Contents

The billion dollar dream
  The economic impact of sleep deprivation

Growth in sleep-driven innovations
  Tackling the "sleep problem" with soft and hard solutions
  Differential approaches to sleep: An east-west dichotomy?
  Overall, China and the U.S. dominate the market
  In the East, herbals and manufacturing hubs are blossoming

Popping pills? North America shows preference for medicated aids
  Pharma takes center-stage of hard-solutions
  Electronic and medical device players take lead on soft solutions?
  Bridging the gap with global partnerships
  Going to the mattresses: a closer look at litigation
  In conclusion

References
How do you sleep at night? It seems like a pertinent question in the time of a pandemic. As national governments employ isolation measures to protect public health, the world has invariably changed for all of us. The current pandemic has not only resulted in wide-spread disruptions to regular life, it has caused serious disruptions to our sleep.

Throughout human history, renowned scholars from Aristotle¹ to Freud² have been perplexed by the enigma of sleep. However, it is only in the last decade or so that the importance of sleep has made its way from a topic of research to a fixture of our collective conscience.

Nonetheless, its biological purpose remains a mystery. Every night, we undergo a significant transformation: we leave waking consciousness for a few hours and transverse into the land of dreams. After, we have almost no recollection of the time that just passed and rarely ever comprehend what it is like to be asleep when we are. Everyone needs to sleep but understanding why we sleep has proved a difficult question to answer.

Scientific journals referencing sleep and epidemiology

![Graph showing the increase in scientific journals referencing sleep and epidemiology from 1950 to 2030](source: PubMed)
Every night, we undergo several physiological changes that involve almost every tissue and system within our bodies, with quality, duration and consistency of sleep all playing a vital role in our health and well-being. Nothing underscores the importance of sleep more than the academic interest in the lack of it, also known as sleep deprivation.

There are several reasons why our interest in sleep is at an all-time high:

- **Sleep problems are associated with accidents and human errors**: By the end of 2020 the number of people killed in motor-vehicle crashes is expected to double to 2.3 million deaths worldwide, of which approximately 230,000–345,000 will be due to sleepiness or fatigue.

- **Sleep problems are common**: The National Sleep Foundation recommends seven to eight hours of sleep for people over age 64 and seven to nine hours for ages 18 to 64. Nearly 50% of us sleep less than these recommendations. In fact, more than 75 percent of Americans between ages 20 and 59 report having sleeping difficulties regularly.

- **Sleep problems are likely to increase**: In a world filled with constant cognitive stimulation from electronic devices, there are numerous anecdotal reports that indicate that technology prevents us from getting adequate sleep.

- **Sleep problems are associated with short- and long-term effects on our health and well-being**: There is evidence to suggest that a chronic lack of sleep, and poor quality of sleep, increase the risk of disorders, including high blood pressure, cardiovascular disease, Type 2 Diabetes, depression, and obesity. A 2018 study highlighted that losing just one night of sleep led to an increase in beta-amyloid, a protein in the brain associated with impaired brain function and Alzheimer’s disease. The results suggest that sleep deprivation may increase the risk for beta-amyloid build-up.
The economic impact of sleep deprivation

The cumulative effects of getting less sleep could be compromising more than just individual health and well-being. There’s evidence that suggests an unavoidable impact on our economy. According to Rand Corporation, the U.S. loses the equivalent of 1.2 million working days per year due to people not getting enough sleep. Therefore, if everyone in the US who sleeps fewer than six hours a night got between six and seven hours of sleep, there would be a $226.4 billion boost to the economy. That’s roughly the same as the gross domestic product of the entire country of Peru.

“If everyone in the US who sleeps fewer than six hours a night got between six and seven hours of sleep, there would be a $226.4 billion boost to the economy.”
Source: << Matt McLean / Sleep Cycle / IMF / The Economist>>
Sleep is everywhere, and healthcare professionals are constantly reinforcing how much we need it. To some extent, lack of sleep has become the culprit for all life’s problems. In Matthew Walker’s Why We Sleep, a good night’s sleep is the key to becoming cleverer, more attractive, slimmer, happier and heathier, while warding off cancer. With most of us getting less sleep than we should, it’s no surprise that increased recognition in the field of medicine has created an adjacent market for solving the ‘problem’ of sleep. Collectively, the sleep industry is estimated to be worth between $80-$100 bn globally. By 2021, the global market for sleep aids and technologies is expected to rise at a compound annual growth rate (CAGR) of 5.1% year over year.

There appears to be four primary factors contributing to the growth of the sleep industry globally:

- The rising age of the population
- Growing rate of obesity globally
- Changing lifestyles
- An increased number of individual populations suffering from mental disorders coupled with a growing awareness in the treatment of sleep

Using patents as a proxy for innovation, the sleep industry has grown exponentially in the last 10 years and is now entering a period of modest, but robust growth.
Tackling the “sleep problem” with soft and hard solutions

The diversity of technology in the sleep ecosystem reflects the increasing number of established sleep problems and the overall desire for improved quality, quantity and sleep experience. In fact, WebMD now suggests “there are more than 85 recognized sleep disorders”14 from insomnia to sleep apnea. Based on patents, two distinct categories of solutions have emerged, which we have classified as “hard” and “soft” solutions.

“Hard” solutions are anything that is ingested by the end-user with the aim of alleviating a sleeping condition; this includes medicinal remedies or herbal consumables in the form of pills, powders, drinks, concentrates, emulsions or any other forms. By contrast, a “soft” solution is anything that is not ingested by the end-user. Soft solutions address sleep deficiency through innovation in apps, wearable technology (like fitness trackers), smart beds/pillows/mattresses and other wearables, external monitors that make the bedroom part of the internet of things (IoT), and devices meant to optimize the sleep environment by regulating light, noise, temperature, and humidity.

Patent filing trends related to sleep innovation suggest that the overall market is slowly rising. The below graph shows that annual patent filings for both hard and soft solutions have grown year over year from 2010 to 2015. Although the number of annual patents filed dropped slightly in 2015, overall patent filings continued a steady upward trajectory for subsequent years. It’s important to note the 18-month lag between submitting a patent application and having that application published which leads to a ‘gap’ in data. For this reason, measuring growth in the industry relative to patent filings is determined by priority, filing and grant rates.
The rise in patent filing trends from 2013 to 2017 correlates with investment from many companies in the development of sleep monitoring technologies combined with increased consumer appetite for products to help overcome sleep disorders. The current patent filing behaviours of companies like Xiaomi, Samsung, Google, Apple, Fitbit, Philips, Panasonic, and Bose suggest that they are continuing to actively invest in wearable technology focused on analyzing sleep patterns, irregularities and other essential parameters. For this reason, the sleep tech sector will likely continue to see an increase in the development of advanced technologies.

By further examining annual patent filings since 2013, sleep-related innovation appears to be rising at a greater rate in the category of soft solutions. With an increase in the awareness of sleep problems and the adoption of tech devices that help monitor sleep deprivation, the sleep tech devices segment has seen a major boost.

When looking at the CAGR of the soft solution segment from a market growth perspective (a growth of up to 16% is expected from 2018 to 2025) and the CAGR of the soft solution segment from a patent filing perspective (3.67% when considering the patents filed from 2010 to 2018), both suggest that it’s an area worthy of investment. A steeper CAGR in the innovation of soft vs. hard solutions is understandable as many people are often wary of turning to hard solutions first (drugs and medicinal remedies) to address sleep deprivation.

The below table showcases the top five categories of hard and soft solutions based on the total number of patents filed. The number of patents filed illustrates that these 5 categories are the highest saturated classes of patents. For new entrants to the sleep industry or those who are looking to innovate in these domains, these categories are likely to have the greatest opportunities for licensing and partnership.
Differential approaches to sleep: An East-West dichotomy?

While data points towards sleep as a global issue, there’s a complicated set of biological, social and cultural factors that influence our attitudes towards sleep. For example, prior to the industrial revolution, sleep was widely practiced in biphasic cycles or “shifts” to allow more time for chores, prayers and other activities during the night. This explains why siestas are common practice in certain cultures and why inemuri is an accepted practice in the offices of Tokyo rather than London. Subtle differences in the ideology of sleep and its meaning ultimately dictate how we treat sleep problems. While it’s important to not overgeneralize, there is evidence to support differential approaches to sleep treatments and innovations between regions. There appears to be a higher volume of soft solution innovations filed in the East vs. the West, particularly related to sleep tech devices.

“There appears to be a higher volume of soft solution innovations filed in the East vs. the West, particularly related to sleep tech devices.”
Overall, China and the U.S. dominate the market

The U.S. market alone was estimated to be valued at just under $30 bn in 2018, and is one of the dominant and leading regions for revenue with a focus on sleep, sleep disorders and insomnia. Concurrently, the Asia-Pacific (APAC) market is estimated to be the fastest growing region in terms of revenue related to sleep disorders. Lucrative opportunities are likely to come out of the APAC region due to a growing awareness of sleep disorders and continued investment in healthcare infrastructure.

Comparing solutions by geography

Both North America and Asia-Pacific regions show promise when it comes to the market potential of sleep-related technologies and innovations. China and the U.S. are dominating these two regions, with China maintaining the largest patent protection relative to other countries. Although it looks like the hard solutions sector dominates certain regions of the world, annual growth in patent filings suggest that soft solutions are the primary focus of investment and an area of growth in the sleep deprivation industry.

In further reviewing the distribution of patent filings of the top 2 patent filers globally, both the East (China) and West (United States) are showing more significant innovation and investment in soft solutions.
In the East, herbals and manufacturing hubs are blossoming

In reviewing the patent filings for hard solutions, approximately 22% of all hard solution patents are herbal solutions. 99.4% of these are Chinese patents, with the remainder filed in Taiwan, South Korea, Japan and Turkey. Application and publication trend graphs from PatSnap’s platform show a rapid increase in herbal solutions patents from 2010-2015, coinciding with increased investment in these areas.

Countries such as China, Japan, and Korea are becoming manufacturing hotspots for the sleep market. This may be due to increased demand for sleep products in these markets relative to the population size, in addition to these being ideal locations for manufacturing based on labor costs, industrial scalability, effective sourcing of raw materials, tax incentives and existing manufacturing capabilities.
People have used substances to aid sleep for as long as recorded history. It’s perhaps no surprise that hypnotic drugs have their epidemiological origins in Hypons, the Greek god of sleep, and that morphine has taken its lead from Morpeus, the god of dreams. Developments in medicine and psychiatry have since disproven the effectiveness of opioids and alcohol in treating sleep disorders and their addictiveness has been well-documented. There are now various classes of sedative-hypnotics including benzodiazepines, barbiturates, agonists, and other miscellaneous drugs. Flurazepam was the first benzo-derivative marketed for sleep in 1970, and within two-years, it become the most widely prescribed sleeping pill. However, over the course of 10 years, the popularity of these drugs declined in favour of another type of drug- the ‘Z drug’. Commonly known as the Z Drugs -zolpidem and zopiclone- held the promise of having less adverse effects and being less addictive. These drugs work by facilitating the action of the inhibitory neurotransmitter GABA. As American psychiatrist Wallace B Mendelson, MD explains:

“in subsequent years, new compounds have been developed which function by different mechanisms. Among these are ramelteon, which acts by binding to receptors for the hormone melatonin; suvorexant, which blocks the arousal neurotransmitters known as orexins; and doxepin, actually a new use for low doses of an older tricyclic antidepressant.”

In America there appears to be predilection for prescription medication. More than 50% of Americans take prescription medication and many take over-the-counter drugs in addition to that. Based on patent innovations, it appears that the market for hard solutions including sleep medications, is no exception. The American, Canadian and Australian jurisdictions have primarily innovated and filed drug patents for sleep disorders related to the nervous system (or targeting the nervous systems).
Pharma takes center-stage of hard-solutions

The top assignees in the development of hard solutions are predominantly Western-based companies. The top 3 innovators in the space, Merck, Hoffman La-Roche and Sanofi, focus primarily on hard solutions geared towards developing modulators, antagonist receptors, and other chemical agents to combat sleep irregularities like difficulty falling asleep, staying asleep, etc. Not surprisingly, the patent filing trend shows that some of the traditional players in the pharmaceutical industry like Janssen Pharmaceutical, Pfizer and Bayer are also strong players in this area.

More recently, however, the medicated pendulum appears to have swung in the opposite direction as increasing awareness of the adverse effects of medication may have curbed the preference for hard solutions. In fact, in 2012, a large US study hit the headlines for finding a reported four-fold increased risk of death among users of drugs medically known as hypnotics. Although no significant association was found in the study, this raised public concern about hard solutions. Market research also tends to suggest that there has been significant adoption of sleep tech devices in the U.S. and thus appears to be a lucrative region to file patents for these types of innovations as well. In fact, in the sleep tech devices market, revenue is expected to achieve over 16% CAGR up to 2025 and is forecasted to surpass 27 billion USD by 2025.
The rise in soft solutions has led to an increase in incentive programs to get more sleep. A Bloomberg report revealed that employees at Crazy Inc would be rewarded for sleeping six hours a night at least five days a week, an initiative by founder Kazuhiko Moriyama; the points can be swapped for food in the company cafeteria worth as much as 64,000 yen ($570) per year. Their sleep can be tracked by using an app made by Airweave Inc., a mattress manufacturer.

Japan, chronically known as the ‘sleep deprived-nation’ has seen government-backed incentives for companies developing solutions for overcoming insomnia and other sleep disorders. The crisis around karoshi (the Japanese term for death from overwork as a result of sleep deprivation) has created a sense of urgency among companies and governments to do something about it. Market research suggests that consumers in Korea are also spending more than ever before on products like; smart bed sheets, pillows and lighting equipment that will help them get a “good night’s sleep”.

“Japan, chronically known as the ‘sleep deprived-nation’ has seen government-backed incentives for companies developing solutions for overcoming insomnia and other sleep disorders.”
Electronic and medical device players take lead on soft solutions

The top assignees in the innovation of soft solutions are ResMed and Philips. They both own over 1% of the total market share across all soft solutions. ResMed primarily focuses on respiratory masks which treat sleep disorders, whereas Philips has a diversified portfolio ranging from sophisticated lighting solutions for circadian rhythm control/management, and methods for monitoring and measuring sleep metrics and respiratory devices to treat sleeping disorders. Outside of these two top companies who hold the greatest proportion of patents in the soft solutions space, except for Cardiac Pacemakers Inc, the remainder of the top patent assignees for soft solutions are Eastern located companies. This is likely due to Eastern countries and companies being traditionally known as manufacturing hubs globally. Other assignees in this space are from a variety of industries specializing in consumer electronics, telecommunications and digital data.

Furthermore, evaluation of the total innovation in the sleep industry shows that a greater number of unique assignees have patented in the field of soft solutions in comparison to hard solutions from 2010 onwards. (Approx 8.8K vs 5.7K) This is likely due to the high level of technical expertise needed to patent pharma whereas soft solutions tends to have a lower barrier to entry in terms of R&D investment and legal regulatory board, and therefore has a greater number of unique assignees patenting different kinds of solutions.
The tables below also identify the emerging players who have filed their first patent from 2017 onwards in the categories of both hard and soft solutions. Interestingly, emerging players in both hard and soft solutions are dominated by pharmaceutical and therapeutic companies.

### Emerging players – Hard solutions

<table>
<thead>
<tr>
<th>New Entrant</th>
<th>Focus</th>
<th>Solution Examples</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeida Therapeutics</td>
<td>Therapeutic Medicinal Cannabis</td>
<td>Cannabis medicines to cure sleep disorders</td>
<td>22</td>
</tr>
<tr>
<td>Operations Pty Ltd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCI Co. Ltd</td>
<td>Biotechnology</td>
<td>Herbal Extracts for improving and facilitating sleep</td>
<td>22</td>
</tr>
<tr>
<td>Receptor Holdings Inc</td>
<td>Biopharmaceuticals, Cannabinoid</td>
<td>Synthetic cannabinoid-based medicines</td>
<td>20</td>
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<tr>
<td></td>
<td>Medicines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ojai Energetics</td>
<td>Cannabinoid based products</td>
<td>Cannabis medicines to cure sleep disorders</td>
<td>20</td>
</tr>
<tr>
<td>Enterin Inc</td>
<td>Biomedical</td>
<td>Aminosterol based solutions</td>
<td>15</td>
</tr>
<tr>
<td>Molecular Infusions</td>
<td>Medical Cannabis</td>
<td>Medicinal Cannabinoid based solutions</td>
<td>9</td>
</tr>
<tr>
<td>Indena</td>
<td>Pharmaceutical</td>
<td>Essential oils-based solutions</td>
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</table>

### Emerging players – Soft solutions

<table>
<thead>
<tr>
<th>New Entrant</th>
<th>Focus</th>
<th>Solution Examples</th>
<th>Patent Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yuxin Intelligent Technology Shanghai Co., Ltd.</td>
<td>Only public information is that it’s located in China.</td>
<td>Healthy sleep beds, pillows, mattress</td>
<td>41</td>
</tr>
<tr>
<td>SHENZHEN H&amp;T DATA RESOURCES &amp; CLOUD TECH LTD</td>
<td>Electronic Components</td>
<td>Intelligent Sleep Systems/Devices, Smart Home Devices</td>
<td>38</td>
</tr>
<tr>
<td>Hefei Slip Medical Technology Development Co., Ltd</td>
<td>Medical Device</td>
<td>Beds, Relaxation Devices, Light Control Devices/Systems, Sleep Quality Detection Systems</td>
<td>27</td>
</tr>
<tr>
<td>EDISON LABS INC</td>
<td>Smart Home</td>
<td>Smart Home Solutions</td>
<td>26</td>
</tr>
<tr>
<td>Su Mian Innovation Technology Shenzhen Co., Ltd.</td>
<td>Insomnia Treatment</td>
<td>Sleep inducing and monitoring devices</td>
<td>15</td>
</tr>
<tr>
<td>ID Bed Co., Ltd.</td>
<td>Smart and IoT Mattresses</td>
<td>Smart Mattress</td>
<td>14</td>
</tr>
<tr>
<td>Shenzhen Jialai Zhijia Technology Co., Ltd.</td>
<td>LED Lighting</td>
<td>Mattresses based on IoT</td>
<td>14</td>
</tr>
</tbody>
</table>
Bridging the gap with global partnerships

Evidenced through multiple assignees being listed on patents, there exist a few notable cross-industry participants. Reviewing the total patents that exist in both hard and soft solutions, there are currently 455 licensee agreements for soft solutions and 729 license deals for hard solutions, in which joint assignees are listed.

Amongst the top assignees, there is a greater number of patents with joint assignees listed for hard solutions than for soft solutions. Across both solutions, Western companies are showing a greater collaboration on patenting their inventions than Eastern companies, however there are few assignee partnerships amongst the top Eastern filers of soft solutions.

Most notably, there are some interesting signs of partnerships between Eastern and Western corporations, particularly in the Pharma industry. In the category of hard solutions, there exist several corporate partnerships. Abbvie have several partnerships with Calico Life Sci LLC for modulators and a few other notable joint-assignee partnerships exist between Boehringer Ingelheim Int with Hydra Biosci LLC and Curevac and Hoffman- La Roche with Prothena Biosci which are solutions innovating in xanthine derivatives, RNA vaccine and immune checkpoint inhibitors for the treatment of fatal familial insomnia and treatment of REM Sleep behaviour disorders. Additionally, two other prominent corporate partnerships between East and West exist between Takeda Pharmaceutical Company, a Japanese pharma and biopharma company, and the largest pharmaceutical company in Asia, in partnerships with Intra Cellular Therapies (US) and H. H. Lundbek A/S (Danish).

For soft solutions, there are exist a few notable partnerships between companies and universities and institutes like Omron Healthcare (Japan) and Yamaguchi University, and Beijing Institute of Technology, who has partnered with the Suzhou Indal Tech Res Inst of Zhejiang University. Looking forward, the strength, investment and rapid growth of tech companies in Asia will likely continue to contribute to the rise of patenting activity for soft solutions due to the Asian-based corporations and researchers continuing to invest in this domain.
Going to the mattresses: a closer look at litigation

With the increased interest in sleep solutions, the field has also been moderately litigious. Collectively, 269 plaintiffs have sought to prosecute their patent rights. There are marginally more cases associated with hard solutions but generally the number of litigation cases between the two approaches has been relatively even. Danish pharma giant, H.Lundbeck A/S, who is among the top-filers overall, has been the most assertive plaintiff, seeking remedial action from the courts for their drug-related sleep patents. They, for example, hold exclusive rights to the eurogenic (i.e. wake promoting agent) Modiodal which is also more commonly known by its non-proprietary name Modafinil. Also litigating “hard” solutions, is VANDA pharma, who spent more than $29 million worth in TV adverts for their ‘non-24’ circadian rhythm disorder drugs, have patented these treatments and have subsequently sued MSN Pharma, Apotex Inc and Teva Pharma for infringing on several of these patents.

ResMed, the top filers in the category for soft (i.e. non-consumable) solutions to aid sleep and sleep related disorders, also have the highest number of patents which are involved in litigation; twenty-six. The vast majority of these litigations are infringement cases brought against Fisher & Paykel Healthcare Corporation, a competitor in the field of sleep masks and respiratory aids.

The relatively similar number of cases related to both types of sleep solutions could debunk the myth that heavyweight pharmaceutical companies are more likely than soft-tech companies to prosecute their patent rights; in the world of dreams, it appears there has been just as much ink spilt on drugs as there has on mattresses.
In conclusion

Growth looks promising in the sleep industry and scientific developments continue to enlighten our understanding of this complicated state of consciousnesses. Peeling back the covers will only continue to reveal the ways that our mind and body could be (psychosomatically) connected. Innovations in this field are only scratching the surface, but they do appear to be polarized both in terms of regions and approaches. Looking forward, evidence points toward connected sleep-tech generating additional revenue streams. As devices start to integrate AI, speech recognition, and more advanced analytics to become ‘smarter’, there will be an abundance of sleep meta-data that can be commercialized to enhance our lives if it is used responsibly. Imagine if we could pull sleep-data on entire countries, or governments could predict lifespan and companies could measure how many hours of shut eye we get each night? This presents its own set of ethical questions which will have to be considered. Some organizations may even be able to leverage their existing technology capabilities in the sleep industry; verticals such as medicine and technology could become increasingly blurred and partnerships resulting in the co-ownership or transfer of IP could become more commonplace. Therefore, innovators will need to ensure that proper infrastructure is in place to ensure effective collaboration. As the world turns, more off-patent generic sleep drugs will become available and will also make these products more affordable.

Despite the apparent contrast between the approaches in the East and West, the distinction remains a little blurry. Is there that much that separates a traditional herbal remedy from a novel compound created in a lab? What is more important is understanding that, while we all sleep, there are subtle nuances in the way we approach the topic. These are usually based on a complicated and deep-rooted set of social, cultural, political, economic, and historical factors. After all it is a delicate relationship; the focus should not be on measuring, reconciling or comparing the validity of innovation between East and West. Instead, the focus should be on respecting their differences and finding the synergy between them with a more holistic approach. Until then, we might just have to sleep on it.
References

6. Ibid.
18. Ibid.
26. Changes to sleep patterns naturally occur as part of the normal aging process. For older adults and aging populations, the National Sleep Foundation recommends a minimum of 7-8 hours of sleep per night, however, partnered with rising age, is an increase in the time it takes to fall asleep (sleep latency), an overall decline in REM sleep, and an increase in sleep fragmentation. Globally, the aged population is at its highest levels in human history, making a large proportion of the global population susceptible to poor or disrupted sleep.
27. Worldwide obesity has nearly tripled since 1975. Sleep is important for health of the entire body, and with global obesity rates rising, sleep has become a core foundation to proper regulation of hunger, mental health and physical health. For this reason, many sleep aids and technologies are aimed at this demographic of the population to help combat the risk factors associated with obesity such as sleep apnea, RLS, sleep disorders, bruxism, and narcolepsy.
28. Globally, people are changing their lifestyles. Work culture, environments and habits are changing with a rising preference to a more sedentary lifestyle. These changes can also have adverse effects on sleep.
29. The WHO research indicates that 1 in 4 people globally suffer from mental disorders.
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