The Impact of COVID-19 on the Mental Health of Women in STEMM

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INTRODUCTION

At baseline, disadvantage has been associated with worse mental and physical health (Williams et al., 2018; Vanderbilt and Isringhausen, 2013). However, during times of extreme societal stress, the benefits of privilege are accentuated, and the negative impacts of disadvantage are highlighted. Business tycoons have literally seen their wealth grow by billions since the start of the Coronavirus Disease 2019 (COVID-19) pandemic (Inequality.org, 2020; Forbes, 2020), while according to the U.S. Bureau of Labor Statistics, the number of unemployed people in the United States is 6.8 million greater in October 2020 than in February 2020, with women disproportionately affected, particularly those who identify as Black, Latina, or disabled. The Centers for Medicare and Medicaid Services reports that 4 million individuals enrolled in Medicaid and the Children's Health Insurance Program (CHIP) between February 2020 and June 2020. COVID-19 infection and death rates are higher among those from socioeconomic or race/ethnic minority groups and individuals with underlying health conditions, including mental illness (Boserup et al., 2020; Halpern et al., 2020; Fond et al., 2020). Unfortunately, when large swaths of society experience war, pestilence, famine, and natural disasters, efforts aimed at improving the plight of those less fortunate financially, socially, or professionally become more challenging as economies are threatened. Despite best intentions, private and public institutions that employ women and individuals from underrepresented minorities (URMs) in science, technology, engineering, mathematics, and medicine (STEMM) fields are not immune to the threats to gender equity posed by the worldwide COVID-19 pandemic.

Previous chapters have provided an overview of challenges to maintaining engagement of women in STEMM fields during COVID-19. A number of recommendations regarding mentorship, maintenance of pipeline programs for women to enter and progress to leadership in STEMM fields, flexible work schedules, unconscious bias training, and so forth, have been proffered as mechanisms by which to mitigate the clear risk posed by the pandemic to the progress women have made in STEMM fields over past decades.

This chapter focuses on the mental health impact of the pandemic for academic women in STEMM fields and further supports many of the recommendations made in other chapters.

Discrimination and marginalization have long been recognized as contributing factors to poor mental health (Sutter et al., 2016; Schmitt et al., 2014). Women and other underrepresented groups studying and working in STEMM fields are decidedly disadvantaged to a greater degree than their male counterparts (Myers et al., 2020; Woitowich et al., 2020). Women in academic STEMM fields are more likely to be early in their career (AAMC, 2019), have a lower salary regardless of professional ranking in STEMM (Raj et al., 2019), be a single parent or a primary caregiver (Calisi, 2018; Jolly et al., 2014; Yavorsky et al., 2015), and report experiencing greater work-related stress (Ornek and Esin, 2019) and discrimination in the workplace or their community (Lu et al., 2020; Jagsi et al., 2016). Finally, women in medicine are less likely to be in one of the higher paid subspecialties (AAMC Tables 13 and 16, 2019; Mehta et al., 2019; Raj et al., 2019). Each of these stressors for women is compounded by the same social isolation, work disruption, financial worries and health concerns experienced by others during the COVID-19 pandemic.

Women in STEMM, particularly in fields such as engineering, physics, computer science, and certain subspecialties of medicine are likely to be in the minority and have fewer female role models at the rank of professor or in other leadership positions (AAMC, 2019). While these data are not specific to women in the academy, it is noteworthy that women make up 70 percent of the workforce globally, but only 25 percent of the senior leadership positions (WHO, 2020). As women are more likely than men to use social relationships to cope with stress or threat (Taylor et al., 2000; Smith, 2014), social distancing during the pandemic could exacerbate this relative lack of social support from women colleagues, mentors, and role models. For example, female university students who use a coping style characterized by greater social supports showed a reduction in physiologic response to stress, both across the day as well as during a laboratory stressor (Sladek et al., 2016). Taken together with exposure to fewer women in the workplace and the importance of social support to stress regulation among women, the social distancing required

during the pandemic should be considered by leaders in academic institutions as they create programs to maintain engagement of academic women in STEMM fields.

Women still experience an undue burden of stress secondary to caregiving for family members, whether children or elderly parents (Calisi, 2018; Jolly et al., 2014; Yavorsky et al., 2015; Hopps et al., 2017). In addition to caring for family, women healthcare workers (HCWs) are more likely than men HCWs to be at the bedside, which is currently the epicenter of the pandemic, taking care of patients with COVID-19, managing the distress of family members of the sick and dying. Women HCWs are more likely to work shift-based schedules, which can be unpredictable and negatively impact circadian rhythms and sleep (Lai et al., 2020). Finally, women across the globe carry a greater burden of disease associated with depression, anxiety, posttraumatic stress and insomnia at baseline (Bracke et al., 2020). Importantly, the main mental health conditions most exacerbated by recent societal stressors—such as terrorist attacks, natural disasters (e.g., flood, fire, ice, earthquakes), and infectious disease (Severe Acute Respiratory Syndrome [SARS], Middle East Respiratory Syndrome [MERS], Ebola, and COVID-19)—are insomnia, depression, anxiety, posttraumatic stress, and alcohol and drug use (Esterwood and Saeed, 2020; Cabarkapa et al., 2020). All but alcohol and drug abuse are disorders that occur more frequently among women. Finally, it is well documented in both preclinical and human studies that chronic and unpredictable stress such as that occurring during the COVID-19 pandemic is the most detrimental form of stress for health (Yaribeygi et al., 2017). Gender differences in stress exposures and sex differences in biological response to stress (reviewed below) may interact to increase risk of mental health problems for women during the pandemic.

Hence, the mandate to consider the mental health impact of the COVID-19 pandemic as a major threat to maintaining women's engagement in STEMM fields is clear and critical. To this end, this chapter provides evidence that psychosocial, professional, and biological factors contribute to greater risk for mental health concerns among academic women versus men in STEMM fields. The goal is to galvanize institutional leaders to focus on the mental health of women faculty and to create programs that consider

their unique needs as women and as individuals who may be unduly impacted by the pandemic secondary to intersectionalities with gender such as race, ethnicity, and lived-experience. The chapter ends with recommendations for actionable areas of intervention and research in the short- and long-term to avoid losing women from STEMM fields due to burnout and mental illness. Where there are specific data from previous epidemics and the current pandemic to inform research and interventions to promote well-being among academic women in STEMM fields, they will be highlighted. Otherwise, much of the literature regarding key indicators and evidence-based assessments for burnout and mental illness, sex differences in stress physiology, gender differences in stress exposures, access to medical care, and risk for mental health conditions reviewed herein is not specific to academic women STEMM fields or specific to this pandemic. Data that form the basis of recommendations for support of women in STEMM during and after the COVID-19 pandemic are based upon studies of gender differences in the workforce, gender differences in stress exposures, sex differences in stress physiology, epidemic/pandemic impact on the workforce in specific STEMM fields such as medicine and nursing, and impact of lockdowns on university students and faculty more generally. Finally, the majority of the data reviewed assumes that women are those identified as women at birth. Where possible, we describe how the intersectionality of gender minority status may be impacted by the current crisis. Likewise, we utilize data from the general population to extrapolate to racial and ethnic groups with a few exceptions noted.

KEY INDICATORS OF RISK AND WELL-BEING

There is a reciprocal relationship between employee well-being and institutional success (Attridge, 2007, 2009). Employee well-being affects institutional metrics and culture, while institutional culture, policies, and procedures impact individual employee well-being. This section will discuss key indicators that leaders can use to identify risk of declining employee well-being, including burnout, mental illness,

and sleep disturbance (Table 1), track professional fulfillment, and aid in identifying key areas of strategic focus.

Burnout: A Key Indicator of Overall Mental Well-being and Job Satisfaction

Burnout can be easily measured and has been documented to affect individuals in the workforce, though considerable attention has been paid to individuals in healthcare professions. It is important for academic medical centers to focus on the prevalence and prevention of burnout among HCWs including impacts on patient safety, quality of care, and professionalism (Panagioti et al., 2018). Burnout correlates with reduced patient satisfaction and an eroding of communication between patients and clinicians while increasing the risk of being named in a malpractice suit. Across the workforce more generally, high levels of burnout (variably defined) have been associated with a number of somatic conditions; high blood pressure (von Kanel et al., 2020), coronary artery disease, and diabetes, to name a few (Guan et al., 2017). Women in medicine (Rabatin et al., 2016; Linzer et al., 2000; Gold et al., 2020), nursing, and basic science research are noted to report higher levels of personal and work-related burnout than men in similar roles (Messias et al., 2019) These gender differences in the individuals' relationship to work starts out early in academic training. A recent study from Germany comparing freshmen medical students with STEM students indicated that STEM students started and continued in this 3-year longitudinal study to demonstrate greater burnout related risk patterns compared to medical students. Women students showed a more unfavorable pattern regardless of group (Voltmar et al., 2019).

Institutional leaders have available to them several validated tools to measure burnout, including Maslach Burnout Inventory – Human Services Survey for Medical Personnel (MBI-HSS MP), the Oldenburg Burnout Inventory, the Single Item Burnout Measure embedded in the Mini-Z, and the Copenhagen Burnout Inventory (designed to be used for any occupation; Table 1) ("Valid and Reliable Survey Instruments to Measure Burnout, Well-Being, and Other Work-Related Dimensions – National Academy of Medicine," n.d.). Similarly, there are several validated tools to measure composite well-being

including the Stanford Professional Fulfillment Index and the Well-being Index. As mentioned earlier, leaders in the medical fields can use patient satisfaction scores as a bellwether for provider well-being. These tools can easily be used to monitor burnout and well-being among those in the STEMM environments, with particular attention to vulnerable populations such as women, trainees, and those races/ethnicities that are underrepresented in STEMM.

Factors Contributing to Burnout

The pandemic has exacerbated many of the long-standing factors that contribute to greater burnout among women, compared to men, in the STEMM professions. Prior to the pandemic, women in STEMM report greater emotional exhaustion, a domain of burnout, greater cynicism, and lower academic efficiency in environments described as "chilly" and unwelcoming to women (Jensen and Deemer, 2019). Among university-level teachers, gender impacts which symptom of burnout the individual is most likely to experience. A comprehensive review of burnout among university teachers working in multiple countries indicates that men are more likely to report cynical and negative approaches to others (depersonalization), while female teachers were more likely to report greater emotional exhaustion (Wyatt and Robertson, 2011), both symptoms of burnout (Maslach and Jackson, 1993). Half of the 12 articles reviewed examined gender differences in rates of burnout, with most indicating that women were more likely to score higher than men on all dimensions of burnout (Wyatt and Robertson, 2011). Being younger, having a larger student load, and growing tuition among students was associated with greater symptoms of burnout. Review of burnout across multiple types of employment supports that the gender difference in burnout is greater in the United States compared to the European Union, and women are indeed more likely to experience emotional exhaustion as a symptom of burnout, while men report more depersonalization (Purvanova and Muros, 2010).

Other studies also indicate that female gender and younger age (<40 years of age) are both associated with higher levels of burnout among working women (Eden et al., 2020). Culturally, women are more likely

to take on home-related childcare and domestic responsibilities even when in a dual working relationship (Jolly et al., 2014). When women physicians are performing more of the domestic responsibilities, they are more likely to wish a career change, particularly when in a procedural field (Lyu et al., 2019). Women are also more likely to take time at home or reduce hours to accommodate COVID-19, propagating gender inequities and gap in compensation, especially when leaders decide not to extend an opportunity to women out of concern that they have "too much on their plate" (Brubaker, 2020). In addition, high task load of the workplace environment contributes to enhanced burnout (Harry et al., 2019). Juggling more domestic responsibilities, women are experiencing a higher overall cognitive load, putting them in a higher risk of burnout. Leaders in STEMM environments can take steps to measure the climate for women in their institution, have a process to monitor if more women than men are decreasing hours or full-time equivalents, and evaluate the task load placed on employees using a validated tool such as the NASA Task Load Index (Task Load Index, n.d.).

Assessing Mental Illness in the STEMM Workforce

As discussed below, the COVID-19 pandemic is accentuating the gender differences in mental health concerns such as depression, anxiety, posttraumatic stress, and insomnia (Carmassi et al., 2020; Pappa et al., 2020). Delays in clearance for conducting research due to COVID-19 are leading to researchers experiencing increased burnout, sleep disturbance, poor appetite, increased interpersonal problems, and decreased motivation (Sharma et al., 2020). COVID-19, racial injustices, and geopolitical unrest are affecting academic faculty in multiple domains professionally and personally (Gruber, 2020). Each of these outcomes serves as a surrogate measure of well-being and risk for mental health problems during and after the pandemic. Validated tools such as the 2-item and 9-item Physician Health Questionnaires (PHQ-2 and PHQ-9; Kroenke et al., 2001, 2003), the General Anxiety Disorder-7 Item (GAD-7; Spitzer et al., 2006) questionnaire, the Posttraumatic Stress Disorder Checklist (PCL; Bovin et al., 2016), and the sleep-related impairment measures—the Insomnia Severity Index (ISI) or the Pittsburgh Sleep Quality Index (Buysee et

al.,1989)—are excellent measures to assess likelihood of a serious mental condition (Morin et al., 2011; Spitzer et al., 2006; "Valid and Reliable Survey Instruments to Measure Burnout, Well-Being, and Other Work-Related Dimensions – National Academy of Medicine," n.d.; Yu et al., 2011). A description of these instruments and symptom severity range is included in Table 1. Given continued concerns among the academic and medical workforce that seeking mental health care will adversely affect their professional standing among their peers and threaten their career opportunities (Feist et al., 2020), institutions may experience resistance to widespread assessment for mental health conditions. Utilizing burnout scales or assessments for sleep disturbances may be a less stigmatizing method to obtain a proxy for faculty mental health during and after the pandemic.

COVID-19–Specific Stress Measure

Essential workers in STEMM fields, such as medicine and nursing, work at the epicenter of this crisis and face increased risk for infection and overall higher rates of stress from the pandemic. The recently developed COVID Stress Scales (CSS; Taylor et al., 2020) categorizes stressors from the pandemic into five categories: danger and contamination fear, social and economic stress, traumatic stress symptoms, checking and reassurance seeking behavior, and xenophobia. Recent findings suggest that the five factors of the CSS form a COVID Stress Syndrome. In the general population, each of these factors can contribute to increased substance use and abuse risk. These factors can be compounded in essential workers, placing this group at particularly high risk for substance use and abuse (McKay and Asmundson, 2020). While there are no data specifically for women and URM groups regarding scores on the CSS, one can extrapolate that any group that came into the pandemic with health disparities or lower professional standing (e.g., lack of seniority and lower salary) could experience the pandemic as a greater threat to their health and financial stability.

COVID-19 PANDEMIC: A UNIQUE IMPACT ON STRESS PHYSIOLOGY

While the pandemic is particularly "stressful" for academic women in STEMM fields for reasons previously discussed, gender differences in stress exposures must be considered in the context of how sex as a biological variable (SABV) can impact physiologic responses to stress (Bale and Epperson, 2015). A key concept in physiology is homeostasis, which can be defined as the ability of a system to maintain stability when challenged with changes in the environment and other external or internal conditions (Billman, 2020). Stress is often defined as a "state of real or perceived threat to homeostasis" (Smith and Vale, 2006). Even uncertainty can be threatening when the individual imbues it with negativity. In addition to exacerbating ongoing stress, pandemics can lead to a novel condition that threaten well-being (Centers for Disease Control and Prevention, 2020c) at multiple levels.

Stress elicits major responses from the nervous, endocrine, cardiovascular, and immune systems (Chu et al., 2020; Dimsdale, 2008). Given sex differences in response to stress that have been previously reviewed (Bale and Epperson, 2015; Haitao et al., 2020; Takahashi et al., 2020), the differential impact of COVID-19–associated stress on women versus men warrants continued study and attention. Neuroendocrine and immune responses are considered "first responders" of the stress system and trigger engagement of other organ systems. Figure 1 depicts the neuroendocrine *responses* comprised of two pathways, the sympathetic-adrenomedullary system (SAMS) and the hypothalamic-pituitary-adrenocortical axis (HPAA) responses to stress or threat (Gunnar and Quevedo, 2007; Kandel, 2013). While stress initially activates many brain regions, particularly the amygdala, alerting the individual to potential threat, signals for both the SAMS and HPAA converge within the hypothalamus. SAMS hypothalamic regions project to the brainstem and subsequently via multisynaptic circuits to the adrenal medulla to elicit secretion of the catecholamines, epinephrine, and norepinephrine (Dum et al., 2019). Epinephrine and norepinephrine release leads to increases in heart rate, blood pressure, and general awareness, hallmarks of the fight-or-flight response. For the HPAA, activation of the periventricular nucleus (PVN) of the hypothalamus leads

to secretion of corticotropin releasing factor (CRF), which then stimulates release of adrenocorticotropic hormone (ACTH) from the anterior pituitary that in turn leads to secretion of cortisol from the adrenal cortex. Inappropriate HPAA or SAMS response to current stressors, whether accentuated or dampened, is associated with adverse effects on the brain and other body organs (see Figure 1.E and 1.F), leading to suboptimal health (McEwen, 2017; Epperson et al., 2017; Hantsoo et al., 2019; Morrison et al., 2017; Shanmugan et al., 2020a, 2020b; Bale and Epperson, 2015).

Sex Differences in Stress Response

Sex differences in stress response are well-characterized and change across the developmental lifespan (Bale and Epperson, 2015). It is important to focus on adult stages of development given the collection's focus on women in STEMM. From puberty to reproductive senescence, the reproductive hormones estrogen and progesterone fluctuate across the menstrual cycle in women not using steroid contraceptives and are exceptionally high during pregnancy. Animal studies have shown that estrogens modulate HPAA function differently than progesterone and androgens. Estrogens enhance and progesterone and androgens inhibit the HPAA in response to stress and consequently the release of cortisol (for reviews, Handa, Burgess, Kerr, and O'Keefe, 1994; Bale and Epperson, 2015). While women and men respond to stress by achieving similar circulating levels of cortisol depending upon reproductive status, stress-induced increases in glucocorticoid levels can be of longer duration in women (Gallucci et al., 1993). The longer duration of elevated cortisol levels in women may reflect the greater sensitivity of hypothalamic and anterior pituitary sites to stress resulting in increased secretion of CRF and ACTH, respectively. Likewise, menstrual cycle status (follicular or luteal), use of steroid contraceptives and reproductive stage (pre-, peri- or postmenopause) impacts women's physiologic responses to stress (reviewed by Bale and Epperson, 2015).

Similarly, there are sex differences in how stress triggers immune response. The innate and adaptive immune systems provide initial and second order lines of defense against infection (Punt et al., 2018; Konsman et al., 2002; Dantzer, 2006; Segerstrom and Miller, 2004). Glucocorticoids, such as cortisol,

modulate the immune system and dampen the effects of inflammatory cytokines (Chrousos, 2010). In addition, the longer-lasting elevations of cortisol elicited by stress in women could promote a longer-term suppression of the immune system in women (Gallucci et al., 1993). That 80 percent of patients with autoimmune diseases are women raises the possibility that sex differences in immune responses are critical in women's health (Ngo et al., 2014). Indeed, many aspects of both innate and adaptive immune systems show heightened responses in women compared to men including Type I Interferon activity, T cell numbers, and antibody responses (Klein and Flanagan, 2016). As for the neuroendocrine system, the effect of sex varies across the lifespan. Having an underlying health condition places the individuals at greater risk of viral infection, for example, viruses like COVID-19, and worse clinical course (Noor et al., 2020; Monreal et al., 2020). For women in STEMM, having an underlying immune abnormality can keep one from being an essential worker or coming to the research lab if they work in high-risk areas for infection. They must also depend upon their lab mates to maintain social distancing at work and in their personal lives so that they can come to work without added worries. Clearly, these biological factors are not modifiable by academic institutions. However, knowledge regarding sex differences in stress physiology can further galvanize university leadership to focus resources on programs meant to dampen stress for women faculty and trainees in STEMM.

COVID-19 Stress and Sex Differences

Several organizations—such as the Centers for Disease Control and Prevention (CDC), Veterans Administration, state governments, and public health agencies—have developed web pages that address the unique stress presented by the COVID-19 pandemic. A wide range of COVID-19–associated sources of stress are listed, including personal, family, and community health (due to risk of infection); financial (due to loss of job or wages); childcare (due to school and/or day-care closures); social isolation; and the uncertain future trajectory of pandemic and its consequences (UN Policy Brief, 2020; Park et al., 2020). As previously reviewed, these kinds of stressors can affect women and men differently. As women tend to be

the major caregivers within an extended family, they will directly experience more stress as they care for themselves, loved ones, or friends who contract disease. More women have needed to reduce hours or quit jobs to tend to family and loved ones as well as children at home due to school closures (McKinsey Global Institute, 2020), challenging productivity at work. Along with social isolation and sheltering, there has been an increase in domestic violence during the COVID-19 pandemic, adding yet another stressor for women (Boserup et al., 2020).

Impact of COVID-19 Stress on STEMM Women

There are groups of women in STEMM that bear a particular burden of stress generated by the COVID-19 pandemic: (1) frontline health workers, (2) mothers in STEMM, and (3) academics in STEMM. As with any pandemic, frontline health workers are most at risk for exposure and contracting SARS-CoV-2. However, approximately 77 percent of frontline workforce in healthcare is comprised of women, placing a greater overall infection risk for women in this STEMM field (Roberson and Gebeloff, 2020).

Mothers in STEMM face additional COVID-19 stressors and consequences (Staniscuaski et al., 2020). Prenatal care, delivery, and infant needs present financial challenges and stress (Ahlers-Schmidt et al., 2020). Concerns about infection during pregnancy not only create stress but lead to avoidance of medical services and worries about how delivery will occur (Preis et al., 2020a, 2020b; Berthelot et al., 2020). Given that increased maternal stress will negatively impact the progression of pregnancy, it is imperative all mothers receive care that minimizes disease exposure and delivery complications. Similar to women in STEMM with underlying medical conditions, women who are pregnant have to take into consideration the location of their work and whether colleagues and lab mates are careful about their own exposures. Institutional procedures to ensure safety in the workplace by ensuring access to testing, screening those who come to campus and rapidly responding to contain outbreaks are essential for these women to be able to utilize lab facilities.

With respect to academic women in STEMM in general, the COVID-19 pandemic has exacerbated many stresses women in academia face under usual conditions (Howe-Walsh and Turnbull, 2016). The mantra "publish or perish" emphasizes that survival, let alone success, in academia requires one to continually publish papers and obtain funding. The gender-biased impact of the pandemic on women in academics has already been observed as a decrease in productivity. Women published fewer papers and received fewer citations of their work since the pandemic began (Amano-Patino et al., 2020; Gabster et al., 2020; Andersen et al., 2020).

While there is some optimism on the part of business leaders that the pandemic will lead to greater opportunities for women and individuals of color to progress professionally, employees are more skeptical. A recent survey conducted by Catalyst: Workplaces that Work for Women in partnership with Edelman Intelligence, queried 1,100 U.S. adults in full-time employment between June 1 and 5, 2020, about their beliefs regarding the pandemic and gender equity in the workplace. The respondents included 250 business leaders of large companies and 850 employees of large multinational companies. While the survey was not focused on women in academic STEMM fields, the data highlight relevant differences between employers and employees by gender. Leaders (75 percent and 78 percent) expressed confidence that the COVID-19 pandemic is an opportunity to create a more inclusive workplace for women and people of color, respectively. Women employees (61 percent) were somewhat more likely than men employees (55 percent) to express skepticism that their employer is fully committed to taking the action necessary to create a more inclusive work environment for women. Regardless of gender, employees (60 percent) compared to business leaders (28 percent) were more likely to report fear that COVID-19 would negatively impact their prospects for promotion. Notably, women business leaders and women employees reported greater work-related stress compared to their male counterparts. However, a silver lining in this report is that 32 percent of male employees and 64 percent of male business leaders surveyed reported having taken on a more equitable share of chores at home. Slightly more women than men expressed the belief that the new working

environment during COVID-19 will give them more flexibility in work-life balance and control over their schedules in the future (Catalyst.org, 2020).

COVID-19: MENTAL AND PHYSICAL HEALTH OF WOMEN IN STEMM

When considering the impact of the pandemic on the mental health of women in STEMM fields, it is critical to consider that women are also at greater risk of medical (e.g., endocrine, immune, rheumatologic, neurologic) conditions frequently comorbid with depression and anxiety. Many of these conditions are stress-sensitive, increasing the risk of an exacerbation during the pandemic (Gazerani et al., 2020). As previously described, during periods of concern regarding risk of infection, women are unduly burdened. Women are more likely to be diagnosed with autoimmune diseases that put them into an "at-risk" category that could impact their ability to work in any STEMM field that requires some level of social contact. Likewise, pregnancy and childbirth raised concerns about added risk for both mom and baby, particularly early in the pandemic.

Access to healthcare was a concern regardless of gender during the initial COVID-19 surge (Wright et al., 2020; Saqib et al., 2020), impacting anyone needing ongoing treatment for a mental or physical health concern. After a short transition period, most mental health care was and continues to be successfully provided via telehealth platforms (Shore et al., 2020). However, care for other medical conditions requiring physical examination, hands-on intervention, or in-person treatment have experienced greater challenges during the need for social distancing. Also, there are some psychiatric problems that do not lend themselves well to virtual assessments (e.g., psychosis).

Again, social support, particularly gained from in-person contact, exerts a dampening impact on the adverse effects of stress on health (Connor et al., 2020). During many recent societal stressors (e.g., natural disasters, terrorist attacks) in the United States, individuals have been able to gather with family, friends, and colleagues to grieve and heal. Epidemics and pandemics are unique in their requirement for social

distancing, which is in direct opposition to human nature under times of stress, and increases risk for poor mental and physical health (Umberson and Montez, 2010). Factors such as social isolation, caregiving, and job insecurity, all more common among women during previous pandemics, have been associated with greater mental health concerns (Connor et al., 2020).

It is well documented that the physical and mental health of URM groups and their access to medical interventions, particularly for mental illness were lacking even prior to the pandemic (Breslau et al., 2017; Mangrio et al., 2017; Institute of Medicine, 2011). Given mental health conditions are also associated with a decreased likelihood to see a doctor for any reason, the intersection of COVID-19–related stress, reductions in access to medical care, fear of infection, and other barriers will likely have a greater impact on women and minorities in our society in the months to years to come. Future studies will help determine the relationship between the effects of mental health and chronic health conditions on women compared to men in the setting of COVID-19. Given the increased risk of greater COVID-19 severity among those with co-morbid conditions, further analysis is warranted in future studies (Sabariego et al., 2018).

MENTAL HEALTH FACTORS: WHAT DO WE KNOW AT THIS POINT?

Sex differences abound in the prevalence, age of onset, presentation, treatment and/or severity of psychiatric disorders across the lifespan. Men are more likely to experience disorders that have their onset pre-puberty, including autism, attention deficit hyperactivity disorder (ADHD), Tourette's Syndrome, and oppositional defiant disorder. After puberty, men are more likely than women to abuse alcohol or drugs, though women progress from first use to addiction for several substances of abuse more quickly and suffer greater negative health consequences (Bale and Epperson, 2017). Unfortunately, the disorders that occur more often in women—depression, anxiety, posttraumatic stress and sleep disturbance—are those that are likely to be post-pubertal in onset, to be negatively impacted by ovarian hormone fluctuations and reproductive transitions, and to skyrocket during times of extreme stress. This section of Chapter 4, focuses

on the current evidence from across the globe that women in the general population and those in STEMM fields, particularly those on the frontlines of healthcare, are at greatest risk of adverse mental health effects during and after this crisis. There are few studies focusing on mental health of women in STEMM fields outside of medicine and nursing. Where appropriate data extrapolated from studies focusing on the impact of previous epidemics and the current pandemic on the mental health of women in healthcare and those in the general population will be extrapolated to academic women in other STEMM fields.

Depression and Anxiety

Depression and anxiety are frequently co-morbid conditions and most studies of mental well-being during COVID-19 have measured both, often using standardized ratings such as the PHQ2/PHQ9 and the GAD-7, as previously mentioned (Table 1). This makes comparisons of data from across nations and regions comparable. Unfortunately, the overall message is not promising. The prevalence of depression symptoms, including those in the moderate to severe range, in the general U.S. population are 3-fold higher during than before the pandemic (Ettman et al., 2020). Risk factors include lower economic resources and greater exposures to stressors. Findings were not reported by sex nor type of employment making it difficult to examine these data in relationship to the goal of understanding the impact of COVID-19 upon women in STEMM fields. The one exception in the current literature to date, is the focus on mental health among healthcare workers (HCWs), where the female sex is a consistently reported risk factor for adverse mental health sequelae of the pandemic.

Earliest results came from China, where the SARS-CoV-2 first spread to humans. A cross-sectional study, web-based study conducted in February 2020 showed that overall psychological problems (depression, anxiety, insomnia) were reported by 60 percent of physicians, 51 percent of medical residents, 62 percent of nurses, 58 percent of technicians, and 62 percent of public health professionals. Being a frontline (exposed to COVID-19 infected patients) woman HCW was associated with greatest risk for both anxiety and depression (Que et al., 2020). These data have been borne out in a meta-analyses and scoping

reviews of studies focusing on mental health during COVID-19 compared to the general population (Shaukat et al., 2020; Kristnanamoorthy et al., 2020). Being a shift worker, a nurse, caring for infected patients, and a woman are each most consistently reported as risk factors for depression and anxiety. Importantly, the finding of vulnerability to depression and anxiety among women during COVID-19 is similar to that reported for previous viral epidemics (MERS, Ebola, SARS) (Carbarkapa et al., 2020).

These findings in HCWs extend to trainees. Trainees in healthcare who are exposed to patients with COVID-19 reporting significantly higher stress than trainees not caring for these patients (Kannampallil et al., 2020). This study similarly found that women trainees were more likely to be stressed regardless of patient exposure status, while unmarried trainees were significantly more likely to be depressed, and marginally more likely to have anxiety. Prior to the pandemic, 36 percent of graduate students reported seeking mental health care due to the stress of their studies and uncertainty about their career. A survey of graduate students during the pandemic indicates that depression is equally high for women and men, but women (42 percent) are more likely to report symptoms of anxiety than men (33 percent). Symptoms of psychological distress were even higher among Latinx students and those who identify as lesbian or gay (49 percent) or bisexual (59 percent). Depression was most common among students in the physical sciences and anxiety was more common among those in biomedical research. Of the 5 percent of students who reported not adapting well to online learning, 60 percent reported high anxiety (Woolston, 2020a). With the added stress of having to study virtually in many cases, having reduced laboratory access, and growing concerns about NIH funding, particularly for topics that are not COVID-19 related, and the strain on the global economy, one can expect that graduate students are in greater need of mental health care now and in the months to come (Woolston, 2020b).

Because suicide is more common among those with severe psychiatric and substance use disorders, pandemic-related increases in depression, anxiety, and insomnia are a cause for worry (Ji et al., 2020). A survey conducted with 5,412 adults living in the United States between June 24 and 30, 2020, indicates that

10.7 percent reported serious consideration of suicide in the previous 30 days compared to 4.3 percent of respondents surveyed in June 2018 (Czeisler et al., 2020). In this survey, women were significantly more likely than men to report depression or anxiety, but significantly less likely than men to report an increase use of substances to cope with pandemic-related stress and were less likely to report suicidal thinking within the previous 30 days. Controlling for gender, Hispanics, and non-Hispanic Blacks compared (separately) to non-Hispanic whites were significantly more likely to report both increase in substance use as well as suicidal ideation within the previous 30 days. Finally, controlling for race, ethnicity, and gender, essential workers were more than twice as likely as other workers to report increase substance use and consideration of suicide within the past month (Czeisler et al., 2020). These data are exceptionally concerning as essential workers such as physicians, nurses, veterinarians, and police officers were at higher risk of suicide compared to the general employed population even prior to the pandemic (Milner et al., 2013). Perceived stress due to COVID-19, depressive symptoms, and insomnia predicted high suicide risk in Colombia during the lockdown (Cabballero-Dominguez, 2020). Again, this is worrisome for women in general as previously mentioned, they report higher levels of depression and insomnia at baseline. It is currently unclear if the numbers of completed suicides has increased during the pandemic in the general population. However, the bulk of the evidence suggests that academic women in STEMM fields are at greater risk, as risk factors for suicide (i.e., depression, social isolation, insomnia) are clearly more prevalent in women than men during this and previous pandemics.

Trauma Exposures and Posttraumatic Stress Symptoms (PTSS)

Though men are more often exposed to traumatic events, lifetime prevalence of posttraumatic stress disorder (PTSD) is higher in women (10 percent) than in men (5 percent). Post-trauma sleep disruption—a contributing factor to risk for PTSD onset—is also more common among women than men. Traumatic stressors such as terrorist attacks, earthquakes, floods, infections outbreaks, and war are associated with heightened physiologic arousal, re-experiencing symptoms, and negative effects on mood and cognition,

particularly among exposed women (McLean and Anderson, 2009). There is some evidence from clinical and preclinical studies that menstrual cycle stage and/or ovarian hormones may impact frequency of intrusive memories (Soni et al., 2013), extinction memory (Milad et al., 2010), and condition fear extinction (Milad et al., 2009)—factors that may contribute to greater and more persistent intrusive memories among traumatized women compared to men.

In the early stages (within 1 month) of the epidemic hitting Wuhan, investigators in China examined posttraumatic symptom scores (PTSS) using the Post-traumatic Stress Checklist (PCL-5; Bovin et al., 2016) and sleep quality using the PSQI among current or recent residents of Wuhan. Women reported more PTSS than men. Women experienced higher degrees of re-experiencing symptoms, negative alterations in cognition or mood and hyperarousal compare to men (Liu et al., 2020). Not surprisingly, better subjective sleep scores were associated with lower PCL-5 scores. Treating both the PTSS symptoms as well as the sleep disturbance is critical to recovery as poor sleep quality has been linked to the onset of and maintenance of PTSD (Richards, 2013, 2019).

While it is clear that those women in STEMM on the frontline of the pandemic are at greater risk of poor mental health, review of data from the SARS, MERS, and early studies of HCWs from the current pandemic provide a glimpse into risk and resilience factors for PTSD and PTSSs (Carmassi et al., 2020) (Table 2). One can readily extrapolate from these data in HCWs to consider women in other academic STEMM fields. For example, unpredictability at work and having to learn new strategies in order to accomplish one's work are risk factors for PTSS in the context of a pandemic. Cognitive overload is also a risk factor, particularly in the face of stress and trauma. Providing clarity regarding safety measures and making sure that individuals feel adequately trained to meet the needs of their job during the pandemic are critical for mental health. Social supports and personal traits such as altruism, ability to use humor, making plans, and being able to make meaning of the current situation are protective factors in the face of tremendous work-related stress. While institutions can't mandate spiritual practice, they can create an open

environment in which individuals can discuss various practices that are helpful to them. The institution can discuss stress and burnout in such manner that destigmatizes mental health care and train supervisors and mentors to lead individual and team discussions regarding stress and the threat to one's productivity as a result of the pandemic.

Traumatic exposures during the pandemic must be considered in the context of the individual's previous psychosocial history. For example, one of the primary predictors of PTSD after a traumatic exposure is having experienced a previous trauma (McLaughlin et al., 2017; Miriman et al., 2020; Teicher et al., 2016). Individuals exposed to significant childhood adversity including, but not limited to, poverty, abuse, neglect, and exposure to domestic violence show a dampened glucocorticoid response to current stressors and an altered immune profile that are considered sub-optimal for human health (Epperson et al., 2017; Bale and Epperson, 2015; Morrison et al., 2017). Historical trauma and ongoing discrimination, such as that experienced by African Americans and American Indians, is associated with significant mental health risks at baseline (Vines et al., 2017; Guenzel and Struwe, 2019). Research conducted during the pandemic has shown that American Indians who reported greater impact of historical trauma and low current social supports were more likely to experience psychological distress during the pandemic (John-Henderson and Ginty, 2020). Similarly, diminished heart rate response to an acute laboratory stressor conducted as part of an ongoing study prior to the declaration of the pandemic was associated with greater symptoms of intrusion, hyperarousal and avoidance[1] as measured by the Impact of Events Scale-Revised only 2 weeks after the declaration of the pandemic (Ginty et al., 2020). Data were adjusted for sex, history of adverse childhood experiences, and other baseline characteristics (i.e., age, race, ethnicity, body mass index, etc.). Finally, the lesbian, gay, bisexual, transgender, queer (LGBTQ) community have been impacted by historical trauma, ongoing discrimination, and greater mental health challenges prior to the

[1] Examples of intrusions are unwanted thoughts, reminders of traumatic events, and nightmares. Common symptoms of hyperarousal include irritability, hypervigilance, and difficulty sleeping. Finally, avoidance is a frequent posttraumatic symptom as individuals are avoiding situations that could remind them of unwanted thoughts or the event specifically.

pandemic (Salerno et al., 2020; Vargas et al., 2020). With closure of colleges and universities, students who identify as LGBTQ have the added stress of going home to live with immediate family members who may not support or know their LGBTQ identity. A recent study of 477 LGBT-identifying students ages 18–25 from across 254 college campuses showed that nearly half (45.7 percent) were in this situation (Gonzales et al., 2020).

Sleep Quality

Insomnia is both a symptom as well as a predictor of onset or exacerbation of a number of mental health disorders, including depression, bipolar disorder, PTSD, and substance abuse. Sleep disturbance is also associated with greater risk for suicide among those with mental illness (Liu et al., 2020b; Weber et al., 2020). In an epidemiologic study (Kessler et al., 2011), the estimated prevalence of insomnia, broadly defined, among the adult workforce in the United States was roughly 23 percent (women 27.1 percent vs. men 19.7 percent, $p<0.001$) with estimated individual loss of 11.4 days/worker of lost work performance due to presenteeism (i.e., physically being at work, but not meeting expectations for productivity due to individual factors). In the United States alone, insomnia-related loss of productivity is estimated to be more than $63 billion a year (Kessler et al., 2011). Though prevalence of insomnia is substantially greater among women, there was no interaction between gender and insomnia with respect to presenteeism or absenteeism, indicating that despite a greater burden of insomnia among women, they are as a likely as men to come to work and to be as productive.

Importantly, puberty heralds the onset of this increase in sleep difficulties among women. Periods of hormonal flux such as the premenstruum, pregnancy/peripartum, and perimenopause are also associated with increased risk of sleep disturbances (Mallampalli and Carter, 2014). Insomnia not only impacts work productivity, it is a known risk factor for negative health outcomes such as metabolic dysregulation (Troxel et al., 2010), cardiovascular disease (Sofi et al., 2012), inflammation (Slavish et al., 2018), cognitive difficulties (Fortier-Brochu et al., 2012), and depression (Riemann et al., 2020) to name a few.

Prior to the COVID-19 pandemic, studies examining sleep have focused on the workforce in general or specific patient or demographic populations. At baseline, HCWs, particularly nurses, report worse sleep quality than the general population (Zeng, et al., 2019, Khatony et al., 2020). Psychological stress is a primary contributor to both self-report and polysomnographic reductions in sleep quality (Groeger et al., 2004). Many of the pandemic-related stressors described throughout this chapter create risk for the onset of new and worsening of insomnia and health burdens related to poor sleep quality among frontline healthcare providers (Kobayashi and Mellman, 2012). Since the pandemic and its associated shut-downs across nations, the focus has been HCWs or students versus other populations. Similar to reports with previous coronavirus epidemics (SARS and MERS), insomnia is one of the most common and consistently reported concerns among HCWs (Pappa et al., 2020) and is a predictor of job exit among middle-aged and older adults (Dong et al., 2017).

Currently, most studies published in the wake of the COVID-19 pandemic have examined sleep quality through self-report measures and do not include polysomnography. Luckily, the vast majority of studies during the pandemic have utilized validated measures such as the ICI and the PSQI (Table 1). Overall, data from multiple nations indicates an increase in poor sleep quality and complaints of insomnia in the general population during the pandemic, but to a significantly greater degree among HCWs (Li et al., 2020; Cabarkapa et al., 2020; Sheraton et al., 2020; Romero-Blanco et al., 2020). Given many of the stressors experienced by women HCWs are also experienced by women in other STEMM fields of academics, much of these data are potentially generalizable.

A robust study conducted in Spain between March 1 and April 30, 2020 examined sleep quality among 100 HCWs caring for patients with COVID-19 but compared them to 70 NHCWs (Herro San Martin et al., 2020). Doctors (58 percent), nurses (26 percent), nurses' aides (10 percent), porters (4 percent), and cleaning staff (2 percent) comprised the HCWs who participated. HCWs (41 men, 59 women) reported a higher prevalence (57 percent vs. 34 percent, $p = 0.004$) of new onset or worsening of insomnia compared

to non-healthcare workers (NHCW; 29 men, 41 women). Interestingly, only women were associated with ISI scores above 8 in the non-healthcare worker group (Herro San Martin et al., 2020). Nurses, physical therapists, respiratory therapists, and other non-M.D. frontline providers are more likely to be women, suggesting that women will carry an undue burden of health risks associated with poor sleep quality during the COVID-19 pandemic. It is important to point out that the level of insomnia and poor sleep quality based upon ISI and PSQI scores were elevated above norms for the general population, in this and other studies conducted during the pandemic (Li et al., 2020; Marelli et al., 2020).

Similarly, sleep quality among university students may be unduly impacted by the shutdown. A recent longitudinal (pre- and postlockdown) study of 207 nursing students in Spain revealed that women gender, being a first- or second-year student and living with one's family, and use of alcohol were associated with significantly worse sleep quality as measured by the PSQI (Romero-Blanco et al., 2020). Likewise, a longitudinal study including Italian university students indicated a worsening in sleep parameters, particularly among women students during the lockdown from March 10, 2020 to a partial lifting on May 3, 2020 (Marelli et al., 2020). While 55 percent of students reported clinically meaningful sleep problems before the COVID-19 lockdown, 73 percent fell into this range on the PSQI at after the lockdown was partially lifted. ISI items scores across the lockdown indicated a statistically significant (all p's <0.001) worsening of sleep parameters such as sleep latency, sleep maintenance, and early morning awakening. Social media exposure has been implicated in worsening of student mental health, including sleep, though individual factors such as a ruminative cognitive style interacted negatively with social media exposure and mindfulness was protective (Hong et al., 2020).

Regarding minority populations, the perceived stress of racism (PSR) is associated with worse self-reported sleep quality and an increase in autonomic activity while sleeping. During sleep the autonomic balance between parasympathetic and sympathetic tone should lean towards greater heart rate variability (HRV), a measure of greater parasympathetic tone. Reduced HRV during sleep is associated with

hypertension and cardiovascular disease risk, which are both more common among Black Americans. While HRV is usually greater among Blacks than whites, Blacks who report greater PSR have lower HRV during sleep than Blacks reporting minimal PSR (Bell et al., 2017, 2019). As racism and other forms of discrimination in the workplace remain common (Fededulegn et al., 2019), particularly for women of color, it would be expected that Black women in STEMM fields carry the additional burden of PSR on sleep quality during COVID-19.

Where a woman falls across the reproductive life cycle can influence sleep quality during the pandemic. A recent study (Zreik et al., 2020) in Israel found an increase of self-reported insomnia in mothers with at least one child between the ages of 6 and 72 months during home confinement due to COVID-19. Clinically meaningful insomnia measured using the ISI, among 264 mothers, increased from 11 percent (retrospective report) to 23 percent during the pandemic. There was a correlation between severity of maternal insomnia and maternal report of poor sleep quality and shorter duration of sleep in their child, a well-known dyadic phenomenon. As more than 40 percent of women with full-time jobs in science move to part time after having their first child (Cech and Blair-Loy, 2019), the additional challenges of poor sleep among women with young children further handicaps the growth of women in STEMM fields.

Among middle-aged women, many of whom are at the top of their professional ladder, balancing an increase in work-related expectation with caring for both emerging adult children and elderly parents can greatly impact sleep quality. This process of "sandwiched care" not only impacts sleep but can lead to women leaving academic STEMM fields. A common reason women report leaving the field of engineering in specific is difficulty in balancing work and personal responsibilities, many of which increase as women age and progress up the professional ladder. Moreover, the menopause transition, with its erratic fluctuations in ovarian hormones, can last for more than a decade and significantly worsen sleep quality, mood, and cognition in mid-life women (Epperson et al., 2013). While there are no studies examining the impact of COVID-19–specific stress among mid-life women in STEMM fields, one can extrapolate that

mid-life women are again experiencing the perfect storm of enhanced stress due to the pandemic, greater responsibilities personally and professionally, and hormonal changes, leading to significantly worse sleep quality and reduced quality of life during the pandemic. Importantly, insomnia was found to be a predictor of employed workers (n = 5746) ages 50–70 leaving the workforce due to poor health (Dong et al., 2017). Hence, institutions can ill-afford to ignore insomnia as a potential contributing factor to women to leaving academia during and after the pandemic.

WHAT CAN INSTITUTIONS DO TO IMPROVE MENTAL HEALTH FOR WOMEN IN STEMM?

It is incumbent upon academic institutions to recognize that the stress of the pandemic is going to accentuate the gender gap in science, technology, engineering, mathematics, and medicine. Unlike community-based stressors that have occurred in our nation since the last global pandemic in the early 20th century, the nature of the stressors related to the COVID-19 pandemic and the social distancing required to reduce viral spread are ongoing, world-wide, and with no clear end. This type of stress (e.g., chronic, unpredictable), along with social isolation, is particularly aversive for human health, stress physiology, and immune function. Biological, demographic, sociocultural, personal, and professional factors all conspire to create the perfect storm for women in STEMM to experience worsening mental health during this crisis. Indeed, when it comes to women in healthcare professions, particularly those providing care to SARS-CoV-2 infected patients, the risk for increased depression, anxiety, and sleep disturbance is even greater than that for men in healthcare as well as the general population, which is likely to reflect conditions among women in academics.

While workshops and programs meant to enhance resilience during this crisis are important, this chapter highlighted the importance of individual risk factors (e.g., gender, past history of adversity/trauma, presence of ongoing medical conditions, pregnancy, reproductive stage, current social supports) in risk for

burnout, mental health concerns, and loss to the workforce. While the institution is not responsible for these individuals factors, they should be informed about their influence on the mental health of women and strive to consider these factors as they seek to retain women in STEMM fields. Institutions are clearly responsible for creating a welcoming and inclusive culture, providing clear and accurate communications, and providing safety and structure for their employees. Institutions should also work to provide as much predictability in the workplace as possible and eradicate systemic barriers that promote stress and hinder women's sense of hope in their own success. The following specific suggestions are based upon the evidence of gender-biased burden and mental health concerns for academic women reviewed herein.

Enhancing Protective Factors for Women in Academic STEMM

1. **Creating mechanisms for safe social support, particularly from female colleagues and leaders.** As previously described, women who are able to rely on social supports are less likely to experience the accentuated physiologic responses to stress that can be so detrimental to mental and physical health. Women in some areas of STEMM are unlikely to have many female colleagues or leaders in their subspecialty. Institutions can consider how best to provide the most appropriate interaction with female colleagues for support as well as exposure to individuals who represent the ability to be a woman in a leadership position in STEMM at their institution. Given the limited number of women in STEMM leadership positions, this may require reaching out to women in leadership in a different field of STEMM to serve as a role model. Caution must be exerted to not over-extend the few women in STEMM leadership. Perhaps these women could be incentivized financially to take on these roles and/or asked which tasks they are currently doing that are less important to their career advancement at this time.
2. **Creation of flexible work schedules, and encouragement to use this option when appropriate.** As previously mentioned, cognitive load can be greater in women who are balancing academic and caregiving needs. Flexible work schedules could support retention of women in academics,

particularly if they are balancing work and family caregiving. Careful attention must be paid to make sure that the workload is commensurate with the individual's work effort, that they are not doing full-time work with part-time work and part-time pay. While leadership needs to be aware of the potential for unconscious biases regarding individuals who flex schedules or work part-time as being less committed to their careers; instead, they need to intentionally consider opportunities for professional growth for these individuals. Consideration of cognitive load of employees can be assessed by the NASA Task Load Index (Table 1) and women working part-time should be given tasks that promote their careers in addition to service to the department.

3. **Support for childcare and eldercare; costs may be supplemented by the institution.** For example, Care.com has entered into a relationship with the University of Colorado School of Medicine to provide free membership and care-giving support that is subsidized by the medical school. Agencies that support both child- and eldercare should be considered, as many women in STEMM leadership positions are caught in the "sandwiched" situation in which they are caring for older children and older parents.
4. **Proactive career mentoring, particularly regarding academic productivity and promotion.** It has already been noted that women investigators have had fewer publications and citations during the COVID-19 pandemic (Gabster et al., 2020). Determining institutional barriers to research productivity is critical for women and that requires special attention with additional mentorship, supportive trainings, and actively connecting women with datasets that are publication worthy. It is important for reasons already mentioned to not overburden senior women academics if there are men who could also provide this level of support for junior faculty.
5. **Flexible promotion pathways, but still encouraging women to remain on a promotion path.** There is clear precedent in many institutions for women to spend more years at each academic rank than their male counterparts. As women are producing fewer publications during the pandemic, it

would be prudent to proactively understand institutional barriers to their productivity. Fewer citations of their work can also impact their national and international recognition. With fewer in-person meetings, it is critical that mentors and institutions determine methods for highlighting the work of their female faculty and helping them to make connections nationally.

6. **Provide clear information regarding how to stay safe.** Uncertainty about safety has been highly detrimental for the general population. Uncertainty about an institution's commitment to safety in the medical or research laboratory settings is likely to adversely impact productivity of all investigators. However, if an individual is a single mother, caring for elderly parents, pregnant, or suffering from an autoimmune condition, a sense of unsafety in the workplace can inhibit their access to the lab and thus productivity with respect to their science.
7. **Encourage employees to remain connected with colleagues, friends, and family, according to current social distancing restrictions**. While institutions are not accustomed to being involved in their employees' personal lives, work colleagues make up a large proportion of the academics' social network. Paying close attention to COVID-19 outbreaks, conducting robust contact tracing and then reassuring (if appropriate) others that the outbreak has been contained will lead individuals to feel safer being in-person at work. Creating open spaces on campus for small group gatherings on a regularly scheduled basis can also give a sense of order and safety to social gatherings with colleagues and mentors.
8. **Limiting exposure to news about the pandemic other than that needed to remain safe and informed.** Evidence suggests that over-consumption of social media about the pandemic can be harmful, particularly as studied in university students. These data could be extrapolated more broadly. Making it clear that institutions have the most up-to-date information regarding policies and procedures related to the pandemic could limit individuals seeking information about the pandemic from social media.

Actively Address Mental Health Needs of Women in Academic STEMM Fields

9. **Encourage active self-screening for mental health concerns.** It is clear from the data presented herein that there are and will be continued mental health concerns as a result of the pandemic. As reviewed, women in health care and presumably other areas of STEMM in academics are at greater risk of depression, anxiety, PTSS, and insomnia during the pandemic. Institutions could make the self-screening measures described in Table 1 available to their faculty and staff and encourage them to monitor their own mental health. Given stigma related to mental illness and mental health care treatment, self-assessments could be accompanied by anonymous crisis support lines, links to faculty and staff mental health clinics, and online treatment options.
10. **Promote employee well-being through institutional-backed wellness programs.** When institutions demonstrate that they value faculty, staff and trainee well-being they promote trust in the institution (Dzau et al., 2020). At the organizational level, the institution can integrate the work of chief wellness officers or clinician well-being programs into COVID-19 "command centers" or other organizational decision-making bodies for the duration of the crisis. At a national level, allocation of federal funding to care for clinicians with mental and physical health sequelae of the COVID-19–related service would help workers and their families during these stressful times.
11. **Create schedules and interventions that promote good sleep hygiene.** The data reviewed here emphasized the impact of the pandemic on risk for insomnia even among those without a previous sleep difficulty. While insomnia is a well-known symptom of depression and many other psychiatric conditions, it can also lead to onset or worsening of psychiatric disorders (Lombardero et al., 2019; Li et al., 2016). There is overall less stigma related to sleep disorders, thus making insomnia a socially acceptable target for intervention if there are major concerns regarding psychological safety within a given institution. Primary care providers are in an excellent position to assess whether sleep disruption is a symptom of an underlying mental health condition and make appropriate

interventions or referrals. Academic medical centers are major employers of women in the workforce, particularly physicians in primary care where there is more patient contact and greater rates of burnout and nurses who are often shift workers and at the epicenter of the current crisis. Academic institutions can encourage hospital partners to create schedules that promote consistent sleep patterns for the faculty and staff to the degree that is possible. Making the ISI or PSQI (Table 1) measures available to faculty and encouraging individuals to self-monitor as part of an overall wellness program is a straightforward process that most academic programs can undertake. Online Cognitive Behavioral Therapy for Insomnia (CBTi; Weiner et al., 2020) is effective in the treatment of insomnia, though it comes with some financial costs. Again, couching good sleep hygiene in the context of overall mental health may be a less stigmatizing way to get academics to focus on their mental health and decrease risk for depression, anxiety, and PTSS/PTSD.

12. **Create formal faculty and staff mental health programs with institutional support for administrative and start-up costs**. Stigma regarding mental illness and the act of seeking mental health care remains a significant barrier, with life-threatening consequences. Clinical and research leaders hesitate to report symptoms/concerns as they believe that they must "Be strong for the Team." Physicians in specific are fearful about disclosing mental health conditions (Gold et al., 2016). For example, prior to her suicide, Dr. Lorna Breen, an emergency medicine physician in New York, called her brother to share her fears about seeking care. While being borderline catatonic because of her depression, her largest fear was losing her medical license or being ostracized by her colleagues (Feist et al., 2020). Likewise, results from a recent COVID-19 Climate Survey conducted at the University of Colorado School of Medicine indicated that concerns about confidentiality and a potential negative impact on their reputation and career kept them from seeking mental health care. Once one decides that they need treatment, finding a mental health care provider that accepts one's insurance is a challenge for academics across the United

States and wait times can be excessively long. Universities and academic medical campuses often have mental health clinics for their students, but few have created their own faculty and staff mental health services. The University of Colorado School of Medicine Department of Psychiatry, with financial support from the Chancellor of the CU Anschutz Medical Campus created a faculty and staff mental health program in June 2020. The program allows faculty and staff to obtain mental health assessments and short-term care without having to worry about their insurance or compete with individuals from the general population for mental health care appointments. Typically, faculty and staff are evaluated by phone within a few hours of contact with the clinic and are seen for an in-person or virtual telehealth visit within 48 hours. This has created greater access to and utilization of mental health care by faculty and staff and the program is continuing to grow as the pandemic wears on. Most psychotherapy and psychiatric services are currently being provided through videoconferencing platforms, which is often more convenient for consumers (Shore et al., 2020). Since individuals may be concerned that their employer or colleagues will discover that they are in treatment, telehealth or online programs may provide them the flexibility to have sessions over lunch, before or after the workday from the privacy of home, car, or office. There is also a growing list of app-based therapies for depression and anxiety, as well as mindfulness-based stress management and meditation programs. Most states have crisis support lines that provide completely anonymous support and recommendations.

13. **Greater consideration of intersectionality of race, ethnicity, gender identity, health, and disability when considering programs to promote retention of women in academics.** There is clear evidence that not everyone who recognizes themselves as a woman will come to the pandemic with the same risk factors for mental health concerns. While there are indeed fewer women than men in STEMM fields, there are even fewer women who experience the intersectionality of having multiple identities. For example, a Black woman in STEMM may have

experienced a lifetime of stress due to racism. Her social isolation at work is not new and she may have other factors that contribute to a greater stress burden during the pandemic than her female colleague who is at her same rank, but white. Perhaps as the only woman of color in her department, she may have been in the position of greater task load and cognitive burden as she becomes the woman of color on every committee. Her colleague who is white did not have to contend with the perceived stress of racism, but perhaps she experienced significant childhood trauma and adversity that is being triggered by stressors related to the current pandemic. Women with chronic medical condition are more vulnerable to infection during the pandemic and therefore unable to complete experiments that required significant time in the lab. These intersectionalities can have a significant impact in how individuals experience the stress of the pandemic, their ability to be productive and their relative risk for burnout and other mental health concerns. Hence, women in STEMM are not a monolithic entity that requires one type of intervention to encourage their retention in academics.

In summary, the mental health disorders that arise de novo or are worsened during a wide-spread crisis such as the COVID-19 pandemic are more common among women as well as URM groups in the general population even at baseline. Pandemic-related factors conspire to increase these problems for women in academic STEMM. Social isolation, lack of or disconnection from women role models, previous and ongoing exposures to discrimination and related stress, biological and hormonal factors, economic and family concerns are just a few of the larger social determinants of mental health among women in STEMM. Academic institutions are in the position to stem the loss of women faculty from STEMM fields during and after the pandemic by recognizing their unique needs and considering women as individuals with varying degrees of risk for burnout and mental illness. Interventions to promote well-being should be instituted and

researched in order to determine which interventions are most likely to meet the needs of the diverse array of women in STEMM.

TABLE 1 Measurements for Mental Well-Being Frequently Used prior to and during the Pandemic

Instrument	Description
Physician Health Questionnaire – 2-Item (PHQ-2; Kroenke et al., 2003)	Assesses depressed mood and decreased interest/pleasure. Responses ranging from 0 = *not at all* to 3 = *nearly every day*. Total scores of ≥ 3 are considered indicative of major depression. Reference period = past week
Physician Health Questionnaire – 9-Item (PHQ-9; Kroenke et al., 2001)	Frequency of depression symptoms are measured using a scale ranging from 0 = *not at all* to 3 = *nearly every day*. Scores range from 0 to 27 with mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27) depression. Reference period = past week
Generalized Anxiety Disorder – 7-Item (GAD-7; Spitzer et al., 2006)	Measure of generalized anxiety disorder. Frequency of anxiety symptoms are rated as 0 = *not at all* to 3 = *nearly every day*. Total score range = 0 to 21, with mild (5-9), moderate (10-14), and severe (15-21) anxiety. Reference period = past 2 weeks
Insomnia Severity Index (ISI; Morin et al., 2011) (7 items)	Items 1-3 assessed the nature of insomnia with questions related to problems falling asleep, staying asleep, and early awakening (0 = *no problem* to 4 = *very severe*). Item 4 assessed dissatisfaction with sleep (0 = *very satisfied* to 4 = *very dissatisfied*). Items 5-7 assessed the impact of insomnia by asking about sleep difficulties interfering with daytime functioning, etc. (0 = *not at all* to 4 = *very much*). Scores range from 0-28 with > 10 considered indicative of insomnia.
Pittsburg Sleep Quality Index (PSQI; Buysse et al., 1989) (19 items)	Individuals report on seven components of sleep: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Scores on the seven components (weighted equally on a 0-3 scale) are added for a total score of 0-21. A score of > 5 is considered indicative of poor sleep quality. Reference period = past month
PTSD Checklist for DSM-5 (PCL-5; Blevins et al., 2015) (20 items)	Respondents report on how much they have been bothered by each PTSD symptom using a scale ranging from 0 = *not at all* to 4 = *extremely.* The items tap into four subscales: re-experiencing, avoidance, hyperarousal, and negative alterations in cognition and mood. Total score ranges from 0-80. Reference period = past month
Maslach Burnout Inventory – Human Services Survey for Medical Personnel (MBI-HSS MP; Maslach & Jackson, 1981) (22 items)	Measures 3 aspects of burnout emotional exhaustion (EE; 9 items), depersonalization (DP; 5 items), and low sense of personal accomplishment (PA; 8 items). Frequency of experiences ranges from 0 = *never* to 6 = *every day*. Items are added for a total score ranging from 0 to 54 for EE, 0 to 30 for DP, and 0 to 48 PA. A score of ≥ 27 on the EE subscale and a score of either ≥ 10 on the PD subscale or ≤ 33 on the PA subscale are considered indicative of burnout.
Stanford Professional Fulfillment Index (PFI; Trockel et al., 2018) (16 item)	Measures burnout and personal fulfillment in physicians. Four items assess work exhaustion (e.g., EE at work); 6 items assess interpersonal disengagement use a scale ranging from 0 = *not at all* to 4 = *extremely.* The six items related to professional fulfillment (e.g., my work is meaningful to me) use a scale ranging from 0 = *not at all true* to 4 = *completely true*. The items are added for a total score of 0 to 64. Reference period = past two weeks

Copenhagen Burnout Inventory (CBI; Kristensen et al., 2005) (19 items)	Measure of burnout in any occupational group. Three aspects of burnout assessed: Prolonged physical or psychological exhaustion perceived to be related to personal (6 items) or work life (7 items) and 6 items related to working with clients. Items are rated on frequency; 0 = *never or almost never*, 25 = *seldom*, 50 = *sometimes*, 75 = *often*, 100 = *always* or 0 = *to a very low degree*, or bother; 25 = *to a low degree*, 50 = *somewhat*, 75 = *to a high degree*, and 100 = *to a very high degree*. Subscale range 0–100
NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988) (6 items)	Assesses subjective experience of workload. Individuals report on six dimensions: mental demand, physical demand, temporal demand (i.e., time pressure to complete tasks), performance, effort, and frustration level. Each dimension is rated on a 0 to 100 scale in 5-point increments. The dimensions can be weighted by using 15 pair-wise comparisons of the dimensions (e.g., comparing whether mental demand vs. physical demand contributed more to workload). Each dimension can be chosen from 0 (not relevant) to 5 (more important than any other dimension) times. Ratings of dimensions deemed to be most important in creating the workload of a task are given more weight in computing an overall workload score.

TABLE 2 Risk and Resilience Factors: Documentation from Healthcare Workers Extrapolated to Academic Women in STEMM.

RISK & RESILIENCE

WHILE THE MAJORITY OF RESEARCH FOCUSING ON RISK AND RESILIENCE FACTORS FOR POST-TRAUMATIC STRESS AND OTHER MENTAL HEALTH CONCERNS HAS FOCUSED ON HEALTH CARE WORKERS, MANY OF THE PRINCIPALS CAN BE EXTRAPOLATED TO ACADEMIC WOMEN IN OTHER STEMM FIELDS

RISK FACTORS	HEALTH CARE WORKER	WOMEN IN STEMM FIELDS
Unpredictability at work	Daily caseload	Access to lab/equipment
Managing expectations	Families & patients	Mentors, program officers
Increased acuity	Increase in critically ill	Meeting deadlines
Decision-making burden	Increased executive load	Increased executive load
Traumatic exposures	More deaths per day	Threat of infection, loss of job
New procedures	New treatments to learn	"COVID-izing" research

RESILIENCE FACTORS	HEALTH CARE WORKER	WOMEN IN STEMM FIELDS
Supportive family & friends	Supportive family & friends	Supportive family & friends
Support at work	Supervisor, colleagues	Mentor, collaborators, labmates
Feeling adequately trained	Trainings & supervision	Support to COVID-ize work
Structure in the workplace	Team approach	Structure office & home time
Safety in the workplace	Clear safety instructions	Clear safety instructions
Coping strategies	Humor & planning	Humor & planning
Confidants	Open dialogue about stress	Open dialogue about stress
Personal beliefs/meaning	Altruism & spirituality	Altruism & spirituality

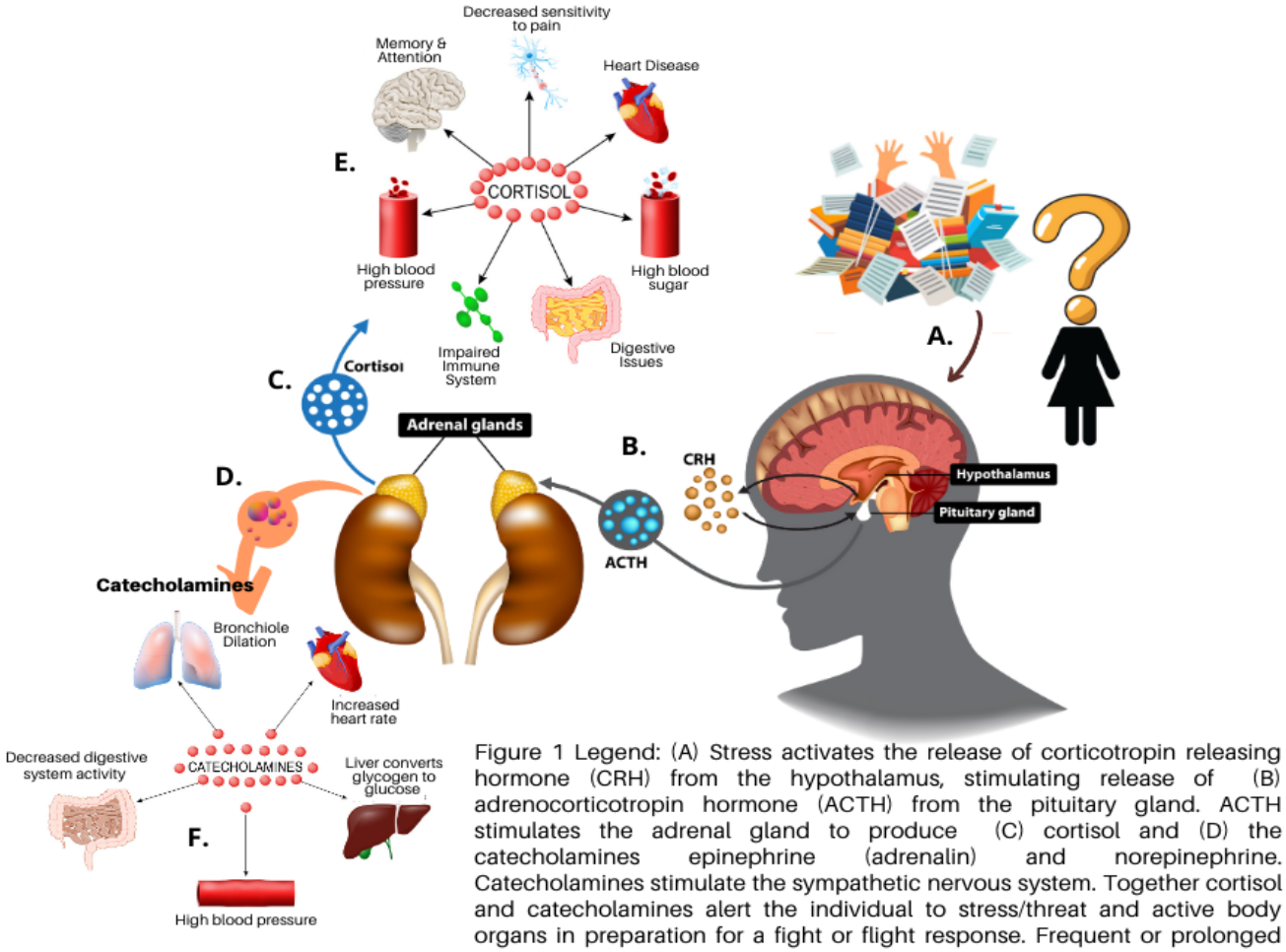

Figure 1 Legend: (A) Stress activates the release of corticotropin releasing hormone (CRH) from the hypothalamus, stimulating release of (B) adrenocorticotropin hormone (ACTH) from the pituitary gland. ACTH stimulates the adrenal gland to produce (C) cortisol and (D) the catecholamines epinephrine (adrenalin) and norepinephrine. Catecholamines stimulate the sympathetic nervous system. Together cortisol and catecholamines alert the individual to stress/threat and active body organs in preparation for a fight or flight response. Frequent or prolonged exposure to cortisol or catecholamines is are associated with adverse health outcomes (E & F). Figure created with Dreamstime royalty-free images.

FIGURE 1 Stress Physiology.

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