REVIEW ARTICLE

Screen Time in Under-five Children

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Context: Screen-viewing in childhood is primarily a mean of entertainment, during the unstructured time. We aimed to review the burden of the problem, delineate the associated factors and correlates, evaluate the impact of screen-time on the overall health of under-five children, and the interventions to reduce screen-time. **Evidence acquisition**: Published articles from January 2009 to June 2018 were searched through PubMed, Clinical Key, Scopus, Embase, and Google Scholar using key Medical Subject Heading words. **Results**: The burden of screen-time varied from 21% to 98% in the middle-income, and 10% to 93.7% in the high-income countries. The social ecological model was used to illustrate associated factors and correlates including child, caregiver, micro and macro digital-media environment related factors. The interventions included increase in the physical activity, reduction in the body mass index, improving sleep and dietary behaviors etc. The effectiveness of these interventions ranged from 0.3 minutes (standard error 13.3) to -47.16 minutes (standard error 2.01). **Conclusion**: Clinicians should obtain history of screen-time in children, and advise limiting the screen exposure according to the child's age. There is a need to generate evidence on burden and effectiveness of interventions among children in the Indian settings, owing to the limited data.

Keywords: *Digital-media, Obesity, Screen exposure, Sedentary behaviors, Smartphone, Television.*

Screen-time or digital-screen exposure is the duration of time spent by the individual in using electronic/digital media like television (TV), smartphone, tablet or computer [1]. As per American Academy of Pediatrics (AAP) guidelines [2], children below the age of two years should not have any screen exposure, and screen time of ≥1 hour per day is considered excessive among children aged 2-5 years. Also, for the proper growth and development of children, the use of digital-media should be restricted while eating meals, or one hour before sleep.

Excessive screen time is predominantly associated with sedentary behaviors in children and adolescents [3]. Excessive screen time is considered as one of the major role players in causing non-communicable diseases (NCDs) [4] and health risks [5] later in life. A longitudinal study reported that there was a rapid increase in TV-time by one year of age, and children who had screen time <1 hour per day at 14 months of age, started watching screens for >2 hours per day when they are aged 30 months [1]. A Japenese study reported that 29.4% of children of age 18 months, 24.5% of age 30 months, and 21% at both ages watched TV for 4 hours or more per day [6]. Children below the age of two years who watched TV for any duration per day, and children aged >2 years who watched TV for >2 hours per day were more likely to show a delay in motor skill development [7]. Further, screen time has been associated with impairments in language development [7,8], and behavioral [6], psychosocial, academic and physical wellbeing [9].

There is limited published data on the duration of screen time, its associated factors and intervention studies on reducing it in the low- and middle-income countries (LMIC). The purpose of this review is to document the burden of screen time, its associated factors and correlates, outline the health impact, and summarize the interventions developed to reduce screen time among under-five children.

Search strategy: A literature review of published articles from January 2009 to June 2018 was performed through searches in PubMed, Clinical Key, Scopus, Embase, and Google Scholar. Medical Subject Headings (MeSH) words used were 'preschooler', 'infant', 'kid', and 'toddler' for child-related terms; and 'screen-time', 'screen-viewing', electronic media related- 'electronic media', 'digital-media', 'TV', 'smartphone', 'mobile phone' for screen-time related terms. When relevant articles were identified, cross-references were searched for related studies.

Inclusion criteria for a searched article included (*i*) peer-reviewed article published in English language in the scientific journals; (*ii*) cross-sectional studies on prevalence of digital-media use, adherence to screen time

guidelines, correlates of digital-media use among under-five children; (*iii*) cohort or case control studies assessing association between at least one digital-media gadget and behavioral outcome or demographic correlate among under-five children; (*iv*) interventional studies in a school-, clinic-, hospital-, family-, home-, or community-based setting to reduce screen time as one of the outcome; and (*v*) studies measuring (proportion or mean) the use of atleast one type of digital-media gadget (like TV, computer or videogames etc) by children. The articles reporting digital-media exposure of caretakers or parents or diseased children or older children were not included in the analysis.

Potentially relevant articles were screened by their titles, and abstracts. When the abstract was not available or had incomplete findings, the entire article was retrieved. Articles describing study protocols, reports, dissertations, models and conference abstracts were excluded. Data extraction form was used to obtain the study information, study design, country, age of participants; exposure *i.e*., screen-based characteristics (*e.g*., duration, frequency, pattern, and measurement and/or description of intervention); outcome/health indicators (*e.g*., measurement type); results (*e.g*., odds ratio, difference in means); and covariates included in the analyses (*e.g*., eating behaviors, emotional outcomes, sleep outcomes, psychological outcomes, nutrition, parental perceptions, parental behaviors, parenting skills, home environment, physical activity of the children). The search was done by two authors, and it was cross checked by the third author for correctly excluding the studies. Any discrepancies were resolved by the fourth author.

We identified 19,833 articles, 19511 were either duplicates or irrelevant, among these 322 articles were screened based on their title and abstract (***Fig.* 1**). Of the 322 studies, 171 articles were excluded based upon the exclusion criteria, and 151 full text articles were assessed. Of these 101 articles were excluded due to a context other than the review. Finally, 50 studies were reviewed including 14 cross-sectional studies [4,7,8,10-20], on prevalence, associated factors, correlates and consequences of excessive digital-media exposure (***Table* I**) [1,6,9,21-28]; 11 overlapping studies and two systematic reviews [29,30] on the associated factors, correlates and consequences of excessive digital-media exposure [1,6,9,21-28]; 16 intervention studies [31-46], three systematic reviews [3,5,47] and four digital-media guidelines [2,48-50] among under-five children. Among the 16 interventions studies, two were pilot-RCTs [31,32], four cluster-RCTs [39-42], and ten RCTs [33-38,43-46] (***Table* II**). All studies relied on the information given by the parents.

BURDEN OF PROBLEM

The results of 14 cross-sectional studies for estimating the prevalence are summarized in ***Table* I**. Prevalence of excess screen time varies from 10% to 93.7% across the high-income countries, and 21% to 98% in the middle-income countries. Four out of 14 cross-sectional studies considered screen time more than 2 hours per day as excessive [4,17,19,20], six used screen time more than >1 hour per day as excessive [6,8,11,14,16,24], whereas three studies reported average screen time [7,12,14,18]. Overall, the screen time ranged from 0.1-5 hours per day among under-fives. Younger children (0-2 years) from the middle-income countries [26] and older ones (0-5 years) from the high-income countries [14] had screen time of >1 hour per day. The maximum duration of screen time was reported among 3-5 years old children in home-based care [16,23]. Four studies [4,15,20,24] reported a higher prevalence of screen time of >1 hour per day during weekends (25% to 63%), as compared to weekdays (10% to 48%). All the studies measured screen time while watching TV, which was perferred over other digital-media devices

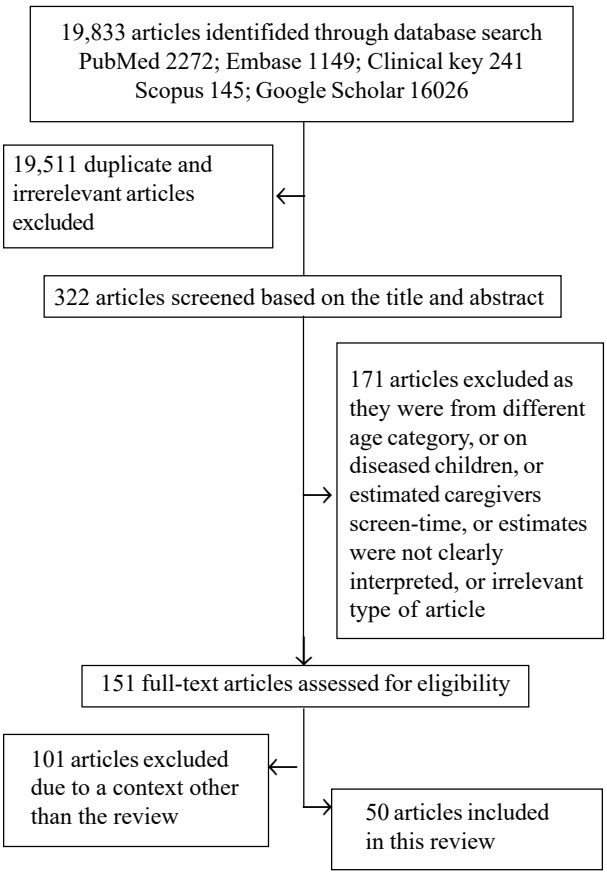

FIG. 1 *Flow diagram depicting the inclusion and exclusion criteria for selecting the articles at each stage.*

TABLE I SUMMARY OF PREVALENCE STUDIES, ASSOCIATED FACTORS, CORRELATES OF SCREEN TIME AMONG CHILDREN AGED 0-5 YEARS.

Place (no. of studies)	*Author (Year) [Ref]*	*Age in years (sample size)*	*Study design*	*Study tool*	*Prevalence of ST*	*Associated factors and* correlates of ST
High-income countries (*n*=16)						
Australia (*n*=3)	Hinkley, *et al.* (2012) [18]	3-5 (1004)	Baseline data of a cohort study known as Healthy Active Preschool and primary years was used.	Survey tool was used to record parents report on DM use (TV/ video/ DVD viewing/ electronic games/ computer use) by the child.	•Average ST/ day 112.5 min (95% CI = 107.8–117.2). •Majority (99.4%) watched TV; 31.1% computer/ other electronic games; 28.8% used computer/ internet other than games	•Positive relationship with age •No relationship with gender
	Downing, *et al.* (2017) [19]	3-5 (100)	Baseline data of a cohort study known as Healthy Active Preschool and primary years was used.	Survey tool was used to record parents report on DM use of (TV/ video/ DVD / electronic games / computer) by the child.	•Mean (SD) sedentary time of children 301.1 (34.1) min/day, and ST was 108.5 (69.6) min/day. •Children spent 108.5 (69.6) min/day in ST.	•Parental concerns about child's sedentary behavior were associated with girls' ST. •Inverse relationship: sleep duration to girls' sedentary time and boys' ST; Parental self-efficacy; Maternal ethnicity to child preferences to sedentary behaviours' and girls' ST •No relationship with gender, child preferences for sedentary behavior.
	Brown, *et al.* (2010) [21]	4-5 (4983)	Data from two waves of the Longitudinal Study of Australian Children (LSAC).	Data were obtained in face-to-face interviews, questionnaires and diaries of the child's TV viewing as reported the parent.		•Positive relationship with child's ST to mothers who worked part-time.
Canada (*n*=3)	Carson, *et al.* (2012) [10]	0-5 (746)	Cross-sectional on participants recruited from the Healthy Living Habits in Preschool Children project.	Data obtained from the parents with the help of questionnaires	•Most participants (93.7%) watched TV and 37.9% played video/computer games .	•Positive relationship with child's age, parental attitudes, parental barriers, parental descriptive norms, parental ST,TV in the bedroom. •Inverse relationship with parental education, parental income, parental self-efficacy.
	Pagani, *et al.* (2010) [9]	2-5(1314)	Longitudnal study data from the Quebec Longi-tudinal Study of Child	Parent reported TV exposure of children on weekdays and weekends.	•11% children at 29 months had ST >2 h/ day. •23.4% of the children at	•Positive relationship with victimi-zation by classmates, BMI, age. •Inverse relationship with class-

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Place(no. of studies)	*Author (Year) [Ref]*	*Age in years (sample size)*	*Study design*	*Study Tool*	*Prevalence of ST*	*Associated factors and* correlates of ST
			Development was taken for recruiting the participant.		53 months had	ST >2 h/day. room engagement, math achievement, PA on weekends, other activities that require physical effort.
	Carson, *et al.* (2010) [11]	4-5 (1633)	Cross-sectional study data was gathered from the Healthy Living Habits in Preschool Children project (2005-2007).	Data were obtained from the parents with the help of questionnaires.	•42% (40% for girls and 45% for boys) of participants engaged in >2 h/day of ST •78% (68% for girls, and 80% for boys) of children engaged in >1 h/day of ST.	•Positive relationship with girls from low socio-economic status neighbourhoods. •Children from low socio-economic status neighbourhoods used more video games whereas those from high socio-economic status neighbourhoods used more computers.
Europe (*n*=1)	Kourlaba, *et al.* (2018) [4]	1-5 (2374)	'Growth, Exercise and Nutrition Epidemiological Study in pre-schoolers' (GENESIS study).	Parents reported weekday and weekend TV/ video viewing by the child on being asked specific questions from a survey tool.	•Average ST 1.32 h/ day, where 26% of children spent ≥2 h/day. 32% of children aged • 3-5 y watched TV >2 h/ day, which was higher, than in children aged 1-2 y.	•Significant relationship with age, parental TV viewing , the region of residence, maternal level of education.
UK (*n*=2)	Barber, *et al.* (2017) [1]	0-3 (1558)	Born in Bradford (BiB) was a longitudinal multi-ethnic birth cohort study (2007-10)	Questions were validated from the Southampton Women's Survey Question-naire which is validated for adults	75% of children aged 1 y exceeded guidelines of zero ST.	•Positive relationship with TV switched on at home, mother's perceptions on ST of children, children of first time mothers, maternal stress, mother not born in the UK.
	Jago, *et al.* (2012)	3-10 (2965)	Cross-sectional	Parents reported weekday and weekend TV/ video viewing by the child on being asked specific questions from survey tool.		•Positive relation with parental ST, access to DM • Maternal ST had stronger relation related to child's ST when compared with that of father's.
USA (*n*=5)	Christakis, *et al.* (2009) [12]	0-5 (168)	Cross-sectional	Research staff went to the enrolled child-care programs to fill up the survey tool with the help of the staff at child care programs.	Mean ST/ day for children in day care was 3.4 h in home-based programs, as compared with 1.2 h in center-based programs.	The children attending home-based child-care programs have more propensity to watch TV on an average day than those in center-based programs. folds (P<0.001).

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Place(no. of studies)	*Author (Year) [Ref]*	*Age in years (sample size)*	*Study design*	*Study Tool*	*Prevalence of ST*	*Associated factors and* correlates of ST
	Asplund, *et al.* (2015) [13]	0-5 (314)	Cross-sectional	A self-administered survey questionnaire parents on DM use (TV/ video games/ computer/ cell-phones and other DM devices) by children.	•53% children met AAP guidelines on ST viewing, •56% met AAP guidelines for no TV in the child's bedroom •Only 29% met both guidelines. •Children were more likely to meet the guidelines if they had <2 TVs in their homes, dinner without TV, or restricted parental ST.	•Positive relationship with age, parental ST and beliefs regarding ST, •Negative relationship with no TV during dinner, healthy parental beliefs, access to TV at home. •No relationship with child's ethnicity, child's BMI category, parent's age, parent's ethnicity, TV in the child's bedroom, survey language.
	Emond, *et al.* (2018) [14]	2-5 (385)	Cross-sectional	An online survey was given to parent where they reported upon DM use of their children	•Children watched mean (SD) 31.0 (23.8) h/week of DM •46% used DM gadgets within 1 h of bedtime •41% used DM gadgets in their bedrooms.	•Positive association with greater household DM use within 1 h of bedtime (P<0.01) in a dose-dependent manner.
	Tandon, *et al.* (2011) [22]	2-5 (10700)	Early Childhood Longitudinal Study-Birth Cohort	Parents reported the DM use (TV/ DVD/ video watching time) of the children.	•66% of children exceeded >2h/day guidelines of ST. •70% of children in Head Start exceeded >2 h/day ST. •The average ST for children was 3.5 h/day	•Children in home-based care had the maximum ST (5.5 h/day), followed by parental care only (4.4 h/day), head start (4.2 h/day) and child-care centers (3.2 h/day). •No relationship with household income, child's race/ethnicity, child's gender, primary language and mother's education, employment status, marital status, primary language.
	Fulton, *et al.* (2009) [15]	2-5 (2861)	Cross- sectional The 1999-2006 data of National Health and Nutrition Examination Survey was used to select parents.	Computerized interviews were administered to parent/ guardian reported the DM (TV/ computer) used by children.	•71% of children (2-5 y) viewed TV for ≤2h/day. •45% of children reported no computer use on the previous day.	•No relationship with overweight/ obesity •Positive relationship with Mexican-American ethnicity •Negative relationship with non-hispanic black ethnicity

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Place(no. of studies)	*Author (Year) [Ref]*	*Age in years (sample size)*	*Study design*	*Study Tool*	*Prevalence of ST*	*Associated factors and* correlates of ST
Japan (*n*=1)	Cheng, *et al.* (2010) [6]	0-3 (479)	Cohort study data analyzed from Japan Children's study.	Parent reported DM usage (TV) of the children	•29% (aged 18 mos) watched TV ≥4 h/day, 24.5% children (aged 30 mos), and 21% at both ages.	•Positive association with TV exposure at young age with hyperactivity–inattention, children of low income groups •Negative relationship with prosocial behavior in older children
Korea (*n*=2)	Byeon, *et al.* (2015) [8]	2 (1778)	National cross- sectional survey	Parent questionnaires through computer assisted personal interview were used to gather data on DM usage by their children.	•The average TV viewing time of children was 1.21 h/ day. • About 44% children had ST between 1-2 h/day.	•Positive relationship with language delay
	Chang, *et al.* (2018) [23]	2-5 (400)	A part of the Internet-Cohort for Understanding of internet addiction Risk factors/ Rescue in Early livelihood (I-CURE) study.	Survey tool was used to gather information from the parent/ reported the DM use (TV viewing) of their children.	•On weekdays, 48% of children watched TV for >1 h/day. •On weekends, 63.1% watched TV for >1 h/day, •23.4% of children used their smartphones for >1 h/day.	•About 65% of children were exposed to TV before 2 years. •Before 1 year of age, 12.2% of children were using smartphones for the first time. •31% of the children were using smartphones before 2 years.
Middle-income countries (*n*=5)						
China (*n*=2)	Lin, *et al.* (2014) [7]	0-3 (150)	Cross-sectional	Survey tool was used to gather information from caregivers about DM (TV, smartphone, iPad, and computer) Of their children.	•Children <2 y watched TV >0 h/ day, and children (≥2 years) who watched >2 h/ day were more likely to show a delay in motor skill development. •Children (0-2 y) watched an average of 67.4 min/day of TV.	•Positive relationship with delayed cognitive development, language development, motor-development, type of care taker •Negative relationship with Maternal education
	Wu, *et al.* (2016) [17]	3-6(202)	Exploratory quantitative study	A validated questionnaire (Chinese) was developed to gather demographics of the children, parents, and home environment and pattern of parent-child and child's		• Positive relationship with antisocial behaviour cartoons, cognitive development, functional development. •Significant relatioship with child's age, child's gender, parent's age,

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Place(no. of studies)	*Author (Year) [Ref]*	*Age in years (sample size)*	*Study design*	*Study Tool*	*Prevalence of ST*	*Associated factors and* correlates of ST
				DM use by the parents.		number of children in the family, parental employment status, family income, location of the computer.
India (*n*=1)	Verma, *et al.* (2018) [24]	6 mo -2 yrs (100)	Prospective	The children were observed at an interval of two years till they attain two years of age – Survey tool was used		• Negative relation with achieving cognitive milestones •No relationship with achieving physical milestones.
Malaysia (*n*=1)	Lee, *et al.* (2016) [16]	4-6 (835)	A part of the South East Asian Nutrition Surveys (SEANUTS)	Questionnaire were administered to the parents/ caregivers that gathered information on DM used by children.	•27% of children (25.7% urban, 32.7% rural) had daily ST of >2 h/day. •Only 24.1% boys from rural areas had ST of <1 h/ day in comparison, 46.2% girls.	• Few (27%) children exceeded daily ST recommendations. • In rural areas, lesser boys (24.1%) in comparison to the girls (46.2%) had ST of <1 h. •No relationship with the area of residence, ethnic group, household income, and maternal education. ethnic groups, household income, maternal education •Boys had significantly higher ST.
Thailand (*n*=1)	Ruangdaraganon, *et al.* (2009) [25]	0-2 (260)	A part of the Prospective Cohort Study of Thai Children (PCTC), that followed up children from birth to 2 years of age.	Parent were interviewed face-to-face and on the telephone to gather information on reported DM (TV viewing) in children.	•Children aged 6 mo (98%), (96.7%) watched TV. •About 22% of children (1 y) spent ≥2 h/day on TV, and 38.4% of 2-year-old children watched TV ≥2 h/ day. •The mean (SD) ST was 1.23 (1.42) h/d (1 year old) and 1.69 (1.56) h/day (2 year old).	•Positive relationship with age; 1 y (95.3%) and 2 y parents believed that TV viewing was beneficial to child's evelopment. •No relationship with delayed language development, Number of household TV, TV in child's bedroom

ST: screen time; TV: television; DM: digital media; PA: physical activity.

TABLE II SUMMARY OF INTERVENTION STUDIES ON SCREEN TIME IN CHILDREN AGED 0-5 YEARS

Place (No. of studies)	*Author(Year) [Ref]*	*Age in years*	*Study design*	*Sample size*	*Intervention group package*	*Control group package*	*Endpoints*	*Mean difference in ST in intervention versus control arm (95% CI)*
Australia (*n*=1)	Hinkley, *et al.* (2015) [32]	2-3	Pilot-RCT	22	Group sessions, family-based activities, problem-solving, and challenges discussed in six sessions. Social cognitive and Family Systems theories were used.	Families just received usual health services.	ST	-31.2 minutes/day (SE=20.3, Interval: -70.99, 8.59)
Canada (*n*=2)	Birken, *et al.* (2012)[46]	2-4	RCT	351	Counseling parents, parties, child involvement and TV turn-off time but no follow-up was done. The Social cognitive theory was used.	Parents received standard counseling from trained personnel on media use. They were given media guidelines published by the Canadian Pediatric Society	Mean total weekday and weekend ST.	-7 minutes/day (SE=15.56, Interval: -37.50, 23.50).
	Haines, *et al.* (2013) [44]	2-5	RCT	121	Motivational coaching at home and by phone, educational materials, TV control device, incentives, and text messages. Follow-up was done. Social-ecological model.	Families were mailed educational materials focused on child development.	Sleep duration, TV viewing and BMI.	-32.4 minutes/day (SE =20.98, Interval: -73.48, 8.68)
Europe (*n*=4)	Yilmaz, *et al.* (2015) [38]	2-6	RCT	412	Family intervention, counseling calls and educational material given to parents. No follow-up was done. The Social cognitive theory was used.	Families just received usual health services.	Mean ST violent behaviors, language development, tobacco smoking, BMI in children and sedentary behavior.	-47.2 minutes/day (SE =2.01, Interval: -51.10, -43.22)
	Puder, *et al.* (2011) [40]	3-5	RCT	652	Multi-dimensional culturally tailored lifestyle intervention, and adapted for the built environment of the preschool class.	The children did not receive any new informative material. They continued their regular school curriculum.	Aerobic-fitness, BMI, motor agility, balance, percentage body fat, waist circumference, PA, eating habits, ST, sleep, psychological health, and cognitive abilities.	-13.4 minutes/day (SE 5.94, Interval: -25.04, -1.76)
	Grieken, *et al.* (2015) [34]	5	Cluster RCT	637	Lifestyle counseling, questionnaires, behavior change, and home environment modifications with follow-up. ASE model,	All parents attended well-child visits. They received general infor-	Duration of outside play, or TV viewing.	-1.6 minutes/day (SE =6.63, Interval: -14.55,11.43)

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Place (No. of studies)	*Author(Year) [Ref]*	*Age in years*	*Study design*	*Sample size*	*Intervention group package*	*Control group package*	*Endpoints*	*Mean difference in ST in intervention versus control arm (95% CI)*
					precaution process model, elaboration likelihood model, and the stages of change model.	mation about nutrition and physical activity.		
	Latomme, *et al.* (2017) [35]	4-6	Cluster RCT	2434	Health education for parents, and children, and classroom environment. Follow-up was done.	Kindergartens received regular schooling curriculum. The intervention material after completion of the intervention.	Computer/ video-games use on weekday and weekend.	Intervention group: Lesser accentuation in computer/ video-games uses on weekday in (+5.48 minutes/day) whereas control group (+8.89 minutes/day). Intervention group on weekend, (+9.46 minutes/ day) whereas, control (+15.43 minutes/day)
New Zealand	Skouteris, *et al.* (2015) [45]	2-4	RCT	104	Parents and children attended weekly workshops on nutrition, PA and behaviors, including guided active play, and healthy snack time. Follow-up was done.	The parents did not receive any health information. They were given the intervention package after the completion of the study duration.	Nutrition, PA, and behaviors, along with ST.	-10.3 minutes/day (SE=8.2, Interval: -26.37, 5.77)
USA (*n*=8)	Fitzgibbon, *et al.* (2011) [42]	2-5	RCT	618	The intervention delivered by classroom teachers. Diet plan, and health education for teachers and parents. Social cognitive theory, and self-determination theory. No follow-up was done.	Parents received information upon general health concepts.	PA, nutrition and total ST.	-27.8 minutes/day (SE =13.92, Interval: -55.8, -0.52)
	Fitzgibbon, *et al.* (2013) [43]	2-5	RCT	157	School-based and family-based components used. Social cognitive Theory, Health Belief Model and Self-determination theory. Follow-up was done.	Parents received information upon general health concepts.	BMI and ST.	15.6 minutes/day (SE 25.71, Interval: -34.79, 65.99)
	Foster, *et al.* (2015) [41]	2-5	RCT		Community meetings, parent health education, and consultations along with follow-up.	Parent-child dyads attended community meetings. They got the EatPlayGrowTM curriculum to teach healthy habits.	ST, BMI, child's growth, nutrition, and quality of life.	The intervention group showed decreasing ST from a mean of 3.3 hours/day (Interval: 2.3, 4.2) at 6 months to 2.1 hours/ day (Interval: 1.5, 2.7) at 12-month follow-up.
	Taveras, *et al.* (2011) [33]	3-5	Cluster RCT	475	Family counselling, health education, motivational interviewing, and small	Children received usual pediatric care according	Total TV/video viewing, TV in the	-21.6 minutes/day (SE 8.41, Interval: -38.8, -5.12)

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Place (No. of studies)	*Author(Year) [Ref]*	*Age in years*	*Study design*	*Sample size*	*Intervention group package*	*Control group package*	*Endpoints*	*Mean difference in ST in intervention versus control arm (95% CI)*
					incentives. Chronic care model. No follow-up was done.	to the current standards of care.	bedroom, BMI, food frequency, food consumption, anthropometrics and PA.	
	Zimmerman, *et al.* (2011) [31]	3-53-5	Pilot RCT		Families written materials and four monthly newsletters, phone or email, parents encouraged their children, and the research staff encouraged the parents. Social cognitive theory and behavior change model was used. No follow-up was done.	The parents received cues of promotion of their child's safety in several areas. These were not specific to DM.	A significant reduction in commercial content viewing (29 minutes/day [-4.6-63], and positively changed outcome expectations.	-37.1 minutes/day (SE 16.9, Interval: -68.64, -5.56)
	Mendoza, *et al.* (2016) [36]	3-5	Cluster RCT	160	Curriculum for students in the classroom, and staff training on the day program using the Social Cognitive Theory.	Parents received information upon general health concepts.	TV viewing and sedentary time.	-25.3 minutes/day (Interval - 45.2, -5.4)
	Knowlden, *et al.* (2015) [39]	4-6	RCT	57	Group-by-time interaction was detected for child fruit and vegetable consumption using Social cognitive theory. Telephone counselling and online surveys were conducted.	The parents received a knowledge-based program. It incorporated educational sessions for parents on child development. Telephone counselling and online surveys were conducted.	Child PA, sugar-free beverage consumption, and ST.	-0.3 minutes/day (SE=13.3, Interval: -26.37, 25.77)
	Epstein, *et al.* (2008) [37]	4-7	RCT	70	Weekly time budgets for media use, and alternatives to sedentary behavior, monthly newsletter, TV allowance, parental skills, and rewards for children. No follow-up was done.	Children received free access to TV, computers and money for participating in the trial. The parents received general parenting tips.	Mean TV viewing, and computer games weekday and weekend.	In the control group, the mean (SD) number of hours of ST decreased by 5.2 (11.1) hours/week whereas, in intervention group declined by 17.5 (7.0) hours/week; remained about the same at 24 months.

ST: screen-time; TV: television; RCT: randomized control trial; PA: physical activity; BMI: body mass index.

[11,12,14,15,17,19-21,24]. Three studies also reported the average screen time from using smartphone [17,20,24] and five studies on computer usage [11,12,14,15,19,21] separately or along with the TV. However, they have not documented the screen time of these gadgets separately, and have provided the aggregated time.

The differences in the prevalence rate of excessive screen time among under-fives can also be attributed to the associated factors like, digital-media environment [14,17,18,23], parental behaviors [1,4,12–14,17] and government regulations [2,48–50]. The preference of TV over other digital-media devices is evident among under-fives [11,12,14,15,17,19–21,24]. A systematic review reported that computers are preferred by older children [5]. All the studies have reported screen time through watching TV; in addition, a pevious [19] and some recent studies have measured screen time on using computers, smartphone, iPad, or hand-held games [7,11,12,17,24]. However, the screen time from watching TV far exceeds than that from new-age gadgets. Earlier the device is introduced, there is an increased propensity to exaggerated use with an increase in age [8,24,26].

FACTORS ASSOCIATED WITH INCREASED SCREEN TIME

Twenty-eight studies including 14 cross-sectional studies, 11 overlapping studies, 3 systematic reviews [1,3,4,6–30] and one guideline [2] were reviewed to document the factors associated with screen time. A systematic review identified 36 correlates of children (0-8 years) specifically with mobile screen exposure [29]. Another review identified 33 correlates in children under the age of three years [30]. Both these systematic reviews have used bio-ecological model to explain various correlates at five levels: (*i*) child biological and demograpic factors; (*ii*) family biologic and demographic factors; (*iii*) family structure; (*iv*) behavioral factors; and (*v*) socio-cultural/environmantal factors. These reviews reported the associations with screen time to be either positive, negative or none. We have used the social ecological model [10,19] to explain all the 40 factors (23 from 28 studies and 17 additional factors from systematic reviews) to be associated with digital-media exposure among children at four levels. As per this model, there is an interplay (bidirectional) of the factors affecting the behaviors at four levels including intrapersonal level (child-related factors), interpersonal level (caregiver-related factors), immediate environmental level (child care environment) and macro-environment level (socio-cultural environment) [12,14,30]. We have clubbed the child and family level behavioral factors with child and family factors, respectively (***Fig.* 2**).

Intrapersonal: Child-related Factors

At intrapersonal level, the factors associated with digital-media exposure include child's demographic, behavioral and biological factors. As the child grows older, his screen time accentuates [4,6,11,14,26]. Hyperactivity-inattention [6], daily sleep duration, and sedentary preferences [12] were found to be positively associated with a child's digital-media exposure. Boys were more hyperactive [6] and watching more screens [14] in

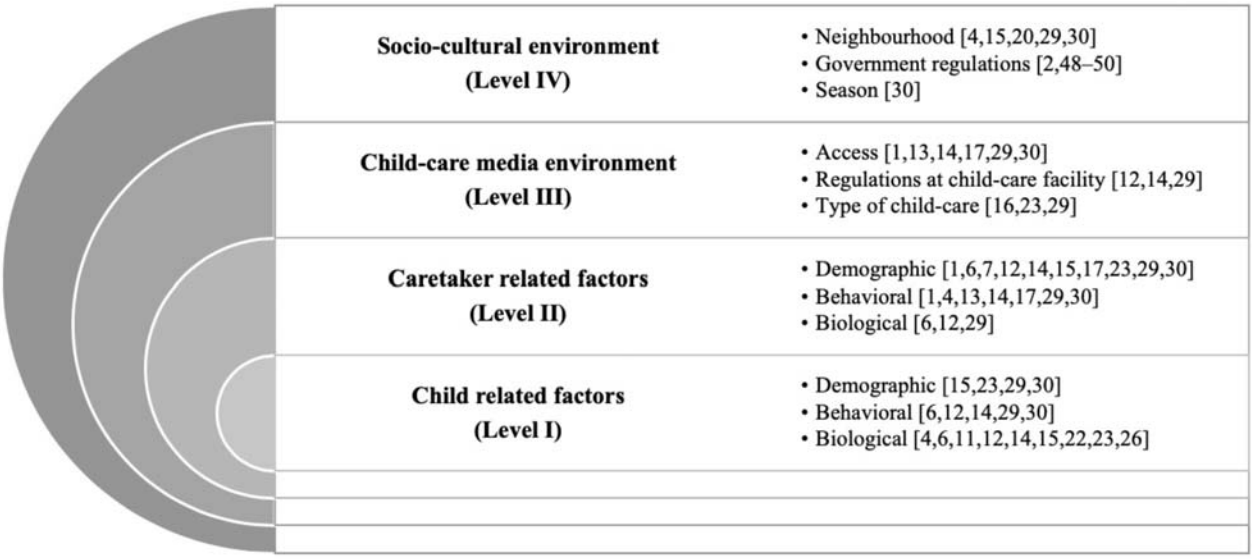

Fig. 2 *The interactions of associated factors and correlates of screen-time among under-five children using the Social-Ecological model.*

comparison to girls. However, three studies did not report any gender-based differences in screen time [11,12,23]. Another study concluded that the child's demographic factors [23] have no associations with child's digital media exposure.

Interpersonal: Caregiver-related Factors

These factors play a role during interactions between the parent/caregiver and the child. Paternal age [12], time spent on work by mothers [22], maternal stress [1,30], parental screen time [1,4,13,14,17,29,30], mother's place of delivery [1,15], and shorter breastfeeding [30] were positively related to child's screen time. Children of first-time mothers had increased in screen time [1]. Parental income [14], parent's occupation [29], socioeconomic status of the family [6,15], maternal ethnicity [12], maternal body mass index [30], decreased level of education [7,14] and physical activity [29] of the parents'/ caregivers were negatively associated with average digital-media exposure of the child. Parents' perceptions [1,17], attitudes, beliefs towards the importance of digital-media exposure and the amount of time they spent with the child [29] played a pivotal role in a child's digital-media exposure. Mother's relational and personal well-being, parent's sex, country of birth [29], and cognitive stimulation at home [30] were also associated with child's screen time. However, there were no associations reported with parental demographic characteristics [23], ethnicity of the family [17,23], two-parent household, number of children at home, or non-parental child-care [30].

Immediate Environment

Digital media micro-environment

The digital-media micro-environment is the home environment within which the family lives *i.e.*, the micro digital-ecosystem of the house. The access to digital-media gadgets [13,14,17,29,30], screen time rules at home [12,14], TV switched-on in the background at home [1,14,17], home-based care [16,23], parenting skills [14], computers placed outside the child's bedroom and TV on during dinner [29], infant crying duration and heavy TV use [30] are positively related to digital-media exposure in children. Parental self-efficacy [12], and type of care [29] were negatively associated with screen time of the child. The TV time/content restrictions had no association with the child's screen time [30].

Digital media macro-environment

The socio-cultural, geographical and environment factors are the macro-environmental factors that affect the digital-media usage of the family. These represent the macro digital-ecosystem of the community surrounding the house. Interactions at the macro-digital ecosystem cannot be controlled and may vary from region-to-region. The place of residence [4,15,20,29,30], season (winter) [30] and the government services that are available in that area [2] affect the digital media exposure of the children. A study reported that boys of rural areas had higher screen time than in the urban areas [20]. Another study reported that it was higher among girls belonging to lower socioeconomic status as compared to those of higher status [15].

CONSEQUENCES OF INCREASED ST

The consequences of augmented screen time may be early/preliminary and late/long-standing [1,4,6-12,14-26,28] as shown in ***Fig.* 3**. Early consequences are considered as those that are reported during under-five development period among infants, toddlers and preschoolers; and late are those that are reported after this period.

The watching of indiscriminate media content [9], especially if unsupervised [2], might hamper a child's behavioral outcomes. Moreover, restricting children in one position for >1 hour has additional negative health outcomes [2]. Sedentary behaviors related to screen time among children might be induced by the parents [1,12,18] as they are the role models for the children [1,4,12], or due to the parents' perceptions about the importance of screen time [12,14,26], physical environment-induced (access, presence of bedroom TV, number of gadgets at home etc.) [1,4,12,14,15,17,20]. However, it is reported that not all digital media is bad as a child's level of physical activity [47], skill development [28], gain in knowledge [21] early learning, cognitive and functional development [10] improved with specific contingent videos. American Academy of Pediatrics 2016 guidelines [2] reinforce that one-to-one interaction may, in turn, lead to improved parent-child engagement, and quality of social interaction for healthy development.

Early Consequences

The child's frequency of TV watching was found to be significantly associated with delayed motor skills, cognitive [7] and language [7,8] development. The content of TV has a detrimental effect on cognitive development [7]. A Japanese study observed that children aged 30 months, had increased chances of being hyperactive/inattentive due to excessive TV-viewing [6]. Augmented digital media usage leads to reduced sleep, which in turn leads to increased TV exposure that seems to have a wider impact on the sleep quality [12]. Greater household chaos leading to excessive screen time is also related to disrupted nighttime sleep [18]. An Indian study reported a delay in achieving cognitive milestones of

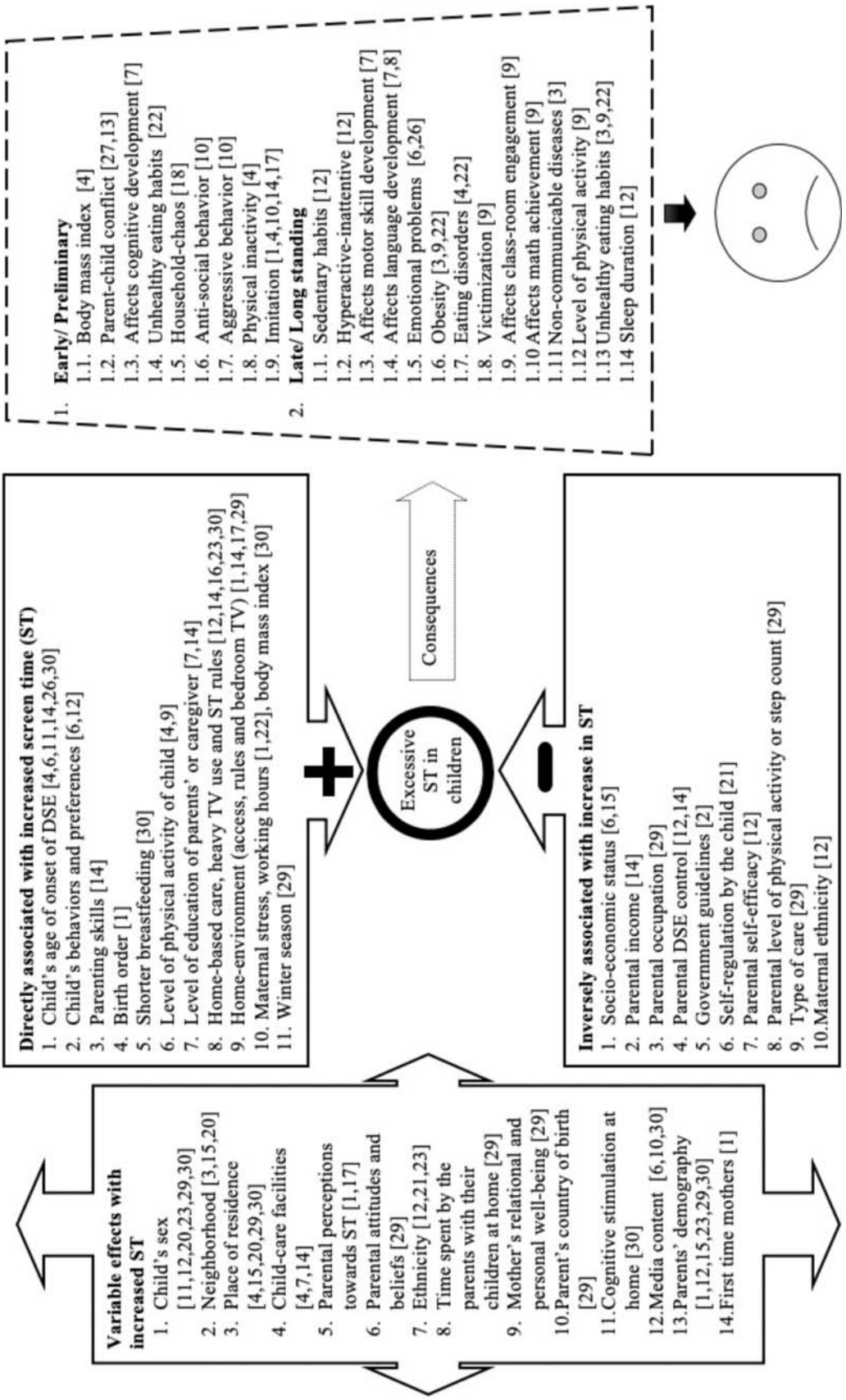

FIG. 3 *Associations and consequences of excessive screen time in under-five children.*

children (below 2 years) with respect to digital media exposure [25]. There are less parent-child interactions [27] and increased chances of conflicts [13] when the parents' attention is absorbed. Children try to mimic their parental screen time behaviors [1,4,14,17] and/or the programs they watch on screens [10]. Child's aggressive [6,10] and antisocial behaviors [10] are related to augmented screen time. Due to a lack of positive role models, and indiscriminate watching of media content, children might have behavioral problems [10].

Late Consequences

Long-standing consequences of digital media use predict worsened behavioral outcomes in the children when they grow older [26]. Development path of the children exposed to excessive digital-media may lead to unhealthy adolescence [9]. In the school, they are less likely to get engaged, and may be prone to victimization [9]. Children with accentuated screen time have a predominantly higher prevalence of overweight [22], obesity [19] and NCDs [3].

INTERVENTION STRATEGIES

The setting for delivering the interventions was mainly at family [31,32,35-37,39,43,44], and/or home level [31,38,40,43-45], with a few at school [34,35,41,42,46], or clinic- [39,43], or community-level [33]. Most of the interventions were based on behavior change theories such as; social cognitive theory [31,32,34,35,38,42,44], social determination theory [34,35] family systems theory [32], social ecological model [36], health belief model [35], chronic care model [39], attitude social influence self-efficacy model, precaution process model, elaboration likelihood model, the stages of change model [40] or none [33,37,41,43,46]. The intervention packages specifically focused on increasing the information related to digital-media, by holding counseling sessions or using educational material. Educational materials were mostly shared with parents [31-33,36-41,43,45], followed by teachers [34,35,42,46] children [37,46] and community members [33]. Seven studies had focused primarily on screen time reduction [31,32,38,39,41-43], and six studies [33,35-37,40,41] additionally included a follow-up with the participants post-intervention to assess the adherence to the intervention. Some studies had interventions to increase the physical activity [34,37,40,45,46] and reduce the sedentary time [42], body mass index [33,35,36,44,46], sedentary behavior [42,44], violent behaviors, tobacco smoking, [44], and modify the eating behaviors of children [33,34,37,45,46]. The reduction in screen time among under-five children varied from 0.3 (SE=13.3) minutes to 47.16 (SE=2.01) minutes in the high-income countries. The most effective intervention strategy was theory-based and delivered at the family level [44]. The child's knowledge regarding engagement in screen-based activities [31,34-36,42,43,45,46], home-based rules regarding TV turnoff time [38], and the alternatives used by parents for reducing digital-media use had a significant effect on reducing the screen time. The comparator group in most of the studies received the usual health care services except in two studies, where session on media use were held and national guidelines on media use among children were shared. [33,45] .

Intervention studies to reduce screen time has been reported from high-income countries only [31-46]. (***Web Table* II**). There is no published intervention studies from LMICs. The intervention strategy of utilizing a child's knowledge to engage in sedentary behavior [31,34-36,42,43,45,46] was found to be effective in reducing the excessive ST. Also, primary caretaker's role to mediate [31,33,36-41,43,44] the digital media exposure among children was central in regulating the screen time.

CONCLUSIONS

The results of this review have highlighted that there is a high prevalence of excessive screen time among under-five children in the high - and middle-income countries. There are several health impacts of excessive screen time including emotional, sleep, behavioral issues impairing the growth and cognitive development of under-five children. Most of the high-income countries have made guidelines for limiting the excessive digital-media usage for all age groups including Canada [48], Australia [50], and Itlay [49] while, several LMICs have no such guidelines. The findings of this review might be useful for the policymakers in formulating such guidelines in these countries.

Based upon the results of this review, we recommend that pediatricians should explore the history of screen time from the parents of all under-five children visiting them in the clinics and about the digital-media home environment, and advise to not to use digital gadgets for children less than 2 years and limit it to one hour for children age 2-5 years. The policy-makers and associations like Indian Academy of Pediatrics should formulate guidelines on permissible limits of screen time among children. As, there is a paucity of data on the prevalence of screen time among under-fives from LMICs, such studies should be planned to understand the cultural context of screen time use in these settings. Also, culturally appropriate interventions to reduce the same in the LMICs should be designed. Such studies are of utmost importance considering the worsening mental [5-7,10] and physical health of children [4,5,9], and to prevent NCDs.

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