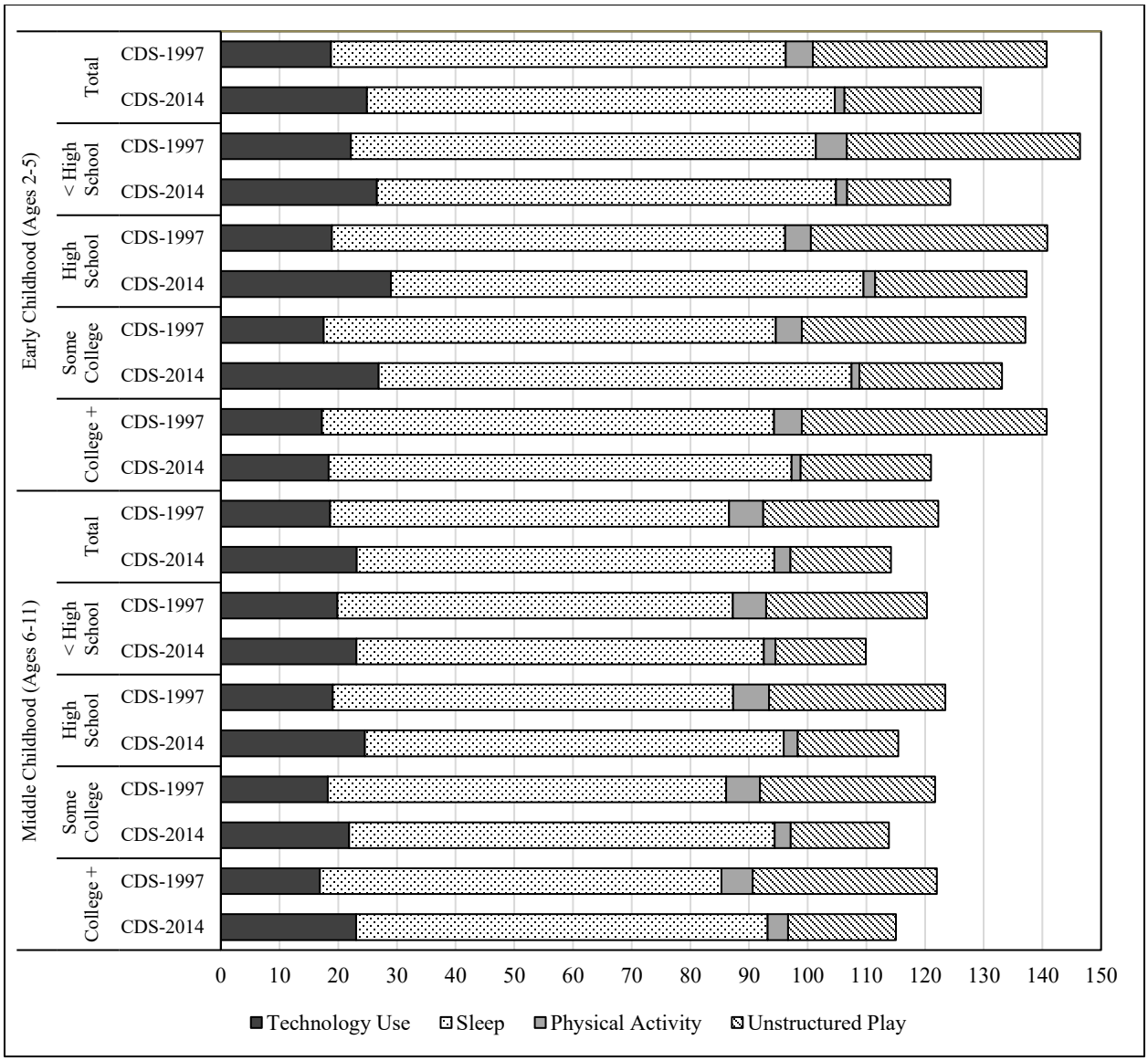

Figure 2. Total Time in Technology Use, Sleep, Unstructured Play, and Physical Activity by Primary Caregiver Education, CDS-1997 and CDS-2014

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries. N = 1,329 for early childhood; N = 1,873 for middle childhood.

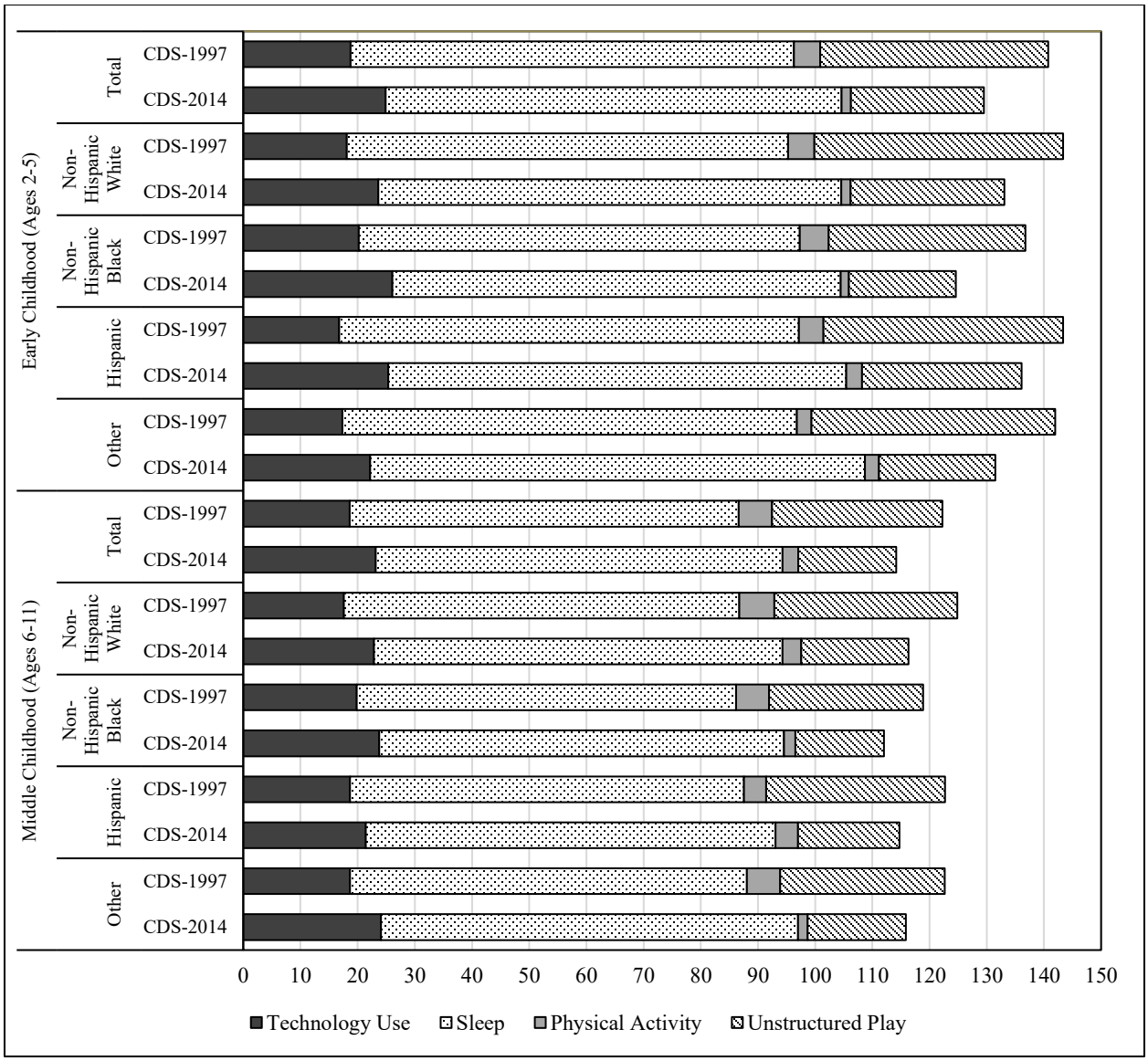

Figure 3. Total Time in Technology Use, Sleep, Unstructured Play, and Physical Activity by Race/Ethnicity, CDS-1997 and CDS-2014

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries. N = 1,329 for early childhood; N = 1,873 for middle childhood.

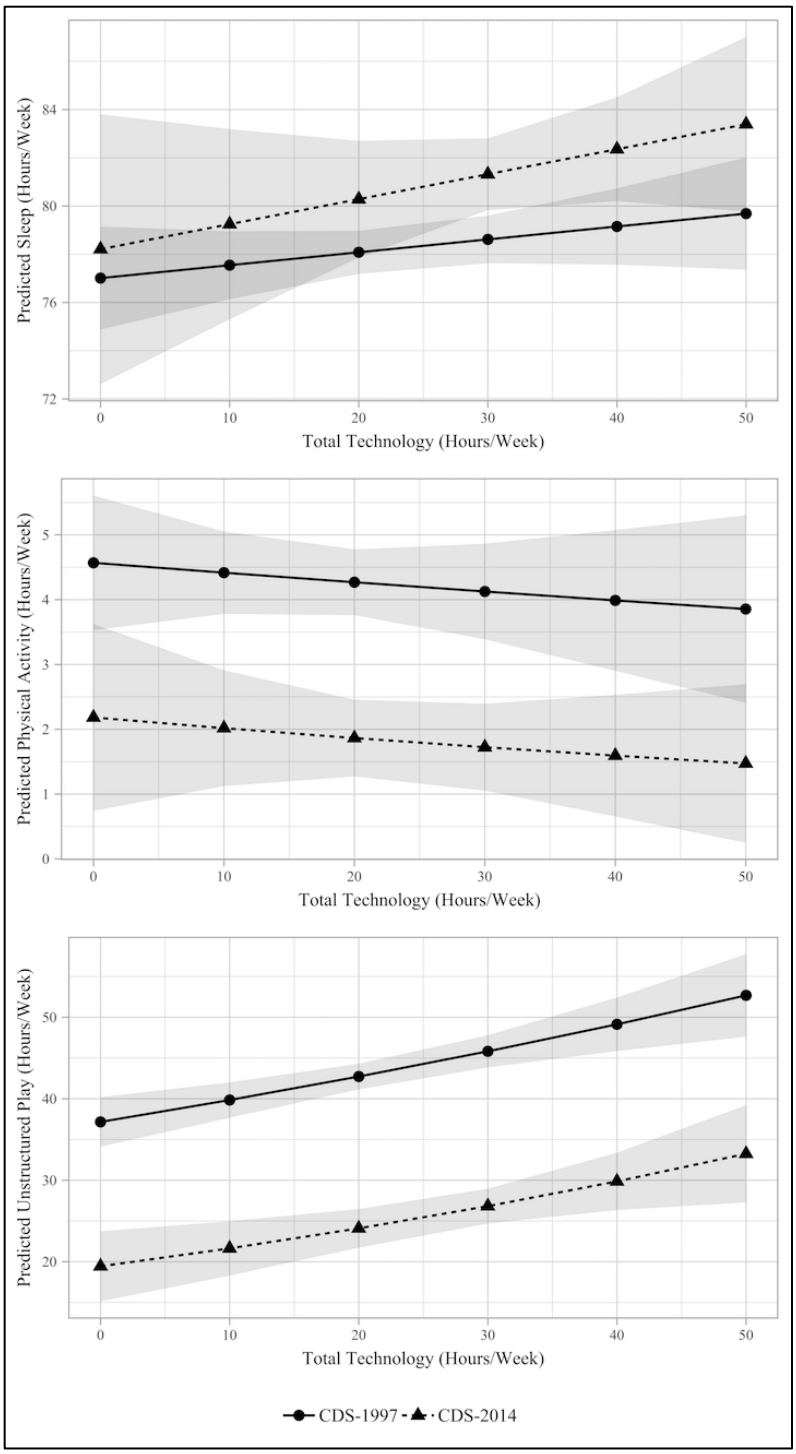

Figure 4. Estimated Weekly Values of Sleep, Physical Activity, and Unstructured Play by Total Tech Time for Early Childhood Sample, CDS-1997 and CDS-2014 *Source:* Panel Study of Income Dynamics Child Development Supplement Time Diaries. $N = 1{,}329$. *Note:* Estimated values from multivariate regression models with all covariates held at mean values.

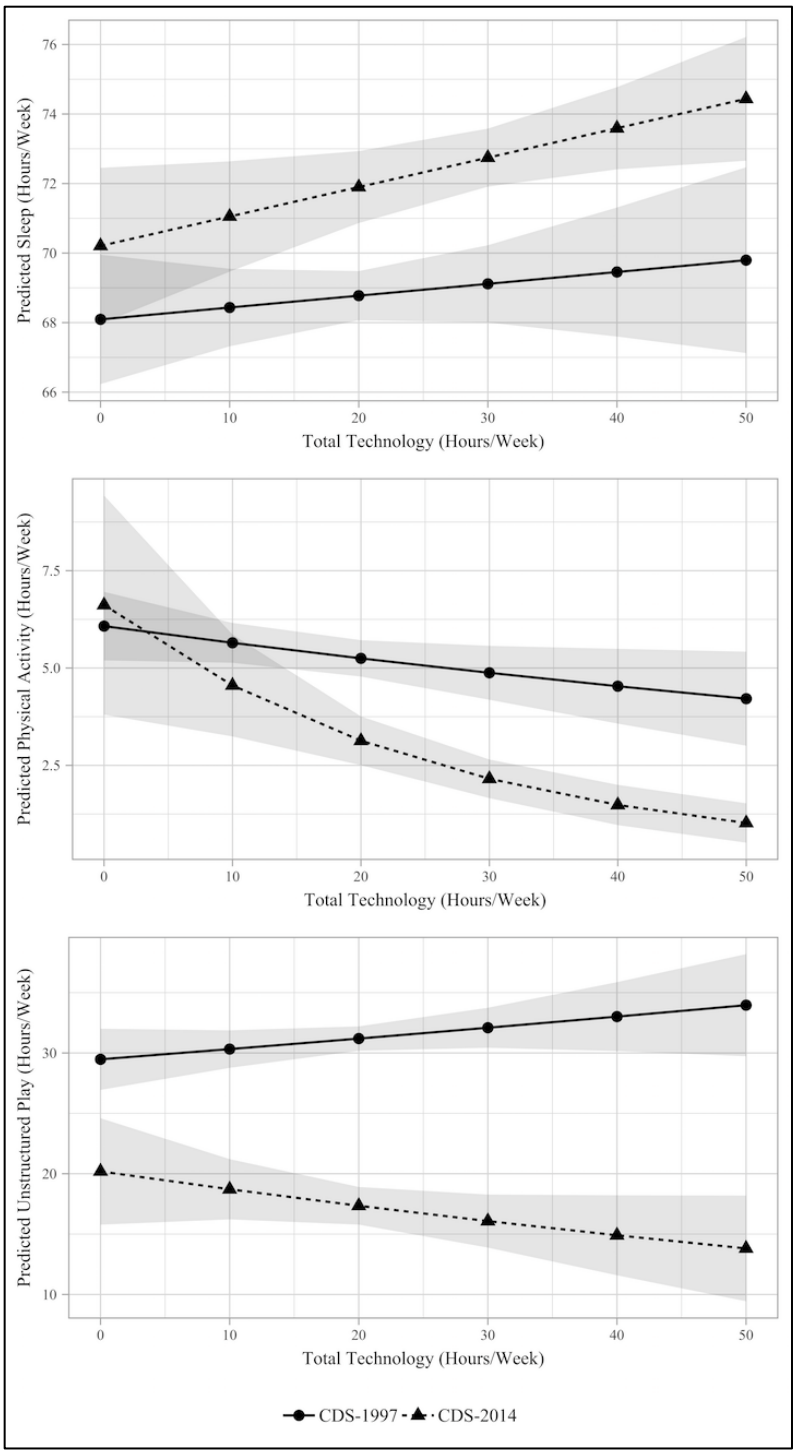

Figure 5. Estimated Weekly Values of Sleep, Physical Activity, and Unstructured Play by Total Tech Time for Middle Childhood Sample, CDS-1997 and CDS-2014

Source: Panel Study of Income Dynamics Child Development Supplement Time Diaries. $N = 1{,}873$. *Note:* Estimated values from multivariate regression models with all covariates held at mean values.