Shift work pains and circadian solutions

A report by Arcascope

Summary

1 Introduction

1.1 Putting the worker and others at risk

Working nights does a number on the body: From increased risks of cardiovascular disease,[22] diabetes, and cancer, to excessive alcohol consumption and worsened nutrition,[6] shift work is associated with a whole host of long-term negative health effects.[11]

The risks are not limited only to the workers themselves: Many catastrophes have taken place during the night shift, including the Exxon Valdez oil spill, the Three Mile Island nuclear reactor meltdown, and the American Airlines Flight 1420 crash.[3,15,17]

What's causing these health and safety risks to shift workers? It's more than just "being sleepy." Working night shifts causes profound disruption of the body's internal circadian clock. This clock strongly promotes sleep once a day, often overlapping with the time when night shift workers are on the job.[2] For the workers themselves, this can mean feeling dangerously fatigued for some hours of their shift, then feeling better as the shift nears its end. It can also mean they find themselves unable to sleep once they're not on shift—an insomnia caused by the fact that their body is no longer sending its daily sleep-promoting signal in the hours they're able to try to sleep.[1]

1.2 A chronic experience of jet lag

This inability to sleep despite feeling tired may feel familiar. It's similar to what travelers can experience when they cross time zones: jet lag. Yet while most travelers can get over jet lag in a matter of days, shift workers are trapped in a constant, never-ending jet lag, with almost none of them adjusting to their night schedule.

There are a couple of reasons why: Shift workers often rotate between day and night shifts, or have irregular schedules that flip from one schedule to another.[14] Shift workers also have family commitments and other constraints on their time that pull them towards a day work schedule, and can cause a kind of circadian whiplash in their systems.

Many of the symptoms reported by jet lagged people are also reported by shift workers. In our own surveys with night shift workers, the most commonly cited disruptive side effects are fatigue, irritability, and the fact that their days off are spent feeling tired. These symptoms don't get better with time: While 22% of the entire population of shift workers surveyed rated the disruptiveness of shift work as the maximum 10 on a 10-point scale, among shift workers who have been working nights for at least five years, 30% gave it the most disruptive score.[1] In other words, the most senior shift workers may be some of the ones most affected by it.[23]

1.3 Shift work is here to stay

Despite the substantial drawbacks of shift work, society requires 24-7 operations to function. Workers risk their health and safety to work

1. Shift work by the numbers

74%
Moving shift workers to a better "time zone" (or phase position) reduces excessive sleepiness by 74%.[4]

43%
The percent of shift workers who respond with an 8 or higher to the question "How disruptive is working night shifts to you, on a ten point scale?"[1]

2-3x
Medical shift workers who are poor sleepers are 2-3 times more likely to report feeling depressed than colleagues who are able to sleep in long, uninterrupted bursts.[12]

2.7x
Depressed medical shift workers are 2.7 times times more like to say yes to "Are you concerned you have made any major medical errors in the last three months?" than non-depressed shift workers.[12]

16%
Workers on a lighting intervention report 16% less fatigue than workers on no intervention for shift work.[16]

2-4x
People following our recommendations shift 2-4x faster than they would by "slam shifting," or following the schedule most people do by default.[4,7,19]

26%
Error rates dropped to 26% of previous values when night shift workers were put on a lighting intervention.[18]

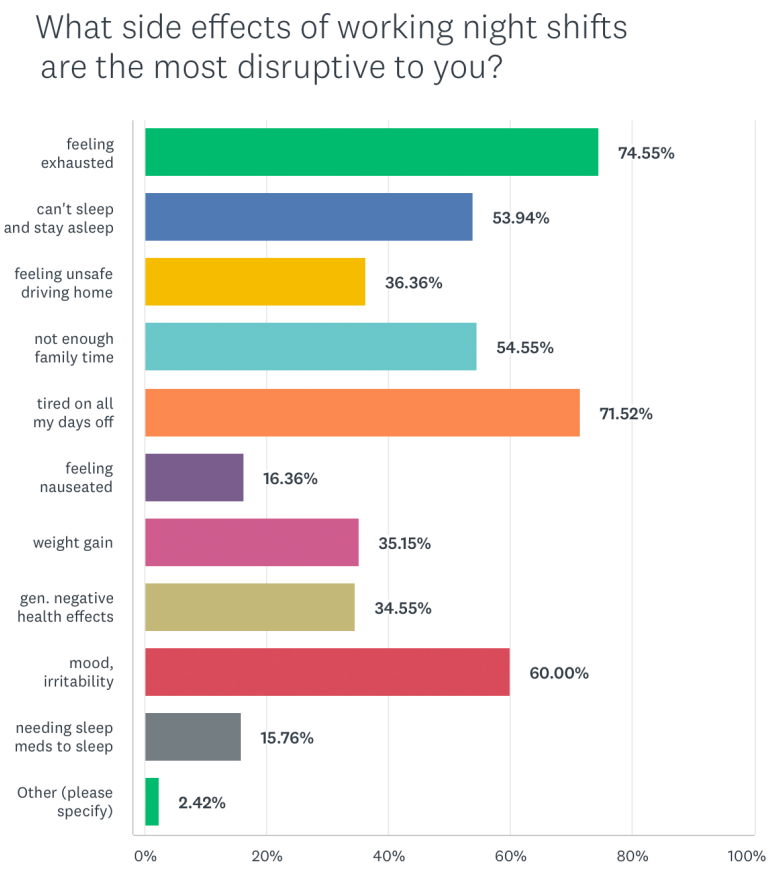


Figure 1 Most commonly cited disruptive symptoms for shift workers[1]

night shifts, but without them, essential operations like emergency response teams and hospital services would grind to a halt. But if shift work isn't stopping anytime soon, how can we help the 30 million workers in the U.S. on a non-day schedule adapt better to the demands of their job?

52%

2. Percent of shift workers who report using blackout curtains to help manage working night shifts[1]

14%

3. Percent of shift workers who report using alcohol to help manage working night shifts[1]

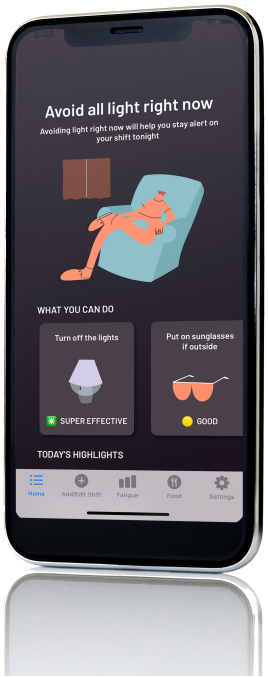
2 Our solution

Shift work's problems are caused by a body that's at the wrong time. We're a timing solution engine. We track shift workers through their devices, and make timing recommendations, like when to get light, when to try to sleep, when to eat, when to take melatonin, and best times for exercise. These recommendations are customizable for the individual and designed to work around their night shift schedule.

What happens when shift workers start timing things the right way? They feel better, sleep better, and report fewer errors. We want our app, *Shift*, to help shift workers around the world get there.

2.1 How it works: For employees

Our app, *Shift*, is all about **when**. When to eat, when to try to sleep, and most of all: when to seek and avoid light exposure. We track you



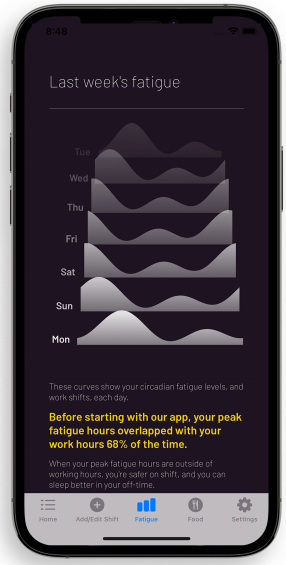
through your phone and wearable data and generate personalized prescriptions for how you should time your life. These schedules can be customized for your goals, whether that's sleeping as much as possible, or spending more time with your family.

2.2 How it works: Employers

We protect user privacy: no individual data is visible to employers, even in a de-identified format. Instead, we offer employers an overall team Circadian Health Report, which represents the average across all their team members. This report includes:

- The fraction of shifts when an employee was near their peak fatigue levels while working
- Average sleep duration across the team
- Average sleep regularity across the team

You can use these reports to track how circadian health predicts error rates, retention, and overall employee satisfaction.



3 The science

Okay, but how does it work under the hood? To answer that question, we need to back up and look at the science. Your circadian clock signals that it's time for night by secreting melatonin, the body's hormone for night. Melatonin is suppressed by bright light exposure, and the time when melatonin starts to rise is a gold standard circadian biomarker. Shift workers can have melatonin onset times anywhere around the 24-hour clock. Functionally, this means it's like they can be in any time zone in the world, without ever leaving home.

3.1 Light is key

What's causing them to be so temporally spread out? The main answer is light exposure. Light is the number one input, or *zeitgeber* (German for "time giver"), to the body's internal clock. When workers are on night shifts, they're getting light exposure at what can be the worst time for their bodies' wellbeing. But it doesn't have to be that way: after all, for someone living in a different time zone, a work shift starting at 7:00 pm could align with the start of their day. By getting smart about light, we can put people functionally in a different time zone than the one they live in. But this requires *real time circadian tracking*.

3.2 Circadian tracking

Circadian tracking means figuring out what "time zone" a worker is in. You might think that you could just ask when the last time they went to bed was. Unfortunately, that can be a worse proxy than random guessing for their internal time.[5]

This has consequences: if you don't accurately know their circadian time, you might end up shifting them in the entirely wrong direction. This is due to the fact that light exposure can either delay or advance a person depending on the timing of exposure. As a result, precision is needed in designing a schedule to match a person's starting circadian phase (a.k.a. their personal time zone). Data from the Henry Ford Health System suggests that using non-personalized light schedules will result in less than a third of workers getting a schedule that shifts them where we want it to.[4]

Arcascope has developed novel methods for non-invasively tracking the human circadian clock and has deployed them in the real world. We've found our methods to be 3-5x more accurate than alternative non-invasive approaches at predicting dim light melatonin onset, while allowing real-time determinations of internal time that are impossible with gold standard methods.[5,10]

3.3 Circadian shifting

The next challenge is to design a schedule that works for a shift worker, based on their schedule, personal phenotype, and goals. The best schedule for someone working a string of night shifts will be different from someone who is alternating between day and night shifts. Similarly, someone who wants to spend more time in the day with their family may prefer a schedule that prioritizes that over a schedule that prioritizes additional sleep at all costs.

A general principle with shifting for shift work is to move the worker's peak fatigue hours outside of their working hours, through carefully timed exposure to bright light. This is also known as a "compromise" phase position,[13] and it's aimed at striking a balance between at-work performance and health and wellbeing off the job.

Rather than adopting a purely nocturnal schedule, a compromise phase position keeps someone close to, but not fully, adjusted to a night schedule. This moves their peak fatigue to occur after they return home from a shift, minimizing risk for accidents at work and promoting sleep afterwards. At the same time, it makes it so that shift workers are not prevented from sleeping at night during their days off. Studies assessing the compromise phase position have found that it improves fatigue, performance, and mood compared to the baseline of circadian disruption.[20,21] In particular, shift workers on one-size-fits-all lighting prescriptions report better mood, better sleep, and fewer errors.[16]

Arcascope's algorithms are capable of generating **personalized** (not one-size-fits-all) prescriptions for achieving compromise phase position and more, depending on the preferences of the user. Someone who wants to shift as fast as possible can do so at least twice as fast as they otherwise would by following our recommendations.[7,19] Someone concerned about safety while driving home may want their peak fatigue hours to happen later than someone with a shorter commute. Someone for whom alertness on the shift is the highest priority may be told to take naps at strategic times.

No two shift workers are exactly the same in the shifts they work and the ways they handle them. We make unique solutions for each of them.

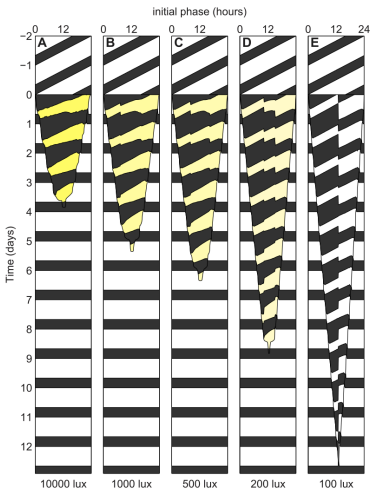


Figure 2 Optimal schedules for shifting the circadian clock as quickly as possible. Taken from Serkh and Forger.[19]

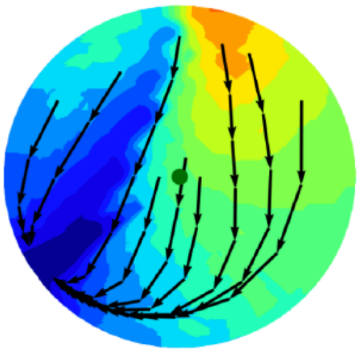


Figure 3 Visualizing the process of adjusting, or entrainment.[9]

4 The future

Right now, we're a wearable analytics company with an app that tells our users how to time their life based on analysis of their wearable signals. In the coming years, that's going to change: we'll tell our users' environments how to time themselves.

Imagine walking into your workspace and having the lighting brighten automatically, delaying you so you stay alert during your shift. Then, as the night goes on, that light shifts subtly—making it so you can sleep during your hours off at home. When you get home, the temperature is already cooling to make it so you have an easier time sliding into sleep. Your environment is never on a fixed schedule— always adapting itself to mirror what your body needs. This is a circadian-smart future.

5 Conclusion

Arcascope's advanced technology puts you in control of your biological clock. Our algorithms use direct measurements of the body's timekeeping to help shift workers sleep better, feel better, and be safer on the job.

> What do hospital emergencies, cramming for an exam, and space exploration have in common? They all involve defying an evolutionary pressure so great that the potential price includes development of life-threatening diseases such as cancer, depression, obesity, diabetes, and cardiomyopathy.
>
> Night shift workers therefore stand at the frontlines of a biological battle, literally risking their health to fulfill essential services for our culture and society.
>
> — *Circadian Biology: The Early Bird Catches the Morning Shift*, Karen Gamble and Martin Young[8]

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