

Measurement of screen time among young children aged 0–6 years: A systematic review

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Summary

The impact of screen-based devices on children's health and development cannot be properly understood without valid and reliable tools that measure screen time within the evolving digital landscape. This review aimed to summarize characteristics of measurement tools used to assess screen time in young children; evaluate reporting of psychometric properties; and examine time trends related to measurement and reporting of screen time. A systematic review of articles published in English across three databases from January 2009 to April 2020 was undertaken using PROSPERO protocol (registration: CRD42019132599) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Included articles measured screen time as outcome, exposure, or confounder in children 0–6 years. The search identified 35,868 records, 1035 full-text articles were screened for eligibility, and 622 met inclusion criteria. Most measures (60%) consisted of one to three items and assessed duration of screen time on a usual day. Few measures assessed content (11%) or coviewing (7%). Only 40% of articles provided a citation for the measure, and only 69 (11%) reported psychometric properties—reliability $n = 58$, validity $n = 19$, reliability and validity $n = 8$. Between 2009 and 2019, the number of published articles increased from 28 to 71. From 2015, there was a notable increase in the proportion of articles published each year that assessed exposure to mobile devices in addition to television. The increasing number of published articles reflects increasing interest in screen time exposure among young children. Measures of screen time have generally evolved to reflect children's contemporary digital landscape; however, the psychometric properties of measurement tools are rarely reported. There is a need for improved measures and reporting to capture the complexity of children's screen time exposures.

KEYWORDS

mobile devices, preschoolers, psychometric properties, screen-based devices

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1 | BACKGROUND

Screen-based devices are now ubiquitous in the lives of children and families. Over the past 20 years, the daily duration of time that children are exposed to screen-based devices is increasing, while age at first exposure is decreasing.¹ Concurrently, the range of devices available and their uses has rapidly expanded. While home-based television viewing was once the primary mode of screen viewing, contemporary screen-based devices now accessible to young children also include computers, game consoles, and mobile digital devices such as smartphones and tablets.² The advent of mobile devices has altered where and how children experience screen time, including solitary viewing, simultaneous device use, viewing traditional television content on mobile devices, viewing outside of the home, and use in early childhood education and care settings.³

This shift has altered the way that children interact with screen-based devices. Television viewing is considered largely passive, as is streaming movies or shorter video content to mobile devices.⁴ Yet smartphones and tablets also offer children opportunities for cognitive engagement, with content delivered via e-books, games, and bespoke applications (commonly referred to as apps). The interactive nature of these activities, when combined with quality educational programming and covieing, may offer benefits to children such as enhanced language skills⁵ and improvements in movement competence.⁶ Video-chat is another interactive use of screen-based devices with potentially positive consequences as it supports social connection in a global society.⁷

Although newer interactive screen-based devices may offer benefits, the association between excessive use of screen-based devices and negative consequences in young children are well documented, most notably cognitive and social/emotional delays, reduced physical activity, higher energy intake, poor sleep, and obesity.^{8,9} Due to potential for negative consequences, the American Academy of Pediatrics (AAP)⁷ recommends that use of screen-based devices by children younger than 18 months be avoided, except for video-chat, whereas for children aged 2 to 5 years, use of screen-based devices should be limited to 1 h/day of quality programming. Similar screen time recommendations have been issued by the World Health Organization¹⁰ and government health agencies including Canada and Australia.^{11,12} However, it is important to note that scientific evidence underpinning these recommendations is based primarily on television viewing. The extent to which contemporary screen-based devices are beneficial or harmful to child health and development continues to be an active area of research and a topic of considerable public and scientific debate.¹³

An important methodological consideration that has received relatively little research attention is the measurement of screen time. If knowledge translation related to benefits and harms of screen time is to advance and be relevant to contemporary society, it is critically important that methods used to assess screen time in young children are fit-for-purpose and reflect the current screen media landscape. Some researchers have recently argued that the assessment of "screen time" is meaningless unless measures describe what screen

users are doing and why.¹³⁻¹⁵ Time, that is, total duration, may be less important and could mask important differences in screen use. While newer measures assessing use of screens by children are being developed,^{14,16,17} the methods used to quantify screen time in young children in studies conducted over the last decade are rarely scrutinized. To our knowledge, no previous review has systematically documented *how* screen time is measured in experimental and observational studies of young children aged 0 to 6 years. A systematic review in 2007 examined studies of children up to 18 years of age but was limited to those that included a measure of the frequency and duration of television watching as the main exposure or outcome of interest.¹⁸ Additionally, small studies of 50-100 participants were excluded from that review. Furthermore, no previous review has examined time trends in the assessment of screen time in young children to determine if screen time measurement tools have kept pace with technological advancements.

An equally important methodological consideration is the extent to which investigators are employing psychometrically sound measures of screen time with documented evidence of validity and reliability. Of concern, the use of items or instruments lacking appropriate evidence of validity and/or the prerequisite levels of reliability can severely inflate measurement error and reduce statistical power.¹⁹ This results in the reporting of inconsistent results and/or potentially spurious associations (or nonassociations) with health and developmental outcomes. To date, however, the quality of reporting in relation to the psychometric properties of instruments to measure screen time in young children has not been systematically evaluated.

To address these important methodological considerations, the objectives of this systematic review are threefold: (1) to summarize characteristics of measurement tools used to assess screen time in children aged 0 to 6 years; (2) to evaluate reporting of psychometric properties in research literature; and (3) to examine time trends in relation to assessment of screen time in young children and reporting of psychometric properties.

2 | METHODS

2.1 | Protocol and registration

The systematic review was registered with PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD42019132599; <http://www.crd.york.ac.uk/PROSPERO>) and is reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews.²⁰

2.2 | Search strategy

A systematic literature search was performed across three databases: PubMed, Embase, and PsycINFO. Database searches, initially conducted on March 13, 2019, and updated to April 30, 2020, were restricted to articles published in the previous 10 years (i.e., from

2009), in English language, and in young children aged 0–6 years. No study design limits were applied. Search terms were developed based on published literature^{8,21–24} in conjunction with an academic librarian, and subsequently piloted in PubMed, then tailored to each database. Search terms were organized into two constructs: (1) population of interest, for example, young child, preschool, or infant; and (2) exposure of interest: specific measure of screen use, for example, television, video gaming, or screen time—defined as composite measures of screen use, obtained via device-based or self-report methods. An example of a full search strategy is presented in Table S1.

2.3 | Inclusion and exclusion criteria

Search results were exported into EndNote (Version X9),²⁵ and duplicates removed. Citations were then imported into Covidence²⁶—a web-based software platform specifically designed for systematic reviews—then screened using a priori defined inclusion and exclusion criteria. For inclusion, the study sample had to include young children (i.e., 0–6 years) and measure time spent viewing any screens or evaluate measurement properties of a tool designed to measure screen time. Articles were also included if the sample comprised children older than 6 years, but the mean sample age was between 0 and 6 years, or they reported on a subgroup of children within this range. Articles were excluded if it was not published in English or after 2009; conducted in humans; an individual study (i.e., systematic reviews and commentaries); or available in full-text publication. Articles that described or reported on the results of screen-based interventions such as telehealth, internet, or m-Health platforms but did not measure screen time were also excluded.

2.4 | Selection of included articles

Each article was screened against the inclusion and exclusion criteria by two independent reviewers (COT and either RB or SGT) in two stages: (1) title and abstract screening and (2) full-text screening. Discrepancies were resolved by a third reviewer (RB or SGT). Reasons for exclusion at full-text screening are shown in Figure 1. In addition to the structured search, reference sections of relevant systematic reviews and articles citing relevant psychometrics studies identified in the search were manually reviewed for potentially eligible articles.

2.5 | Data extraction

Data were extracted into a custom Access database by one author (COT). In addition, data extraction was completed independently on a subsample of records ($n = 49$) by a second author (RB) and cross-checked for accuracy. Data were subsequently uploaded into the SAS statistical package (Version 9.4)²⁷ for calculation of sample frequencies.

3 | RESULTS

The search identified 35,868 unique records. Of this, 1035 full-text articles were screened for eligibility, and 622 met inclusion criteria (Figure 1).

Descriptive characteristics of the 622 articles are summarized in Table 1. Children had a mean age of 42.1 months ($SD = 18.3$), and approximately half were girls (48.5%, $SD = 6.0$). Sample size ranged from nine participants²⁹ to 77,003.³⁰ Most studies were conducted in the Americas, Europe, and Western Pacific regions. Within these regions, the majority were conducted in high-income countries. Articles were published in 205 different journals, and based on Scopus Subject Areas, the majority were allocated to Medicine, Nursing, and Psychology.²⁸

The key characteristics of instruments used to measure screen time are summarized in Table 2. Most measures were self-administered (76.3%), that is, completed by parents and were part of a questionnaire (92.4%). Three quarters of articles (76%) used a tool that was exclusively designed to measure screen time. All articles collected a parent/caregiver proxy report of child screen time except one article,⁶⁴⁹ which did not report on the method used. No articles used a device-based method to measure screen time. Of the 622 articles, 28.7% measured screen time using a single item, whereas 31.5% measured screen time using only two to three items. Most articles (80%) measured screen time exposure at home and childcare on a daily rather than weekly basis (86.5%), with 50% measuring screen time on a typical or usual day/week. Most articles (84.9%) employed measures assessing the duration of screen time rather than the frequency of screen viewing or the combination of viewing frequency and duration. Just under half of articles measured screen time using open-ended items, whereas approximately one third employed measures with fixed or multiple-choice items. Only 67 (10.8%) included items assessing content viewed, and only 46 articles (7%) assessed parental coviewing.

Approximately 50% of articles assessed screen time using a composite measure that encompassed watching TV or DVD/VCR, along with use of digital technologies such as computers, game consoles, tablets, or smartphones (Figure 2). Approximately one quarter of articles measured television watching only, whereas approximately one fifth measured screen time exposure based on the combination of television watching, DCD/VCR, and computer use. Only 20 articles (3%) focused exclusively on young children's use of handheld digital technologies such as smartphones and tablets.

Figure 3 summarizes the distribution of articles by publication year and modes of screen time assessed. Over the last decade, annual publication of articles measuring screen time in young children has more than doubled from 28 articles in 2009 to 71 articles in 2019. Since 2009, the number of articles employing composite measures of screen time, that is, assessing exposure to newer digital technologies such as tablets and smartphones, in addition to television watching, grew considerably, accounting for approximately 60% of articles published between 2015 and 2019. Conversely, the number of articles employing “traditional” measures of screen time (television only or

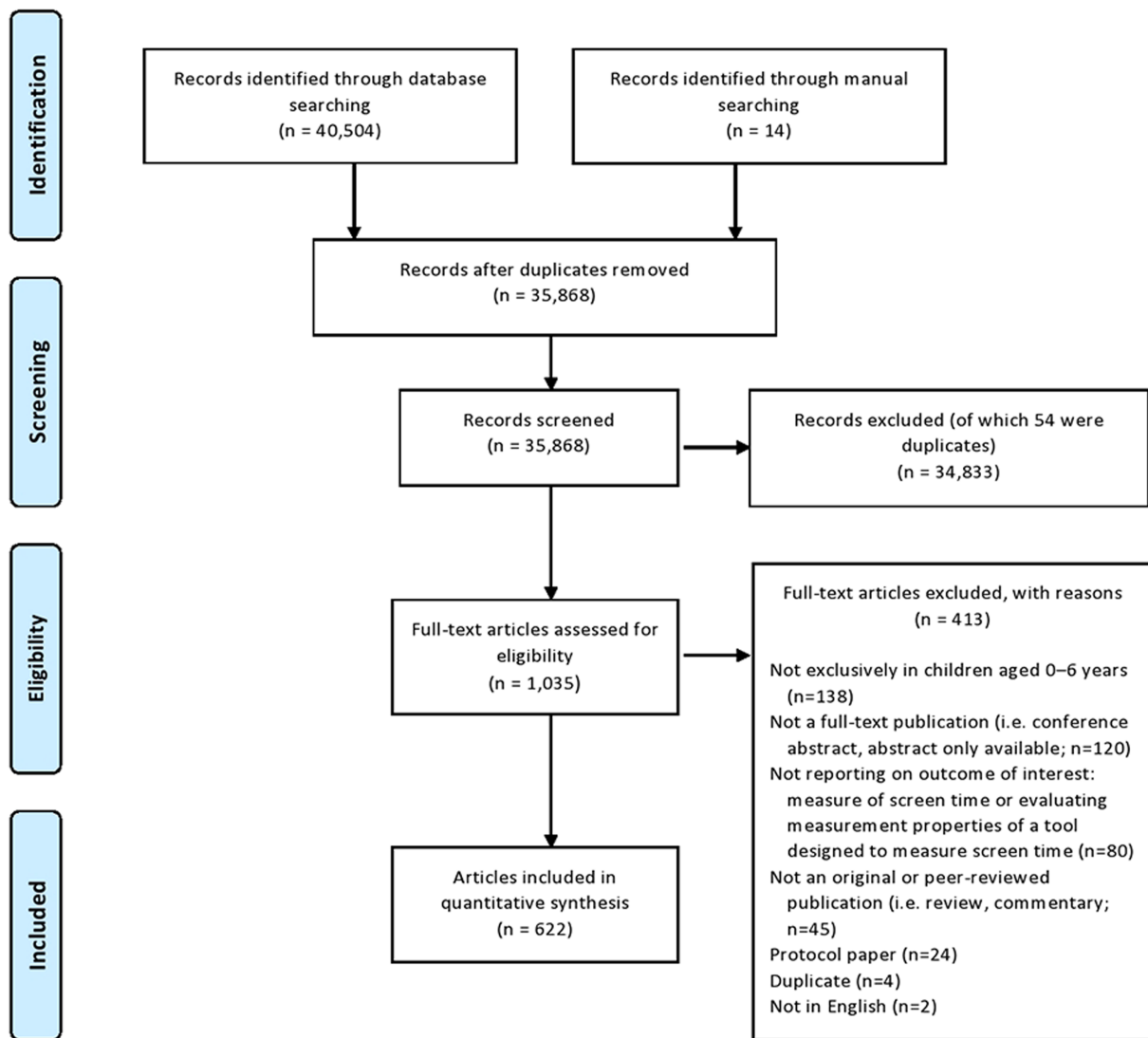


FIGURE 1 PRISMA flow chart of articles through the review process

television, DVD/VCR, and computer use) diminished; but even in articles published in 2019/2020, the practice remains. Prior to 2015, only a small percentage of articles exclusively measured young children's exposure to handheld digital technologies such as smartphones and tablets. Of the 20 articles of this type identified in the review, 16 (80%) were published since 2016.

The results related to the quality of psychometrics reporting are summarized in Table 3. Of the 622 articles identified, 250 (40.2%) provided a citation for the measure and 192 (30.9%) included a sample item in the article. For those articles providing a citation, 88 (35.2%) cited a methods paper documenting the psychometric properties of the measure. Sixty-nine (11.1%) of the 622 articles reported the psychometric properties of the measure used to assess screen time. Of this, 58 (84.1%) reported evidence of reliability and 19 (27.9%) reported evidence of validity. Only eight of the 69 articles (11.9%) reported both evidence of reliability and validity, and most ($n = 62$; 89.9%) reported psychometrics for children aged 0–6 years.

Trends over time were evident with an increasing number of articles reporting a sample item, citation, or methods article in 2017–2020 compared with previous 4-year intervals. There was improvement in the proportion of articles reporting tool psychometric properties in 2013–2016 compared with the previous 4-year interval (increasing from 8.5% to 13.6%) but very little change in the number of articles reporting both reliability and validity of the tool used to measure screen time.

The articles reporting psychometric properties are summarized in Table S2. Of the 58 articles reporting evidence of reliability, 46 assessed test–retest reliability, 11 assessed internal consistency, and one assessed both internal consistency and test–retest reliability. Test–retest reliability was most frequently evaluated using intraclass correlation coefficients (ICCs) ($N = 39$), with the remaining articles using Pearson or Spearman correlation coefficients ($N = 6$), Kappa statistics ($N = 1$), or percent agreement ($N = 1$). ICCs ranged from 0.44 to 0.94. Sixteen articles reported a range of ICC values for test–retest reliability, and for six of these, the lower bound was well

TABLE 1 Descriptive characteristics of articles that included a measure of screen time among young children aged 0–6 years

Measurement	N (%)
<i>Study characteristics</i>	
Study design	
Case control	8 (1.3)
Cross-sectional	366 (58.8)
Cohort	164 (26.4)
Quasi-experimental	18 (2.9)
Randomized/nonrandomized controlled trials	66 (10.6)
Child's age	
Infant (0 to <18 months)	71 (11.7)
Toddler (18 to 36 months)	114 (18.8)
Preschooler (>36 months)	421 (69.5)
Not reported	16 (2.6)
WHO region	
African	4 (0.6)
Americas	287 (46.1)
South-East Asia	15 (2.4)
Europe	173 (27.8)
Eastern Mediterranean	9 (1.4)
Western Pacific	130 (20.9)
Multiple WHO regions	4 (0.6)
Subject area^a	
Agriculture and Biological Sciences	12 (1.3)
Arts and Humanities	13 (1.4)
Biochemistry, Genetics and Molecular Biology	19 (2)
Computer Sciences	2 (0.2)
Dentistry	2 (0.2)
Environmental Science	14 (1.5)
Health Professions ^b	38 (4.1)
Medicine	491 (52.3)
Multidisciplinary	23 (2.5)
Neuroscience	12 (1.3)
Nursing	135 (14.4)
Psychology	101 (10.8)
Social Sciences	58 (6.2)
Not reported ^c	18 (1.9)

Abbreviation: WHO, World Health Organization.

^aSubject area was defined by Scimago (based on Scopus Subject Areas).²⁸

^bIncludes allied health professions.

^cNo Scimago results were found for five different journals across $n = 18$ publications.

below acceptable benchmarks for reliability (<0.50). One article only reported that ICCs were greater than 0.40. Of the 11 articles assessing internal consistency, 10 reported Cronbach's alpha and one reported composite reliability. Internal consistency was generally acceptable. When alpha coefficients were below accepted benchmarks, they were typically based on a small number of items.

Of the 19 articles reporting evidence of validity, 18 assessed concurrent validity with accelerometer-based measures of sedentary behaviors, direct observation, ecological momentary assessment (EMA), and television monitoring devices serving as criterion measures. Correlations with accelerometer-based measures were generally weak (<0.30) and of marginal statistical significance. Stronger validity coefficients (>0.40) were reported when direct observation, EMA, and television monitoring devices served as criterion measures. One article assessed convergent validity and reported moderate but statistically significant inverse correlations between screen time and measures of executive function, language and literacy skills, and home cognitive environment.¹⁴

4 | DISCUSSION

This systematic review reveals that over the last decade, the annual publication rate of articles measuring screen time in young children has more than doubled. The year-to-year growth in publications reflects the increasing scientific interest in delineating the health and developmental impacts of screen time in young children. The review also provides evidence to show that measures of screen time have evolved to reflect children's contemporary digital landscape, measuring not only television but also exposure across the varied range of screen-based devices now available to children. Between 2009 and 2019, the number of articles reporting the use of composite measures of screen time that included television watching in combination with digital technologies such as computers, game consoles, tablets, and smartphones increased nearly fivefold, accounting for 60% of articles published between 2017 and 2019. However, not all studies are keeping pace with changes in digital technology. In absolute terms, the number of articles measuring only the duration of television watching remained relatively constant over the last decade, raising some concerns that a nontrivial number of studies may not be capturing young children's exposure to newer screen-based technologies.

Despite widespread use of measures to assess screen time, across regions and disciplines of study, only a small percentage of articles provide a comprehensive description of the measures used. Indeed, many articles reported very little about the measurement of screen time beyond a sentence that it was measured. The origin of measures was difficult to determine, with less than half of all articles providing a citation for the tool. When authors provided a citation, they typically cited other articles using the measure and not a methodological study evaluating validity and/or reliability in children aged 0 to 6 years. Few articles reported details of the validity and reliability of the measures used, with only approximately 10% reporting some information regarding psychometric properties. On the positive side, when reported, reliability and validity statistics were generally at or above acceptable benchmarks.

To improve the quality of psychometrics reporting and advance our understanding of the potential harms and benefits of screen time in young children, manuscripts should include adequate reporting of measures used to assess screen time. This includes details of the items

TABLE 2 Characteristics of instruments used to measure screen time in young children aged 0–6 years

Tool characteristic	N (%)	Citation
Mode of administration		
Parent-completed	474 (76.3)	30–503
Interview-administered	147 (23.7)	14, 29, 504–648
Not reported	1 (0.2)	649
Tool type		
Questionnaire	575 (92.4)	14, 29–35, 37–45, 48, 51–86, 88–95, 97–160, 162–173, 175–181, 184–206, 208–211, 214–244, 246–251, 253–271, 275, 278–293, 295–321, 323–336, 338–343, 346–360, 362, 365–414, 417–448, 450–455, 457–494, 496–498, 500, 502–517, 519–526, 529–559, 561–580, 582–591, 593–605, 607–621, 623–627, 629–640, 642, 644–646, 648, 649
24-h diary/log	47 (7.6)	36, 46, 47, 49, 50, 87, 96, 161, 174, 182, 183, 207, 212, 213, 245, 252, 272–274, 276, 277, 294, 322, 337, 344, 345, 361, 363, 364, 415, 416, 449, 456, 495, 499, 501, 518, 527, 528, 560, 581, 592, 606, 622, 628, 643, 647
Number of items in questionnaire tools (N = 575)		
1 item	165 (28.7)	30, 33, 34, 38, 58, 62, 64, 67, 73, 74, 83–85, 90, 91, 93, 95, 97, 100, 105, 108–110, 117, 119, 121, 131, 134, 136, 139, 143, 144, 146, 148, 149, 151, 153, 156, 165, 166, 169, 181, 185, 186, 191, 195, 198, 204, 205, 208, 211, 218, 228, 230, 232, 235, 239, 241, 247, 259, 261, 266, 267, 269, 278, 283, 288, 292, 300, 301, 304, 305, 309, 310, 312, 316, 317, 323, 324, 329, 332, 333, 338–340, 347, 351–353, 356, 362, 366, 373, 375, 379, 386, 390, 393, 396, 403, 405, 409, 419, 420, 432, 439, 441, 452, 493, 507–509, 511, 513–515, 517, 520, 521, 530, 531, 533, 534, 536, 537, 542, 543, 545, 546, 552, 557, 559, 561–563, 567, 570, 571, 573, 574, 576, 577, 579, 584–586, 588–590, 595, 597, 598, 600–602, 604, 605, 608, 609, 626, 627, 638, 640, 642, 649
2–3 items	181 (31.5)	31, 32, 35, 37, 45, 51, 53, 57, 59, 61, 70, 71, 79, 86, 88, 94, 98, 104, 107, 111, 112, 114, 115, 118, 120, 132, 135, 137, 140, 141, 145, 164, 170, 171, 178, 179, 184, 187–190, 192–194, 196, 197, 201, 202, 206, 216, 220, 224, 226, 229, 233, 236, 237, 240, 242–244, 251, 258, 262, 268, 270, 275, 284–287, 290, 291, 295, 298, 306–308, 311, 313, 315, 318, 320, 325–328, 330, 331, 334, 336, 346, 350, 354, 355, 358, 359, 365, 367, 368, 370, 377, 381–383, 385, 387–389, 392, 397, 402, 410, 417, 423, 424, 426, 431, 433, 435, 437, 440, 443, 448, 451, 453, 454, 462, 464, 466, 468, 471, 472, 474, 475, 478, 479, 483, 484, 486, 490, 496–498, 510, 516, 523, 524, 526, 529, 538–541, 544, 549, 550, 553–555, 564, 565, 568, 569, 572, 575, 578, 582, 583, 591, 593, 599, 603, 607, 614, 616, 620, 632, 634, 639, 648
3–5 items	95 (16.5)	39, 42–44, 48, 52, 60, 63, 65, 66, 68, 80–82, 89, 92, 113, 122, 123, 125–130, 133, 138, 142, 147, 150, 152, 155, 157, 162, 163, 167, 175–177, 180, 199, 203, 209, 210, 217, 219, 221, 225, 248, 263–265, 281, 293, 296, 302, 321, 335, 341, 374, 376, 378, 384, 391, 398, 400, 401, 404, 413, 414, 427, 430, 436, 444, 445, 458, 461, 467, 481, 491, 503–505, 522, 532, 547, 548, 610, 615, 617, 623, 624, 630, 637, 641
More than 5 items	92 (16.0)	14, 40, 41, 54, 56, 72, 75–78, 101–103, 106, 116, 124, 154, 158–160, 168, 172, 173, 200, 214, 215, 222, 223, 227, 231, 234, 249, 250, 253–257, 260, 279, 280, 282, 289, 299, 303, 314, 319, 343, 348, 357, 360, 369, 371, 372, 394, 399, 406–408, 411, 422, 428, 434, 442, 447, 457, 459, 460, 465, 473, 485, 489, 492, 494, 506, 512, 519, 525, 551, 556, 558, 587, 611–613, 618, 629, 633, 635, 636, 644, 645
Not reported or missing	42 (7.3)	29, 55, 69, 99, 238, 246, 271, 297, 342, 349, 380, 395, 412, 418, 421, 425, 429, 438, 446, 450, 455, 463, 469, 470, 476, 477, 480, 482, 487, 488, 500, 502, 535, 566, 580, 594, 596, 619, 621, 625, 631, 646
Screen time setting		
Home only	52 (8.4)	33, 36, 42, 48–50, 77, 78, 114, 126, 134, 152, 153, 159, 195, 208, 219, 230, 237, 242, 279, 280, 294, 295, 311, 314, 360, 374, 384, 393, 396, 404, 419, 442, 451, 461, 468, 469, 472, 510, 516, 525, 538, 548, 587, 592, 597, 611–613, 619, 638
Childcare only	2 (0.3)	117, 545
Home and childcare	495 (79.6)	14, 30–32, 34, 35, 37–41, 43–47, 51–66, 68, 70–72, 74–76, 79–94, 96–98, 101–108, 111–113, 115, 116, 118–125, 127–133, 135–139, 141–143, 145, 147–151, 154–158, 160–168, 170, 172–184, 186–194, 196–207, 209, 210, 212–218, 220–229, 231–236, 238–241, 243–245, 248–265, 267, 268, 270–278, 281, 282, 284–293, 296, 298, 299, 301–303, 305–308, 310, 312, 313, 315–317, 319–331, 333–355, 357–359, 361, 363–373, 376–383, 385, 387–392, 394, 395, 397–403, 405–411, 413–418, 420, 422–424, 426–428, 430–437, 439–441, 444, 445, 447–449, 452, 454–460, 462, 464–467, 471, 475, 478–481, 483–487, 489–492, 494, 495, 497–499, 501–506, 508, 511, 512, 514, 515, 517–524, 526–528, 530–532, 534, 536, 537, 539–543, 546, 547, 549–560, 563–

TABLE 2 (Continued)

Tool characteristic	N (%)	Citation
Not specified	73 (11.7)	568, 570–575, 577–579, 581, 583, 584, 586, 588–591, 593, 595, 596, 598, 599, 601–607, 609, 610, 614–618, 620–622, 624, 626–630, 632–636, 639–645, 647–649 29, 67, 69, 73, 95, 99, 100, 109, 110, 140, 144, 146, 169, 171, 185, 211, 246, 247, 266, 269, 283, 297, 300, 304, 309, 318, 332, 356, 362, 375, 386, 412, 421, 425, 429, 438, 443, 446, 450, 453, 463, 470, 473, 474, 476, 477, 482, 488, 493, 496, 500, 507, 509, 513, 529, 533, 535, 544, 561, 562, 569, 576, 580, 582, 585, 594, 600, 608, 623, 625, 631, 637, 646
Recall interval		
Day	243 (39.1)	14, 30, 33, 34, 40, 45, 49, 50, 58, 60, 63, 64, 66, 69, 71, 73, 74, 83, 85, 87, 90–93, 100, 101, 104, 105, 108, 109, 112, 114, 119, 121, 131, 132, 135–137, 140, 144, 146, 149, 151, 155, 164–166, 174, 175, 177, 184, 189, 191, 192, 194, 196, 198, 200, 202, 204, 207, 213, 218, 224, 232–235, 240–243, 251, 252, 259–262, 266, 267, 270–274, 278–280, 283, 288, 290–292, 299–302, 304, 305, 310, 312, 316, 318, 322–325, 327, 328, 337, 339, 341, 344, 345, 348, 349, 351, 352, 356, 362, 366, 375, 376, 379–384, 387, 390, 393, 402, 403, 405, 407–410, 414–416, 420, 422, 426, 432, 434, 439, 441, 449, 451–454, 456, 460–462, 468, 469, 475, 479–481, 486, 490–492, 496, 499, 500, 508, 509, 511, 514, 515, 517, 518, 520, 523, 526–533, 536, 539, 540, 542, 543, 550, 552, 553, 557, 559–561, 563, 566–568, 571, 573, 576–578, 581, 584, 585, 589, 590, 592–594, 598, 599, 601–606, 608–610, 616–618, 621, 622, 627, 636, 639–643, 647, 648
Weekday and weekend day	268 (43.1)	31, 32, 35, 36, 39, 41–44, 46–48, 51–57, 59, 65, 70, 72, 75–82, 84, 86, 88, 89, 96, 102, 103, 106, 107, 113, 115, 116, 118, 120, 122, 123, 125–130, 133, 134, 138, 141–143, 145, 147, 152, 154, 157–163, 167, 168, 170–173, 176, 178–180, 188, 190, 193, 197, 199, 201, 203, 206, 208–210, 212, 214–217, 219–223, 225, 226, 229, 236, 239, 244, 248–250, 253–258, 263–265, 268, 275–277, 281, 282, 284–287, 289, 293–296, 298, 303, 306, 307, 313–315, 317, 319–321, 329–331, 333–336, 340, 342, 343, 346, 350, 354, 355, 357–361, 363–365, 367–372, 374, 377, 378, 385, 388, 389, 391, 392, 394, 395, 397–401, 404, 406, 411, 413, 417, 421, 423–425, 427, 428, 430, 431, 433, 435–437, 442, 444, 445, 448, 457–459, 464–467, 470, 471, 474, 478, 483–485, 489, 494, 495, 498, 501–503, 506, 516, 519, 522, 524, 525, 541, 547–549, 551, 554–556, 558, 564, 565, 579, 583, 587, 591, 595, 607, 611–613, 615, 619, 623, 624, 629, 630, 632, 633, 635, 637, 644, 645
Weekday only	26 (4.2)	61, 62, 139, 186, 195, 230, 231, 311, 373, 418, 419, 440, 476, 477, 510, 521, 546, 570, 574, 586, 588, 596, 628, 634, 638, 649
Weekend day only	1 (0.2)	181
Week	36 (5.8)	37, 38, 68, 97, 98, 110, 117, 124, 148, 150, 156, 182, 183, 187, 205, 227, 238, 245, 308, 326, 353, 446, 447, 487, 488, 497, 504, 505, 512, 534, 537, 538, 572, 575, 614, 620
Not specified	48 (7.7)	29, 67, 94, 95, 99, 111, 153, 169, 185, 211, 228, 237, 246, 247, 269, 297, 309, 332, 338, 347, 386, 396, 412, 429, 438, 443, 450, 455, 463, 472, 473, 482, 493, 507, 513, 535, 544, 545, 562, 569, 580, 582, 597, 600, 625, 626, 631, 646
Recall period		
Usual/typical duration	311 (50.0)	30, 33, 35, 37, 39, 41, 43, 44, 46, 47, 51, 57–59, 62, 65, 70, 72, 75, 76, 80–82, 84–86, 88–90, 92, 97, 98, 102–104, 106, 113, 117–124, 126–136, 141, 147, 149, 152, 154, 158–160, 162–167, 170, 172, 173, 175–177, 180, 181, 184, 186, 187, 190, 192–194, 197, 198, 200–203, 206, 209, 210, 214, 215, 217, 219, 221–224, 226, 227, 229, 230, 236, 238, 243, 244, 248–250, 253–258, 260, 261, 263–265, 268, 281, 282, 285–287, 289, 291, 293, 295, 296, 298, 301–303, 306–308, 311, 313–315, 321, 324–331, 334–336, 340, 341, 349, 350, 355, 357, 358, 360, 365–369, 371, 374, 377, 378, 381–384, 388, 389, 391–394, 398, 399, 404–409, 411, 413, 414, 417–419, 424, 427, 428, 431, 433–437, 440–442, 444–448, 451, 452, 454, 457, 459–461, 464–467, 469, 471, 479, 481, 483–486, 488–494, 496–498, 502, 503, 506, 510, 511, 515, 517, 519, 521–523, 526, 527, 530, 532, 539, 540, 543, 548, 549, 555, 556, 558, 565, 566, 568, 570, 572, 575, 578, 581, 583, 586–592, 594–596, 599, 602–605, 614–617, 621, 628–630, 633–635, 637, 640–643, 645, 647, 649
Specific time period	79 (12.7)	36, 38, 49, 50, 54–56, 68, 77, 78, 87, 93, 96, 115, 156, 161, 168, 174, 178, 182, 183, 207, 212, 213, 231–234, 240, 245, 252, 271–274, 276, 277, 279, 280, 294, 310, 322, 337, 342, 344, 345, 353, 361, 363, 364, 376, 380, 397, 415, 416, 422, 439, 449, 456, 462, 475, 480, 495, 499, 501, 504, 505, 512, 518, 560, 567, 593, 606, 610, 618, 620, 622, 639, 644
Not specified	232 (37.3)	14, 29, 31, 32, 34, 40, 42, 45, 48, 52, 53, 60, 61, 63, 64, 66, 67, 69, 71, 73, 74, 79, 83, 91, 94, 95, 99–101, 105, 107–112, 114, 116, 125, 137–140, 142–146, 148, 150, 151, 153, 155, 157, 169, 171, 179, 185, 188, 189, 191, 195, 196, 199, 204, 205, 208, 211, 216, 218, 220, 225, 228, 235, 237, 239, 241, 242, 246, 247, 251, 259, 262, 266, 267, 269, 270, 275, 278, 283, 284, 288, 290, 292, 297, 299, 300, 304, 305, 309, 312, 316–320, 323, 332, 333, 338, 339, 343, 346–348, 351, 352,

(Continues)

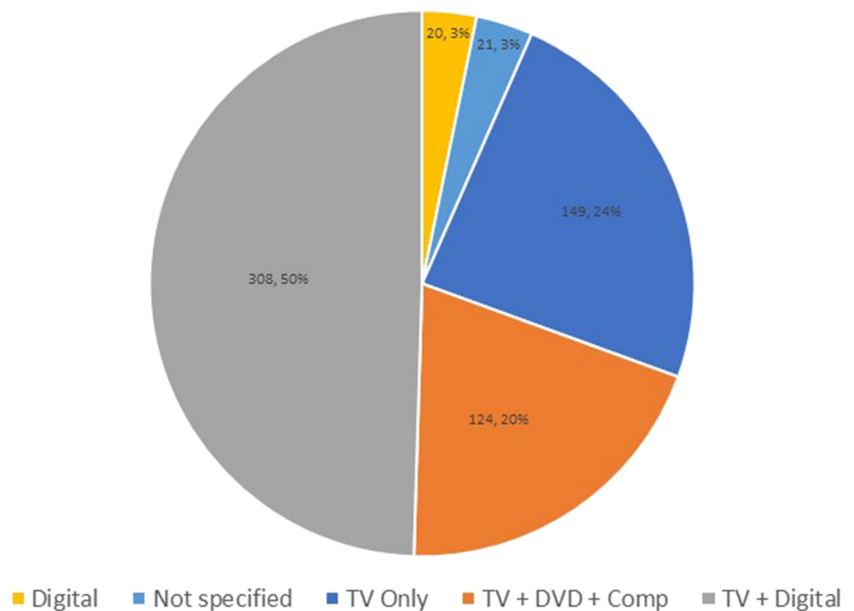
TABLE 2 (Continued)

Tool characteristic	N (%)	Citation
		354, 356, 359, 362, 370, 372, 373, 375, 379, 385–387, 390, 395, 396, 400–403, 410, 412, 420, 421, 423, 425, 426, 429, 430, 432, 438, 443, 450, 453, 455, 458, 463, 468, 470, 472–474, 476–478, 482, 487, 500, 507–509, 513, 514, 516, 520, 524, 525, 528, 529, 531, 533–538, 541, 542, 544–547, 550–554, 557, 559, 561–564, 569, 571, 573, 574, 576, 577, 579, 580, 582, 584, 585, 597, 598, 600, 601, 607–609, 611–613, 619, 623–627, 631, 632, 636, 638, 646, 648
Dimensions recalled		
Duration only	528 (84.9)	30–63, 65, 66, 69–71, 73–91, 93, 95–98, 100–110, 112, 114–145, 147–152, 154–163, 165–170, 172–174, 176, 178–181, 183, 184, 186–195, 197–199, 201–206, 208–220, 222–226, 228–236, 238, 239, 241–245, 249–251, 253–255, 258–261, 263–268, 270, 272–278, 281–296, 298–318, 320–340, 342, 344–347, 349–374, 377–380, 384–393, 395–398, 400–403, 405, 407, 409–412, 415–421, 423–428, 430–437, 439–449, 451–454, 457, 460–462, 464–469, 471, 472, 474–479, 482–487, 489, 490, 492, 494–503, 506, 508–512, 514–533, 536, 538–543, 545–568, 570–574, 576–579, 581–586, 588–614, 619, 621–625, 627–630, 632–634, 637–640, 643, 645–649
Frequency only	13 (2.1)	94, 111, 182, 246, 271, 450, 455, 488, 493, 534, 537, 569, 626
Frequency and duration	59 (9.5)	14, 68, 72, 92, 113, 164, 175, 177, 196, 200, 207, 221, 227, 237, 240, 248, 252, 256, 257, 262, 279, 280, 319, 341, 343, 348, 376, 381–383, 394, 399, 404, 406, 408, 413, 414, 422, 456, 458, 459, 473, 480, 481, 491, 504, 505, 575, 587, 615–618, 620, 635, 636, 641, 642, 644
Not specified	22 (3.5)	29, 64, 67, 99, 146, 153, 171, 185, 247, 269, 297, 375, 429, 438, 463, 470, 507, 513, 535, 544, 580, 631
Response format		
Fixed choice	201 (32.3)	14, 30, 31, 33, 37, 41–44, 46–48, 52, 57, 63, 64, 69, 71, 80–82, 84, 86, 87, 92, 94, 101, 110–116, 120, 122, 125, 129, 132, 133, 138, 142, 149, 154, 155, 157, 162, 167, 172–176, 180, 184, 187, 189, 197, 198, 200, 201, 208, 216, 217, 219, 227, 229, 240, 243, 244, 246, 248, 251, 252, 255, 256, 258, 260, 263–265, 267, 272–274, 276, 277, 291, 293, 294, 296, 302, 305, 311, 313, 320, 325, 327, 328, 337, 338, 340, 341, 343, 346, 348, 350–353, 359, 361, 363, 366, 368, 370, 372, 375, 379, 381–385, 387, 390–392, 395, 397, 398, 400, 401, 403–405, 407, 410, 413, 414, 416, 436, 437, 442, 444, 445, 449, 450, 455, 457, 459–461, 465, 466, 481, 483–485, 488–490, 492, 493, 495, 501, 502, 511, 515, 517, 523, 524, 526, 531, 534, 547, 550, 552, 555, 561, 563–565, 568, 569, 573, 574, 586, 602–606, 614, 618, 626, 630, 632, 636, 639, 642
Open-ended	286 (46.0)	32, 34–36, 38, 40, 45, 49–51, 53–56, 58–62, 65, 66, 68, 70, 72, 73, 75–79, 83, 88, 93, 96–98, 102, 103, 106, 107, 117, 119, 121, 123, 124, 126–128, 130, 131, 134–136, 147, 150, 152, 156, 158–161, 164–166, 168, 170, 177, 178, 181, 183, 190–194, 196, 199, 202–204, 206, 207, 209, 210, 212–215, 218, 220–226, 230, 232–234, 236, 238, 241, 242, 245, 249, 250, 253, 254, 257, 259, 262, 268, 271, 275, 279–282, 284–290, 292, 298, 301, 303, 304, 307, 308, 310, 312, 314–317, 319, 321, 322, 324, 326, 329–331, 334, 335, 339, 344, 345, 355–358, 360, 364, 365, 367, 369, 371, 373, 374, 376–378, 380, 388, 389, 393, 394, 396, 399, 406, 408, 411, 415, 417–420, 422, 424, 426–428, 430, 431, 433, 435, 439, 440, 447, 448, 452, 456, 458, 462, 469, 475, 479, 480, 486, 491, 497, 503–506, 508–510, 512, 514, 516, 518–522, 525, 527–530, 532, 533, 536–538, 540, 543, 546, 548, 551, 554, 556, 557, 567, 570–572, 575–578, 581, 583, 584, 587, 589–593, 595, 596, 599, 601, 607, 609–613, 615–617, 620–622, 627–629, 633, 634, 637, 638, 640, 643–645, 647, 649
Not specified	135 (21.7)	29, 39, 67, 74, 85, 89–91, 95, 99, 100, 104, 105, 108, 109, 118, 137, 139–141, 143–146, 148, 151, 153, 163, 169, 171, 179, 182, 185, 186, 188, 195, 205, 211, 228, 231, 235, 237, 239, 247, 261, 266, 269, 270, 278, 283, 295, 297, 299, 300, 306, 309, 318, 323, 332, 333, 336, 342, 347, 349, 354, 362, 386, 402, 412, 421, 423, 425, 429, 432, 434, 438, 441, 443, 446, 451, 453, 454, 463, 464, 467, 468, 470–474, 476–478, 482, 487, 494, 496, 498–500, 507, 513, 535, 539, 541, 542, 544, 545, 549, 553, 558–560, 562, 566, 579, 580, 582, 585, 588, 594, 597, 598, 600, 608, 619, 623–625, 631, 635, 641, 646, 648
Content assessed		
Yes	67 (10.8)	14, 40, 49, 50, 92, 94, 96, 98, 150, 172, 182, 183, 196, 227, 240, 244–246, 248, 249, 252, 257, 260, 271, 299, 319, 327, 348, 363, 364, 369, 387, 390, 407, 408, 450, 454, 455, 460, 467, 473, 480, 482, 483, 492, 502, 507, 512, 518, 524, 527–529, 539, 540, 556, 560, 580, 581, 592, 618, 621, 622, 628, 636, 643, 647
No	555 (89.2)	29–39, 41–48, 51–91, 93, 95, 97, 99–149, 151–171, 173–181, 184–195, 197–226, 228–239, 241–243, 247, 250, 251, 253–256, 258, 259, 261–270, 272–298, 300–318, 320–326, 328–347, 349–362, 365–368, 370–386, 388, 389, 391–406, 409–449, 451–453, 456–459, 461–466, 468–472, 474–479, 481, 484–491, 493–501, 503–506, 508–511, 513–517, 519–523, 525, 526, 530–538, 541–555, 557–559, 561–579, 582–591, 593–617, 619, 620, 623–627, 629–635, 637–642, 644–646, 648, 649

TABLE 2 (Continued)

Tool characteristic	N (%)	Citation
Coviewing assessed		
Yes	46 (7)	14, 50, 54, 80–82, 99, 106, 133, 180, 182, 183, 212, 217, 232, 233, 246, 248, 263–265, 319, 348, 408, 421, 442, 444, 445, 450, 455, 462, 467, 473, 480, 490, 501, 512, 518, 529, 580, 610, 621, 622, 628, 629, 636
No	576 (93)	29–49, 51–53, 55–79, 83–98, 100–105, 107–132, 134–179, 181, 184–211, 213–216, 218–231, 234–245, 247, 249–262, 266–318, 320–347, 349–407, 409–420, 422–441, 443, 446–449, 451–454, 456–461, 463–466, 468–472, 474–479, 481–489, 491–500, 502–511, 513–517, 519–528, 530–579, 581–609, 611–620, 623–627, 630–635, 637–649

FIGURE 2 Distribution of articles included in the review by modes of screen time assessed



used and a citation for the methodological paper in which the measure was developed and tested. Supporting evidence of validity and reliability in the population under study should be provided. Journal editors and reviewers should monitor the reporting of screen time measures during peer review and advocate for greater transparency in reporting so that screen time assessment methods can be replicated in other studies.

Just as the range of devices assessed has expanded, there are appeals to move beyond measurement of duration of screen time to include measures of quality of screen use,¹⁵ namely, the content viewed and the context in which screens are being used.⁶⁵⁰ The AAP emphasizes the importance of adult interaction during media use, particularly for children under the age of 2 years, that is, the parent watching with the child and reteaching the content.⁷ However, apart from some notable exceptions,¹⁴ comprehensive screen time measures are absent from the research literature. The results of this systematic review confirm that studies conducted over the last decade have primarily employed brief assessment tools consisting of between one and three items designed to measure the total duration of screen time on a usual day, with fewer than 10% of articles assessing frequency of

screen use. Only approximately 10% of articles identified assess content viewed, whereas 7% of the articles identified assessed coviewing. Of note, measures with greater than three items did not necessarily provide a more comprehensive assessment of screen time. Rather, these tools tended to include separate items to assess duration across segments of the day, for example, morning versus afternoon, and hence, the number of items increased. Development of measures that can accurately estimate duration that a child spends engaging in different screen time activities¹⁵ (e.g., passive television watching, coviewing age-appropriate content, and social interaction using video-chat) will greatly enhance the evidence base regarding the impact of screen time on health and developmental outcomes.

One aspect that was consistently reported across articles was the use of self-report measures by proxy. A systematic review published in 2007¹⁸ examining television viewing in children and adolescents argued that self-report methods for assessing television exposure have not kept pace with research interest, calling for an increase in the use of objective measures. Despite that call, no articles that used a device-based method of assessing screen time were identified in the present systematic review. Radesky et al. describe the use of “mobile

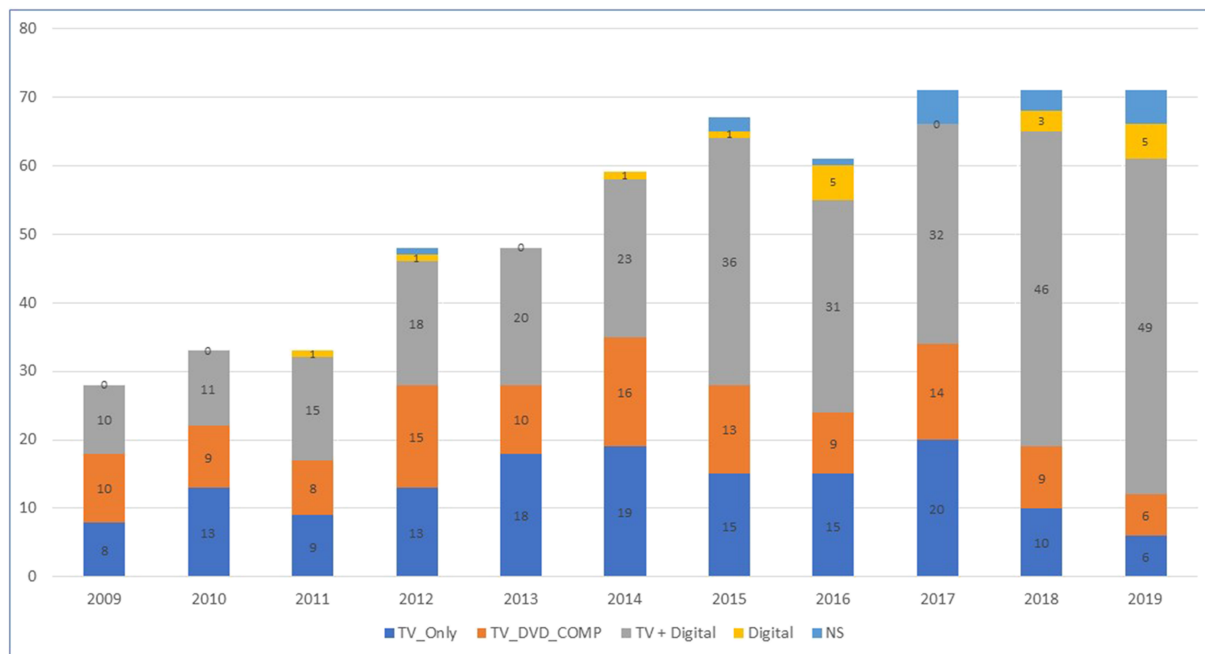


FIGURE 3 Distribution of articles included in the review by publication year and modes of screen time assessed

TABLE 3 Summary of the analyses evaluating the quality of psychometrics reporting in articles measuring screen time in young children aged 0–6 years

	N	Citation for measure ^a	Methods article cited ^b	Sample item reported ^a	Psychometrics reported ^a	Reliability reported ^c	Validity reported ^c	Reliability and validity reported ^c	Psychometrics were for the same study population ^c
All	622	250 (40.2)	88 (35.2)	192 (30.9)	69 (11.1)	58 (84.1)	19 (27.9)	8 (11.9)	62 (89.9)
By publication period									
2009–2012	142	37 (26.1)	9 (24.3)	37 (26.1)	12 (8.5)	7 (58.3)	7 (58.3)	2 (16.7)	11 (91.7)
2013–2016	235	106 (45.1)	36 (34.0)	74 (31.5)	33 (14.0)	30 (90.9)	6 (18.2)	3 (9.1)	27 (81.2)
2017–2020 ^d	245	107 (43.7)	43 (40.2)	81 (33.1)	24 (9.8)	21 (87.5)	6 (26.1)	3 (13.6)	24 (100)

^aPercentage is based on the total number of included papers and the number of papers for each publication period.

^bPercentage is based on the number of papers providing a citation for the measure used.

^cPercentage is based on the number of papers reporting the psychometric properties of the measure within the publication.

^dData include papers published to April 2020; 2017–2020 represents duration of 40 months compared with previous increments of 48 months.

device sampling,¹⁷ using application usage data collected by mobile devices to assess daily duration of device use among children aged 3 to 5 years. Data were compared with a single item assessing parent report of duration of child's device use on a typical day, resulting in only 30% of parents being considered accurate reporters. This approach is promising, but challenges remain regarding how to assess usage across multiple devices and distinguish between individual users when young children tend to share devices with other family members.⁶⁵¹

5 | STRENGTHS AND LIMITATIONS

The current review has several strengths. An extensive search for all articles that measured screen time in young children as outcome or

exposure since 2009 was conducted, resulting in nearly 36,000 titles and abstracts to review and over 1000 full-text articles examined for inclusion. To supplement this search, an extensive manual search of relevant systematic reviews and individual studies identified in the structured search was conducted. The review and extraction processes were rigorous, whereby titles and abstracts and full-text records were reviewed by two independent authors, and a subsample of records independently checked for accuracy after data extraction. The Access database used for data extraction was custom designed to reduce possibility of data entry errors. However, there are some limitations. There is a possibility that not all relevant publications were found through the systematic search or cross-reference searches. Locating studies that measured screen time is a challenge as information on measurement of screen time is often lacking in the titles and abstracts, particularly if screen time was not a primary outcome

measure. Measures published in languages other than English, or in the gray literature, were not included in this review. There are additional tools that have been used to assess screen time among children under 6 years of age but were excluded, because the relatively large age range of participants resulted in a mean age in the sample of greater than 6 years. There may also be a larger number of measures that assess content and coviewing, but due to the lack of detail in reporting of items, these were not able to be identified and included in frequencies. Given the wide range of measures used and inconsistency of reporting, we did not attempt to estimate average screen time duration across publications.

6 | CONCLUSION

This systematic review identified a more than doubling in the number of publications in the decade 2009–2019, which have used predominantly brief tools to measure screen time duration among young children. There is a notable shift from measuring exposure to television, DVDs, and computers to measures that also encompass contemporary digital and mobile screen-based devices. The development of measures that contain items assessing content and context of screen use, in addition to duration of screen time, will contribute to understanding the impact of screen-based devices on children's health and development.¹³ However, to advance the study of the potential harms and benefits of screen time in young children, more robust and transparent reporting is required, including details of the items used, correct citations of methodological papers in which the measure was developed, and supporting evidence of validity and reliability.

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CONFLICT OF INTEREST

No conflict of interest statement.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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