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Evaluating the Evidence and Viability of Occupational Social Support Countermeasures Delivered Prior to Long-Duration Spaceflight to Enhance Behavioral Health

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Executive Summary

This report presents the methods and results of research requirement study on the topic of pre-flight occupational social support as a potential behavioral health countermeasure delivered prior to long-duration spaceflight. The work specifically is intended to satisfy the requirements of NNJ14HK46P, "Pre-Flight Social Support Network." The study incorporated literature review and operational assessment components to consider the potential utility of pre-flight countermeasures to: (1) mitigate against stressors associated with preparing for, and engaging in, long-duration spaceflight and (2) enhance astronaut behavioral and emotional well-being before and during long-duration spaceflight

Methodology:

The evidence review encompassed several literatures judged to be potentially relevant to spaceflight, given that there is no direct evidence gained from the spaceflight literature and only minimal, indirect evidence from close spaceflight analogues. The literatures reviewed included both observational and intervention studies relevant to occupational social support that were conducted among military personnel, first respondents and other emergency personnel, law enforcement officials, and among other professionals working in potentially high-stress occupations (physicians, physician trainees, business executives). Interventions reviewed included both those involving direct provision of social support (e.g., mentoring, executive coaching), as well as training in skills intended to enhance both provision and receipt of social support within the occupational setting (e.g., social resilience training).

The operational assessment involved semi-structured phone interviews of 8 subject matter experts, including retired astronauts, space analogue participants, astronaut trainers, Behavioral Health and Performance Operations personnel, and a military scientist with experience in conducting research relevant to social support. We additionally conducted an informal interview with a representative from the NASA mentoring program. Content domains included: identification of high-priority countermeasure behavioral health outcome targets, identification of currently available sources of support for astronauts accessible prior to long-duration spaceflight, assessment of the feasibility of delivering social support countermeasures, identification of potential barriers and facilitators of new social support countermeasures, and applicability of analogue contexts to research examining organizational support countermeasures.

Primary Findings and Recommendations:

- Astronauts would likely benefit from, and be receptive to, at least some forms of social support countermeasures delivered within an occupational context.

- "Pre-flight" may be construed to encompass several phases, including astronaut candidacy training, astronaut without flight assignment training, training after flight assignment (varies according to mission), and more immediate prelaunch preparation.

Subject matter experts indicated that social support networks are more readily accessible during candidacy training. We therefore recommend that new operational and research efforts focus on subsequent pre-flight phases, and in particular, training after flight assignment, which was identified as a high-stress period in which other forms of social support (e.g., friends, family) may not be as accessible due to extensive travel and training requirements.

- The evidence review reveals two general types of potentially effective countermeasures: (1) those that involve direct delivery of support (e.g., mentoring) and (2) those that involve enhancement of the ability to provide and receive social support effectively (e.g., social resilience training). Support may additionally be provided in different delivery platforms, including one-on-one support, strengthening of informal peer networks, didactic training, and team-level training. The optimal delivery mechanism will likely differ according to the type of countermeasure (e.g., mentoring is likely best provided one-on-one, whereas social resilience training has potential to be provided in team formats).

- Social support may also be categorized into sub-constructs including (1) instrumental (i.e., concrete/tangible forms of assistance), (2) emotional (i.e., demonstrations of care, trust, empathy, encouragement – and/or other positive emotional expressions), (3) informational (i.e., provision of information and/or advice), and (4) appraisal (i.e., self-evaluative information sharing) support. There is currently a paucity of research that systematically evaluates optimization of matching the type of support provided to the context (including stressor considerations, professional phase, and individual difference factors). Research and operational efforts to consider the type of support provided according to context (e.g., specific phase of "pre-flight" training) would likely be beneficial.

- The operational assessment suggests that time constraints are a potential barrier to implementation, given the level of demand on astronauts during some pre-flight periods. Delivery of countermeasures within team contexts (e.g., National Outdoor Leadership School [NOLS] or NOLS-like exercises) or in "organic" formats (e.g., sports participation to enhance social networks) may facilitate receptivity.

- Although spaceflight analogues differ in certain characteristics (e.g., prior interactions among team members prior to the analogue from spaceflight), close analogues may nonetheless be beneficial conduits for social support research efforts.

1. INTRODUCTION

1.1 Statement of the Problem/Background

Long-duration spaceflight brings with it a number of challenges potentially affecting the well-being and performance of astronaut crew members. Such factors are well-documented and include, amongst others, potential isolation, communication failures, close living quarters for extended durations, extended separation from family and friends, stress within team dynamics, restriction of routine activities (e.g., sports, social activities, hobbies), and periods of significant workload. It is anticipated that future missions to Mars, due to unique characteristics such as significant communication delays and the extended duration of the mission, will exacerbate stressors observed on the International Space Station and in analogue contexts designed to mimic some aspects of long-duration spaceflight. Preparation for such a mission is likewise not without its challenges and is often associated with extensive travel away from home and demanding training requirements, possibly for a period of several years. Relatedly, astronauts report greater stress pre-mission than during or post-mission. Thus, there is a need to deliver countermeasures that boost stress resiliency prior to mission launch – both to address stressors confronted while preparing for spaceflight and to help bolster resilience during spaceflight.

Support from others (i.e., social support) within the workplace may form the basis of a candidate countermeasure to apply pre-flight for those embarking, or potentially embarking, in long-duration spaceflight. As discussed below within the findings of the literature review, social support delivered within organizational settings has proven to be an effective buffer to both routine occupational challenges, as well as to extreme, or traumatic, stress. Thus, the overarching goal of this research review project is to consider organizational social support as a potential pre-flight countermeasure designed to enhance behavioral health outcomes prior to long-duration spaceflight, including manned missions to Mars.

1.2 Definitions

This report centers on social support delivered pre-mission within occupational contexts and its impact on behavioral health outcomes. Within this general framework, we first sought to

define social support. Review of the literature suggests that there are four commonly identified forms of social support: (1) instrumental (i.e., concrete/tangible forms of assistance), (2) emotional (i.e., demonstrations of care, trust, empathy, encouragement – and/or other positive emotional expressions), (3) informational (i.e., provision of information and/or advice), and (4) appraisal (i.e., self-evaluative information sharing) (e.g., Heaney & Israel, 2008; Langford, Bowsher, Maloney, & Lillis, 1997). Closely related constructs include leadership support (from pre-mission leaders/chain of command), team cohesion (of the pre-mission team), perceived organizational support, mentoring, organizational coaching, and peer support. We take into consideration such closely related constructs (e.g., leadership support, team cohesion) but consider them primarily as predictors of behavioral health outcomes, rather than as outcomes in and of themselves. We define within occupational contexts to include support provided from within NASA and/or from within the astronaut's professional community outside of NASA (e.g., retired astronauts). Reflecting the objectives of this research report, we do not consider as potential social support countermeasures professional mental health services (e.g., contacts with NASA Behavioral Health and Performance Operations) within or outside of NASA, support from family, friends, and non-occupational community sources, or from society more generally.

Through discussion with subject matter exerts, we defined pre-flight (i.e., pre-mission) broadly to encompass astronaut candidacy (1-2 years), astronaut without flight assignment, training after flight assignment (varies according to mission), and more immediate prelaunch preparation, but focus our recommendations more extensively on training after flight assignment and prelaunch preparation. Although countermeasures delivered during the pre-flight period would ideally be relevant to spaceflight, and certain social support formats would potentially extend to spaceflight, we do not take into consideration countermeasures designed for exclusive delivery during spaceflight or during the post-mission re-integration.

We defined behavioral health outcomes to encompass mood states, expressed emotion, mental health disorders, stress reactions, emotional/psychological adaptation, successful coping, resilience, posttraumatic growth, intermediate (i.e., mediating) person-level psychological constructs (e.g., emotion regulation), psychophysiological indicators of stress

response (e.g., sleep, psychophysiological reactivity), neurocognitive performance, interpersonal conflict, social isolation, work satisfaction, and non-technical aspects of work performance (e.g., overall productivity). We did not consider team variables such as team cohesion, team care, and team resilience.

1.3 Objectives

Our overarching goal was to better understand the potential role of organizational social support countermeasures delivered pre-flight in promoting astronaut behavioral health, including the use of social support as a mechanism to enhance adaptation to long-duration spaceflight missions, such as a Mars mission. Our specific objectives were as follows:

1. To conduct a review of literature addressing social support systems and interventions as they relate to behavioral health outcomes in spaceflight and analogous settings;
2. To conduct an operational assessment of current pre-flight social support mechanisms that are currently in use, as well as the feasibility and perceived benefits and barriers to implementing social support countermeasures pre-flight;
3. To generate prioritized research recommendations based on the evidence review and operational assessment.

1.4 Overview of Work Conducted

We began the work with the literature review. We first attempted to constrain the populations of interest as narrowly analogous as possible to astronauts engaging in long-duration spaceflight. We specifically examined literatures pertinent to professions engaged in spaceflight (i.e., astronauts) and those functioning within exploration environments (i.e., isolated, confined, extreme environments), the military, and as emergency responders. However, we found that we needed to expand the literature review to other potentially high-stress occupations to capture in particular evidence relevant to social support interventions. We therefore expanded our review to include healthcare and law enforcement professionals more broadly than those engaged in emergency

response, as well as to business executives. Specific search terms are delineated in the subsequent literature review section under Methodology (Section 2.2).

We used our literature review to inform our operational assessment, which included topics relevant to identification of behavioral health targets, identification of currently available sources of social support for astronauts, feasibility, barriers and facilitators, and applicability of analogue contexts to research examining social support countermeasures. We interviewed 8 subject matter experts (SMEs) (2 retired astronauts, 2 BHP Operations personnel, 2 astronaut trainers, 1 space analogue participant, and 1 military organizational support expert). We additionally informally consulted with representatives from NASA's mentoring program. The specifics of the operational assessment methodology can be found in the subsequent operational assessment section under Methodology (Section 3.2).

2. LITERATURE REVIEW

2.1 Overview of Content Domains

This literature review covers English language publications written on the topic of social support delivered within professional contexts. It encompasses both observational studies of the relationship between social support and behavioral outcomes and interventions designed to increase social support in occupational settings. The available literature of potential relevance to spaceflight primarily touches on three of forms of social support (instrumental, emotional, informational), with less coverage of social support related to "appraisal" support. As possible, we link the social support construct measured in each study reviewed to one or more of these terms; however, depending on the specific study, the component social support constructs were not reliably well-articulated.

In keeping with a behavioral health emphasis, as discussed in detail above, we narrowed behavioral health outcomes to include emotional well-being, stress responses, resilience, work performance, and quality of life. Of note, the timing of both measurement in observational studies and delivery of interventions in intervention studies often reflected the period of recovery from prior stress exposure or was not unlinked to specific events. Assessment or delivery of social support was,

however, rarely timed in relation to preparation for a specific event, as might be the case in for social support in pre-flight for astronauts preparing for long-duration spaceflight.

Finally, we considered populations of potential relevance. Because the spaceflight literature is extremely limited in the area of occupational social support and behavioral health, we expanded the review to include space analogue participants, military personnel, emergency service responders, and members of other high-stress professions. Each population for inclusion was purposefully selected for unique occupational and situational characteristics that increase the applicability to astronauts and long-duration spaceflight.

More specifically, space analogue participants (e.g., crew members working in desert environments, Antarctic winter-overs) were selected on the basis of key contextual factors that emulate spaceflight (e.g., social isolation, harsh weather/environmental conditions). Both military and emergency service responders (e.g., emergency medical technicians, police officers/constables, World Trade Center responders, firefighters, ambulance personnel) were selected based on their regular exposure to highly demanding, potentially stressful situations – inclusive of those with the potential for death and/or serious injury. Other high-stress professions (e.g., business executives, correctional officers, physicians not involved in emergency care) are relevant to astronauts based on the highly selective nature of their jobs (e.g., physicians), personality characteristics (e.g., business executives), and/or exposure to high-stress environments (e.g., correctional officers), although no single profession is similar on all attributes to astronauts.

Some important differences between the selected populations and astronauts engaged in long-duration spaceflight include the absence of exposure among non-astronauts to specific spaceflight attributes (e.g., lack exposure to radiation, availability of oxygen, presence of gravity) and the younger typical age at time of study relative to astronauts at the point in their careers when they are most likely preparing for, or engaged in, long-duration missions (typically in their 40s and 50s). In the absence of spaceflight research that examines behavioral health outcomes as a function of organizational social support, we find these populations to provide information that may be extrapolated to astronauts despite important differences between the populations included and astronauts.

2.2 Methodology

The literature review was completed in 5 stages. Each stage is detailed below. The electronic database used for Stages 1-3 was PubMed. Stage 4 included supplemental findings from secondary search (e.g., using PsycInfo) and expert recommendation. During all stages, only those articles relevant to human research were included (i.e., excluded research dealing solely with animals).

In Stage 1, "Selection of Terms," we worked to generate a comprehensive list of appropriate search terms and ended with 5 separate searches. The table below provides the exact search terms used. Searches 1 and 2 were formulated to include: (1) professional support terms + (2) mental health outcome terms + (3) population-specific terms. Search 3 focused on: (1) mental health outcome terms + (2) executive coaching terms. Search 4 was composed of: (1) mental health outcome terms + (2) peer support/mentoring terms + (3) population-specific terms. Search 5 emphasized unit cohesion and included: (1) "unit cohesion" + (2) mental health outcome terms + (3) population-specific terms.

Overall, the approach at this stage was to be liberal in term inclusion, so as to ensure the maximum number of returned articles. This approach was selected in order to minimize the likelihood of overlooking relevant research. Stage 1 resulted in a total of 3,412 potential articles for inclusion.

STAGE 1: SELECTION OF TERMS		
Search #	**Search Terms**	**Number of Raw PubMed Results**
Search 1: Spaceflight/Space Analogues/Military	((professional support* OR organizational support* OR intervention* OR emotional support* OR social support*) **AND** (mental health* OR psychological* OR psychiatric* OR behavioral health* OR stress* OR resilience* OR mood* OR anxiety* OR depression* OR PTSD OR post traumatic growth OR anger* OR irritability* OR quality of life* OR well-being* OR fatigue*) **AND (**space analog* OR military* OR special forces* OR survival training* OR aviation* OR combat* OR deployment* OR space flight* OR isolated environment* OR unusual environment* OR extreme environment* OR winter over* OR submarine* OR polar expedition* OR arctic* OR mars mission*))	1,996
Search 2: Emergency Service Responders	((professional support* OR organizational support* OR intervention* OR emotional support* OR social support*) **AND** (mental health* OR psychological* OR psychiatric* OR behavioral health* OR stress* OR resilience* OR mood* OR anxiety* OR depression* OR PTSD OR post traumatic growth OR anger* OR irritability* OR quality of life* OR well-being* OR fatigue*) **AND (**first responder* OR firefighter* OR police* OR emergency medical responder* OR EMR* OR emergency medical technician* OR EMT* OR paramedic*))	843
Search 3: High Functioning Groups	((mental health* OR psychological* OR psychiatric* OR behavioral health* OR stress* OR resilience* OR mood* OR anxiety* OR depression* OR PTSD OR post traumatic growth OR anger* OR irritability* OR quality of life* OR well-being* OR fatigue*) **AND** (executive coach*))	6
Search 4: Mentoring	((mental health* OR psychological* OR psychiatric* OR behavioral health* OR stress* OR resilience* OR mood* OR anxiety* OR depression* OR PTSD OR post traumatic growth OR anger* OR irritability* OR quality of life* OR	539

	well-being* OR fatigue*) **AND** (mentor* OR peer support* or coach*) **AND (**space analog* OR military* OR special forces* OR survival training* OR aviation* OR combat* OR deployment* OR space flight* OR isolated environment* OR unusual environment* OR extreme environment* OR winter over* OR submarine* OR polar expedition* OR arctic* OR mars mission* OR first responder* OR firefighter* OR police* OR emergency medical responder* OR EMR* OR emergency medical technician* OR EMT* OR paramedic* OR executive* OR physician* OR doctor*))	
Search 5: Unit Cohesion	((unit cohesion*) **AND** (mental health* OR psychological* OR psychiatric* OR behavioral health* OR stress* OR resilience* OR mood* OR anxiety* OR depression* OR PTSD OR post traumatic growth OR anger* OR irritability* OR quality of life* OR well-being* OR fatigue*) **AND** (space analog* OR military* OR special forces* OR survival training* OR aviation* OR combat* OR deployment* OR space flight* OR isolated environment* OR unusual environment* OR extreme environment* OR winter over* OR submarine* OR polar expedition* OR arctic* OR mars mission* OR first responder* OR firefighter* OR police* OR emergency medical responder* OR EMR* OR emergency medical technician* OR EMT* OR paramedic* OR executive* OR physician* OR doctor*))	28
	TOTAL:	3,412

In Stage 2 "Initial Screening Based on Titles/Abstracts," we manually sorted through the original 3,412 articles identified during Stage 1 to screen in only those papers that were relevant to: (1) organizational support + (2) mental health outcomes + (3) a population of interest. During this initial screening, decisions of inclusion were based solely on review of the article title and abstract. For ease of further sorting, a PDF of each article identified in Stage 2 was compiled in an electronic folder. Additionally, each article was summarized (e.g., author, independent

variable, population, type of research, outcomes) in a Microsoft Word document. Stage 2 resulted in a total of 130 potentially relevant papers.

STAGE 2: INITIAL SCREENING BASED ON TITLES/ABSTRACTS	
Screened in only those papers with titles/abstracts relevant to: (1) organizational support + (2) mental health outcomes + (3) population of interest	
Search #	**Number of Included PubMed Results**
Search 1: Spaceflight/Space Analogues/Military	49
Search 2: Emergency Service Responders	26
Search 3: High Functioning Groups **/ Search 4:** Mentoring	36
Search 5: Unit Cohesion	19
TOTAL:	130

In Stage 3 "PubMed Inclusion Decisions," we carefully reviewed the 130 articles that were screened in during Stage 2 to determine their relevance to: (1) organizational support + (2) mental health outcome + (3) a population of interest. In making the inclusion decisions, we implemented an organizational system in which articles were divided into those that were observational versus those that included countermeasures/interventions. To insert additional organization, final papers for inclusion were also sorted by population of study (i.e., spaceflight/spaceflight analogue participants, military personnel, first responders/emergency medical personnel/law enforcement personnel, and other professionals in high-stress occupations). Details of the organizational system are provided in the table below. Stage 3 resulted in a total of 75 articles.

STAGE 3: PUBMED INCLUSION DECISIONS	
Carefully reviewed those studies screened in during Stage 2. Decided on the below organizational system, dividing studies of social support in the workplace into those that were: observational vs. those inclusive of countermeasures/intervention. Further sorted by population of study: spaceflight/analogues, military, first responders/emergency medical personnel/law enforcement personnel, and other professionals.	
Professional Social Support Studies	**Number of Included PubMed Results**
Observational Studies	
Spaceflight/Analogues	1
Military	27
First Responders/Emergency Medical Personnel/Law Enforcement AND Other Professionals: Physicians and Physician Trainees	15
Countermeasures and Interventions	
Spaceflight/Spaceflight Analogues	1
Military	12
First Responders/Emergency Medical Personnel/Law Enforcement AND Other Professionals: Coaching/Mentoring/Emotional Intelligence	19
TOTAL:	75

To increase coverage of the relevant literatures, Stage 4 consisted of a "Search Expansion" beyond the results obtained from PubMed. Specifically, in Stage 4, we: (1) conducted a secondary search (e.g., using leads from Stage 3 articles, informal PubMed search), and (2) consulted with a military behavioral health expert to obtain additional articles – some of which were in press and not yet publically available. Stage 4 resulted in a total of 111 articles.

STAGE 4: SEARCH EXPANSION (BEYOND PUBMED)	
Expanded our search beyond PubMed. Included: (1) secondary search using leads from the articles obtained in Stage 3/PsycInfo, and (2) advice from consultation with a military behavioral health expert.	
	Number of Results
1: Secondary search (e.g., using leads from articles obtained in Stage 3, PsycInfo)	33
2. Consultation with a military behavioral health expert	3
Stage 3: Articles included from PubMed search	75
TOTAL:	111

Finally, in Stage 5 we made our "Final Overall Inclusion Decisions." In this final stage we assessed the 111 articles obtained from Stage 4 based on their relevance to our goals and scientific rigor of each study. The final number of articles included within this report (and within the reference section) is 73. A detailed breakdown is provided in the Stage 5 table below.

STAGE 5: FINAL OVERALL INCLUSION DECISIONS	
Examined all articles obtained in Stage 4 and included only those that were most relevant to our goals, or when redundant in objectives with other studies, were most scientifically rigorous.	
Professional Social Support Studies	**Number of Overall Included Results**
Relevant Elsewhere in Report (e.g., Introduction, Conclusion)	3
Observational Findings	
Spaceflight/Spaceflight Analogues	1
Military	16
First Responders/Emergency Medical Personnel/Law Enforcement	14
Other professionals: Physicians and Physician Trainees	2
Countermeasures and Interventions	
Spaceflight/Spaceflight Analogues	1
Military	11
First Responders/Emergency Medical Personnel/Law Enforcement	9
Other Professionals: Coaching/Mentoring/Emotional Intelligence Training	16
TOTAL:	73

2.3 Social Support in the Workplace: Observational Findings

2.3.1 Spaceflight and spaceflight analogue settings

Overall, the literature examining organizational social support in spaceflight and spaceflight analogue contexts is very limited. Our review revealed only one relevant observational study (Luger et al., 2014), the findings of which highlight the importance of prelaunch training (inclusive of psychosocial education, or "informational support") to reduce later tension. More specifically, Luger et al. (2014) performed a prospective study inclusive of two groups: (1) individuals living in the Moroccan Sahara desert (n=14; average participation duration=23.9 days) emulating Mars, and (2) those working at the Mission Support Center in Innsbruck, Austria (n=14; average participation duration=18.4 days). Notably, the "Mars" group underwent a prelaunch preparation week, whereas the Mission Support Group did not. With regard to the prelaunch preparation week, the "Mars" group reported lower levels of stress during this time compared with subsequent weeks. Importantly, the Mission Support Center group reported higher levels of tension in week one compared with the "Mars" group. The lack of a preparation period was thought to account for the greater tension among the Mission Support Center group. Supporting this possibility, in the last two weeks of the mission, group interaction increased significantly for the Mission Support Center group. Alternative explanations for tension during week one for Mission Support Center members include larger Mission Support Center workload, issues with communication, and high turnover of personnel. Based on their findings, Luger et al. recommend that, like the field crew, the Mission Support Center personnel would benefit from a prelaunch period inclusive of psychosocial training and time for team members to become more familiar with each other, before being launched into a mission.

2.3.2 Military settings

Both US and international armed forces have long been interested in the potential effects that the social climate of military units, including leadership support, peer support, organizational support, and unit cohesion, may have on their workforce. The culture embraces in particular the idea that establishing close bonds (emotional support) with other unit or team members protects against the adverse effects of stress exposures. The military literature has focused in

particular on “unit cohesion,” a term that has been applied to indicate the “togetherness” of the unit but has also been used interchangeably with the concept of unit social support or “unit support.” In considering the support received in the military, measures often encompass both support (instrumental, information, emotional) from leadership and peers, with some measures also capturing perceived support at the organizational level.

Most studies of unit cohesion and unit support in the military examined the association of retrospective accounts of cohesion or support experienced during war zone deployment with behavioral health outcomes, and in particular posttraumatic stress symptoms, following return from the war zone. In a meta-analysis of the military support literature pertinent to operational deployments to the Gulf War, Iraq, and Afghanistan, Wright, Kelsall, Sim, Clark, and Creamer (2013) found that low unit cohesion during deployment was associated with greater risk of developing posttraumatic stress disorder (PTSD) following war zone deployment. Extending beyond PTSD symptoms, other studies of military social support have documented associations between group cohesion/support and other behavioral health outcomes following deployment, such as sleep quality (Pietrazk, Morgan, & Southwick, 2010) and perceptions of overall health (Mulligan et al., 2010), with higher levels of support associated with more favorable outcomes. Alcohol misuse may be an exception, however, as certain facets of group cohesion may have a counterproductive effect on alcohol use behaviors in some contexts (Du Preez, Sundin, Wessely, & Fear, 2012).

Regarding potential mechanisms, the positive impact of unit support in buffering the adverse effects of war zone stress exposure on subsequent PTSD symptoms may operate in part via altering the perception of threat – a potent predictor of PTSD symptoms. Franz et al. (2013) found that higher levels of an aggregated measure of pre-deployment and deployment unit support was associated with lower levels of perceived threat while in the war zone, which in turn were associated with less severe post-deployment PTSD symptoms. Results of a longitudinal study of Israeli soldiers (GIlbar, Ben-Zur, & Lubin, 2010) suggest that unit cohesion/support may exert positive influence on outcomes via its positive associations with perception of mastery and use of adaptive coping strategies (i.e., problem-focused coping) and

negative association with coping strategies that were not as adaptive in the context of military operations (e.g., emotion-focused and avoidant coping). It is not clear, however, how long the positive effects of unit support may endure, especially once separated from the sources of that support. A recent study of longitudinal posttraumatic symptom progression in Israeli military veterans conducted over 20 years, for example, suggests that the positive effects of the unit social climate do not predict long-term PTSD symptom trajectories (Karstoft, Armour, Eliklit, & Solomon, 2013).

Moreover, as suggested by Wright et al. (2013), the relationship between support received and behavioral health is likely complex, as loneliness, distress, and other social factors may adversely influence capacity to access social support (e.g., Benotsch et al., 2000). Similarly, psychological distress may impact the perception of support. For example, Barnes, Nickerson, Adler, and Litz (2013) examined longitudinal associations between perceived organizational support, defined as "employee beliefs about the extent to which the organization values their contributions and cares about their well-being" (p. 178), and PTSD symptoms in military personnel deployed to a peacekeeping mission in Kosovo. The results of Barnes et al. (2013) indicated that, whereas higher PTSD symptoms were associated with less favorable subsequent appraisals of organizational support, perceived organizational support was unrelated to subsequent PTSD symptoms. These findings suggest that stress may be associated with worsening perceptions of support from an organizational entity. An implication of this research is that even when an organization is typically perceived as supportive, during periods of relative stress, the organization may need to employ additional efforts to create a climate of support.

Although much of the military research has focused on support provided during operational deployment, the period prior to military deployment may be of greater relevance to the pre-mission phase of long-duration spaceflight. A few studies have examined occupational social support in relation to stress-related behavioral health outcomes prior to military operational deployment. In a study of over 1500 Army soldiers, most of whom had no deployment experience, Brailey, Vasterling, Proctor, Constans, and Friedman (2007) found that unit support (from peers, leaders, and the organization) mitigated the adverse effects of prior stressful life

events on current stress-related symptoms. Consistent with the implications of Karstoft et al. (2013), the results of two prospective US military studies measuring unit support prior to war zone deployment suggest that the impact of workplace social support on behavioral health outcomes may be greatest strongest at times more proximal to the delivery of the support. Specifically, Han et al. (2014) found that post-deployment PTSD symptoms were predicted by unit support during deployment but not by pre-deployment unit support. Further, unit support during deployment was no longer significantly associated with post-deployment PTSD symptoms when a more global measure of post-deployment social support was taken into account. These results mirror those of a prospective study of Army National Guard soldiers assessed before and after deployment to Iraq (Polusny et al., 2011), which found that post-deployment social support was more strongly associated with favorable PTSD symptom outcomes than was pre-deployment unit support.

Other military studies of occupational social support have also examined occupational factors as outcomes, in general finding positive associations between unit cohesion and behavioral occupational outcomes and between supportive leadership and favorable outcomes. For example, Ahronson and Cameron (2007), examining Canadian military personnel, found that perceptions of task-related cohesion were predictive of job satisfaction. In an archival study that separated group- and individual-level effects of unit cohesion, Griffith (2002) found that (a) individual-level soldier reports of cohesion showed stronger moderating effects against stress than did group-level cohesion and (b) the experience of supportive unit leadership and peer relations increase unit identity, enhance military retention and soldier perceptions of combat readiness. These findings complement those reported by an earlier meta-analysis (Oliver et al., 1999), which found that unit cohesion across military service branches was most strongly related to perceptions of job and military satisfaction but was also related to work performance, especially at the group level. Relatedly, in a review of the impact of leadership characteristics on occupational performance, Britt, Davison, Bliese, and Castro (2004) found that certain leadership characteristics relevant to support (e.g., the provision of information about expectations and roles) facilitates key occupational variables such as role clarity, self-

efficacy regarding, and job engagement, that in turn have been found to decrease the adverse effects of stress.

2.3.3 First responders, emergency medical personnel, and law enforcement

Observational studies in the emergency responder literature provide several insights into the basic relationship between organizational support and behavioral health outcomes under conditions of high stress. The most commonly studied outcome in the emergency responder literature is PTSD, likely due to the increased potential for exposure to psychological trauma among emergency responders. In addition to examining non-traumatic stressors (e.g., work overload, ambiguity at work) as moderating factors that potentially further exacerbate PTSD and other adverse behavioral health outcomes in emergency responders, of relevance to this report, lack of social support has also been commonly identified as a work-related stressor contributing to poor behavioral health outcomes.

Research examining social support from the co-workers and supervisors of emergency responders (i.e., firefighters, ambulance personnel) has indicated that impoverished social support from peers and co-workers is associated with burnout, fatigue, and PTSD symptoms (e.g., Saijo, Ueno, & Hashimoto, 2012; van der Ploeg & Kleber, 2003). Demonstrating the importance of social support from within the workplace, results of a nationwide survey of ambulance personnel in Norway (N=1180) showed that a lack of social support from one's co-workers was the most frequent and the most severe form of organizational stress (Sterud, Hem, Ekeberg, & Lau, 2008). In relation to trauma-related stress responses, Carlier, Lamberts, and Gersons (1997) found that among a sample of police officers exposed to trauma, "dissatisfaction with organizational support" was among the factors that predicted stress symptoms 3 months after trauma exposure.

In regards to the potential positive effects of social support on emergency workers, research on World Trade Center responders, police officers, medical rescue workers, and firefighters (Oginska-Bulik, 2013; Pietrzak et al., 2014) has shown that "support" (undefined regarding type of support) from supervisors and co-workers may actually lessen PTSD symptom severity and

encourage post-traumatic growth (e.g., spiritual development, appreciation of life, enhanced relationships with others, positive changes in self-perception) after the experience of trauma. Relatedly, longitudinal evidence suggests that supportive work cultures predict both health and occupational performance outcomes (Biggs, Brough, & Barbour, 2014a; 2014b). For example, measuring outcomes across an 18-month period, Biggs et al. (2014b) found that individual perceptions of a supportive work culture by civilian staff and police officers working within an Australian state police service was associated with subsequent indications of greater engagement in work and higher levels of colleague and supervisor support. Further, qualitative examination of strategies used by paramedic science students (N=8) to cope with emotional stress identified a form of emotional social support as being especially important (i.e., simply talking about hard experiences – "off-loading" – with mentors/colleagues/friends/partners) (Williams, 2013; p. 207).

Law enforcement officials (i.e., correctional officers and police officers outside the context of emergency response) have also received scientific attention in relation to social support within the workplace. This may in part reflect impoverished social support within the workplace for some law enforcers. In particular, correctional officers, tasked with keeping facilities safe and secure, are reported to confront both psychological harassment/intimidation in the work environment and negative interactions with co-workers/supervisors – events related to adverse outcomes such as, psychological distress and job stress (e.g., Bourbonnais, Jauvin, Dussault, & Vezina, 2007; Moon & Maxwell, 2004).

In a systematic review (N=8 studies) examining organizational stressors and burnout/stress among correctional officers, Finney and colleagues (2013) identified difficulties with the organizational climate/structure to be the most consistent risk factor for burnout and stress. Finney et al. (2013) defined organizational climate/structure by the organization's: (1) administrative strengths (e.g., clarity of policies), (2) support (e.g., pride shown for an employee's accomplishments), and (3) justice (e.g., procedural [how a decision/outcome is reached] and distributive [the decision/outcome itself]). In this context, organizational climate/structure reflects multiple forms of social support, including informational support

(organizational administrative components), emotional support (support for employee's accomplishments), and instrumental support (organizational justice processes).

Based on the clear contribution of work-related stressors to psychological distress, an organization's "psychosocial safety climate" (Dollard, Tuckey, & Dormann, 2012) has been identified as being particularly important in creating a psychologically healthy and safe work environment for employees, including police officers. The psychological safety climate is pertinent to social support within the workplace in that it is characterized by attempts within an organization to lessen, control, and/or remove psychosocial hazards for employees in the workplace – thus, proactively safeguarding the psychological well-being of employees. Further, a psychosocial safety climate encompasses management's interest in the "psychosocial working conditions and worker psychological health and safety" (Dollard & Bakker, 2010 as cited by Dollard et al., 2012; p. 694). In this regard, the concept of a psychosocial safety climate emphasizes the importance of emotional support. Dollard et al. (2012) found that in a sample of police constables, the positive association between change in workgroup distress and emotional demands was moderated by high emotional resources – only when the psychosocial safety climate was high.

2.3.4 Other professional settings: physicians and physician trainees

The medical professional literature (e.g., medical students, medical residents, attending physicians), indicates that work stress is both common and associated with a need for increased support. For example, in a sample of physicians (N=50), 40% reported feelings of low personal accomplishment, 34% reported high levels of emotional exhaustion, and 28% reported high levels of depersonalization, which all relate to burnout (Bruce, Conaglen, & Conaglen, 2005). Further, respondents reporting emotional exhaustion also indicated a greater reported need for support, especially in the form of receiving validation of their decisions (informational and emotional support), talking with others about their mistakes (informational and emotional support), and receiving reassurances regarding their own professional ability (informational, emotional support, and appraisal support). When asked about preferences for the format of a "peer support program" in the workplace, physicians expressed greatest interest in one-to-one

support (53%), followed by group support (28%), a combination of one-to-one and group support (9%), and a handful of physicians reported no desire for formal support of any kind, with one individual explaining that informal work support was sufficient (9%) (Bruce et al., 2005).

The medical professional literature also highlights two additional areas of importance when considering workplace sources of social support for high-functioning individuals: (1) barriers to finding support, and (2) desired sources of support (Hu et al., 2012). Using a convenience sample of 108 residents/attending physicians, Hu et al. (2012) examined the experience of stress, willingness to find support, barriers to finding support, and useful forms of support. Similar to Bruce et al. (2005), Hu et al. (2012) found that majority of the sample experienced stress (e.g., 79% had a stressful experience related to either patient care [53%] and/or personal life [57%] in the past year). Further, and also in line with findings from Bruce et al. (2005), nearly all (94%) of the sample reported that they would like support for at least one type of stressful event (e.g., 50% reported desiring support for interpersonal work conflict, 50% reported desiring help for mental illness).

Adding to the Bruce et al. (2005) findings, although the majority of physicians surveyed by Hu et al. (2012) experienced major stress and reported a desire for help, this high-functioning group also reported a number of serious barriers to seeking help. Examples of barriers included limited time (89%), worries about confidentiality (68%), concerns about negative career impact (68%), and trouble accessing services (52%). When asked about the likelihood of asking for support from various resources, physicians strongly favored receiving support from colleagues (i.e., 70% would get help from physician faculty, 61% from residents, 56% from program directors, 51% from chief residents), as compared with organizational units designated by the institution to provide support (i.e., 40% reported they would seek help from Physician Health Services, 29% from Employee Assistance Program, and 15% from the Graduate Medical Education).

2.3.5 Summary of the observational evidence

There is as yet little empirical evidence from the spaceflight/spaceflight analogue literature regarding the impact of occupational social support networks on behavioral health. Much of evidence regarding occupational support and behavioral outcomes is derived from military studies, particularly those examining the relationship between unit support and cohesion during the war zone and the subsequent development of PTSD symptoms following re-integration upon return from the war zone. In general, the military literature suggests that occupational support (both from peers and leaders) exerts immediate positive effects in mitigating against stress responses but that these may dissipate over time, especially once the occupational source of support is no longer accessible.

Research involving emergency responders highlights the negative repercussions of impoverished support mechanisms, suggesting that lack of co-worker social support is the most frequent and most severe organizational stressor. Lack of support from co-workers and from supervisors is associated with a number of poor health outcomes among emergency responders. Conversely, support from co-workers and supervisors is associated with less severe PTSD symptoms and greater post-traumatic growth following trauma. Further, data from the correctional officer literature support the importance of organizational climate/structure to burnout and distress. Relatedly, the literature points to the importance of an organization's "psychosocial safety climate" for the health and safety of police constables. Finally, the medical professional literature emphasizes an overwhelming desire for support from others, especially support delivered one-to-one from colleagues, but identifies barriers to seeking support (e.g., limited time, concerns about confidentiality/negative career impact).

2.4 Social Support in the Workplace: Countermeasures and Interventions

2.4.1. Spaceflight and spaceflight analogue countermeasures

We found only one article (Holland & Curtis, 1999) addressing countermeasures in spaceflight or spaceflight analogue context that are potentially informative to social support provided within work environments. In their paper, Holland and Curtis (1999) reviewed countermeasures

relevant to the pre-flight time frame. Specifically, this article covers the behavioral health countermeasures employed for several missions that were part of the Lunar-Mars Life Support Test Project: Phase I (1 person/15 days), Phase II (4 people/30 days), Phase IIA (4 people/60 days), and Phase III (4 people/91 days). Phase III, the 91-day mission, will be the focus here as it is the most analogous to a long-duration Mars flight. Several work-related countermeasures employed during training and preparation, with potential relevance to organizationally provided social support, included: team building and Confined Team Operations Training. In terms of preparing crew members – including lessons on how to work together and problem-solve under stress – the authors mention the importance of "an outdoor challenge course" in which crew members were divided into various group formations and asked to problem-solve a number of situations (including those that were physically challenging). The outdoor course concluded with a group debriefing of lessons learned/applications to the real mission (Holland & Curtis, 1999; p. 54). The article emphasized the interpersonal nature of the outdoor challenge training, noting that its biggest impact was that team members got to really know each other. Both the importance of the "human factor in the overall success" of the mission (p. 55) and the importance of pre-mission training are supported and highlighted by this article (Holland & Curtis, 1999).

2.4.2 Military programs

The US military has implemented several programs devoted to increasing psychological resiliency. In 2011, as part of a commissioned report (Meredith et al., 2011), RAND evaluated 23 resiliency programs, most of which were embedded within the military (a few others selected for their potential military application). Although many of these interventions are not directed at social support, a subset includes components (e.g., positive command climate, teamwork, cohesion) relevant to occupational social support. Of the 23 programs summarized in the 2011 RAND report, 18 incorporated creation of the positive command climate (e.g., MMFT), 16 incorporated teamwork training (e.g., Marine Operational Stress Control and Readiness [OSCAR]), and 12 incorporated unit cohesion (e.g., Battlemind, now referred to as "Resilience Training"). At the time of the report, few programs were evaluated via randomized

controlled trials or even quasi-experimental designs. Since then, there has been additional empirical evaluation and new programs developed, but with rare exception, most programs await a strong evidence base.

Of the military programs targeting resilience that include an occupational social support component, Battlemind/Resilience Training has the most extensive evidence base, including randomized controlled trials (e.g., Adler, Bliese, McGurk, Hoge, & Castro, 2009; Adler, Williams, McGurk, Moss, & Bliese, 2015; Castro, Adler, McGurk, & Bliese, 2012). Of relevance to occupational social support countermeasures, the full set of Battlemind procedures includes a component entitled "Self and Buddy-Aid," which normalizes anger, withdrawal, and sleep problems following war zone deployment (informational support) and emphasizes what soldiers can do for themselves and – relevant to emotional social support – what they can do to assist fellow soldiers (Adler, Castro, & McGurk, 2009). Service members are encouraged specifically to monitor other service members for signs of trouble and to provide support to each other, as appropriate. Battlemind has been shown to be effective, immediately following combat, in mitigating against posttraumatic stress and depression symptoms, sleep problems, and stigma in regards to stress-related symptoms (Adler, Bliese, et al., 2009) and successful in promoting better adjustment (fewer PTSD and depression symptoms, better life satisfaction) 4 months after return from combat (Castro, Adler, McGurk, & Bliese, 2012). Battlemind/Resilience Training also has high acceptability among military service members (Adler, Bliese, et al., 2009; Castro et al., 2012).

Of relevance to the pre-flight period, a randomized trial of an abbreviated version of "Resilience Training" (Battlemind renamed) implemented during basic combat training (Adler et al., 2015) found no differences between Resilience Training and a control intervention (Military History) on measures of depression, anxiety, or sleep problems but found that anxiety decreased more quickly in the Resilience Training group. Additionally, although Resilience Training had a slower rate of increase in-group cohesion over time than the control condition, Resilience Training was associated with greater confidence in helping others and was perceived more positively by those participating in it, as compared with the control intervention. The

author concluded that this abbreviated version of Battlemind/Resilience Training offered some benefits to soldier behavioral health and facilitation of peer support but may not benefit the unit climate. However, the degree to which abbreviating the protocol versus the timing of the implementation (during basic training vs. following the stress of battle) accounted for the relatively attenuated positive findings, as compared with prior research on Battlemind, is unclear.

As another major initiative aimed at increasing psychological strength and positive performance while reducing the incidence of maladaptive responses, the US Army implemented the Comprehensive Soldier Fitness (CSF) program in 2009 (Cornum, Matthews, & Seligman, 2011). Like Battlemind/Resilience Training, CSF is strongly guided by positive psychology principles and incorporates multiple components in addition to those relevant to social support constructs. The implementation begins with universal progressive training at initial entry into the Army but also includes subsequent individualized training based on individual needs identified via a standardized assessment tool, as well as a mechanism to create master resilience trainers who subsequently become the teachers of resilience throughout the Army.

The social component of CSF is built on the principles of social resilience, which is defined by Cacioppo, Reis, and Zautra (2011) as "the capacity to foster, engage in, and sustain positive relationships and to endure and recover from life stressors and social isolation." The construct is considered to be multi-level and include (1) ways of relating (e.g., agreeableness, humility, openness), (2) interpersonal competencies (e.g., attentive listening, empathy, communication of care and respect for others, responsiveness to the needs of others, compassion), and (3) collective characteristics and competencies (e.g., cohesiveness, tolerance, rules for governance). As described, social resilience, thought to contribute to both individual and team-level functioning, most strongly pertains to appraisal support, informational support, and emotional support.

Strong empirical support of CSF remains lacking, although systematic longitudinal efforts have been initiated (Lester, McBride, Bliese, & Adler, 2011). The Penn Resiliency Program, on which CSF is based, has support from the civilian population (mainly studies of prevention of

depression in child, youth, and college samples), showing reduction primarily in non-clinical symptoms, according to a recent review of its potential applicability to military samples (Steenkamp, Nash, & Litz, 2013). In a study of the master resilience training component of CSF, which is geared at developing military trainers, Griffith and West (2013) collected online questionnaires from Army National Guard soldiers and civilians about their resilience training experience. Overall, the results suggested that most respondents found the training to be helpful, improve their competencies in coping with stressful circumstances, and subsequently use these competencies in their military and civilian jobs. Of relevance to social support, two of the competency areas reflecting the most self-reported changes were increased self-awareness (of relevance to self-appraisal support) and connection with others (of relevance to emotional support). Further, self-reported change in resiliency competencies were associated with fewer behavioral health symptoms.

Focusing more purely on social resilience, the Army has used rigorous scientific methods (i.e., a randomized controlled trial design) to examine the effects of social resilience training on specific aspects of social resilience including improving maladaptive social cognition and decreasing loneliness (Cacioppo et al., 2015). In this study, the investigators randomly assigned 48 regular active duty Army platoons (n = 939 soldiers) to social resilience training or cultural awareness (as an active control condition). In regards to timing around a mission, although there was no specific expectation regarding an upcoming war zone deployment, platoons were drawn from operational brigades subject to constant preparation for deployment to combat zones. The timing of the intervention, therefore, has some relevance to the "pre-flight" period for astronauts.

The social resilience intervention incorporated 8 sessions that targeting building skill relevant in particular to self-appraisal and emotional support: "Survival Skills" (i.e., introduction to the concept of social fitness), "Mind-Reading" (i.e., learning about how to obtain information about others non-verbally while avoiding confirmatory bias in doing so), "Learning to Connect at a Distance" (i.e., skills and values required to consider one's own interests within the context of concern for the unit), "Expanding Unit Cohesion" (i.e., expanding unit identity while recognizing

diversity among team members), “Building Social Resilience” (how to share positive and negative experiences with others; role flexibility), “Dealing With Your and Others’ Feelings of Isolation” (recognizing and coping with social isolation, prevention of spreading “social pain”), “Conflict Resolution” (recognition and de-escalation of conflict), and “Capstone” (application of previous lessons via planned scenarios). The results suggested that social resilience training, compared with cultural awareness training, produced “small but significant” improvements in social cognition (e.g., increased empathy, perspective taking, and hardiness) and decreased loneliness (Cacioppo et al., 2015).

2.4.3 First responder, emergency medical, and law enforcement programs

Consistent with observational studies of medical professionals that indicate preference for one-to-one support from medical colleagues (Bruce et al., 2005; Hu et al., 2012), intervention and countermeasure studies among first responders, emergency medical personnel, and law enforcement center around the concept of peer-based assistance (e.g., Dowling, Moynihan, Genet, & Lewis, 2006; Levenson, O'Hara, & Clark, 2010) and the cultivation of a supportive work environment (Drewitz-Chesney, 2012). Although this literature pertains to astronauts preparing for spaceflight in that the populations regularly experience high stress, these studies differ from astronauts preparing for spaceflight in that the interventions are typically applied in the respondent context after the experience of extreme stress (versus prior to a specific mission such as long-duration spaceflight).

Grauwiler, Barocas, and Mills (2008) reviewed studies examining peer assistance programs for police officers. Peer support programs were first implemented for police in 1981, in response to a Los Angeles shooting that involved police. These programs are based on the idea that peers are uniquely equipped and able to aid others in the recognition of work-related stress and provide assistance before the stress becomes dangerous. This form of assistance is administered directly from peer to peer (within the same organization) and entails instant and continuing assistance following both general occupational stress and acute crisis. Depending on the need, peer assistance can be in the form of emotional support, instrumental support,

and/or informational support. To serve in a police peer-based assistance program, there is a thoughtful selection and training process.

As cited in the Grauwiler et al. review, the findings of studies examining peer-based assistance for police officers suggest that peer support is effective in that it: (1) provides help to those who are otherwise uninterested/unwilling to get professional help, (2) may decrease stigma related to mental healthcare, and (3) with time, is generally accepted among police officers (Finn & Tomz, 1998). Finally, Grauwiler et al. provided recommendations for implementation of peer-assistance programs, which were in part based on the assumption that privacy concerns often prevent individuals from seeking help. Specifically they recommended taking into consideration the physical location for assistance (i.e., on work grounds vs. off work grounds), legal concerns (e.g., parameters of confidentiality should be clearly communicated), and the official relationship between the organization and the peer-assistance program. They further recommended effective advertising of the program. Unfortunately, as noted by the authors, a limitation of this review is that the research included fails to examine the perception of peer assistance effectiveness from the standpoint of those getting help.

Peer support may be beneficial to emergency medical personnel, as well. Wen et al. (2013) examined the reaction of individuals receiving peer assistance by analyzing the response of emergency medical residents to Emergency Medicine Reflection Rounds. Emergency Medicine Reflection Rounds consisted of a small group (9 residents, 2 faculty facilitators – both emergency medicine attending physicians) who met monthly for an hour-long, confidential meeting to review challenges (e.g., admitting to mistakes, issues with dying/death, ethical dilemmas, emotional/physical wellness). At the start of each group meeting, the faculty facilitators encouraged residents to share any concerns they had. After issues were shared, time was allotted for reflection by the other residents and facilitators (e.g., this included sharing of related experiences). Participants completed an anonymous online survey in which 100% of the residents strongly agreed that Emergency Medicine Reflection Rounds improved their well-being. One resident explained that, “Often, we feel like we’re all alone. It’s reassuring to know that other residents have similar experiences” (Wen et al., 2013; p. 176).

Other work-related social support intervention research in the first responders and law enforcement fields has focused on training leaders to be more supportive (e.g., Beaton, Johnson, Infield, Ollis, & Bond, 2001; Muller, Maclean, & Biggs, 2009). For example, one study examined the utility of an organizational-level intervention dedicated to increasing awareness of supportive leadership practices for police (Muller et al., 2009). For this study, supportive leadership was defined as, "attitudes, communication, behaviors, and actions by managers and supervisors that enable staff to feel supported thereby to work effectively, productively, and appropriately" (Supportive leadership Workshop: Participant Workbook, 2003 p. 3; as cited in Muller et al., 2009). Qualitative semi-structured telephone interviews with 44 managers and supervisors who attended the intervention workshop revealed that ideas of supportive leadership were typically accepted and that the strategies reviewed during the intervention either reinforced existing practices or facilitated new supportive leadership strategies (e.g., providing employees with feedback, involving employees in decision making). Participants highlighted the utility of seeing supportive leadership techniques modeled by senior work colleagues (and inversely, the damage that can be done when supportive leadership is not modeled) (Muller, Maclean, & Biggs; 2009).

2.4.4 Other professional settings: professional (non-sports) coaching, mentoring, and emotional intelligence training

The literature relevant to other stressful professions, similar to the broader organizational social support literature, emphasizes the importance of work-related social support in three forms: professional coaching, mentoring, and emotional intelligence training.

2.4.4.1 Professional coaching

Within the context of life- and workplace-support interventions, coaching can be defined as a, "result-oriented, systematic process in which the coach facilitates the enhancement of life experience and goal-attainment in the personal and/or professional life of normal, non-clinical clients" (Grant, 2003 p. 254 as cited in Theeboom, Beersma, & Vianen, 2013). In this regard, coaching involves provision of informational support and has commonly been applied in the context of "executive" coaching intended for high-level business professionals. In reviewing the

literature on professional coaching, the first-hand account of a physician turned medical director, stressed the importance of having someone to talk to about decisions – and how this becomes more obvious the higher up one is within the hierarchy of an organization (Adler, 2001). Based on his own experience, Adler (2001) further opined that executive coaches help high-level executives to foster leadership skills related to conflict management, strategic planning, and staff performance.

In another commentary on executive coaching, Ludeman and Erlandson (2004) emphasize the importance of coaching, specifically for alpha-males (i.e., individuals who take on the dominate role in work and social settings). For example, they assert that because alpha-types are often less emotional; those with alpha-type personalities may have difficulty connecting interpersonally with other team members and therefore fail to build team cohesion. The article also includes strategies for coaching alpha-types (e.g., requiring commitment/willingness to change, communicating with "alphaspeak" through providing hard data to support points). Conversely, Berglas (2002) highlights the potential pitfalls and dangers associated with executive coaching, describing its potential to function as a non-realistic "quick fix" approach to nuanced issues.

The use of coaching in the professional workplace is steadily growing. Exemplifying this, the International Coach Federation was initiated in 1995 and currently has over 20,000 members, a number that grows by 500 each month (International Coach Federation, 2015). With the increased popularity of professional coaching, the question of an adequate evidence base is paramount. The effectiveness of coaching for mental and emotional well-being (e.g., stress, self-efficacy, anxiety, depression) among executives and managers has been examined through randomized controlled trial (Grant, Curtayne, & Burton, 2009), quasi-experimental (Moen & Skaalvik, 2009), and within-subjects (Luthans & Perterson, 2004) designs.

To examine the overall effectiveness of coaching on performance and behavioral health outcomes, Theeboom, Beersma, and van Vianen (2013) conducted a meta-analysis of 18 studies that evaluated coaching interventions. Results suggest significant positive effects of coaching on several outcome categories, including goal-directed self-regulation (e.g., goal-

setting/attainment/evaluation), work attitudes (e.g., commitment to the organization, job satisfaction), coping with work stressors/demands (e.g., mindfulness, self-efficacy), well-being (e.g., stress, burn-out, anxiety, depression), and performance/skills (e.g., job performance ratings). Effect sizes range from Hedges g = 0.43 for coping with work stressors/demands to Hedges g = 0.74 for goal-directed self-regulation (Theeboom et al., 2013). The results of this meta-analysis, therefore, suggest that coaching can be an effective organizational tool for enhancing individual experience/well-being; however, the mechanisms of how coaching works remain poorly understood.

In addition to studies examining the typical "executive" coaching, there also is research examining cognitive behavioral coaching as a means to provide professionals with additional support within the workplace. Cognitive behavioral coaching is inclusive of both appraisal social support (e.g., pattern identification within one's life) and informational social support (e.g., action planning for the future). Gardiner, Kearns, and Tiggemann (2013) performed a study among rural general practitioners with a quasi-experimental design in which they examined a cognitive behavioral coaching intervention group (n=69), a "baseline" group derived from another study in which the intervention was not delivered but similar measures were gathered at a single time point (n=205), and a no-treatment control group (n=312). The cognitive behavioral coaching, led by two "qualified coaching psychologists," consisted of three phases: (1) pre-workshop (e.g., completion of stress questionnaire, subjective stress ratings), (2) workshop (e.g., individual and group coaching focused on the past [e.g., pattern identification], present [e.g., current stressors/solutions], and future [e.g., action planning]), and (3) post-workshop (e.g., email coaching for up to 6 weeks, an interview to assess goals, completion of stress questionnaire). Results indicated that those receiving the cognitive behavioral coaching intervention had lower scores of distress after the coaching intervention, compared to the baseline group. Further, significantly fewer of those who underwent the intervention reported considering leaving the profession after the intervention (40%) as compared with before the intervention (81%) (chi-square (2) = 16.31, $p < .001$). Finally, at 3-year follow-up, 94% of the cognitive behavioral coaching intervention group continued to work in general practice, whereas only 80% of the control group remained in this profession (chi-

square (1) = 4.89, p = 0.027). Thus, cognitive behavioral coaching proved to be effective in both decreasing distress and lessening job burnout rates among rural general practitioners.

Research examining the use of coaching during times of organizational change (Grant, 2014) has likewise found coaching to be an effective intervention in enhancing adaptation to change. Grant (2014) performed a within-subjects study of managers and executives (N = 31) at a consulting organization for global engineering. Both qualitative and quantitative measures were used and results showed that receiving coaching was related to decreased depression, increased ability to cope with change, better solution-focused thinking, and heightened goal-attainment.

2.4.4.2 Mentoring

Mentoring can be broadly defined as, "the process whereby an experienced, highly regarded, empathic person (the mentor), guides another individual (the mentee) in the development and re-examination of their own ideas, learning, and personal and professional development." (Standing Committee on Postgraduate Medical and Dental Education, 1998 as cited in Steven, Oxley, & Fleming, 2008; p. 553). Our review revealed a few empirical studies pertinent to mentoring interventions for high-level professionals.

In the first, Tietjen and Griner (2013) examined a formal mentoring program for physicians working as full-time clinical practitioners (N=27) and found that 96% of the participants felt that their expectations of the mentoring program had been met (e.g., by providing new insights, goal-setting, planning next career steps). The formal mentoring in this study consisted of: (1) careful mentor selection (i.e., senior physicians in good standing who were believed to be "good listeners who are supportive, nonjudgmental, practical, and enthusiastic"; p. 642), (2) informal mentor training, (3) specification by mentees of their goals for the year, concerns to be addressed, and mentor preference, (4) confidential 1-hour meetings that ended with agreement on what had been discussed and the division of responsibility for next steps, (5) a post-meeting summary authored by the mentor and reviewed by the mentee for accuracy, and

(6) post-meeting contact initiated by either the mentor and the mentee through phone/email/in-person meeting (Tietjen & Griner, 2013).

The other two mentoring studies were also conducted with physicians and indicated that mentoring is associated with positive behavioral health outcomes. Using qualitative methodology, Steven, Oxley, and Fleming (2008) interviewed individuals involved in a mentoring process (N=49 mentors, mentees, medical directors, and others related to the mentoring process) in England and found that mentoring was associated with perceived benefits in multiple areas of life (e.g., personal well-being, professional practice, development). Finally, Harrison, McClean, Lawton, Wright, and Kay (2014) studied the impact of mentorship for new physicians entering their first senior post. Semi-structured interviews (n= 6 clinical directors, n=4 deputy medical directors, n=5 medical directors) and focused thematic analysis revealed the potential for increased commitment to the organization, increased perception of support, and enhanced emotional well-being (Harrison et al., 2014).

2.4.4.3 Emotional intelligence training

Finally, outside of coaching and mentoring, research in potentially stressful, high-level professional contexts has examined the use of training focused on emotional intelligence for medical residents and faculty (Dugan, Weatherly, Girod, Barber, & Tsue, 2014). Emotional intelligence may be important to consider in planning for organizational social support as it provides benefit for peer and supervisor interactions. In a prospective longitudinal, cohort study, Dugan et al. (2014) examined three levels of emotional intelligence training: (1) four years of recurring emotional intelligence measurement, (2) seven years of interactive emotional intelligence training (inclusive of simulations high in stress and high in risk), and (3) continual mentoring/modeling of emotional intelligence skills. Emotional intelligence scores increased from pre- to post-training, as did patient satisfaction scores (Dugan et al., 2014). Further, most (97%) participants reported that they “enjoyed the program” (p. 720).

2.4.5 Summary of countermeasure and intervention evidence

There were no studies directly assessing a social support countermeasure in the spaceflight or spaceflight analogues literature. A review article pertaining to pre-mission spaceflight analogues (Holland & Curtis, 1999), however, emphasized the importance of the "human factor" to mission success. In keeping with an emphasis on the "human factor," research on emergency medical personnel and law enforcers commonly identified the utility of peer-based assistance for those in high-stress professions.

Of potentially more direct relevance to spaceflight, the military has implemented a number of multifaceted programs with social support components. The most direct evidence supporting positive changes in behavioral outcomes comes from the Army's Battlemind/Resilience Training program; however, this program is typically implemented following missions, as opposed to serving as a pre-mission countermeasure. In the one study in which Battlemind/Resilience Training was applied during a pre-mission time frame (Adler et al., 2015), the results were attenuated, as compared with trainings implemented after return from the combat zone, perhaps as a function of its focus on ameliorating stress symptoms following exposure to extreme stress. The Army has implemented CSF training as a more preventative countermeasure; however, as of yet, there has been minimal empirical evidence generated regarding its effectiveness. Of particular interest to social support countermeasures delivered during the pre-flight period, there is currently a single, yet methodologically rigorous, study suggesting the social resilience training in the military is effective in improving social fitness and decreasing loneliness (Cacioppo et al. 2015).

Research among other high-stress professions suggests that professional (e.g., executive) coaching and mentoring may lead to positive effects in a number of domains including well-being and job performance/skills. Further, these countermeasures are well-received by professionals. Yet, much of the literature remains speculative and involves cross-sectional studies, non-randomized designs, and/or small samples. There is also evidence that emotional training, overlapping conceptually with some aspects of social resilience training, may be

beneficial for medical professionals in increasing skills that support social interactions in the workplace.

2.5 Literature Review: Overall Summary and Conclusions

This literature review emphasizes the importance of organizational social support to the mental well-being of its employees – especially high-achieving individuals in high-stress jobs.

Both observational and countermeasure/intervention studies emphasize the crucial role of the "human factor" to successful outcomes. Overall, observational findings highlight the strong relationships between social support from one's unit/co-workers/leaders/supervisors and behavioral health outcomes – both the negative impact when there is a lack of social support and, conversely, the positive impact in buffering against stress when social support is present. Importantly, although organizational social support has been shown to have a clear relationship to behavioral health outcomes, the duration of its impact is less clear once the social support is no longer provided. Additionally, the medical professional literature highlights that many professional prefer one-to-one support from colleagues in comparison with support delivered in other formats.

The intervention literature reflects countermeasures that address many of the facets of social support identified as potentially beneficial and acceptable to professionals in the observational literature. More specifically, the military has implemented both multifaceted programs with social support components, as well as training directed specifically toward building social resilience. These interventions target behavioral health outcomes of relevance to long-duration spaceflight (e.g., loneliness, sleep, emotional well-being) but are not typically delivered one-on-one – a format suggested to be more desirable by medical professionals. They nonetheless have a strong emphasis on refinement of nuanced skill relevant to receipt and provision of social support. Literature from other high-stress occupational contexts reflects interventions targeting behavioral health outcomes that are more typically delivered in one-on-one formats, including coaching (e.g., executive and cognitive-behavioral coaching), mentoring, and emotional intelligence training.

3. OPERATIONAL ASSESSMENT

3.1 Overview of Content Domains and Objectives

The primary objectives of the operational assessment were to determine whether organizational support countermeasures were needed and whether delivery of potential countermeasures would be feasible within astronauts' work environments. The specific content domains covered included: (1) identification of high-priority targets (e.g., behaviors, stressors) for potential countermeasures; (2) identification of currently available sources of support for astronauts accessible to them prior to long-duration spaceflight (i.e., existing resources and/or countermeasures); (3) feasibility assessment of potential methods of delivering social support countermeasures; (4) identification of potential barriers and facilitators of new social support countermeasures; and (5) applicability of analogue contexts to research examining organizational support countermeasures.

3.2 Methodology

The formal operational assessment phase included 8 SMEs. In addition, informal consultation regarding NASA's mentoring program was also conducted. SME categories (see, "Categories of experts interviewed" for additional detail) were established by Dr. Jennifer Vasterling, Dr. Jason Schneiderman, and Ms. Diana Arias. With the exception of the military expert (selected by Dr. Vasterling), all other SMEs were recruited and scheduled by invited by Ms. Arias, Ms. Holly Patterson and Mr. Stephen Vander Ark.

All interviews were led by Dr. Jennifer Vasterling, and notes were taken by Ms. Charlene Deming. To protect confidentiality, all notes have been de-identified (i.e., identifying information such as name of interviewee, name of others referenced has been removed). All interviews were completed by phone. The duration of telephone interviews ranged from 30 minutes to 1 hour. The informal consultation was likewise conducted by phone.

3.2.1. Categories of experts interviewed

SME category decisions were guided by: (1) inclusion of those representing others who would potentially benefit from receipt of social support countermeasures (i.e., current or retired astronauts) or who are familiar with analogue contexts determined within the scientific literature to be of relevance to long-duration spaceflight (e.g., winter-over space analogue), and (2) adequate sampling of those employed by NASA who have either experienced/observed organizational social support or are an in a role to provide such support. More specifically, we interviewed: 2 retired astronauts, 2 BHP Operations personnel, 2 astronaut trainers, 2 space analogue participants, 1 military organizational support expert, and 1 representative from the NASA mentoring program.

3.2.2 Interview content domains and procedures

Interviews were semi-structured, and interviewees were provided with a list of content domains and example questions from each domain prior to the interview. Our goal in making questions available prior to the interview was to allow interviewees time to formulate thoughtful, intentional responses.

Interview questions were designed based on findings from the literature review – with a list of partially overlapping yet distinct questions for each category of SME (see appendix for examples of interview topic/question outlines for different SME categories). All questions were open-ended to encourage discussion and sharing of relevant details. Each interview concluded with the question "Is there anything that we haven't asked about that you think would be important for us to know?" This final question was included to provide an opportunity for the interviewee to discuss any relevant information that we did not cover.

The basic constructs that appeared important based on the literature review, and thus were assessed across interviewees, included:

- Potential countermeasure targets

  Example Question:

  What are the most significant challenges confronted by astronauts during astronaut training and preparation for spaceflight?

- Current sources of social support and relevant countermeasures

  Example Questions:

  To what extent is organizational and interpersonal support available within the professional environment during astronaut training? During preparation for spaceflight?

  What are your perceptions on the extent of social support in place within the astronaut's community and whether there are particular aspects of their professional environment that have potential to become more supportive in terms of fostering sustained, positive relationships with astronauts?

- Potential methods of delivery

  Example Question:

  If a countermeasure were developed to increase organizational support of any type, from which components of an astronaut's professional community (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) do you think receiving support might be most meaningful during astronaut training and preparation for long-duration spaceflight?

  To what extent should such measures facilitate "organic" interactions (vs. reflect structured programming)?

- Potential barriers and facilitators

  Example Questions:

  How receptive would most astronauts be to countermeasures designed to increase social contact or support?

  What barriers would you anticipate in delivering countermeasures aimed at increasing social support within the professional environment during astronaut training prior to long-duration spaceflight?

- Analogue environments

  Example Questions:

  What, if any programs, is the Army currently implementing to increase support from within the organization?

  Would long-duration work in the Antarctic serve as a reasonable analogue for research examining the potential effectiveness of social support countermeasures delivered prior to long-duration spaceflight?

3.3 Results: Expert Perspectives

3.3.1 Countermeasure targets

Experts concurred that provision of support from within the organization to counter the adverse effects of increased operational demands prior to long-duration spaceflight would be beneficial to astronauts. Several experts noted that "pre-flight" could potentially encompass many years, with different phases bringing with them distinct challenges. These pre-flight periods could be defined broadly as: (1) astronaut candidacy (1-2 years), (2) astronaut without flight assignment (2-10 years), (3) training after flight assignment (varies according to mission), and (4) more immediate prelaunch preparation.

A desire to perform well and uncertainty regarding performance, for example, were identified as potentially prominent concerns during both astronaut candidacy training and astronaut without flight assignment phases. Prior to flight assignment, concerns about being selected for a mission can be particularly salient. Similarly, stress related to recovery from error begins

relatively early in the astronaut's career and extends throughout. Experts additionally noted challenges related to work-life balance during these pre-flight training periods, including spending enough time with family and friends, as well the potential for career demands to interfere with the ability to form intimate relationships or start a family. One expert noted that work-life balance concerns, however, are somewhat mitigated during candidacy training due to the excitement and novelty of this period and become significantly more prominent in subsequent pre-flight phases. More general job-related stressors may also arise during the astronaut without flight assignment phase. Finally, a rigorous travel schedule that requires the astronaut to be away from home for month at a time during training after flight assignment arose as a prominent practical and social stressor.

A common theme of challenge confronting astronauts during the training after flight assignment and immediate prelaunch preparation phases was concern about their families. These concerns reflected both anticipatory concerns about not being available to family members in times of potential need during long-duration spaceflight and more immediate concern about the extended separation from family during training and preparation from spaceflight. Examples of concerns included regret about missing routine, yet important events (e.g., sporting events for their children), concern that they could not assist family members in need while training remotely (or during spaceflight), and the loss of support and pleasure they receive from family members. Transition times (from being with family to without them and vice versa) were described as particularly challenging due to the adjustments required. Not having a family was also noted to increase stress while preparing for long-duration spaceflight, reflecting the absence of reliable logistical support for managing household affairs while away.

3.3.2 Existing sources of support and countermeasures

Various formal and informal sources of support within the professional environment were identified by experts and vary to some degree according to the specific phase of "pre-flight." During the 2 years of astronaut candidacy training, astronauts often form strong, sometimes lifelong, bonds with peers. Experts described significant sources of support during this period, including receiving support from more-experienced astronauts. During this period, the

Astronaut Office in itself is viewed as having a culture of support – "a sense of coherence of social support that is similar to a flying squadron where senior members of the astronaut class are expected to help the younger folks." Astronaut candidates are encouraged to reach out to veteran flyers but are also often approached by veteran astronauts in offerings of support. Typically, a more-experienced astronaut is designated as a "Mom" or "Dad." The role of the class "Mom" or "Dad" is to advocate for the candidates and generally "look out for them." During candidacy training, astronauts are also provided with behavioral support via various training exercises, some of which is designed to provide them with tools that will enhance the social environment, including both their ability to receive and give social support. These trainings include amongst other components, stress and conflict management, active listening, cross-cultural training, and an expeditionary workshop. The latter includes such skills training as teamwork, group living, self-care/self-management, living with others, and team care. Some of this is delivered via Space Week and some via the National Outdoor Leadership School (NOLS), an experience universally endorsed by experts as being effective and meaningful – both for building technical skills and for increasing trust/interpersonal communication within the crew. For example, one retired astronaut commented that out of NOLS grows an "intimate ability to read each other." This expert further described NOLS as "transformative" for a crew, noting that "you learn through consequences to be a team."

Some experts noted that support becomes less available during subsequent phases of the pre-flight period – times in which the astronauts are no longer with their fellow classmates, during which trainings are more technically oriented, and after the initial excitement associated with candidacy training has dissipated. These post-candidacy pre-flight periods were also universally described by experts as generally being more stressful. At least one expert commented that more team-delivered training (vs. individual training) would be beneficial to astronauts during all subsequent pre-flight phases, including the astronaut without flight assignment phase. Although various types of professional behavioral support (e.g., fatigue management training) are offered subsequent to candidacy training, astronauts are described as having significant time pressures that may prevent them from engaging in formal support countermeasures. Less

formal mechanisms of support (e.g., intramural sports) are available to astronauts but are not consistently accessible, especially during training for specific missions, due to extended travel.

Closer to launch, there is a crew support program in which one astronaut serves as a "concierge" astronaut to another astronaut soon to embark. The Crew Support Astronaut (CSA) typically provides instrumental support (e.g., driving the astronaut's family to the launch; helping with some aspects of care for an astronaut's children during spaceflight; helping arrange household management) but may also be in the position of providing emotional support to the astronaut and/or their family. One expert commented that additional training of CSAs (and astronauts more generally) in psychological insights from a clinical science and healthcare perspective would be helpful.

3.3.3 Potential countermeasure formats

Potential formats discussed included peer-to-peer support, mentoring (from more-experienced astronauts), instrumental support similar to the CSA program, team building exercises in demanding circumstances such as NOLS training and "astronaut hell week," social/sports contexts, and structured instruction. Different formats were considered to potentially be more or less useful at different phases of pre-flight. Team building exercises such as NOLS were universally appreciated as extremely effective mechanisms in facilitating peer support among team members and as ways to build skills that could be used during long-duration spaceflight to create a mutually supportive environment. Formats that occur naturally (e.g., social events and sports) were generally favored over support that was more contrived and/or mandated. The exception to this would be the CSA program, given its emphasis on provision of concrete, instrumental support. Mentoring is recognized as beneficial but is viewed as best when evolving through natural relationships with potential mentors, rather than via a forced dyadic assignment. One expert also remarked that any support structure begun prior to launch should continue during spaceflight to provide continuity of the supportive relationship. The same expert strongly believed that a countermeasure (started pre-flight) that allowed the astronaut to provide support to others on the ground would be quite rewarding to the astronaut. An example would be linking an astronaut to a specific school or class within a school. Finally,

there was concurrence that a support countermeasure would be most successful if not targeting perceived problematic behaviors/emotions delivered in the form of a mental health intervention.

3.3.4 Perceived barriers and facilitators

A demanding work schedule and higher-priority training needs were cited commonly as the most significant barriers to implementing a structured social support countermeasure. Travel while training for a mission was also cited as a barrier but was paradoxically named as a context in which more support is needed. Some experts believed that astronauts would be receptive to social support countermeasures, but others were less certain about this. As described above, the degree of receptiveness is thought to depend to some extent on competing demands, perceptions about the target of the countermeasure, and the degree to which the countermeasure is weaved in naturally to the astronaut's work and social activities rather than artificially.

3.3.5 Analogue environments

Army and Antarctic winter-overs were discussed. The Army has instituted several initiatives related to social support within the work environment. These are described in the literature review. In particular, social fitness training, is geared toward enhancing the social resilience of individuals and of the team of individuals. Targeted outcomes, for example, include but are not limited to social cognition, work group attitudes, culture awareness, and health and well-being. According to the military expert, one key finding that has emerged is that social isolation for extended periods can be quite damaging. This expert also mentioned mindfulness training as a potentially useful component of a social support countermeasure. There are significant differences between military contexts and astronaut training, however, including selection processes (for entry into the military versus astronaut training), work group composition, work group duration, and level of competition among work group members (e.g., less in military as compared with astronaut candidacy training and pre-mission selection).

Antarctic winter-overs can be characterized by significant stress prior to deploying including getting one's affairs in order, a challenge mentioned by experts as also being pertinent to some astronauts. As with astronauts, this expert felt that less-experienced participants in winter-overs would stand to benefit more from mentoring than would the more-experienced winter-over veterans. Similar to responses in reference to mentoring of veterans, this expert felt that natural, versus assigned, mentor pairings would be more successful for winter-over crew members. This expert also noted the importance of establishing social networks among participants prior to deploying, if possible, also noting the more extensive time that astronaut teams have together prior to long-duration spaceflight as compared with winter-over teams.

3.4 Summary of Operational Assessment Findings

In summary, most experts agreed that social support within NASA is important to astronauts and will grow in importance as the duration of spaceflight increases for Mars missions. Social support needs and optimal formats may differ according to the particular phase of "pre-flight," with more support structures currently in place for astronaut candidacy training. Potential pre-flight targets among others include extensive travel, balancing work-life demands, anxiety regarding performance/selection, and family. Experts agreed that mentoring could be beneficial, especially for less-experienced astronauts. There was strong endorsement of experiential team building programs, such as NOLS. Experts also suggested that "organic" support countermeasures (versus countermeasures perceived to be forced or contrived) would be most effective. Suggestions included embedding these within social events, sports, and community connection. At least one expert believed that structured training that increased familiarity with mental health knowledge could be embedded in training. Structured countermeasures are not currently in place for winter-overs, although the analogue expert noted the benefits of social connection prior to deployment. The military has some social resilience training in place (discussed within the literature review) but is not fully analogous to the pre-flight context.

4. OVERALL CONCLUSIONS

4.1 Integrated Summary: Literature Review and Operational Assessment

Our operational assessment indicated that astronauts would likely benefit from, and be open to receiving, at least some types of social support countermeasures, especially when the countermeasure is delivered in an "organic" manner that capitalizes on existing or new relationships perceived to be routine, is not judged to compete with other training events, and is not delivered as a formal mental health intervention or as purely didactic training. A focus on organizational- or team-level interventions rather than individual stress-reduction techniques is consistent with a recent review on stress reduction in the workplace (Noblet & LaMontagne, 2006). The research literature suggests that social support countermeasures may be quite beneficial in buffering against the effects of exposure to both routine and extreme stressors. Varying types of support may be more or less beneficial to astronauts during different pre-flight phases and depending on specific circumstances. For example, it could be hypothesized that emotional support may be particularly helpful during periods of extended travel and intense training when the astronaut is separated from family and friends. Self-appraisal support may be particularly helpful in preparing the astronaut for long-duration spaceflight as a behavioral tool that could be invoked throughout the flight. Similar hypotheses could be made for the circumstances under which informational and instrumental support, or some combination of the various support constructs, are applied. Unfortunately, however, there is scant literature that attempts to address which types of support (and their related interventions) are best matched to specific situations.

Although social support within the organizational context is clearly linked to positive behavioral outcomes following exposure to severe stress, there is less available information directly analogous to the pre-flight period. The smaller body of existing evidence that may be construed as pertinent to pre-flight (e.g., pre-deployment for military populations; during physician training), however, suggests that social support provided prior to pre-flight would likely promote behavioral health during the pre-flight period. Based on literature suggesting that the effects of social support tend to be most impactful more proximal to the delivery of the

support, it is less clear whether the positive impact of social support provided pre-flight would endure throughout spaceflight unless continued during spaceflight.

Military interventions such as social resilience training are now being applied to buffer exposure to future stressors, but may require modification (e.g., avoidance of a purely didactic format) to be effective in the context of long-duration spaceflight. Peer-based support, mentoring, and professional coaching formats may have utility, as they have potential to capitalize on existing relationships and are typically non-didactic but would also be considered developing in terms of a rigorous evidence base. Of note, several experts remarked on the effectiveness of NOLS training, which may deserve consideration as a delivery model for certain social support interventions. Finally, the operational assessment suggested that unique sets of stressors and challenges may characterized different pre-flight periods, highlighting the possible utility of tailoring social support countermeasures according to the specific pre-flight period.

4.2 Recommendations for Research Portfolio

Observational studies examining which types of social support (instrumental, informational, emotional, appraisal) are most relevant to various pre-flight contexts, especially in regards to the specific phase of pre-flight, would be an important foundational step in the subsequent development of social support countermeasures. Based on the operational assessment, it would likely be beneficial to focus efforts on the provision of social support during post-candidacy phases of pre-flight and, in particular, during the period of training once the astronaut has been selected for a mission. Ideally, such research would be conducted within close analogues that mimic the attributes of each pre-flight phase and/or empirical program evaluation of current support mechanisms (e.g., the instrumental support provided via the Crew Support Program).

In regards to intervention research, as with observational research, efforts would also likely be best targeted to pre-flight phases following astronaut candidacy, and in particular, post selection for a specific long-duration mission. Interventions may be considered in two broad categories: (1) those that directly provide social support via strengthening social support networks or providing individual support (e.g., mentoring/coaching) and (2) those that reinforce the astronaut's skills in

receiving and giving support (e.g., emotional intelligence or social resilience training). The latter could be hypothesized to have more enduring effects, potentially benefitting the astronaut not just during pre-flight but also during spaceflight. However, the operational assessment suggests that such training may be best delivered at the team level within the context of broader team training (e.g., NOLS). The medical professional literature suggests the potential acceptability of one-on-one countermeasures. Although seemingly contradictory to the stated desire for team-level training, it may be that interventions that involve direct provision of social support include a one-on-one component (e.g., mentoring), whereas those that involve training of skills related to social resilience include a team-level component. The military is currently conducting research on social resilience training; however, it is at a more didactic and less contextualized level than might be tested for astronauts.

4.3 Recommendations for Current Operations

Based on the operational assessment, astronaut candidates appear to receive significant support from the organization, as well as training that may be relevant to social support. However, social support and relevant training appear to be relatively less available after astronaut candidacy. Thus, operational efforts, like research efforts, are probably most needed during post-candidacy periods, and especially during the extended period of training subsequent to being selected for a mission. SMEs identified in particular the need to maintain organized sports and other social activities during mission training. Interventions that would be considered enjoyable and routine to astronauts would likely be more effective than social opportunities that are perceived as contrived. Although outside of the occupational context, relationships with the community (e.g., with schools) that are facilitated before spaceflight may have lasting benefits if periodic continuing communication were made possible during spaceflight. Likewise, mentoring relationships with other astronauts/retired astronauts may hold the possibility of continuing support from the pre-flight period through spaceflight. Care, however, would need to be taken to allow mentor/mentee pairs to be well matched. NASA has an existing mentoring program, which may have potential application to astronauts if tailored specifically toward their culture and job requirements.

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6. APPENDIX

- ASTRONAUT QUESTIONS OUTLINE -

I. Background

There is indication from military, first respondent, and executive contexts that instrumental and interpersonal support provided within professional organizations can enhance aspects of performance, reduce certain health risks, and increase resiliency among high-performing personnel who operate in complex, high demand contexts. We are interested in your thoughts on whether pre-flight countermeasures designed to increase organizational, leadership, and peer support might be helpful to astronauts before and during long-duration spaceflight.

II. Question Domains

- <u>Potential countermeasure targets</u>
  - What are the most significant challenges confronted by astronauts during astronaut training and preparation for spaceflight?

- <u>Current levels of available organizational support</u>
  - To what extent is organizational and interpersonal support (e.g., mentoring, social support, etc.) available within the professional environment during astronaut training? During preparation for spaceflight?
  - How important is social contact with professional colleagues to astronauts?

- <u>Methods of delivery</u>
  - If a countermeasure were developed to increase organizational support of any type, from which components of an astronaut's professional community (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) do you think receiving support might be most meaningful during astronaut training and preparation for long-duration spaceflight?

- <u>Astronaut receptiveness</u>
  - How receptive would most astronauts be to countermeasures designed to increase social contact or support? To what extent should such measures facilitate "organic" interactions (v. reflect structured programming)?

- <u>Barriers</u>
  - What do you see as the greatest potential barriers in delivering countermeasures designed to provide social support to astronauts prior to long-duration spaceflight?

- BHS OPERATIONS PERSONNEL QUESTIONS OUTLINE -

I. Background

There is indication from military and first respondent contexts that social support from within organizations and professional communities can help attenuate adverse stress reactions and promote resiliency among personnel confronted with high, or even extreme, stress. We are interested in your thoughts on whether pre-flight countermeasures designed to increase organizational, leadership, and peer support might be helpful to astronauts before and during long-duration spaceflight.

II. Question Domains

- Current social support – your perceptions on the extent of social support in place within the astronaut's community and whether there are particular aspects of their professional environment that have potential to become more supportive in terms of fostering sustained, positive relationships with astronauts

- Intervention targets – your opinion regarding the most significant mental health and behavioral concerns facing astronauts both before and during (long-duration) spaceflight

- Existing countermeasures and interventions –
    - current professional mental health services in place before and during spaceflight and your opinion of which are most and least effective
    - current social support countermeasures outside the context of professional mental health services and your opinion on whether NASA should broaden its role in this regard

- Methods of delivery – from which components (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) of the astronaut's professional community do you think receiving social support might be most meaningful? Pros and cons of each.

- Astronaut receptiveness – to various formats of a social support countermeasure (e.g., structured mentoring, group training in peer support, individual training targeting strengthening of social resilience)

- Barriers – any barriers not otherwise discussed in delivering countermeasures aimed at increasing social support within the professional environment for astronauts

- ASTRONAUT TRAINER QUESTIONS OUTLINE -

I. Background

There is indication from military and first respondent contexts that social support from within organizations and professional communities can help attenuate adverse stress reactions and promote resiliency among personnel confronted with high, or even extreme, stress. By social support, we mean both instrumental (e.g., providing concrete assistance to facilitate task completion) and emotional (e.g., providing encouragement) support. We are interested in your thoughts on whether pre-flight countermeasures designed to increase organizational, leadership, and peer support might be helpful to astronauts before long-duration spaceflight.

II. Question Domains

- Current social support – your perceptions on the extent of social support in place within the astronaut's community during astronaut training and whether there are particular aspects of their professional environment that have potential to become more supportive in terms of fostering sustained, positive relationships with astronauts

- Intervention targets – your opinion regarding the most significant stressors facing astronauts during astronaut training

- Existing countermeasures and interventions – current social support countermeasures available during astronaut training (outside the context of professional mental health services) and your opinion on whether NASA should broaden its role in this regard

- Methods of delivery – from which components (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) of the astronaut's professional community do you think receiving social support might be most meaningful during astronaut training? Pros and cons of each.

- Astronaut receptiveness – to various formats of a social support countermeasure (e.g., structured mentoring, group training in peer support, individual training targeting strengthening of social resilience)

- Barriers – any barriers not otherwise discussed in delivering countermeasures aimed at increasing social support within the professional environment during astronaut training

- SPACE ANALOGUE QUESTIONS OUTLINE -

I. Background

We are considering the potential utility of organizational social support countermeasures prior to long-duration spaceflight. By social support, we mean both instrumental (e.g., providing concrete assistance to facilitate task completion) and interpersonal (e.g., providing encouragement) support. There is indication from military and first respondent contexts that social support from within organizations and professional communities can help promote resiliency among personnel confronted with high, or even extreme, stress. Based on your experience in analog environments, we are interested in your thoughts on whether pre-flight countermeasures designed to increase organizational, leadership, and peer support might be helpful to astronauts before long-duration spaceflight.

II. Question Domains

- Lessons from Antarctic analog environments
  - What are the primary stressors that individuals confront *prior to* - as they are preparing or training for - an Antarctic winter-over?
  - Have you noticed particularly successful (or conversely unproductive) methods of managing stress during the preparatory stage?
  - What are the primary stressors that individuals confront during Antarctic winter-over?
  - Are there countermeasures that could be applied prior to winter-overs that might help with stress or other behavioral health concerns during the winter-over?
  - To what extent does interpersonal or emotional support from peers or other professionals play a role before winter-overs? During winter-overs?

- Methods of delivering social support – Based on your experience in an analog environment, if NASA developed a program to enhance social support provided to astronauts prior to long-duration spaceflight, from which components (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) of the astronaut's professional community do you think receiving social support might be most meaningful during astronaut training? Any obvious pros and cons of each?

- Barriers –What barriers would you anticipate in delivering countermeasures aimed at increasing social support within the professional environment during astronaut training prior to long-duration spaceflight?

- Research context- Would long-duration work in the Antarctic serve as a reasonable analog for research examining potential effectiveness of social support countermeasures delivered prior to long-duration spaceflight?

- MILITARY RESEARCH EXPERT QUESTIONS OUTLINE -

I. Background

We are considering the potential utility of organizational social support countermeasures prior to long-duration spaceflight. By social support, we mean both instrumental (e.g., providing concrete assistance to facilitate task completion) and interpersonal (e.g., providing encouragement) support. There is indication from military and first respondent contexts that support provided from within organizations and professional communities can help promote resiliency among personnel confronted with high, or even extreme, stress.

II. Content Domains

- Social Fitness Training in the Army
  - What are the objectives?
  - What are its basic components?
  - Who delivers the training? To whom is it delivered? When is it delivered in relation to the deployment cycle (if applicable)?
  - What is the current state of the evidence base for the efficacy and/or effectiveness of the training?
  - What, if any, barriers have been encountered in executing this training?
  - Potential applicability to the training and preparatory of phases of long-duration spaceflight

- Other Army (or other military branch) initiatives that tap into enhancing unit, leadership, and/or organizational support
  - Which, in your opinion, are the best of these, and why?
  - Which, in your opinion, have not worked well, and why?

- Mentoring (if not already discussed)
  - Do you see a role for structured mentoring in enhancing social support within the workplace?
  - Are there mentoring programs in the Army? If so, what types of outcomes have been measured?

- Operational aspects of organizational support as a potential countermeasure
  - Based on your experience with Army programs, what barriers would you anticipate in delivering countermeasures aimed at increasing social support within the professional environment during astronaut training prior to long-duration spaceflight?
  - Based on your experience with Army programs, if NASA developed a program to enhance social support provided to astronauts prior to long-duration spaceflight, from which components (e.g., peer colleagues, leaders, educators, mentors, retired astronauts) of the astronaut's professional community do you think receiving social

support might be most meaningful during astronaut training? Any obvious pros and cons of each?

- Would there be any military contexts that might serve as a reasonable analog for research examining potential effectiveness of social support countermeasures delivered prior to long-duration spaceflight?

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13. ABSTRACT *(Maximum 200 words)*
This report presents methods and results of a literature review and operational assessment interviews on pre-flight occupational social support as a potential behavioral health countermeasure delivered prior to long duration spaceflight. The literatures reviewed included observational and intervention studies relevant to occupational social support conducted among military personnel, first respondents and other emergency personnel, law enforcement officials, and other professionals working in potentially high stress occupations. Interventions reviewed included those involving direct provision of social support (e.g., mentoring, executive coaching), as well as training in skills intended to enhance provision and receipt of social support within the occupational setting (e.g., social resilience training). The operational assessment involved semi-structured interviews of 8 subject matter experts, including retired astronauts, space analogue participants, astronaut trainers, a NASA mentoring program representative, Behavioral Health and Performance Operations personnel, and a military scientist with social support research experience. Content domains included: identification of high priority countermeasure behavioral health outcome targets, identification of currently available sources of support for astronauts accessible prior to long duration spaceflight, assessment of the feasibility of delivering social support countermeasures, identification of potential barriers and facilitators of new social support countermeasures, and applicability of analogue contexts to research examining organizational support countermeasures.

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