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ENWR 1510-15/45

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December 1, 2019

When Bodies Survive:

Recovering and/or Adapting in the Context of Chronic Stress

If you cut your hand, white blood cells called neutrophils would rush through your bloodstream—a thousand times faster than any of your other cells can move—to reach the injury, fight infection, and begin healing the damaged tissue.[1] Your cells have built-in systems to evaluate and repair DNA that either inherited flaws in the DNA's code or that experienced damage by outside factors (see Cooper and Hausman 207-218). Bones fill in their own fractures (Hewings-Martin); muscles repair torn tissue (see OpenStax). The human brain heals itself by restoring tissue where possible and repurposing alternate sites within itself as needed, forming new pathways and functionality (see for example YouRong, et al). In other words: your body is well-equipped to heal you. So please take heart as I spend a few pages talking about the wide-ranging damage caused by chronic stress. I want you to recognize chronic stress as a severe threat to human health; I also want you to be hopeful, as I am hopeful, about the body's possibilities for coping with and healing from chronic stress.

Defining—and Distinguishing Types of—Stress

Stress itself is a relatively new term, at least used in connection with human affairs. Endocrinologist Hans Selye introduced the term in publication in 1935, with a paper on rat placentas; in 1936, he further defined the term as "the non-specific response of the body to any

demand for change." Selye had borrowed term from physics, where "stress" has a much more specific definition, referring to "force per unit area that arises from externally applied forces" ("Stress," *Encyclopaedia Britannica*). Over the 80-plus years since Selye brought the term to biology and, by extension, psychology, stress research has expanded dramatically, and the term has entered the general public's vocabulary. Most common causes of stress come from human relationships, work or the lack thereof, financial pressure, and medical conditions, among others (see "Holmes-Rahe Stress Inventory"; see also "Stress in America"); stress disorders are often commonly associated with trauma (see Vasterling and Brewin, as well as "WHO guidelines on conditions specifically related to stress"). Broadly, stressors fall into three major categories: environmental, psychological/emotional, and biological (Salleh 9).

Good Stress, Bad Stress

Importantly, stressors don't always produce negative effects, and they are not all tied to negative events or situations. Hans Selye (again) distinguished between positive stress, or *eustress*, and negative stress, or *distress* (see Figure 1). Researchers call short-term stress "acute," and this acute stress can actually improve performance—an athlete, a student, a worker, and on and on can all see performance gains under certain kinds of stress.

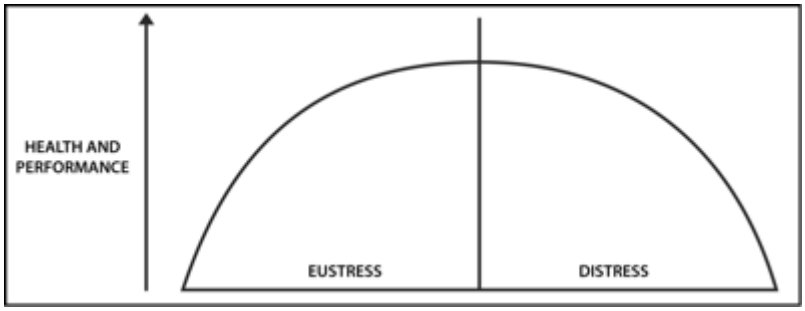

Figure 1. Diagram showing the dichotomy between Hans Selye's ideas of positive stress, or *eustress*, and negative stress, or *distress*. (Figure from Salleh 10.)

If stress lasts for six months or more, however, the condition turns from acute to "chronic" (see Hammen). In their chronic form, the same stressors that helped in an acute situation begin to harm the individual, leading to physical and psychological damage—and experiencing chronic stress leads an individual to have negative, rather than positive, outcomes from even potentially positive acute stress (Epel 152).

The Importance of "How Much, for How Long"

Furthermore, while some stressors are inherently negative (such as losing a job or the death of a loved one), some stressors can be positive: the Holmes-Rahe Stress Inventory, a common tool for assessing individual stress levels,[1] lists marriage, outstanding personal achievement, and even vacation among top contributors to stress—the key is how much change a person is having to adjust to, because even good adjustments take from a person's limited resources.

"Positive" Stressors	"Negative" Stressors
Marriage	Death of spouse
Marital reconciliation with mate	Divorce
Vacation	Major personal injury or illness
Outstanding personal achievement	Being fired at work
Major improvement in financial state	Major decline in financial state

Figure 2. Selected stressors from the Holmes-Rahe Stress Inventory, frequently associated with either positive or negative life events. The complete inventory is available online via the American Institute of Stress.

Recognition of Mind-Body Connections

One of the most compelling dimensions of stress research is the inextricability of mind and body, our daily experiences and thoughts bound up with our biology. Early on in *The Body Keeps the Score,* psychiatrist Bessel Van der Kolk reflects on his psychiatric training—completed after his

[1] The Holmes-Rahe inventory is based on a 1967 review of 5000 medical patient records, and since tested in military and cross-cultural environments—see Rahe et al; Komaroff, et al; Masuda, et al; Woon, et al.

MD education and licensing—in which he learned to focus on the humanity of patients above their clinical diagnoses. His advisor in a renowned training hospital

> discouraged us [residents] from reading psychiatry textbooks during our first year. . . . [He] did not want our perceptions of relation to become obscured . . . . I remember asking him once: "What would you call this patient—schizophrenic or schizoaffective?" He paused, stroked his chin, apparently deep in thought. "I think I'd call him Michael McIntyre," he replied. (26)

Van der Kolk goes on to note that the same director, "taught us that most human suffering is related to love and loss and that the job of therapists is to help people 'acknowledge, experience, and bear' the reality of life—with all its pleasures and heartbreak" (26) Does all that sound a bit . . . squishy? This human element, the idea that medicine connects somehow with the subjectivity of emotion, seems to be what inhibited advances in stress research for so long.

In a 2006 interview, medical professor Esther Sternberg discusses this tension, observing that science sort of "forgot" long-received wisdom, that

> stress can make you sick, that believing can make you well, that loving could make you well. All of these things are things that your grandmother told you, that you know in your heart of hearts. Right? That the ancient Greeks knew, that the ancient Asians, the Chinese, Japanese tradition. Go into any culture — Indian tradition — this is known for thousands of years. In every era, scientists and physicians have tried to explain these connections using their best available tools. So the question of how emotions and disease are linked were assumed in the time of Hippocrates' ancient Greece, 500 B.C., in the time of Galen, the Romans, and all through the centuries. And if we've known this for so long, where did we go wrong and when did we go wrong? (3:55–4:44)

Sternberg reports that in her own early research, she hedged her bets, writing with reserve out of a need to be taken seriously. Over the past several decades, however, Sternberg and other scientists have established incontrovertible evidence linking disease and emotion, and that documentation has allowed for tremendous progress in studying how enduring long periods of stress can in fact result in dramatic medical outcomes.

Stress Research in Medicine

Today, stress research is intimidatingly expansive. While single-authored books and individual research articles are helpful, anthologies offer collections of research that provide invaluable senses of scope and scale. For example, in a 2004 collection titled *Biobehavioral Stress Response: Protective and Damaging Effects*, the editor—psychiatrist Rachel Yehuda and neuroendocrinologist Bruce McEwen—aim to expand readers' sense of the ties between biology and behavior, in admittedly technical language. Chapters consider specifics of neurological pathways, genetic potential and expression, activity in the "hypothalamus-pituitary-adrenal axis," glucocorticoid functionality, and various effects of stress on hormones, saliva production, and sexual function. Another overview of the technical research taking place appears in psychiatrist Jennifer Vasterling's and psychologist Chris Brewin's 2005 edited volume, *Neuropsychology of PTSD: Biological, Cognitive, and Clinical Perspectives*. The contributing authors in this collection work to bring together neurobiological, clinical, and cognitive research into trauma and post-traumatic stress disorders. One looks at neuroimaging research as a means to understand "structural and functional anatomy of PTSD"; another focuses on that "hypothalamus-pituitary-adrenal axis" to study brain chemistry in response to trauma; others write about electrophysiology, the structures involved in "encoding and retrieval of traumatic memories," "learning and memory in aging trauma survivors," and the role of pharmacological approaches to treatment.

While the technical language may be off-putting to many (or most) general readers, these two collections together provide a sense of what stress research looks like in more recent years. Contemporary stress research sheds light on DNA health, cellular mutations, and immune

system responses—all items that are important to understanding both the toll of chronic stress and the parallel potentials for recovery.

Telomeres and DNA Health

Elizabeth Blackburn is one of three scientists who received the Nobel Prize in 2009 for their work on telomeres, stress, and aging. Telomeres, which many describe as sort of protective endcaps on stands of DNA as if they were the plastic covers at the end of your shoelaces, respond to both the normal stresses of aging and additional stresses we place on them through "rough lifestyle[s]." Telomere damage "doesn't cause any particular disease"; it seems to speed up the aging process, which includes bringing on predisposed diseases earlier in one's life than they otherwise might have presented (see Weintraub). Yet Blackburn went on from her Nobel Prize to co-author with health psychologist Elissa Epel a book called *The Telomere Effect: A Revolutionary Approach to Living Younger, Healthier, Longer*, in which she argued for adopting healthier patterns in exercise, diet, and stress management to preserve and even lengthen telomeres in order to improve physical health. Others have similarly found that diet, meditation, and exercise can lengthen telomeres (see Ornish, et al).

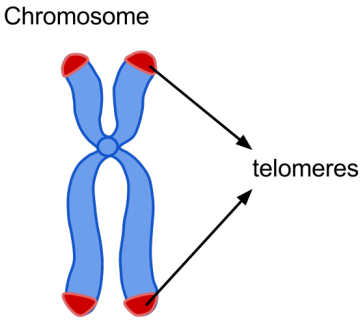

Figure 3. Telomeres, nucleotide sequences at the end of each chromosome, deteriorate each time DNA replicates as a part of the biological aging process. This deterioration can be accelerated or slowed down through lifestyle choices including diet, exercise, and meditation (Weintraub; Blackburn and Epel; Ornish, et al.) Figure redacted from Azmistowski17's "Hayflick Limit."

Cellular Mutations and Treatment

Other biological effects of stress are potentially more distorted. In 2007, molecular geneticist Rodrigo Galhardo, along with biochemist P. J. Hastings and physician Susan Rosenberg report on "mutation as a stress response." In their article, Galhardo et al point out that genomic mutation is a key component of evolution[2]; they therefore observe specific mutatic stress responses in bacteria, yeasts, and human cancer cells. "In our view," the authors write, "there is no controversy" about whether stress-induced mutagenesis takes place (2). Furthermore, while some cellular mutations are positive and successful adaptations to new environments, the authors' suggestion of "possible restriction of random mutagenesis in genomic space" (1) makes clear that others (for example, the kind of mutations that lead to human cancers) are undesirable.

Yet a 2012 article in *Science* reporting on extensive research into how cellular mutation takes place under stress makes clear that such mutations are the body's attempt to persist. Even under severe stress, the authors report, DNA repairs itself without mutation whenever possible; mutation only takes place when cells are not adapting properly to their environments and the body assesses that mutation would increase the chances of survival (see Mamun, et al, as well as Baylor College of Medicine, "Gene network illuminates stress"). Of course, the body's "intention" to survive is not particularly comforting when the result is a life- or quality-of-life threatening condition such as cancer or rheumatoid arthritis. Research into these conditions, while robust, continues to face unclear information regarding the network of causes, but chronic

[2] To which I would add that much (though importantly, not all) evolution leads to biological "progress." I'm recalling a conversation with a biologist friend of mine from years ago, as we compared notes on biological evolution and textual transmissions—manuscripts as revised over time. I was trying to think through the issue of original vs. authoritative editions; my friend gave me the insight that in biology, researchers don't talk about any one genetic copy as superior or inferior. Unlike in literature, where we might assume that an "original" or "revised" edition is authoritative, biologists simply observe factually the "ancestral" copies and descent trees to document relationships and mutations without assigning value.

stress is only one of many factors in developing these conditions, and possibly one of the smaller factors involved. That is to say, while chronic stress *can* lead to these conditions, the percentages of chronic stress sufferers who *will* sustain these conditions is still small.

Furthermore, when the body's natural defenses prove inadequate, medicine is often able to intervene—using surgery, radiation, and chemical treatments to kill cells that have turned on their own ecosystem in order to restore a reproductive environment for healthy tissue (for a helpful introduction to these treatment options, see the Mayo Clinic's overview page, "Cancer treatment"). Today, while nearly 40 percent of adults will face a cancer diagnosis at some point in their lives, nearly 70 percent of those individuals will still be alive after 5 years, and cancer rates as a whole are positively correlated with increased age, meaning cancer is likely to be one of many factors affecting already aging bodies. Perhaps most encouraging, the overall death rate tied to cancer in the United States fell by 26 percent between 1996 and 2015 (for all of the statistics in this paragraph, see "Cancer Statistics" and "Age and Cancer Risk," both from the National Cancer Institute).

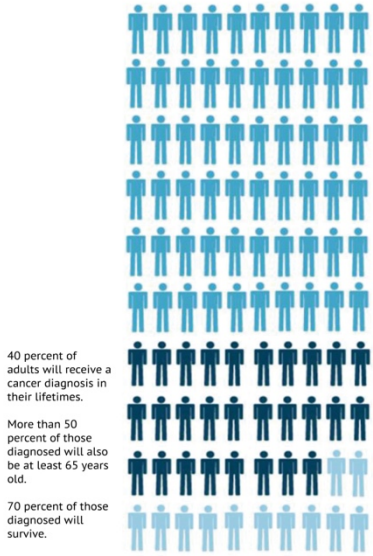

Figure 4. Infographic by author. Recent numbers indicated that 12 out of 100 adults will die of cancer. A large percentage of those individuals will be 65 or older, and cancer may be one of multiple age-related factors contributing to their deaths. Stress is one of many contributing factors in the development of cancer. (Statistics from "Cancer Statistics" and "Age and Cancer Risk," both from the National Cancer Institute.)

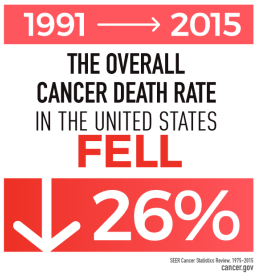

Figure 5. Image from the "Cancer Statistics" page of the U.S. National Cancer Institute site.

In summary, stress can lead to cellular mutations, some of which are positive. Where the mutations are negative, modern medicine continues to improve in fighting destructive tissue and allowing bodies to recover.

Immune System Responses

[plan to summarize the Salleh article and his reporting on autoimmune disorders re: stress]

--bring in Allen et al→Tanaka and Kishimoto

An Integrated Model to Improve Cross-Disciplinary Research

In most individual cases, medical experts can't yet distinguish clearly between stress speeding up inevitable aging or bringing on conditions that would not have occurred otherwise. For example, a stressed patient may present with heart disease at 45. That patient's genes may have foreshadowed that condition later in their life, and stress simply made the condition appear early; on the other hand, stress may have created the condition spontaneously. Some of the lack of connections may lie in the divergence of various research work, as many researchers operate using divergent clinical assumptions, goals, and discourse patterns. Elissa Epel (noted above as Elizabeth Blackburn's co-author of *The Telomere Effect*) was more recently the lead author on a 2018 article for *Frontiers in Neuroendocrinology*. In that article, Epel et al argued that stress science "would be further advanced if researchers adopted a common conceptual model that incorporates epidemiological, affective, and psychophysiological perspectives, with more precise language for describing stress measures" (146). Put more simply, we could get farther if researchers could agree on ways to think and talk about disease, emotion, and the mind-body

connection. The authors propose a unified model to provide essential contexts for stress researchers across disciplines (see Appendix C).

Yet at this point in time, Professor Joseph Tan, a clinical psychologist working with the Life Stress Clinic at the University of Virginia, notes, "[O]ur understanding of the causal interplay between stress and disease across the lifespan isn't sophisticated enough to inform that [distinction], in my opinion." However, he also points out,

> I'm not sure how helpful it would be clinically to make that distinction; [it's] definitely an interesting research question, but clinically, . . . it is enough to understand that stress is associated with a myriad number of negative health outcomes, and helping people ameliorate [those is the] important goal.

In other words, while we know that mutations *do* take place spontaneously in some cases, while in others stress merely brings on conditions we would have faced anyway, we can't usually tell which situation is which on a case-by-case basis, though we hope that research into both causal lines of stress outcomes will ultimately lead to better health outcomes across the board.

Returning to Psychology

With fairly dramatic medical outcomes associated with stress, one might assume that all people would choose to avoid stress if possible. The human psyche, however, is not so straightforward, and nor are the complexities of societal norms. [will discuss the veterans-not-wanting-to-move-beyond-trauma here, from Van der Kolk; may also look up an article or two on how attitudes toward stress varies across cultures]

When people choose to move forward psychologically, however, they can open pathways for physical healing, as well as

~~Recovering from and/or Adapting to Stress-Induced Conditions~~

For those who *do* want to reduce or cope with their stress, [pull a few representative public health advice pages, like WebMD, etc.] / [discuss where those are helpful and where they're infuriating—when, for example, you can't functionally reduce your stress. Bring in my survey/empirical study data here. Briefly—refer to Appendixes for full results]

Even for those who have been enduring extreme circumstances, in most cases, recovery is perhaps surprisingly possible. Recent neurological research has uncovered increasing evidence of neural plasticity—the ability of the brain to adapt, create new synapses and patterns, and to compensate for damage by repurposing atypical tissues. [expand] [discuss the role of medication as well as skills-based treatment]

-Ortiz and Conrad

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Physiologically, too, the individual body is focused on healing and adaptation. Various forms of physical therapy can provide low-intervention assistance to improve muscle condition and function, which in turn improves the functionality of the full musculoskeletal system. [expand] Disability studies, too, have highlighted for years creative adaptations of atypically abled individuals. [expand]

[Something Inspiring Re: Why This Subject Matters]

Those who have experienced extended periods of stress likely recognize the severity of outcomes on their bodies, as well as their minds. They may experience ongoing physical symptoms (from hypertension to recurring headaches to gastrointestinal disorders) and/or psychiatric symptoms

(where mental and physical health combine, most recognizably depression and anxiety). Seasons of chronic stress often leave individuals with a limited sense of optimism and instead, with a sense of wondering if things can improve again, including their own health. Tip sheets and web articles on "stress management" can seem superficial in advising readers to practice deep breathing, exercise regularly, drink plenty of water, and get adequate sleep (see for examples "Stress Management: 13 Ways to Prevent & Relief Stress" from WebMD and "Stress Management" from the Mayo Clinic). Some individuals may find satisfaction and more profound comfort in knowing that the practical advice on such sheets are tied to more complex processes—that mindfulness, exercise, water, and sleep all support the cellular processes the body needs to do its repair work.

In *The Body Keeps the Score*, Bessel an der Kolk studies the enduring toll trauma takes on human bodies. Others have picked up on that theme, including researchers Joseph Allen, et al, in "The Body Remembers," who found that Interleukin-6 (IL-6), a chemical associated with immune disorders and inflammation, remained in human systems as long as fifteen years following periods of poor conflict resolution experiences in adolescence. Chronic stress creates long-term effects for individuals. But the body's remarkable abilities to recover from (and in particularly challenging situations, to cope satisfactorily with) chronic stress provide a searing counterbalance: the body may remember and keep the score, but the body also recovers and thrives. Those enduring chronic stress may take comfort in knowing their current situation need not be permanent, and in seeking out resources to help them begin coping and recovery.

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Appendix A: Study of life stress and health/wellness markers
Data collected/synthesized by author, Oct. 17-20, 2019.

In my study, I conducted a survey and analyzed the results to consider possible links between Holmes-Rahe life stress scores, perceived health and pain, and major medical events. The graphs below show a summary of the study's results.

Figure A1. # of Participants by Age	
18-24	7
25-34	9
35-44	13
45-54	8
55-64	4
65+	2
All	43

Figure A1 shows the breakdown of my participants' ages.

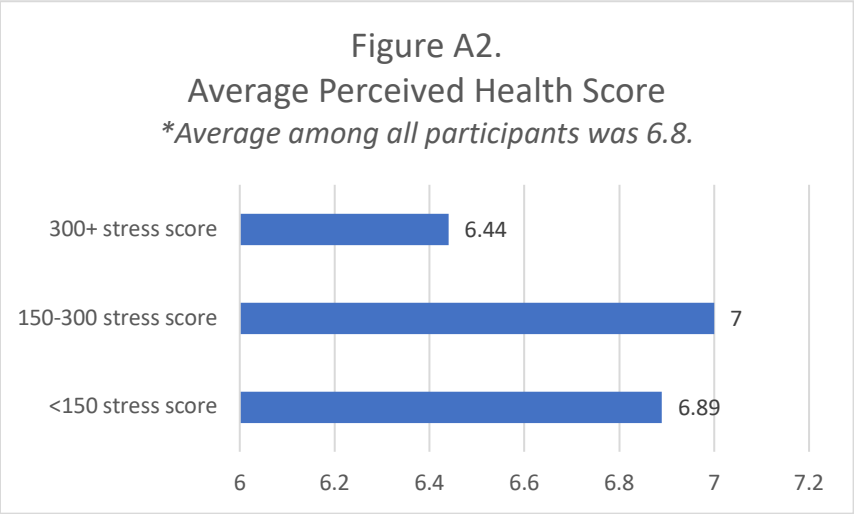
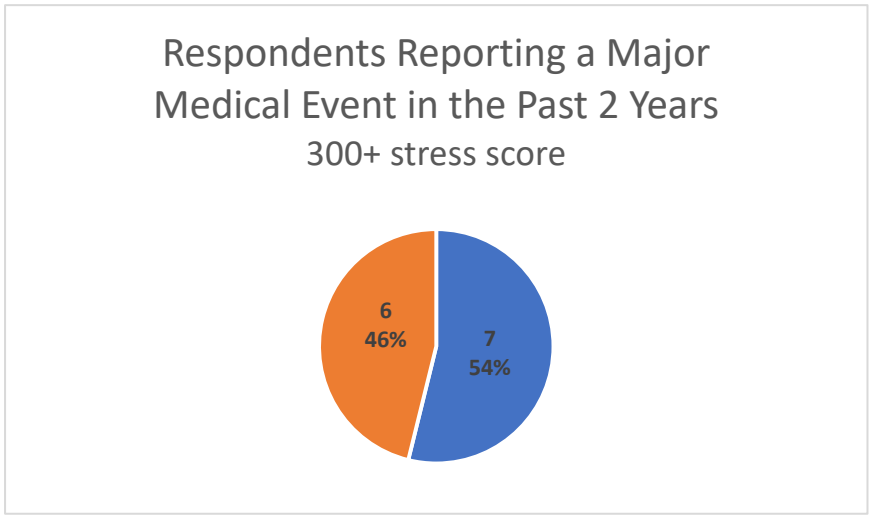
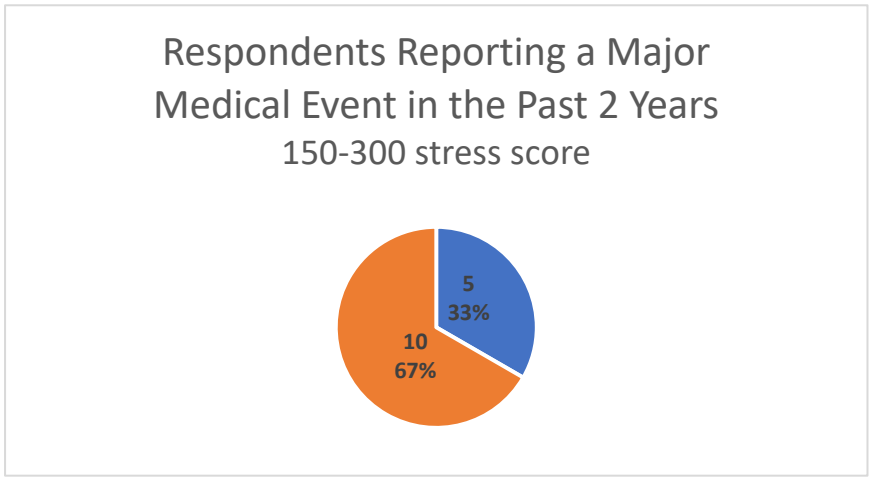


Figure A2 shows how participants ranked their own current physical health on a scale of 1 to 10, with 0 being terrible and 10 being wonderful. The results show similarity across the three

Figure A3





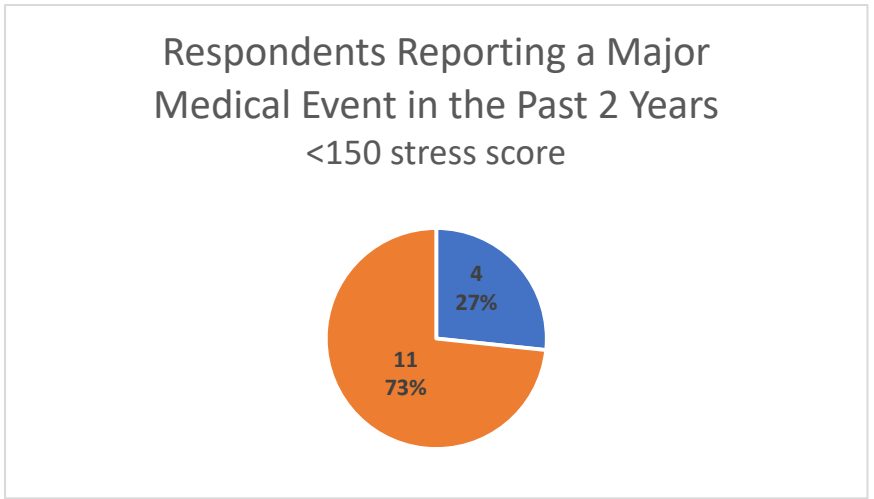


Figure A3 shows whether participants reported experiencing a major medical in the past 2 years, grouped by their Holmes-Rahe stress scores. I defined "major medical event" as including hospitalizations, life-threatening illnesses or accidents, and/or any condition requiring ongoing medical care. While the occurrence of major medical events was similar among the groups with stress scores of <150 and 150-300, the percentage major medical events jumped in the group with stress scores of 300+.

Figure A4

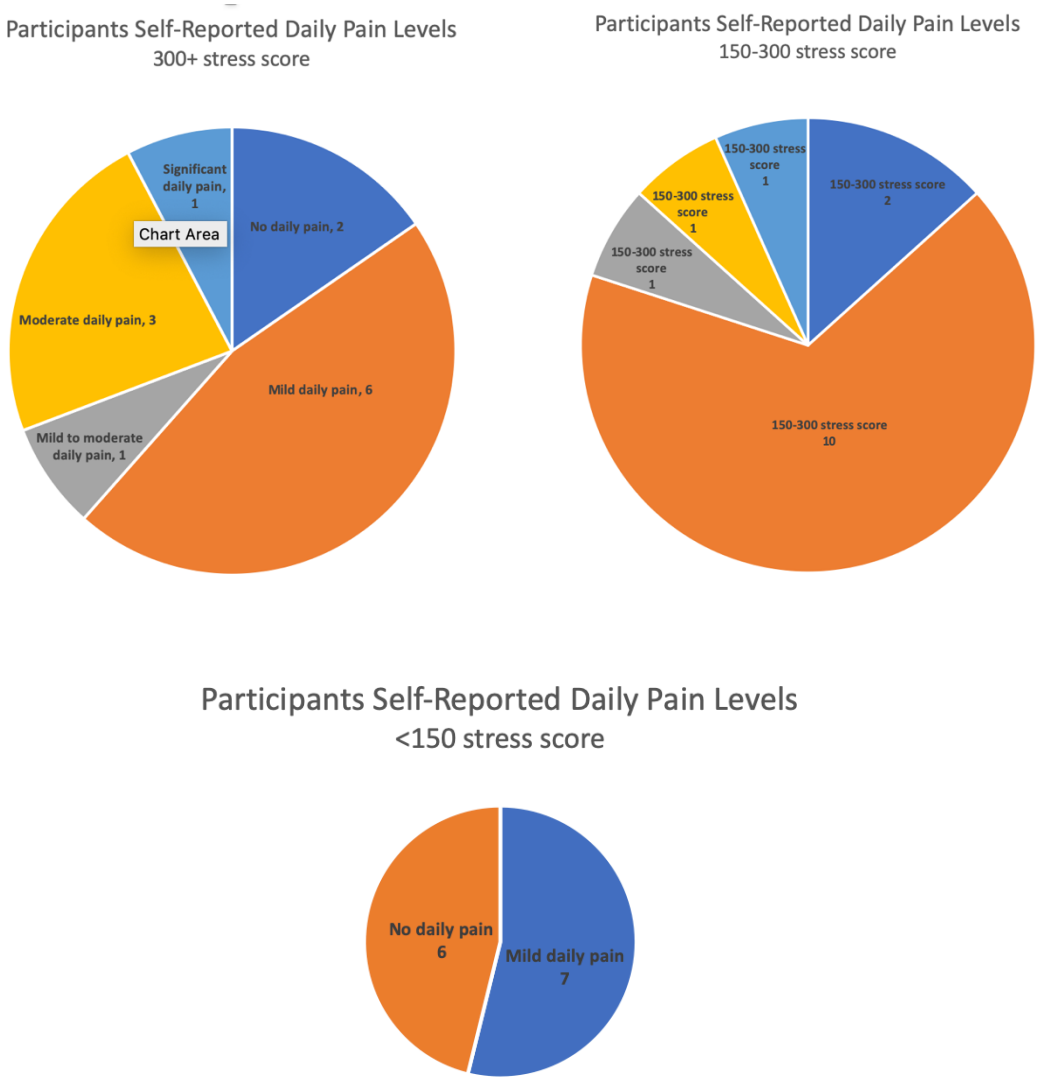


Figure A4 shows how participants ranked their own daily experiences of pain on the following scale:

1—No daily pain
1-2—Mild daily pain
3-4—Mild to moderate daily pain
5-6—Moderate daily pain
7-8—Significant daily pain
9-10—Severe daily pain

Response trends do show a correlation between pain perception and participants' Holmes-Rahe stress score. No respondents in any stress score group reported severe daily pain.

Appendix B

Model reproduced from Elissa Epel, et al. Per the authors: “This figure presents a transdisciplinary model that describes “stress” as a set of interactive and emergent processes. The figure illustrates that stressors are experienced within the context of a person’s life, represented by the contextual factors in the blue triangle. These contextual factors include individual-level characteristics such as personality and demographic factors, the environment in which one lives, current and past stressor exposures, and protective factors; all