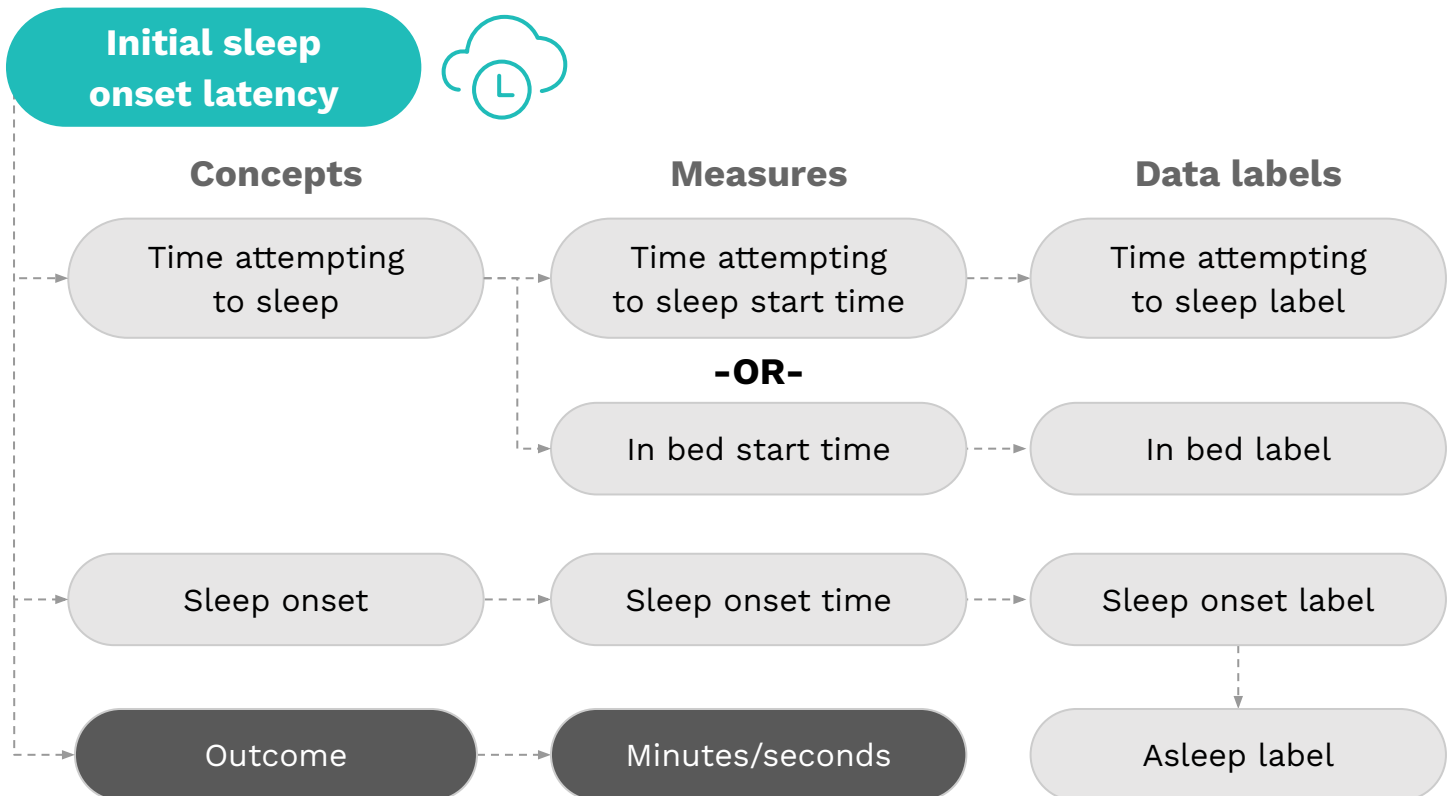
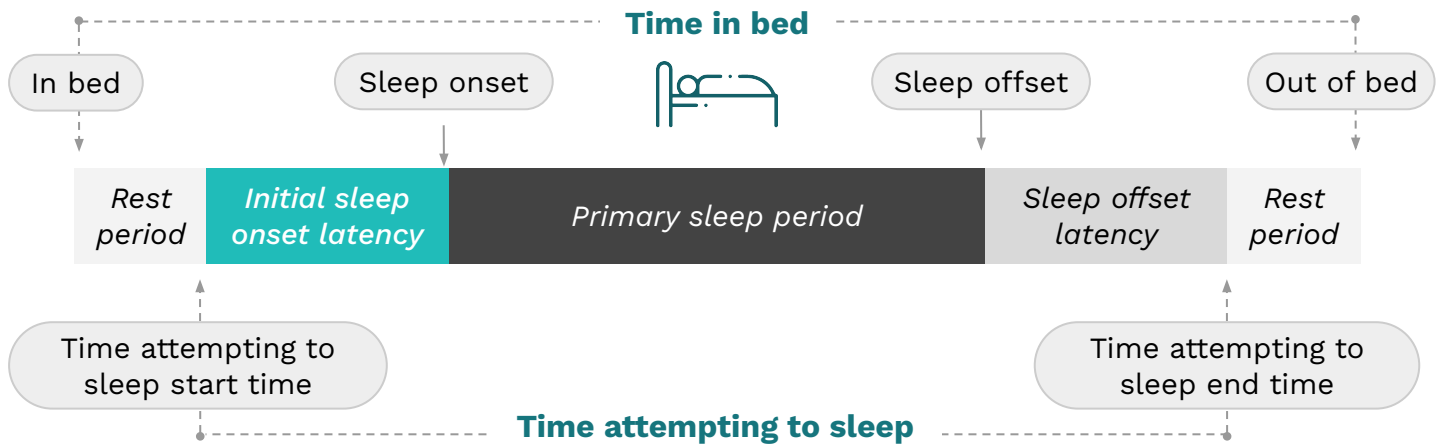


Core Digital Measure of Sleep: Initial sleep onset latency (Duration)

Also known as Sleep onset latency
Type: Duration of time

Definition: Duration of time an individual takes to first achieve sleep after intending to sleep



Measure considerations

Importance: Time it takes someone to get to sleep is an important health indicator.¹

Measure derivation: The difference between the timestamp of the start of the time attempting to sleep and the next sleep onset time.

Specification consideration: The time attempting to sleep is defined as a single primary period. Selecting confirmed sleep in the this period prevents underestimating sleep onset latency.

Optional deviations: Assumes a *measure* or *inference* of an individual's intention to sleep.

- In bed start time can be used as a proxy for time attempting to sleep start time (strong assumption).
- Likely several points at which an individual is recorded as getting into bed, e.g., using the bathroom. Rules for selection and justification necessary.
- For example, selecting the initial timestamp of the longest uninterrupted series of epochs with an in bed label may be an appropriate strategy.

Sleep onset label

Description

An epoch where the individual transitions from being awake to being asleep.

Label definition

A label for the first epoch in a series of epochs with an asleep label=1 that follow a series of epochs with asleep label=0. The valid minimum length of each series must be specified.

For example, a valid minimum length could be ten 30-second epochs of sleep (5 minutes in total). In this case, where sleep is registered for at least than ten consecutive epochs, the first epoch in the series would be awarded the sleep onset label. If a series of epochs is registered for less than ten consecutive epochs, no sleep onset label would be awarded.

Why is this important?

Not all sleep epochs represent a confirmed sleeping bout. Describing, evidencing, and confirming a minimum detected sleep time prior to denoting sleep onset allows for more sensitive sleep measurement.

The sleep onset label can be used to define when individuals achieve sleep and used in conjunction with other parameters to derive important metrics, such as the time it takes for an individual to fall asleep.

Sleep onset time

Variable definition

The **timestamp** associated with a sleep onset label.

Asleep label

Description

“Asleep” is a state consisting of a union of REM and the N1-N3 stages of sleep. A state of sleep can be detected in multiple ways, through changes in brain activity, body motion, respiration, heart rate, etc.

Label definition

A label for each epoch denoting when an individual is recorded to be asleep. The parameters or algorithms for detecting sleep should be clearly defined or referenced.

Alternatively, the asleep label can be defined as the presence of any of: light sleep, deep sleep, REM sleep, and N1, N2, N3 and REM labels presented in the Core Measures Sleep System, where these are collected by the selected technology.

Why is this important?

Detecting and evidencing the detection of sleep is integral to the interpretation of all core digital measures of sleep.

Time attempting to sleep label

Type: Status label

Description

Epochs covering the primary period of time where the individual intends to sleep.

Label definition

A label for each epoch between the point at which the individual intends to start sleeping to the point which the individual intends to stop sleeping.

The intention to start and end sleep could be provided by user input or detected by an algorithm. The parameters or algorithms for detecting the individual’s intention to sleep should be clearly defined or referenced.

Why is this important?

The inclusion of intention is difficult for measurement, as it is non-observable and must be inferred or reported. However, intention is important for distinguishing between epochs that record quiet restfulness (e.g., lying in bed reading) from the active process of trying to achieve sleep. Distinguishing between the two will lead to more sensitive measurement of sleep parameters.

Derived variables

Time attempting to sleep start time

Variable definition

The **timestamp** of the first epoch with the time attempting to sleep label.

Time attempting to sleep end time

Variable definition

The **timestamp** of the final epoch with the time attempting to sleep label.

Time attempting to sleep duration

Definition: A **time duration (seconds)** calculated as the difference between the time attempting to sleep start and end times.

In bed label

Type: Status label

Description

Epochs covering all periods where the individual is in bed.

Label definition

A label for each epoch denoting when an individual is recorded to be in bed. The state of being in bed could be provided by user input, but is likely detected by an algorithm. The parameters or algorithms for detecting that the individual is in bed should be clearly defined or referenced.

Why is this important?

Being in bed does not necessarily mean that the individual has the intention to sleep (see time attempting to sleep label) or is asleep (see sleep staging labels). However, in cases where the intention to sleep is not collected, the in bed label can be used as a less precise default or proxy.

The in bed label also records instances of leaving bed during the **primary sleep period**, which could be useful for some research questions.

Derived variables

Primary in bed start time

Variable definition

The **timestamp** of the first epoch with the first in bed label.

Primary in bed end time

Variable definition

The **timestamp** of the final epoch with the in bed label.

These data must be in line with user-provided parameters for defining which epoch represents the primary in bed start time, accounting for the individual potentially entering and leaving bed multiple times.

In bed duration

Definition: A **time duration (seconds)** calculated as the difference between the primary in bed start and end times.

References

1. Siddiquee, A. T., Lee, S. K., Kim, S., Lee, M. H., Kim, H. J., & Shin, C. (2023). All-cause and major-cause mortality associated with sleep latency in the Korean Genome and Epidemiology Study (KoGES): a population-based prospective cohort study. *The Lancet Healthy Longevity*, 4(7), e316-e325.