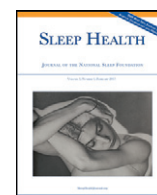




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National Sleep Foundation's sleep quality recommendations: first report[☆]



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ABSTRACT

Objectives: To provide evidence-based recommendations and guidance to the public regarding indicators of good sleep quality across the life-span.

Methods: The National Sleep Foundation assembled a panel of experts from the sleep community and representatives appointed by stakeholder organizations (Sleep Quality Consensus Panel). A systematic literature review identified 277 studies meeting inclusion criteria. Abstracts and full-text articles were provided to the panelists for review and discussion. A modified Delphi RAND/UCLA Appropriateness Method with 3 rounds of voting was used to determine agreement.

Results: For most of the sleep continuity variables (sleep latency, number of awakenings >5 minutes, wake after sleep onset, and sleep efficiency), the panel members agreed that these measures were appropriate indicators of good sleep quality across the life-span. However, overall, there was less or no consensus regarding sleep architecture or nap-related variables as elements of good sleep quality.

Conclusions: There is consensus among experts regarding some indicators of sleep quality among otherwise healthy individuals. Education and public health initiatives regarding good sleep quality will require

[☆] Endorsed by National Sleep Foundation, American Association of Anatomists, American Physiological Society, Gerontological Society of America, Human Anatomy and Physiology Society, Society for Research on Biological Rhythms, Society for Research of Human Development, and Society for Women's Health Research.

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sustained and collaborative efforts from multiple stakeholders. Future research should explore how sleep architecture and naps relate to sleep quality. Implications and limitations of the consensus recommendations are discussed.

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Introduction

Good sleep quality is a well-recognized predictor of physical and mental health, wellness, and overall vitality. Although, the term “sleep quality” is widely used by researchers, clinicians, and the public, this expression lacks definitional consensus. To date, no consistent guidance is available from the scientific community regarding what constitutes normal or optimal, healthy sleep and good sleep quality.

The Webster dictionary’s simple definition of quality is “how good or bad something is.”¹ Thus, a global approach for indexing sleep quality often involves soliciting a self-rating. Such indices likely reflect an individual’s satisfaction with his or her sleep. An extension of this approach involves correlating self-rated sleep quality against other measures such as environmental factors, the timing of sleep, physiologically derived indices, polysomnographic parameters, behavior, pharmacologic interventions, and/or the presence of sleep disorders. One obvious limitation of relying on self-report when assessing sleep quality is the loss of consciousness during sleep, which makes individuals poor self-observers of this particular behavior.

An alternative approach to defining sleep quality involves deconstructing it into its particular objective components. Within this paradigm, “quality” is defined as a combination of constituent elements or processes judged as valuable. It is this approach that guided the current investigation. The purpose of this study was to search for a composite of objectively identifiable sleep features underlying sleep quality. Many questions related to sleep quality and its potential outcomes on health (eg, mood and cognitive performance) exist; however, those questions are outside the scope of this article.

The need for such clarity on sleep quality is of particular and timely importance given the rapid increase in public awareness of sleep as an important component of health and overall well-being. Millions of individuals are using commercially available sleep tracking devices. These devices purport to measure sleep quality and quantity. Therefore, there exists a need to define clearly both sleep quantity and quality using the best scientific evidence available. Sleep quantity recommendations were previously addressed by a National Sleep Foundation (NSF) Sleep Duration Recommendation consensus panel.² Continuing this process, the NSF assembled a panel of experts to answer the question, “What is good sleep quality?” The overall objectives of this Sleep Quality Consensus Panel (SQCP) were to provide scientifically sound recommendations regarding indicators of good sleep quality at different ages across the life-span.

Methods

Participants

To ensure a wide range of perspectives regarding indicators of sleep quality, the NSF assembled an expert panel comprising sleep experts as well as experts in other areas of science and medicine. Because one objective of the SQCP was to provide interpretable recommendations to the public, it was important to include non-sleep experts from related scientific domains. The 18-member panel included representatives selected by stakeholder

organizations (n = 10) as well as sleep experts selected by the NSF (n = 8). Stakeholder organizations that appointed representatives included the *American Academy of Neurology*, *American Geriatrics Society*, *American Physiological Society*, *American Association of Anatomists*, *Gerontological Society of America*, *Human Anatomy and Physiology Society*, *Sleep Research Society*, *Society for Research on Biological Rhythms*, *Society for Research of Human Development*, and the *Society for Women’s Health Research*.

Procedures

Literature review

To ensure that all panelists had access to the same body of evidence, the NSF performed a systematic review of peer-reviewed literature encompassing the years 2005–2015 using PubMed, Web of Science, CINAHL Plus, EBSCO, and MEDLINE databases. Search terms were developed, reviewed, and agreed upon by the panel (see Table 1). Inclusion criteria for individual studies were the following:

- Published in English language
- Published in peer-reviewed scientific journal
- Studied human subjects
- Used objective measures of sleep quality.

A total of 3928 unique articles were identified, 386 articles were selected for full-text review, and 277 studies met the final inclusion criteria. A flowchart of literature search results is depicted in Fig. 1. Study data (ie, sample characteristics, country, study type, measures, and results) were extracted and summarized in alphabetical tables. Separate summary tables were developed for each age group. These tables and the corresponding full-text articles were distributed to panelists for review to inform their ratings. Key articles are summarized in Supplementary table (Appendix A).

Panel deliberations and consensus voting

Panelists were initially tasked with defining age categories and possible indicators of good sleep quality. Based on the literature

Table 1
Search terms used in the systematic review

Sleep terms	Indicators
Sleep quality	Awakenings
Sleep efficiency	Arousals
Restorative sleep	Movement
Sleep consolidation	Restlessness
Restful sleep	Architecture
Efficient sleep	Spindle activity
Refreshing sleep	Duration
High-value sleep	Time in bed
High-grade sleep	Environmental factors
Satisfactory sleep	Stages of sleep
Sleep depth	Sleep cycles
Deep sleep	Phases of sleep
	Perceptions
	Restorative

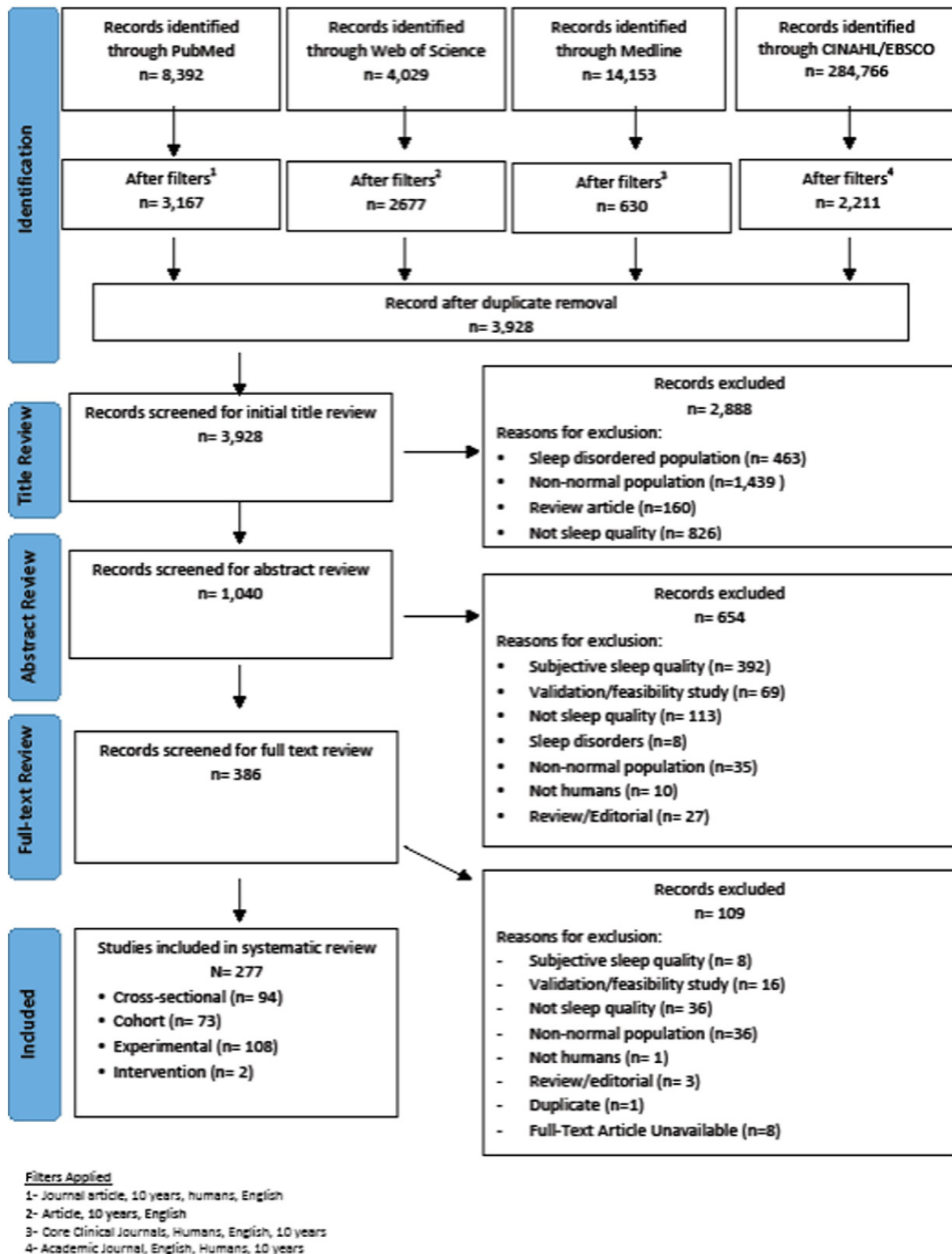


Fig. 1. Flow chart of literature search results.

review and consistent with previous recommendations regarding sleep duration,² panelists agreed on 9 age categories from birth through old age: newborn (0-3 months), infant (4-11 months), toddler (1-2 years), preschooler (3-5 years), school aged (6-13 years), teenager (14-17 years), young adult (18-25 years), adult (26-64 years), and older adult (≥ 65 years).

Similarly, 12 possible indicators of sleep quality were identified, including 4 sleep continuity variables (sleep latency, awakenings >5 minutes, wake after sleep onset, sleep efficiency), 5 sleep architecture variables (rapid eye movement [REM] sleep, N1 sleep, N2 sleep, N3 sleep, arousals), and 3 nap variables (naps per 24 hours, nap duration, and days per week with at least one nap). Table 2 presents

Table 2
Indicators considered by the panel

Term	Measurement	Synonyms	Definition
Sleep efficiency	Percent (%)		Ratio of total sleep time to time in bed
Sleep latency	Minutes		Length of time, in minutes, it takes to transition from wake to sleep
REM sleep ^a	Percent (%)	Paradoxical sleep	Ratio of time spent in REM sleep to total sleep time
N1 sleep ^a	Percent (%)	Light sleep; non-REM (NREM) sleep 1	Ratio of time spent in N1 sleep to total sleep time
N2 sleep ^a	Percent (%)	NREM sleep 2	Ratio of time spent in N2 sleep to total sleep time
N3 sleep ^a	Percent (%)	Slow-wave sleep; deep sleep; NREM sleep 3	Ratio of time spent in N3 sleep to total sleep time
Naps	Number (#)	Sleep episode	Number of naps per 24-h period
Nap duration	Minutes	Sleep episode	Average length of each nap, in minutes
Nap frequency	Days	Sleep episode	Number of days, in the past 7, that a nap occurred
Arousals	Number per hour		An abrupt change from “deeper” stage of NREM sleep to a “lighter” stage, or from REM sleep toward wakefulness, with the possibility of awakening at the final outcome. May be accompanied by increased tonic electromyographic activity and heart rate, as well as by an increased number of body movements
Awakenings (>5 min)	Number per night		Number of episodes, per night, in which an individual is awake for greater than 5 min
Wake after sleep onset	Minutes		Amount of time, in minutes, spent awake after sleep has been initiated and before final awakening

^a REM, N1, N2, and N3 sleep are acronyms commonly defined in sleep medicine.

indicators considered by the panel. Due to the large number of age ranges and possible sleep indicators, it was necessary to consider whether any indicators were not appropriate for one or more age groups. An initial round of voting (round 0) was conducted to rate each possible indicator as appropriate, uncertain, or inappropriate. The panel agreed to keep appropriate and uncertain indicators and eliminate inappropriate indicators for the next round of voting.

Once all indicators were established, panelists were asked to consider each indicator for each age category. To answer the question, “How appropriate is this indicator of good sleep quality,” panelists reviewed the assembled scientific literature and met a total of 5 times (by conference call or in-person). The ballot consisted of a standardized response format for each possible indicator at each age-group, as follows: “For [age group], a [sleep quality indicator] of [value] indicates good sleep quality.”

Over a 6-month interval during which scientific findings were read, reviewed, and discussed, each panelist participated in 3 rounds of voting, as follows:

- The initial vote was cast independently.
- The second round took place at an in-person meeting 6 months later. During the in-person meeting, panelists reviewed round 1 results, deliberated, and participated in the second round of independent voting.
- The third and final round of independent voting took place 2 weeks after the in-person meeting, and ballots were submitted electronically.

Appropriateness was rated from 1 (ie, extremely inappropriate) to 9 (ie, extremely appropriate). A modified Delphi RAND/UCLA Appropriateness Method³ was used to synthesize the collective judgment of experts about the appropriateness of each proposition, based on their interpretation of available scientific evidence. In this approach, expert consensus recommendations are defined as appropriate (panel median of 7–9, without disagreement), uncertain (panel median of 4–6 or any median with disagreement), or inappropriate (panel median of 1–3, without disagreement). Agreement occurs when 80% or more of votes fall within any 3-point range (ie, 1–3, 4–6, or 7–9). Disagreement takes place when more than 20% of votes fall outside any 3-point range.

Results

Appropriateness of possible indicators (round 0)

Among newborns, REM activity and number of awakenings were rated appropriate indicators for grading sleep quality. N3 sleep was rated uncertain. All other possible indicators were rated inappropriate and removed from future consideration. Among infants, N1 sleep and N2 sleep were rated inappropriate and removed; nap duration and nap frequency were rated uncertain and included along with all other possible indicators, which had been rated appropriate. For each remaining age category, all possible indicators were rated appropriate for inclusion and included in future consensus voting.

Panel deliberations and consensus voting (rounds 1–3)

For all included indicators, panelists were tasked with answering the question, “For [age group], a [sleep quality indicator] of [value] indicates good sleep quality.” Votes that resulted in consensus are presented below.

Sleep continuity measures

Sleep latency

Across all age groups, a sleep latency of ≤15 minutes (ie, 0–15) was rated as an appropriate measure for indexing good sleep quality. Sleep latencies ranging from 16 to 30 minutes were judged similarly to be good sleep quality. For all age groups excepting older adults, a sleep latency of 45–60 minutes (ie, 46–60 minutes) indicates poor sleep quality. For all age groups, a sleep latency >60 minutes indicates poor sleep quality. Results are presented in Fig. 2.

Awakenings >5 minutes

Across all age groups, 1 or fewer awakening (ie, 0 or 1 awakening) per night indicate good sleep quality. Among older adults, 2 awakenings per night also qualify as indicating good sleep quality. For all age groups, 4 or more awakenings (ie, 4 or 5 awakenings) per night were voted as not an appropriate indicator for good sleep quality. Among teens, more than 3 awakenings per night do not indicate good sleep quality (Fig. 3).

Inappropriate
 Uncertain
 Appropriate









AGE CATEGORY		SLEEP LATENCY				
		0-15 MINS	16-30 MINS	31-45 MINS	46-60 MINS	61+ MINS
	INFANTS					
	TODDLERS					
	PRE-SCHOOLERS					
	SCHOOL-AGED CHILDREN					
	TEENS					
	YOUNG ADULTS					
	ADULTS					
	OLDER ADULTS					

Fig. 2. Expert consensus regarding sleep latency across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4-6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1-3).

Wake after sleep onset

For all age groups from preschoolers through older adults, a wake after sleep onset of ≤ 20 minutes (ie, ≤ 10 or 11–20 minutes) indicates good sleep quality. For all age groups from preschoolers through adults, a wake after sleep onset ≥ 51 minutes (ie, 51–60 or ≥ 61 minutes) does not indicate good sleep quality. In addition, for school-aged children, young adults, and adults, a wake after sleep onset of ≥ 41 minutes (ie, 41–50, 51–60, or > 60 minutes) also does not indicate good sleep quality (Fig. 4).

Sleep efficiency

Across all age groups, a sleep efficiency of $\geq 85\%$ (ie, 85%–94% or $\geq 95\%$) was judged as an appropriate indicator of good sleep quality. Across all age groups except young adults, a sleep efficiency $\leq 74\%$ (ie, $\leq 64\%$ or 65%–74%) does not indicate good sleep quality. Among young adults, a sleep efficiency $\leq 64\%$ does not indicate good sleep quality (Fig. 5).

Sleep architecture measures

REM sleep

Among newborns, a REM sleep $\geq 41\%$ indicates good sleep quality. Among adults, a REM sleep of 21%–30% indicates good sleep quality. Among newborns, infants, toddlers, preschoolers, and teens, a REM sleep of $\leq 10\%$ does not indicate good sleep quality. Among newborns, a REM sleep of $\leq 20\%$ also does not indicate good sleep quality. Among young adults, adults, and older adults, a REM sleep of $\geq 41\%$ does not indicate good sleep quality (Fig. 6).

N1 sleep

Among school-aged children, teens, young adults, and adults, N1 sleep of $\leq 5\%$ indicates good quality sleep. Among toddlers, preschoolers, school-aged children, teens, young adults, and adults, N1 sleep of $\geq 20\%$ (ie, 20%–25% or $\geq 26\%$) does not indicate good sleep

■ Inappropriate ▨ Uncertain □ Appropriate








AGE CATEGORY		AWAKENINGS (>5 MINS)					
		0	1	2	3	4	5+
	TODDLERS	□	□	▨	▨	■	■
	PRE-SCHOOLERS	□	□	▨	▨	■	■
	SCHOOL-AGED CHILDREN	□	□	▨	▨	■	■
	TEENS	□	□	▨	■	■	■
	YOUNG ADULTS	□	□	▨	▨	■	■
	ADULTS	□	□	▨	▨	■	■
	OLDER ADULTS	□	□	□	▨	■	■

Fig. 3. Expert consensus regarding number of awakenings (>5 min) across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7–9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4–6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1–3).

quality. Among older adults, N1 sleep of $\geq 26\%$ does not indicate good sleep quality (Fig. 7).

N2 sleep

Among all age groups from toddlers through older adults, N2 sleep of $>81\%$ does not indicate good sleep quality (Fig. 8).

N3 sleep

Among school-aged children and teens, N3 sleep of 20%–25% indicates good sleep quality. Among adults, N3 sleep of 16%–20% indicates good sleep quality. Among infants, toddlers, preschoolers, and school-aged children, N3 sleep of $\leq 10\%$ (ie, $\leq 5\%$ or 6%–10%) does not indicate good sleep quality. Among teens, young adults, and adults, N3 sleep of $\leq 5\%$ does not indicate good sleep quality (Fig. 9).

Naps

Naps per 24 hours

Among school-aged children and young adults, taking no naps indicates good sleep quality. Among teens, taking 0 or 1 naps indicates good sleep quality. Across all age groups from preschoolers through older adults, taking 4 or more naps (ie, 4 or 5 naps per 24 hours)

does not indicate good sleep quality. Among school-aged children, taking 2 or more naps does not indicate good sleep quality, and among teens and young adults, taking 3 or more naps does not indicate good sleep quality (Fig. 10).

Nap duration

Among teens, a nap duration of ≤ 20 minutes indicates good sleep quality. Among young adults, adults, and older adults, a nap duration >100 minutes (ie, 101–120 or >120 minutes) does not indicate good sleep quality. For teens, a nap duration >120 minutes does not indicate good sleep quality (Fig. 11).

Nap frequency

Among teens and young adults, napping 0 days per week indicates good sleep quality. Among school-aged children, napping 3 or more days per week does not indicate good sleep quality (Fig. 12).

Discussion

In the judgment of the consensus panel, sleep continuity measures contribute to sleep quality indicators at most ages. Shorter sleep latencies, fewer awakenings, and reduced wake after sleep

Inappropriate
 Uncertain
 Appropriate







AGE CATEGORY	WAKE AFTER SLEEP ONSET						
	≤10 MINS	11-20 MINS	21-30 MINS	31-40 MINS	41-50 MINS	51-60 MINS	61+ MINS
 PRE-SCHOOLERS							
 SCHOOL-AGED CHILDREN							
 TEENS							
 YOUNG ADULTS							
 ADULTS							
 OLDER ADULTS							

Fig. 4. Expert consensus regarding wake after sleep onset across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4-6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1-3).

onset were viewed as indicators of good sleep quality, regardless of age. Similarly, higher sleep efficiency indicates good sleep quality across all age groups, and lower sleep efficiency indicates poor sleep. In aggregate, these findings are consistent with past epidemiologic and meta-analytic findings.⁴

Results regarding sleep architecture and naps were less consistent. There was disagreement (ie, 80% consensus was not reached) regarding many indicators due to a paucity of epidemiologic data among healthy individuals in particular age groups. Nonetheless, 2 consensus findings regarding sleep architecture warrant consideration. First, among young adults, adults, and older adults, there was agreement that elevated REM sleep (ie, $\geq 41\%$) does not indicate good sleep quality. Second, in all age groups except older adults, there was agreement that reduced N3 sleep (ie, $\leq 5\%$) does not indicate good sleep quality. From a public health perspective, these findings address common misperceptions, namely, that more REM sleep is always better.

Regarding naps, fewer naps per 24 hours generally indicate good sleep quality, and more naps per 24 hours do not indicate good sleep quality. Over the life-span, longer naps do not indicate good sleep.

Although the SQCP has taken an important step forward, the following limitations should be noted when considering our results.

1. Some indicators of good sleep quality might be relative rather than absolute. Many panelists agreed that unlike sleep

pathophysiology that defines a disorder when it reaches diagnostic criteria, sleep architecture variables might be better considered in relation to one another rather than individually. A sleep-architecture composite measure indexing pattern normalcy might prove more appropriate for determining sleep quality. Available literature mainly tests sleep architecture variables separately; consequently, the panel was unable to address this issue.

2. Sleep changes as we age, and there are no universally accepted delineations of age category or developmental stage. Furthermore, sleep quality also varies between men and women, with sex-dependent changes across the life-span. Thus, the definition of adults in this analysis included men as well as both premenopausal and postmenopausal women. The current project used age cutoffs to parallel those used in defining optimal sleep duration across the life-span.²
3. Techniques used in sleep quality studies vary widely. For example, objective sleep measures determined by polysomnography may differ from those derived from actigraphy. It is unclear to what extent these inconsistencies influenced the decision making.
4. With respect to napping and sleep quality, the literature does not consistently differentiate between planned and unplanned naps. Consequently, the SQCP was unable to adequately address this important question.

Inappropriate
 Uncertain
 Appropriate









AGE CATEGORY		SLEEP EFFICIENCY				
		≥95%	85–94%	75–84%	65–74%	≤64%
	INFANTS					
	TODDLERS					
	PRE-SCHOOLERS					
	SCHOOL-AGED CHILDREN					
	TEENS					
	YOUNG ADULTS					
	ADULTS					
	OLDER ADULTS					

Fig. 5. Expert consensus regarding sleep efficiency across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7–9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4–6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1–3).

5. Sleep undergoes seasonal changes. Some of these rhythm variations stem from changes in light exposure and are complicated by the geographic latitude in which an individual resides. Other variations related to schedule alterations are related to school or work.
6. Research measures of sleep quality, such as slow wave power, were not considered here. Although valuable for certain scientific applications, such measures were judged to provide limited insight for the home setting of the general population.

The current results suggest a number of practical and research applications. Our findings highlight the multidimensional nature and complexity of sleep quality. During deliberations, it became clear that scientific literature gaps frequently prevented consensus. These gaps need to be filled by future

research. Key among these is advancing understanding of sleep architecture as an indicator of sleep quality. Finally, enhanced assessment of sleep quality is essential to ensure consistency across measures. For example, although panelists agreed that ≥ 41 minutes of wake after sleep onset does not indicate good sleep quality at most ages, panelists also agreed that 4 or more awakenings of ≥ 5 minutes (ie, ≥ 20 minutes total) do not indicate good sleep quality at most ages. Future research should consider the following:

- Systematically exploring the relationship between subjective sleep quality (and/or sleep satisfaction) and objective sleep measures in different age groups
- Further evaluation of sleep microarchitectural indices associated with sleep quality
- Developing and testing composite measures for sleep quality

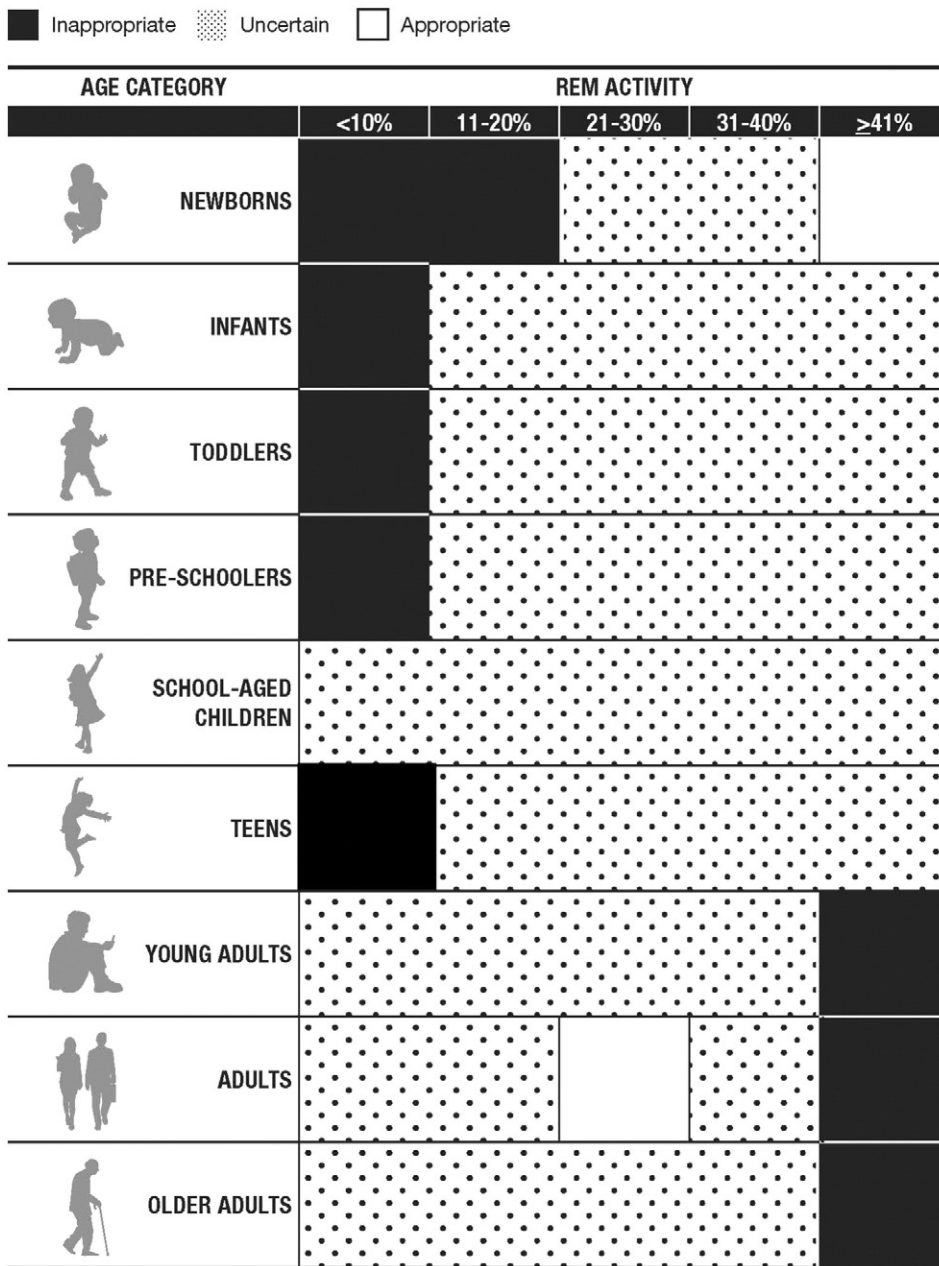


Fig. 6. Expert consensus regarding REM sleep across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, ≥80% of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, ≥80% of votes were 4-6 or ≥20% of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, ≥80% of votes were 1-3).

- Identifying good sleep quality's protective role in maintaining overall health and well-being

Scientists make decisions and recommendations based on best available evidence. The RAND/UCLA Appropriateness Method provides a technique for systematically analyzing experts' interpretations of extant research. This process enables conclusions to be reached even when evidence-based medicine⁵ methods fall short. In the current project, expert panelists advanced our understanding of "sleep quality" by reviewing the literature, deliberating, and voting on the appropriateness of specific indicators of good sleep quality in otherwise healthy individuals.

Disclosures

EMW has moderated noncommercial scientific discussion for Merck and is an equity shareholder in WellTap.
 YD has received funds for seminars, board engagements, and travel to conferences by UCB Pharma, Jazz, GSK, Flamel, Theranexus, and Bioprojet.
 NH has served as a consultant for the Society of Research in Human Development.
 KL has served on an advisory board for Merck.
 The National Sleep Foundation, a 501(c)3 charitable and scientific organization, was the sole funder of this study.
 All other authors have no disclosures.

Inappropriate
 Uncertain
 Appropriate








AGE CATEGORY		N1 SLEEP				
		≤5%	6-10%	11-15%	16-20%	20-25%
	TODDLERS					
	PRE-SCHOOLERS					
	SCHOOL-AGED CHILDREN					
	TEENS					
	YOUNG ADULTS					
	ADULTS					
	OLDER ADULTS					

Fig. 7. Expert consensus regarding N1 sleep across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, ≥80% of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, ≥80% of votes were 4-6 or ≥20% of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, ≥80% of votes were 1-3).

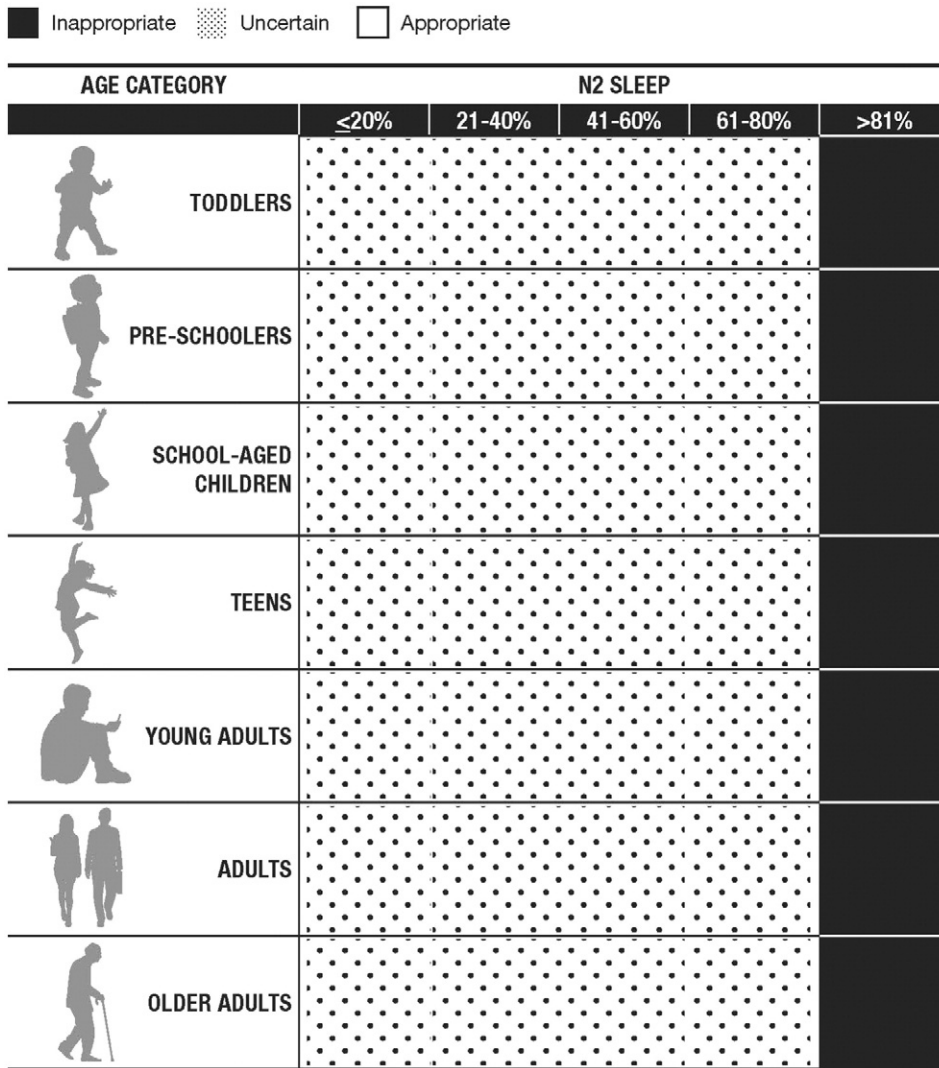


Fig. 8. Expert consensus regarding N2 sleep across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4-6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1-3).

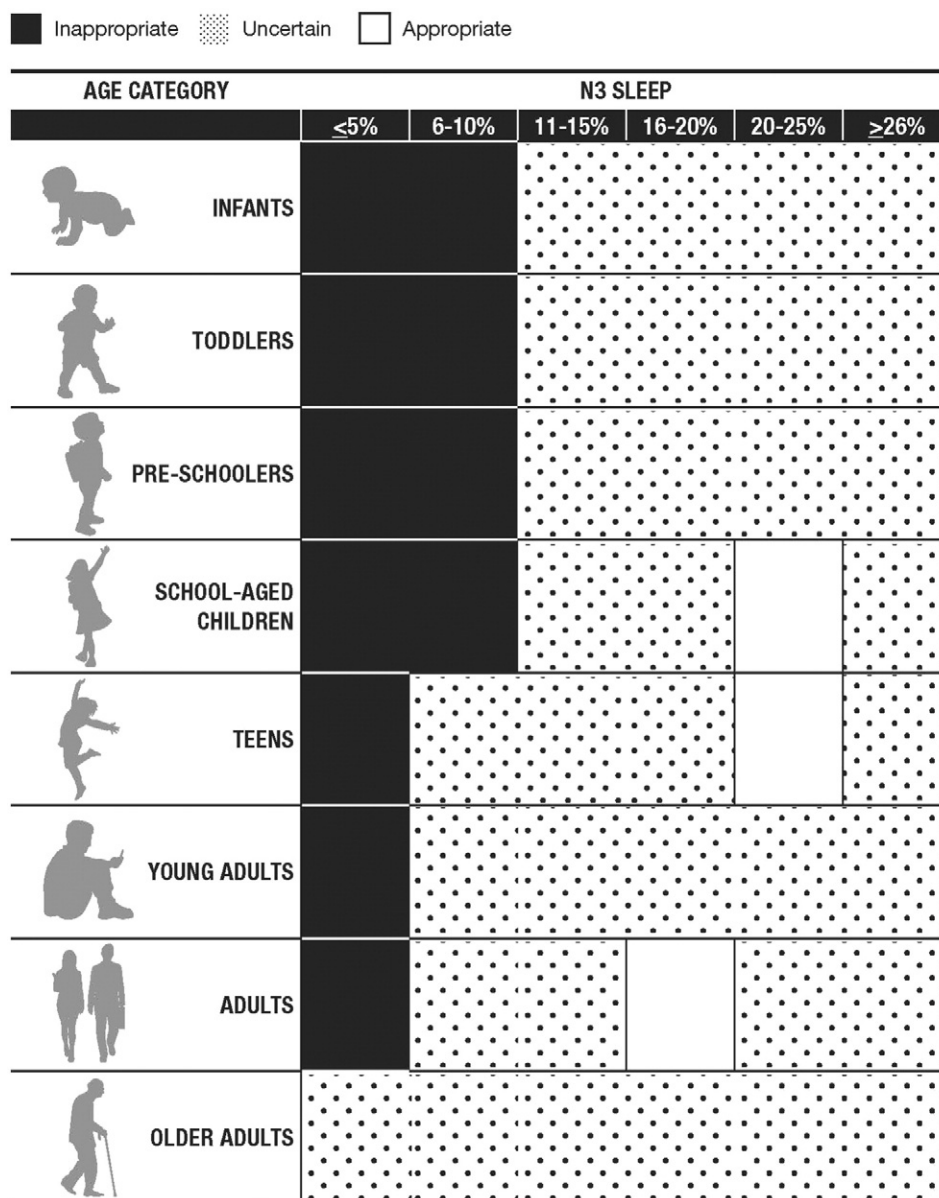


Fig. 9. Expert consensus regarding N3 sleep across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, $\geq 80\%$ of votes were 4-6 or $\geq 20\%$ of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, $\geq 80\%$ of votes were 1-3).

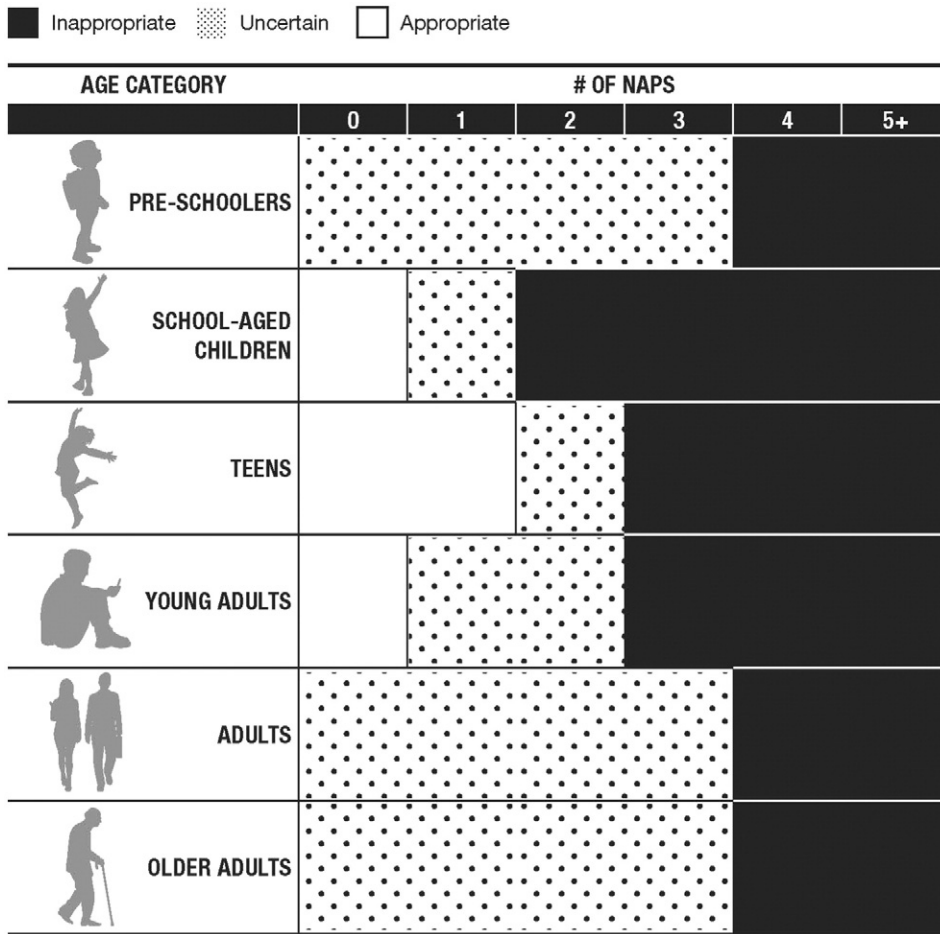


Fig. 10. Expert consensus regarding number of naps per 24 hours across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, ≥80% of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, ≥80% of votes were 4-6 or ≥20% of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, ≥80% of votes were 1-3).

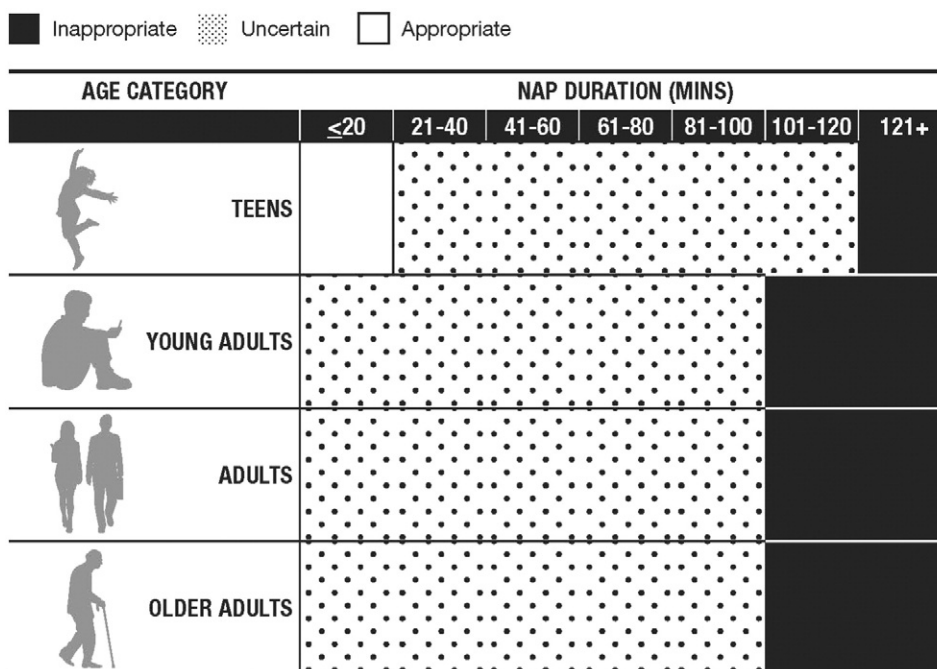


Fig. 11. Expert consensus regarding nap duration across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, ≥80% of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, ≥80% of votes were 4-6 or ≥20% of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, ≥80% of votes were 1-3).

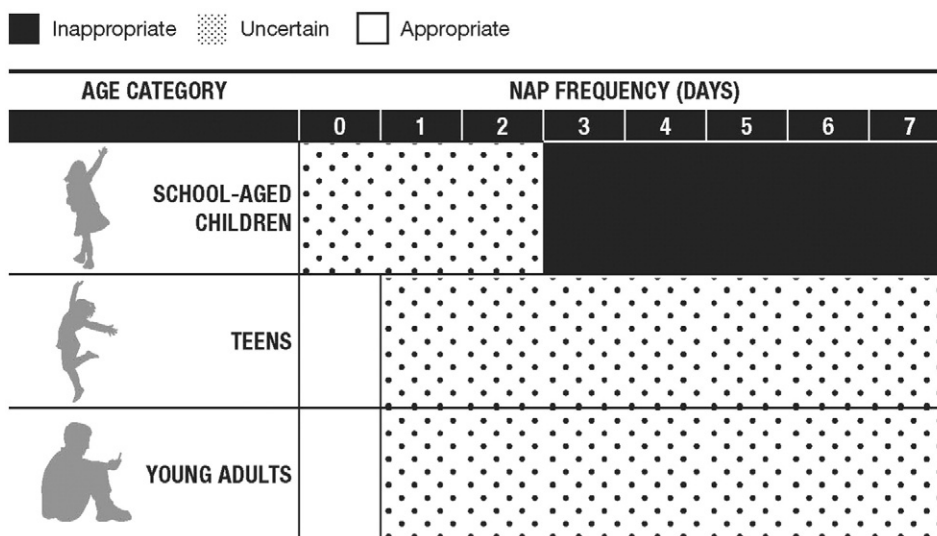


Fig. 12. Expert consensus regarding nap frequency (number of naps per week) across the life-span. White indicates that panelists agreed that this measure was an appropriate indicator of good sleep quality (ie, ≥80% of votes were 7-9). Dots indicate that panelists were uncertain or there was disagreement (ie, ≥80% of votes were 4-6 or ≥20% of votes fell outside any 3-point range). Black indicates that panelists agreed that this measure was not an appropriate indicator of good sleep quality (ie, ≥80% of votes were 1-3).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.sleh.2016.11.006>.

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